SYSTEMATIC PART

Attempt a revision of the previously described Bothriolepinae.

Genus Bothriolepis Eichwald and its comprehension.

Diagnosis. – Bothriolepine forms of very varying size. Anterior median dorsal plate broader across its lateral corners than towards its anterior and posterior ends, normally overlapping the anterior dorso-lateral plate and overlapped by the mixilateral plate. Posterior median dorsal plate generally much narrower anteriorly than across its posterior part. Mixilateral plate generally considerably broader at the transverse plane through its dorsal corner than towards the anterior and posterior ends. The dorsal lamina of the mixilateral plate as a rule broader and extending further dorso-medially than the exposed area of the dorsal lamina of the anterior dorso-lateral plate. Ornament of varying coarsness; in immature individuals fine-meshed reticular and regular; in mature individuals on the whole reticular, or else to a large extent dissolved into short ridges or tubercles and more or less devoid of anastomoses; in mature individuals more or less clearly concentrically and radiatingly disposed.

The genus *Bothriolepis* at present comprises a great number of species. Of the various species referred to it up to 1941 the following seem to be retainable: *B. canadensis* Whiteaves, *B. nitida* (Leidy), *B. minor* Newberry, *B. ornata* Eichwald (genotype), *B. cellulosa* (Pander), *B. panderi* Lahusen, *B. maxima* Gross, *B. turanica* Obrutschew, *B. sinensis* Chi, *B. gigantea* Traquair, *B. obesa* Traquair, *B. leptocheira* Traquair, *B. hydrophila* (Agassiz), *B. macrocephala* Egerton, *B. cristata* Traquair, *B. lohesti* Leriche, *B. gippslandiensis* Hills, *B. ancartitca* A.S.Woodward, and *B. groenlandica* Heintz. To these nineteen species three new ones, *B. alvesiensis*, *B. jarviki* and *B. nielseni*, are here added, all of which are dealt with below in this work[1]).

The species *B. stensiöi* Sohn (Sohn 1938, pp. 111–113) is based simply on a slightly anomalous specimen of *B. canadensis* (Robertson 1938, pp. 299–300) and is, therefore, not maintainable. *B. traquairi* Bryant (Bryant

[1]) Sincg the present work had been sent to the press Gross in a recent paper (1942 a) described four new *Bothriolepis*-species from the Baltic Devonian. For further particulars concerning these species see the Addenda at the end of this work.

1924, pp. 54–55), as we shall see (pp. 398–400 below), will probably reveal itself as a representative of a new genus. At any event it seems unlikely that it belongs to *Bothriolepis*. *B. jeremijevi* Rohon and *B. maeandrina* Hoffmann (cf. Stensiö 1931, p. 10; Gross 1932b, pp. 33–34) are both so imperfectly known that for the time being it cannot be decided whether they actually are maintainable as independent species or whether they are referrible to some one of the other known Baltic-Russian-Asiatic species.

Provided that the reproductions of it published by Eastman are somewhat true (Eastman 1904, fig.1) *B. coloradensis* Eastman cannot possibly belong to *Bothriolepis*, but must be a Remigolepid form (Stensiö 1931, p. 10; Gross 1932b, p. 34; Woodward 1932, p. 39).

Finally, the interesting species *B. tuberculata*, recently described by Gross (1941a, pp. 32–57), in several of its characters differs so considerably from all other *Bothriolepis*-species that it must be considered to represent a new genus. This new genus, which has been named *Grossilepis*, however, is closely related to *Bothriolepis*.

The genus *Bothriolepis* appeared as early as in the Upper Middle Devonian (Evans 1929, p. 150, foot-note 3; Obrutschew 1930; 1935; Gross 1933a, p. 69; 1934, pp. 420, 422; 1940a, p. 535; 1942a, pp. 415–418), but is commonly met with first in the Upper Devonian. It is one of the vertebrate genera that are characteristic of the Upper Devonian and during this division of the Devonian attained a very wide geographical distribution. In fact it was at that time spread practically all over the world (Stensiö 1931, p. 26; Obrutschew 1940, pp. 890–892).

North-American species.

The North-American species here treated are as follows: *B. canadensis* (Whiteaves), *B. nitida* (Leidy), *B. minor* Newberry and *B*? *traquairi* Bryant. In addition an undeterminable *Bothriolepis* from Ellesmere Land will also be discussed.

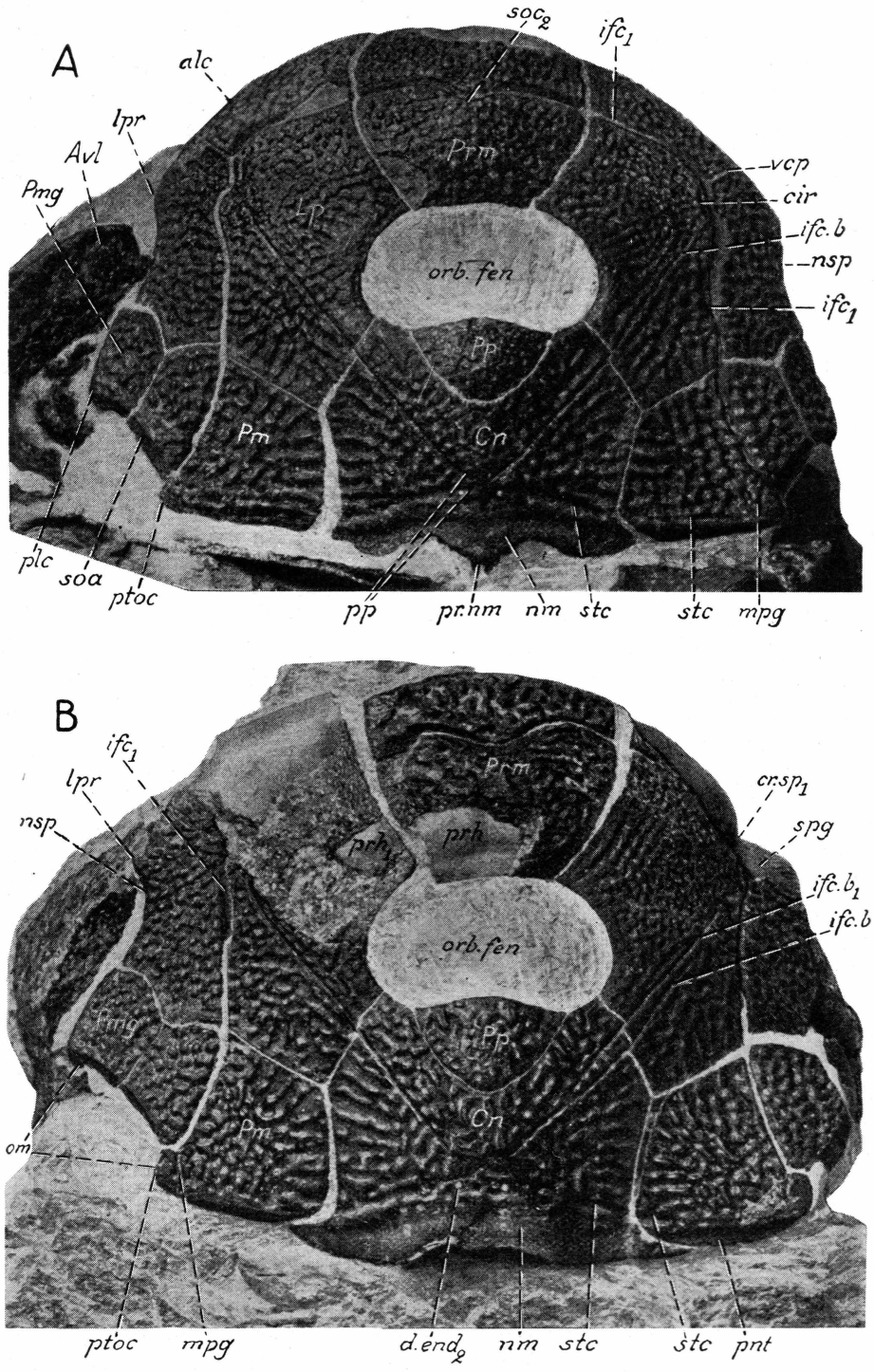
1. **Bothriolepis canadensis** (Whiteaves).

(Text-figs. 1 A, C, D, 2 B–D, 3–12, 15, 19. 20 B, 21 A–C, 23 A–D, 24 A, B, 25, 26 A, 27, 28 A, 29, 30, 31 A, B, E' 32–34, 35 A–C, 36 A, B, 37, 38, 39 A, B, 40 41 A, B, 43 A, B, 44 A, 45 A–C, 46, 47 A, 48 A–C, 50 A, B, 51, 53 A, B, 54–57, 58 A–C, 59, 60, 62, 65, 76–211, 283 B, C.

1938 *Bothriolepis stensiöi*, Sohn 1938, pp. 111–113.
1938 *Bothriolepis canadensis*, Robertson 1938, pp. 299–300.
For complete list of synonyms see Gross 1932 b, pp. 29–30.

Diagnosis. – Species of moderate size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) maximally about 18–19 cm. Length of head about one third of total dorsal length of armour. Head-shield with a breadth : length ratio of 130–152 and much arched an-

teriorly both in rostro-caudal and transverse directions. Margins of head-shield developed as follows. Rostral margin normally considerably shorter than posterior margin, usually strongly convex and often, above all in small individuals, with a rostral angle. Lateral margins converging more or less forwards and about equally long as the centro-nuchal plate is broad across its lateral corners. Obstantic margin of either side comparatively short, normally ending fairly far behind the transverse plane through the posterior boundary of the orbital fenestra. Median division of preorbital recess normally with a practically straight and transverse anterior boundary, and lateral division of the same recess short. Premedian plate often with a fairly well-marked nasal notch; its ventral lateral notch mostly fairly shallow and usually also situated in front of the middle of the ventral lateral margin. Rostral plate somewhat longer than broad. Pineal plate broader than long with a straight or slightly concave anterior margin. Postpineal plate with a convex anterior (orbital) margin. Length : breadth ratio of centro-nuchal plate 65–83. Lateral division of paranuchal-marginal plate usually not particularly broad. Postmarginal plate longer than broad and usually reaching only slightly forwards in front of the paranuchal-marginal plate. Mental plate about two and a half times as long as high. Trunk-armour long and low with a low and flat dorsal wall, but with comparatively high lateral walls. Dorsal wall meeting the lateral wall of either side at an almost right angle and clearly narrower in young individuals than in older ones. Its breadth : length ratio ranging between 80–96. Lateral walls somewhat more than two and a half times as long as high. Tergal angle about at the transition between the anterior and middle thirds of the anterior median dorsal plate or a little further forwards or backwards. Dorsal median ridge in large individuals weakly developed and often partly absent. Median dorsal part of the crista transversalis interna posterior on the posterior median dorsal plate high and well marked. Postlevator thickening fairly pronounced. Postlevator crest often present and well developed particularly in small individuals. Ventral tuberosity of posterior median dorsal plate strongly developed. Anterior median dorsal plate fairly variable as to shape and proportions. Its breadth : length ratio with a total range of 76–112, but normally 80–100 in small and medium-sized individuals, and 90–105 in large individuals. Anterior margin of this plate usually more or less convex, but sometimes nearly straight, and often with a median more or less well-marked concavity or notch. Posterior median dorsal plate comparatively broad in its anterior parts; its breadth : length ratio ranging from 77–117; its posterior median corner always well developed. Dorsal lamina of anterior dorso-lateral plate about twice as long as broad; lateral lamina of this plate normally somewhat more than twice as long as high. Dorsal lamina of mixilateral plate from approximately one and a half times to twice as long as broad; lateral lamina of this plate from about two and a fourth to about two and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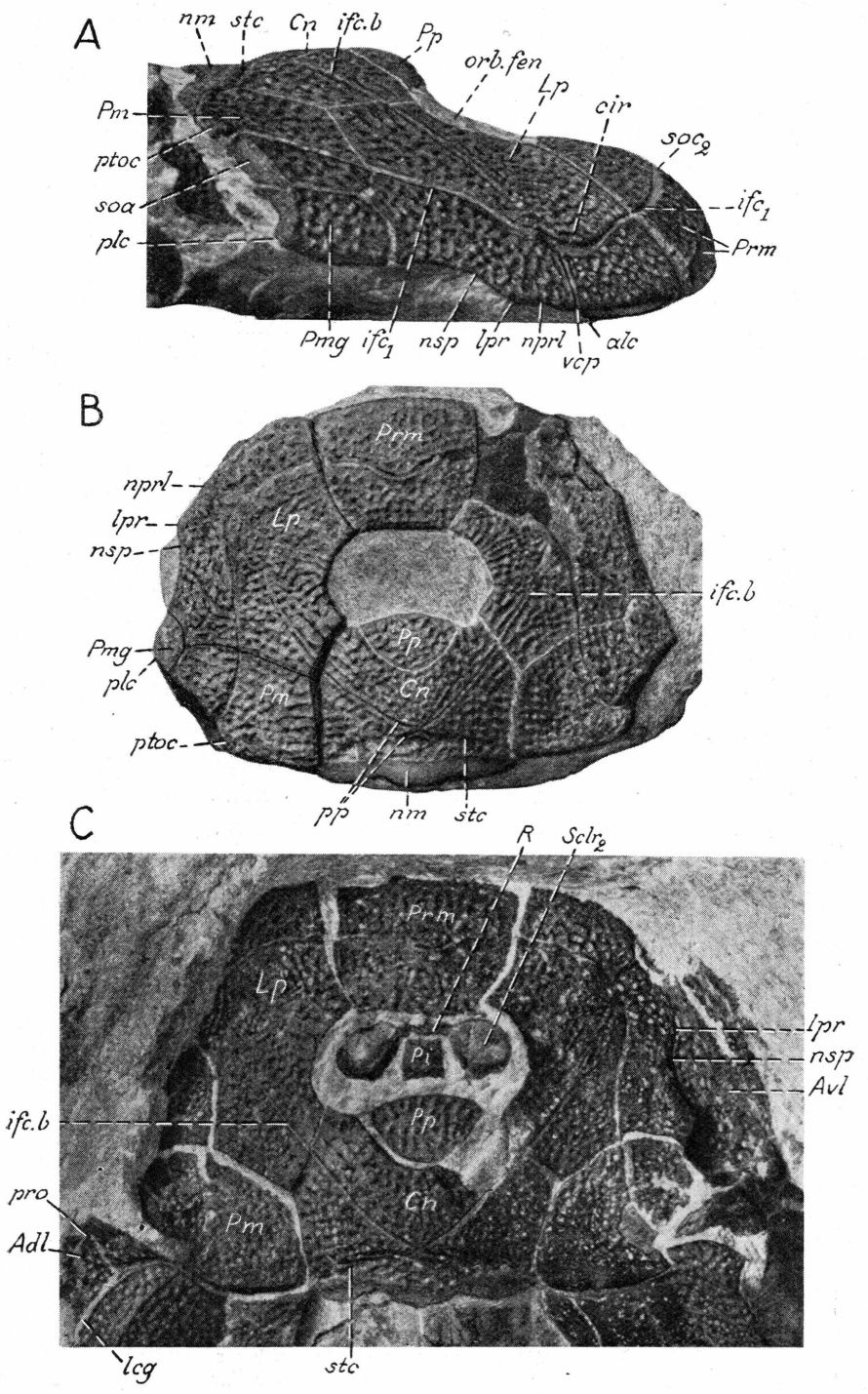
a third times as long as broad. Lateral lamina of anterior ventro-lateral plate from about two and a half to nearly three times as long as high. Ventral lamina of anterior ventro-lateral plate from about one and a half to about two and a fourth times as long as broad. Posterior ventro-lateral plate with an obtuse, and often rather obscure, dorsal corner; its lateral lamina from somewhat less than twice to about two and a half times as long as high; its ventral lamina from not fully twice to about two and a third times as long as broad. Median ventral plate normally comparatively small. Pectoral fin robust particularly in large individuals. Proximal segment from more than five times (small individuals) to about three and a third times (large individuals) as long as broad. Distal segment robust and fairly flat in a dorso-ventral direction. Lateral spines of proximal segment somewhat well developed, but clearly more numerous, shorter relatively, and more obtuse in large individuals than in small ones. Medial spines of proximal segment not particularly numerous, but clearly more numerous in large individuals than in small ones. These spines also fairly well developed; those situated on the dorsal central plate 1 and on the adjacent parts of the medial marginal plate 2 pointing dorsally and practically always independent in their distal parts. Dorsal central plate 1 from about three to about two and a third times as long as broad, and ventral central plate 1 from more than three to almost 2,8 times as long as broad. Ornament in very small individuals consisting of a regular fine-meshed net-work of anastomosing ridges, usually with tubercular elevations at their points of union; ornament in medium-sized and large individuals also fundamentally reticular, but its net-work more or less dissolved into isolated tubercles and nodose, tubercular ridges, more or less vermiculating and with relatively few anastomoses, or to a large extent even completely without anastomoses. Tubercles and tubercular elevations of ridges often with stellata bases.

Text-fig. 76. *Bothriolepis canadensis*. *A*, *B*, two head-shields in dorsal aspect. The one in *B*, deficient anteriorly on the left and right sides and in addition somewhat flattened. *A*, R. M. specimen No. P. 2667. × $^3/_2$. *B*, R. M. specimen No. P. 2318. × $^3/_2$.
Avl, foremost (subcephalic) part of left anterior ventro-lateral plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of the head-shield; *cir*, semicircular pit-line groove; *cr.sp*$_1$, prespiracular crest (impression); *d.end*$_2$, canal for ductus endolymphaticus; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *ifc.b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *nsp*, supraspiracular notch; *om*, obstantic margin; *orb.fen*, orbital fenestra; *plc*, postero-lateral (preobstantic) corner; *pnl*, paranuchal trochlea; *pp*, posterior pit-line groove of skull-roof; *prh*, median unpaired division of preorbital recess; *prh*$_1$, lateral paired division of preorbital recess; *pr.nm*, posterior median process of centro-nuchal plate; *ptoc*, post-obstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median section of supraorbital sensory canal groove, the anterior median pit-line; *spg*, spiracular groove (impression); *stc*, supratemporal (cross-commissural) pit-line groove; *vcp*, vertical pit-line groove of cheek.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Material.

The subsequent description is based mainly on a comprehensive material belonging to the Swedish Museum of Natural History in Stockholm[1]), a material including several hundreds of specimens. Besides this material a few specimens in the possession of the Palaeontological Institute of the University of Uppsala have also been treated. These specimens have kindly been placed at my disposal by professor G. Säve-Söderbergh.

The holotype is an almost complete specimen in the possession of the Geological Survey of Canada, Ottawa.

Description.

Size and general proportions.

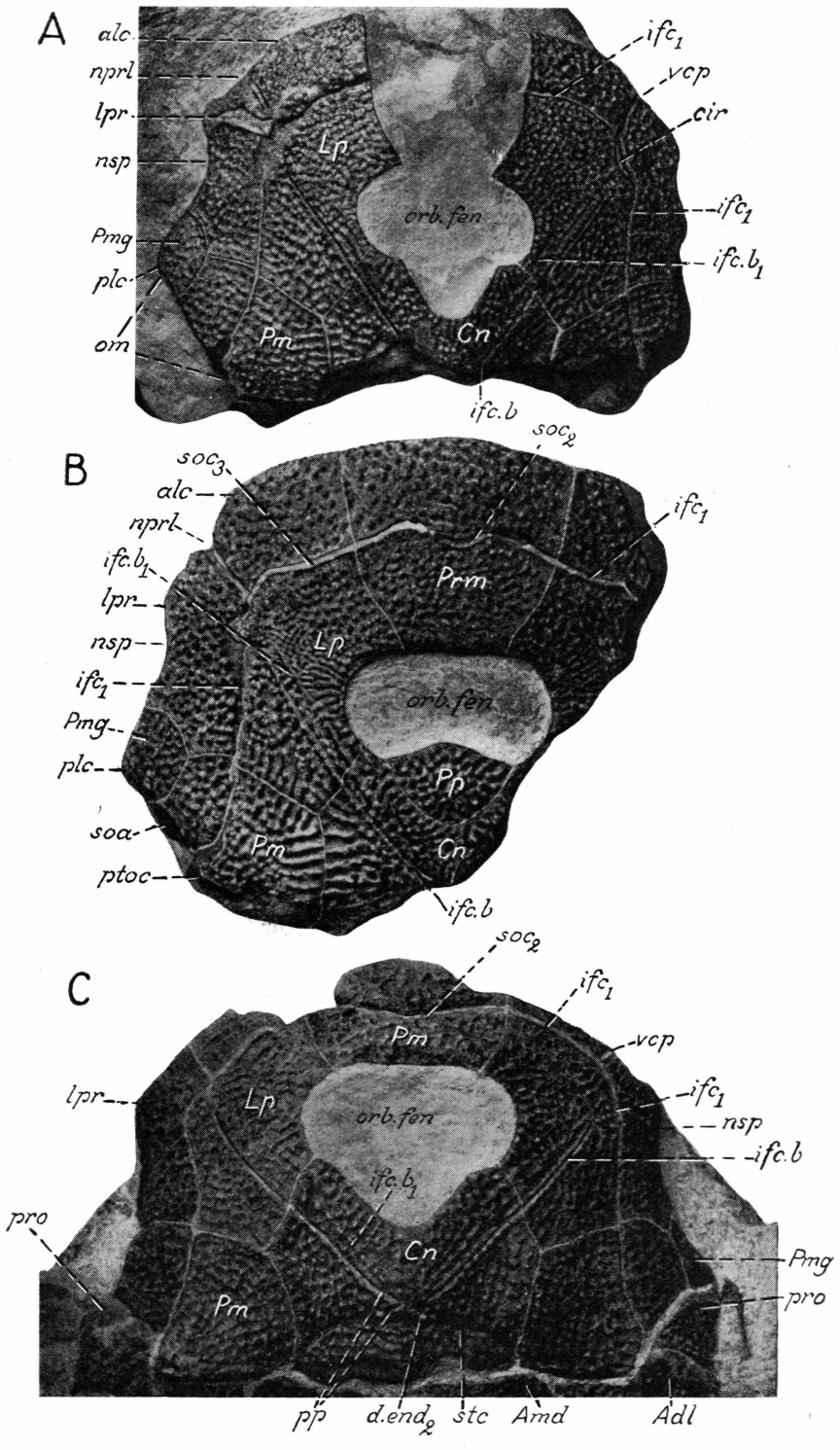
The material examined includes specimens of varying stages of growth, from such specimens in which the dorsal wall of the trunk-armour is only about 1,85 cm long (text-figs. 88A, B, 179A, 204) up to such specimens in which the said wall of the trunk-armour is as much as about 13 cm long (text-figs. 159, 182, 183). The dorsal length of the whole armour (the length of the head-shield + the length of the dorsal wall of the trunk-armour) is from about 2,17 cm up to about 19 cm. Including the unarmoured posterior part of the body the total length amounted in the smallest individuals to about 5,5 cm, and in the largest individuals to about 45–48 cm. As is evident from these statements, *B. canadenois* attained only a moderate size.

The head-shield (text-figs. 38, 40B, 88, 90–92, 95–98, 101, 102, 106, 109, 115–117, 127–134, 140, 147, 148, 154, 155, 157–159, 180A, 181C, 182) usually constitutes about one third of the total dorsal length of the armour, but not rarely it may be a little shorter or a little longer. It is always broader than long, more precisely 130–152% broader than long. Roughly taken it is thus from about one third to about one half broader than long.

The trunk-armour (text-figs. 38, 39A, B, 40, 41A, B, 88, 90–92, 95–98, 101, 102, 106, 109, 114–117, 127–134, 140–143, 146–152, 154–164, 167–169,

Text-fig. 77. *Bothriolepis canadensis*. *A*, slightly flattened head-shield seen from the right side. R.M. specimen No. P. 2667 (same specimen as in text-fig. 76 A). × 3/2. *B*, fairly flattened head-shield in dorsal aspect. R.M. specimen No. P. 2434. × 3/2. *C*, somewhat crushed and flattened head-shield in dorsal aspect. R.M. specimen No. P. 2674. × 2.
Adl, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pi*, pineal plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *R*, rostral plate; *Sclr*$_2$, postero-dorsal sclerotic plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *lcg*, main lateral line groove; *lpr*, supraspiracular process; *nm*, obtected nuchal area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb.fen*, orbital fenestra; *plc*, postero-lateral (preobstantic) corner; *pro*, processus obstans; *pp*, posterior pit-line groove of skull-roof; *ptoc*, postobstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median division of the supraorbital sensory canal groove, the anterior median pit-line; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of the cheek.

[1]) The specimens belonging to the Swedish Museum of Natural History that are reproduced below are denoted with the letters R. M. and a number.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173, 178–183) is of a low and broad type. Its maximum height could be measured only in a single comparatively large specimen (text-fig. 150D; Stensiö 1931, text-fig. 38B) in which it amounts to about two thirds of the maximum breadth. The dorsal wall is always low and strikingly flat, its median part with the dorsal median crista being only fairly slightly higher than the lateral parts situated along the dorso-lateral ridge of either side. The wall in question meets the lateral wall of either side at a nearly right angle, more precisely at an angle of about 90–96°. It increased somewhat in breadth with the proceeding growth of the armour and so in large individuals is nearly as broad as it is long. Only in exceptional cases, in very large individuals, it it seems to be practically as broad as long. Its breadth in small medium-sized individuals is normally 80–90% of the length, whereas in large individuals it generally amounts to 90–96% of the length. The lateral wall is only about two and a half times as long as high and is thus of a shorter and higher type than in several other species, e.g. *B. maxima*, *B. gigantea* and *B. groenlandica* (text-figs. 243J, H, 287B). This wall is not vertical, but inclines so that its outer face is directed laterally and somewhat downwards. Finally, the ventral wall is often about twice as long as it is broad, but may also not rarely be either a little shorter or a little longer in proportion to its breadth.

The unarmoured posterior division of the body (text-figs. 38, 40B, 62) is long and slender. At least in medium-sized specimens this division is somewhat more than twice as long as the dorsal wall of the trunk-armour.

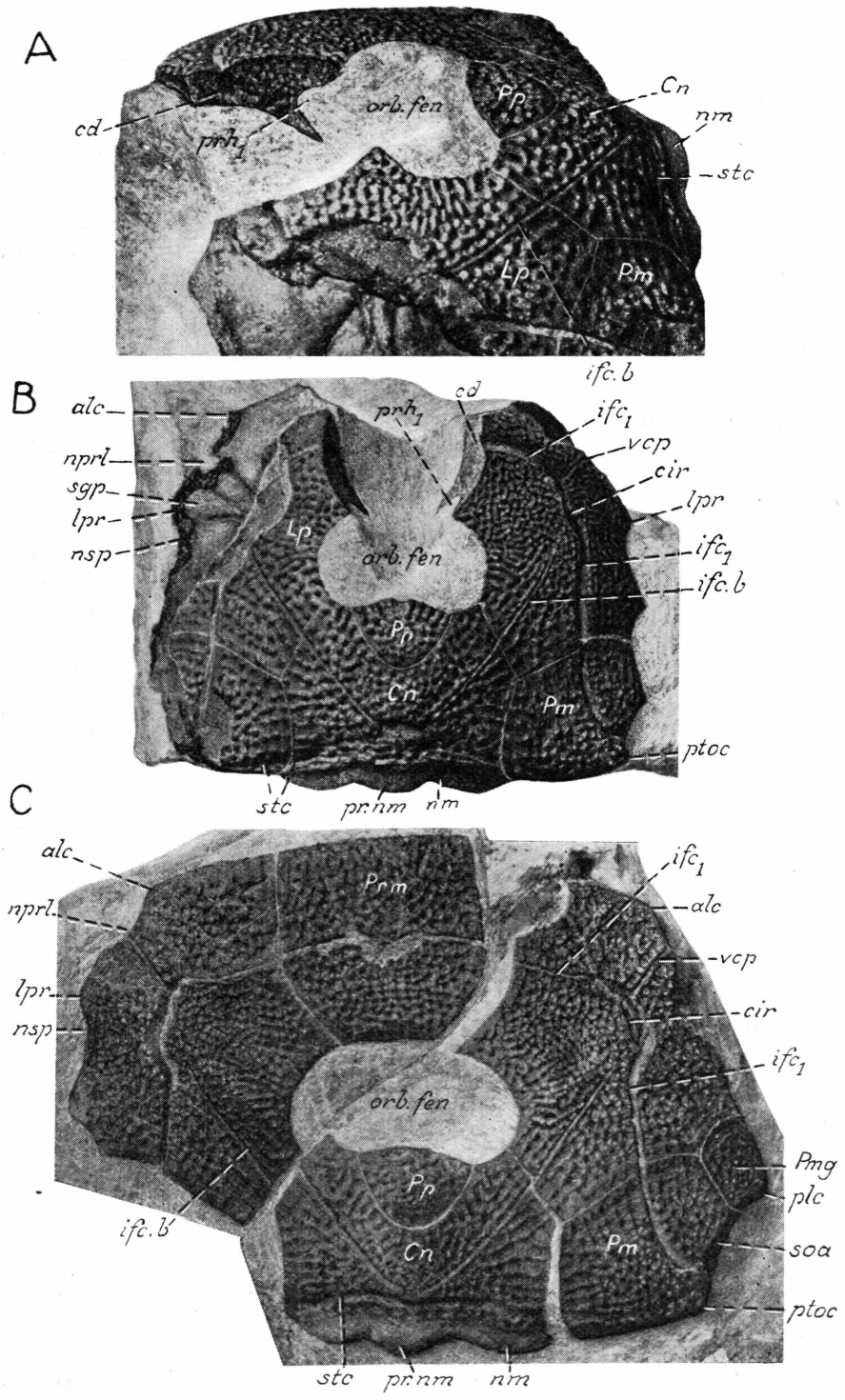
Endocranium and visceral endoskeleton.

Regarding the endocranium and visceral endoskeleton the reader is referred to the general part of this work (pp. 25–40) in which these skeletal formations are discussed.

Head-shield.

The head-shield (text-figs. 4, 9–12, 65, 76–84, 88, 90–92, 95–98, 101, 102, 106, 109, 110–114, 116, 117, 127–134, 140, 147, 148, 154, 155, 157–159,

Text-fig. 78. *Bothriolepis canadensis*. *A*, deficient, fairly flattened head-shield in dorsal aspect. The premedian and post-pineal plates missing, and the hindmost part of the shield broken off. R.M. specimen No. P. 2111. × 3/2. *B*, flattened head-shield, deficient on the right side. Dorsal aspect. R.M. specimen No. P. 2671. × 3/2. *C*, somewhat complete and only slightly flattened head-shield in dorsal aspect. R. M. specimen No. P. 2681. × 2. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of the head-shield; *cir*, semicircular pit-line groove; *d.end*$_2$, external opening of canal for endolymphatic duct; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *ifc.b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb.fen*, orbital fenestra; *om*, obstantic margin; *plc*, postero-lateral (preobstantic) corner; *pp*, posterior pit-line groove of skull-roof; *pro*, processus obstans; *ptoc*, postobstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median section of supraorbital sensory canal groove, the anterior median pit-line; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.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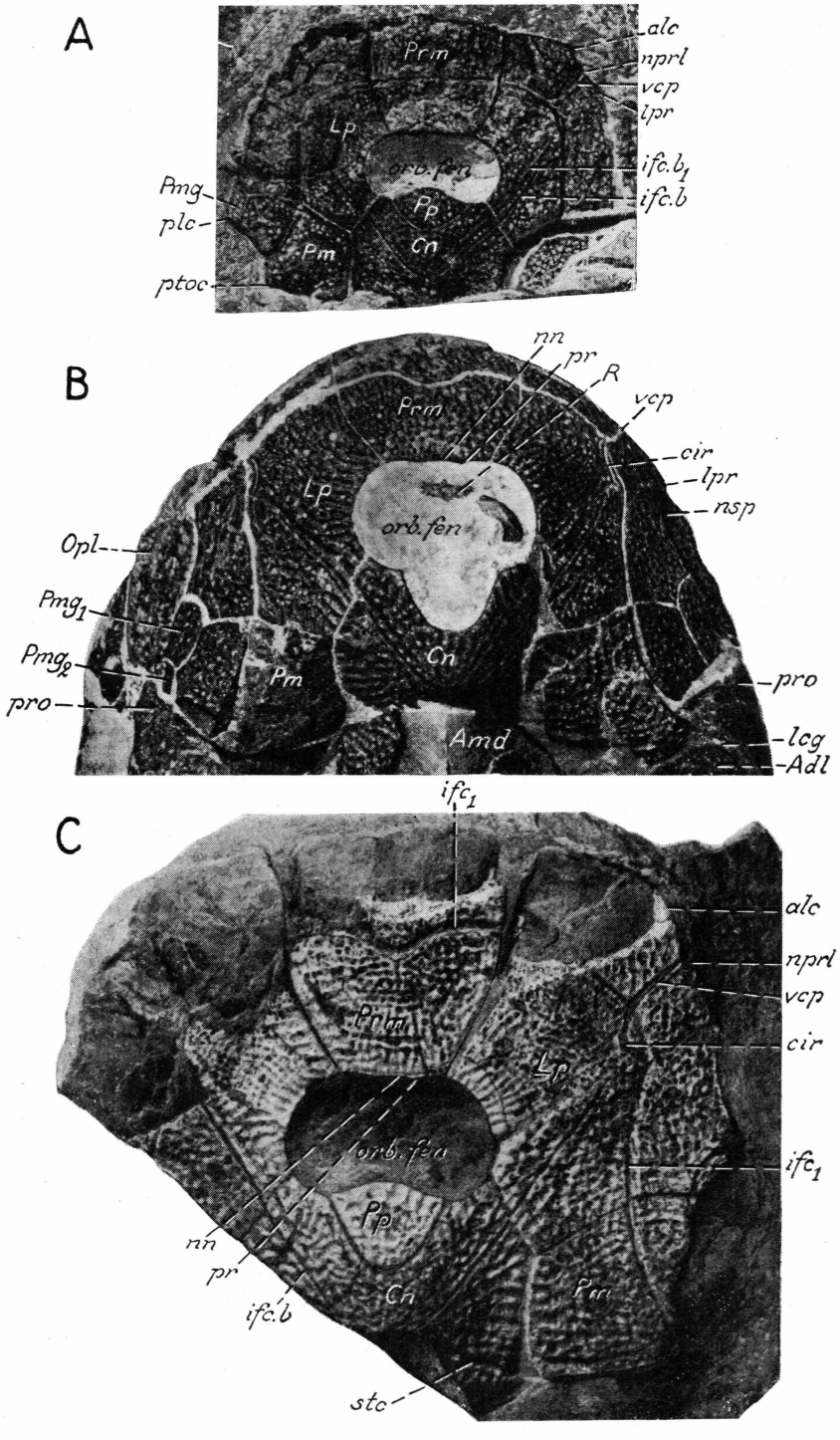
180A, 181C, 182, 185, 203, 205, 208, 209) is fairly variable as to shape and proportions. Its breadth : length ratio ranges between 130–152, but seems generally to be 140–150. The shield narrows clearly in front of its postero-lateral (preobstantic) corners (*plc*). In those cases when it is not too badly crushed or dorso-ventrally flattened (text-figs. 4, 38, 40B, 77A, 81A, 114) its preorbital division is curved much ventrally both in rostro-caudal and transverse directions. In these cases it is also seen that immediately laterally to, and in front of, the orbital fenestra it is somewhat depressed in such a manner that the medial part of the lateral plate and the posterior part of the premedian plate are not situated in the straight anterior continuation of the postpineal plate, but lie somewhat lower down. The orbital fenestra in small specimens is considerably larger in proportion to the size of the head-shield (text-figs. 84A, B, 88, 90–92, 95, 96, 98, 205, 206) than what it is in medium-sized and large specimens (text-figs. 4, 9, 10, 76–83, 84C, 101, 102, 106, 109, 114–117, 127–132, 134, 140, 147, 148, 154–159, 208, 209); and thus normally decreased in relative size during the growth of the individuals. Characteristic of this fenestra is that it is comparatively broad in proportion to the head-shield in all stages of growth, clearly broader than in *B. cellulosa* (cf. text-figs. 218, 219), *B. maxima* (text-fig. 233A), and certain other species. The rostral margin of the shield normally is considerably shorter than the posterior margin. It is convex both in dorsal and ventral aspects (cf. text-figs. 8, 9, 10). Its degree of convexity may vary considerably, but is usually fairly strong. Looked at straight from in front (text-fig. 114) this margin is always clearly concave, a condition which is due to the downward bending of the lateral parts of the shield. In small individuals the margin in question is generally provided with a pronounced rostral angle (*ra*, text-figs. 84A, B, 85A, C, 86A, 88A, B, 91, 92, 98), which sometimes persists in a more or less reduced condition also in medium-sized and large individuals (text-figs. 81B, 82A, 83A, B, 84C, 85E, G, M, 86C, E, G, 101, 114). The antero-lateral corner (*alc*) is well defined. The lateral margin of either side is about as long as the centro-nuchal plate is broad across its lateral corners, and always presents a fairly distinct prelateral notch (*nprl*),

Text-fig. 79. *Bothriolepis canadensis*. *A*, head-shield lacking the premedian plate. Antero-dorso-lateral aspect. R. M. specimen No. P. 2107. × 2. *B*, the same head-shield as in fig. *A*, but in dorsal aspect. × $^3/_2$. *C*, detached parts of a head-shield, partly much flatetned R.M. specimen No. P. 2679. × $^3/_2$.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cd*, area overlapped by premedian plate; *cir*, semicircular pit-line groove; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *lpr*, supraspriracular process; *nm*, obtected nuchal area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb.fen*, orbital fenestra; *plc*, postero-lateral (preobstantic) corner; *prh*$_1$, lateral paired division of preorbital recess; *pr.nm*, posterior median process of centro-nuchal plate; *ptoc*, postobstantic corner; *sgp*, spiracular groove (impression); *soa*, subobstantic area; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.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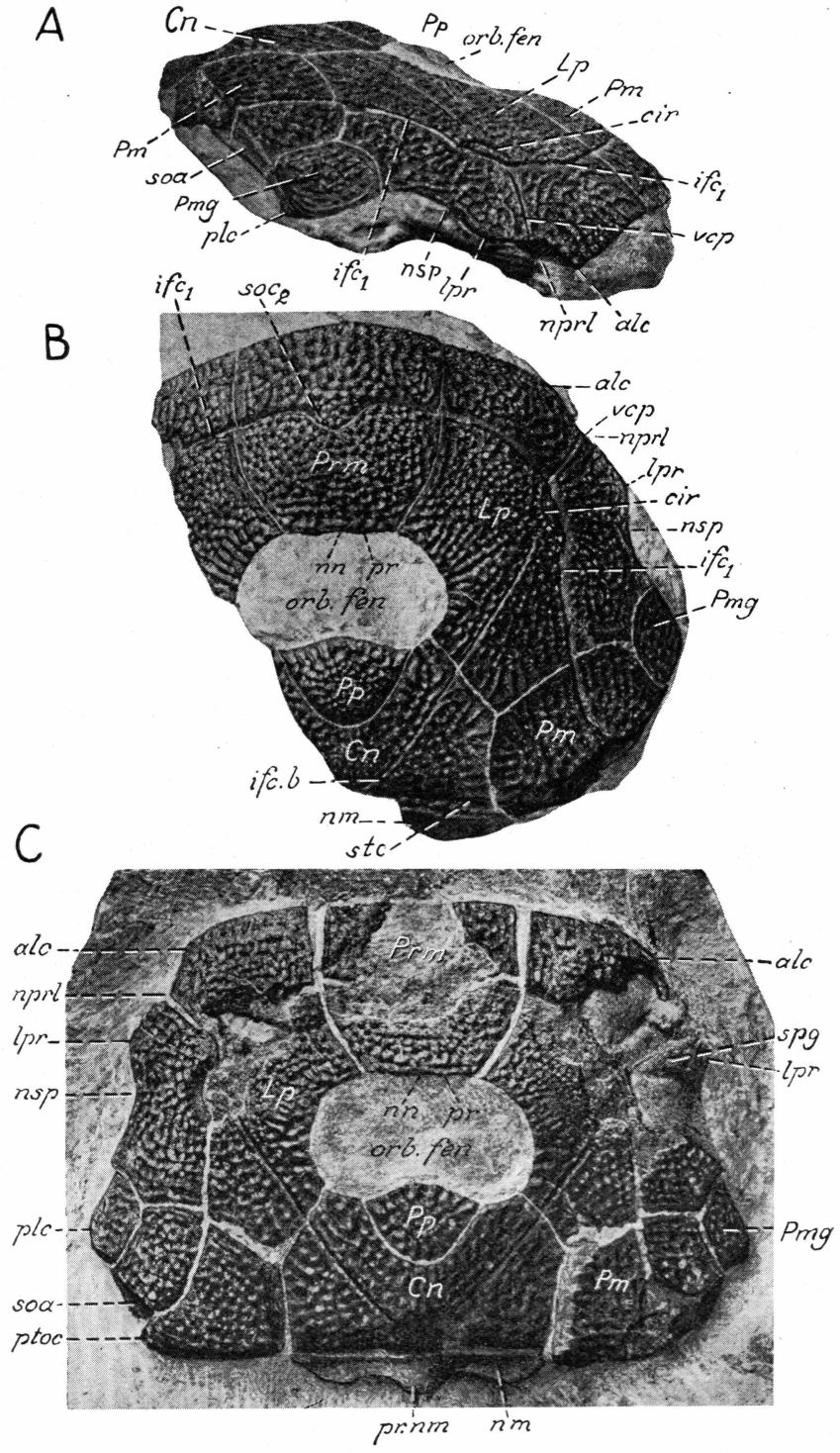
stc

a broad supraspiracular process (*lpr*), and a somewhat well defined supraspiracular notch (*nsp*). The supraspiracular process may be situated opposite the middle or foremost part of the orbital fenestra, but not rarely it lies even somewhat further forwards, opposite the hindmost part of the premedian plate. The postero-lateral (preobstantic) corner (*plc*) lies fairly far behind the transverse plane through the posterior boundary of the orbital fenestra. It is often a little produced backwards into a short postero-lateral process, but in several cases it is rounded off and not particularly pronounced. The obstantic margin (*om*) is comparatively short and does not reach nearly as far forwards as to the transverse plane through the foremost corner of the paranuchal-marginal plate. It varies a good deal, however, as to its relative length. In its anterior part it is somewhat concave, in its posterior part somewhat convex, but as a whole it is normally clearly concave. It faces always laterally and more or less backwards. The subobstantic area (*soa*) is broadest and best developed in its posterior parts, situated on the lateral division of the paranuchal-marginal plate. The postobstantic corner (*ptoc*) is well-defined. The posterior margin varies somewhat in its extent in relation to the breadth of the shield. In very small individuals this margin is convex with a median angle or process only (text-figs. 84A, B, 98A–E), whereas in medium-sized and large individuals it exhibits not only a median process, but in addition also a paired more or less strongly pronounced lateral convexity (text-figs. 76, 77B, 79B, C, 81C, 82, 83, 84C, 93F–O). The obtected nuchal area (*nm*) is broad and well defined anteriorly.

The preorbital recess (*prh*, prh_1, text-figs. 9, 11, 15, 20B, 76B, 79A, B; cf. also Patten 1912, text-fig. 252A) is well developed. The median division (*prh*) reaches forwards to about the transition between the posterior and middle thirds of the premedian plate and has normally a fairly straight transverse anterior boundary. Generally this division is clearly lower in its median part than in its lateral parts, where throughout its rostro-caudal extent it is in open communication with the lateral division of either side. The last-mentioned division (prh_1) is short and extends only a short dis

Text-fig. 80. *Bothriolepis canadensis*. *A*, small, flattened head-shield in dorsal aspect. R.M, specimen No. P. 2853 (same specimen as i text-fig. 115). × 3/2. *B*, a somewhat crushed. but not flattened head-shield in dorsal aspect. R. M. specimen No. P. 2854 (same specimen as in text-figs. 103 A, 162 and 163 B). × 3/2. *C*, deficient, flattened head-shield in dorsal aspect. R. M. specimen No. P. 2328. × 3/2.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; Pmg_1, Pmg_2, anterior and posterior postmarginal plates respectively; *Pp*, postpineal plate; *Prm*, premedian plate; *R*, rostral plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; ifc_1, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove; *lcg*, main lateral line groove; *lpr*, supraspiracular process; *nn*, nasal notch; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *plc*, postero-lateral (preobstantic) corner; *pr*, paranasal process; *pro*, processus obstans; *ptoc*, postobstantic corner; *stc*, supratemporal (cross-commissural) pit-line groove; *vcp*, vertical pit-line groove of cheek.


A
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tance laterally into the lateral plate. Its lateral margin is usually a little concave in its middle part. According to a reproduction given by Patten (1912, text fig. 252A) both the median unpaired and the lateral paired division of the recess may be a little produced into pointed distal ends and may thus in certain cases tend to developed in a manner similar to that in *B. groenlandica* and *B. maxima* (text-figs. 13, 233A). The function of the recess has been explained above (pp. 48–52) in the general part of this work.

The lower side of the head-shield is well preserved in several of the specimens examined (text-figs. 11, 12, 15, 20B, 23D, 25B, 86, 87B, C). On this side of the head-shield we notice above all the otico-occipital depression (*ood*) and the crests bounding this depression (*cr. pm, cr. pto, cr. tv*). We find there also the oblique premedian ridge (*ri*), which often is well developed, and further the poriferous area (*ap*), the spiracular groove (*spg*) with its crests (*cr. sp_1, cr. sp_2*), the prespiracular pit (*p*), the supraotic thickening (*sot*), the ventral opening of the canal for the endolymphatic duct through the centro-nuchal plate (*$d.end_1$*), and a canal (*c.lat*), probably for a lateralis nerve. Finally, this side of the shield shows also certain markings on the postpineal plate (*mr, g*) and the well-pronounced ventrally directed area of attachment (*a. opl*) for the extralateral plate.

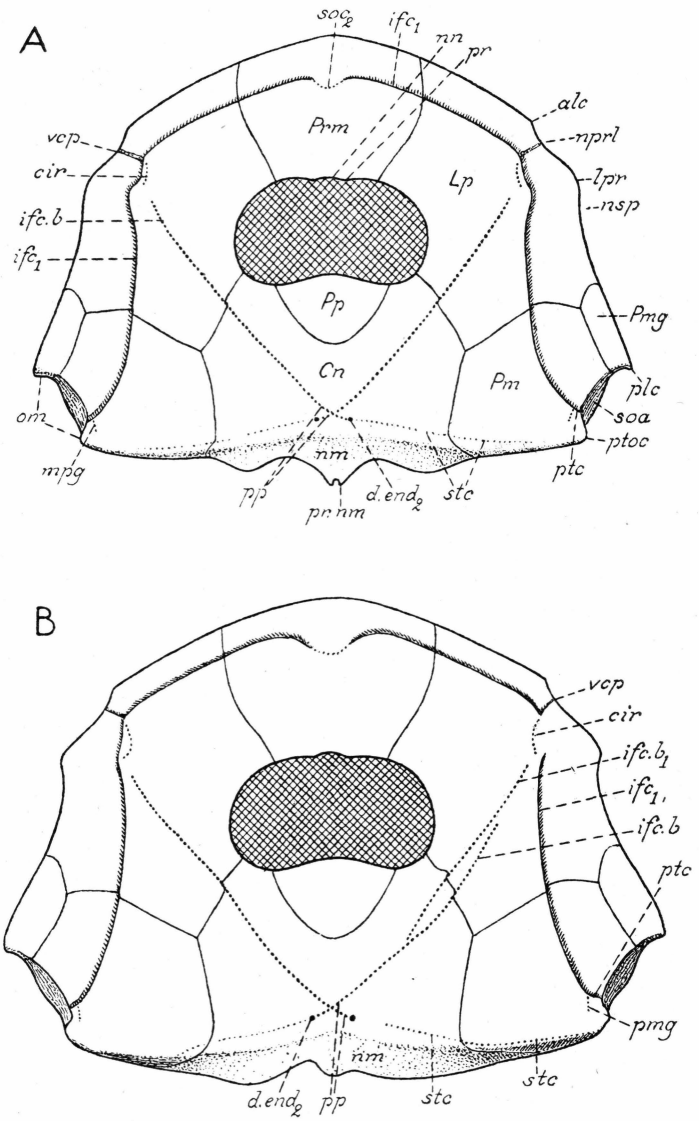
The posterior face of the head-shield (text-figs. 11, 12, 19, 25B) normally exhibits a well developed median occipital crest (*cr.o*). At either side of this crest there are two more or less clearly marked depressions or fossae (*fm*, *fm_1*), probably for the insertion of certain parts of the levator muscles of the head. Immediately laterally to these fossae we find the paranuchal trochlea (*pnt*), which decreases in height and width laterally and throughout its extent is provided with a single continuous articular area.

We shall now proceed to a brief account of the various bone-plates composing the head-shield.

The premedian plate (*Prm*, text-figs. 4, 8–12, 20B, 34, 76–84, 85, 86, 208, 209) normally in small individuals is broader than long, but then grew proportionally more in length than in breadth so that in fully mature

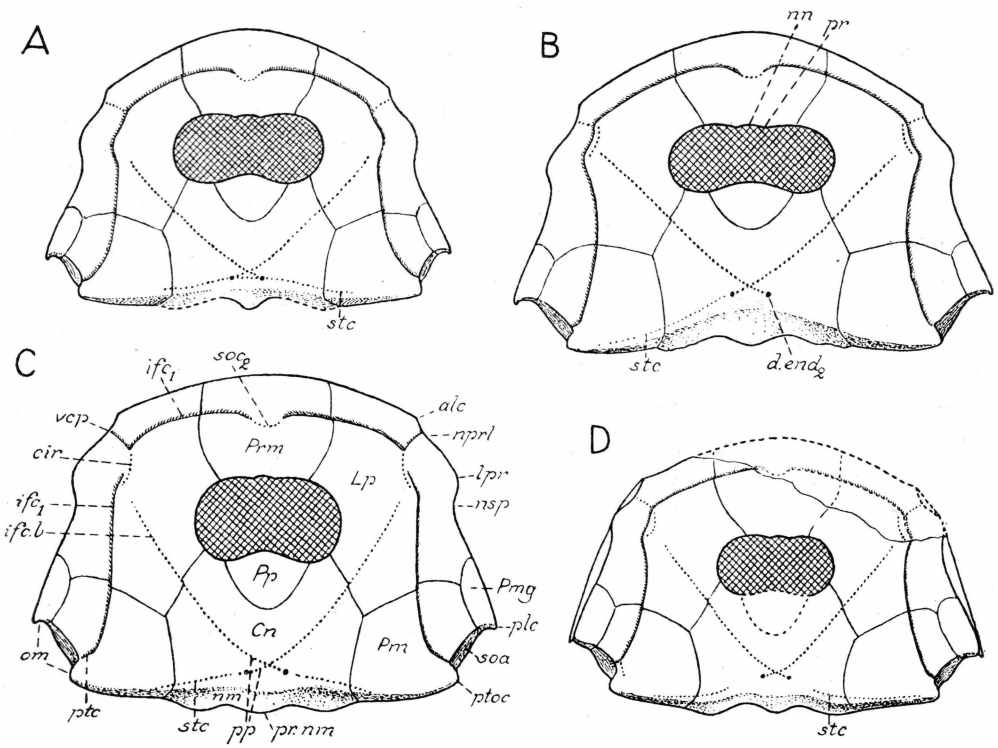
Text-fig. 81. *Bothriolepis canadensis*. *A*, a slightly flattened head-shield seen from the right side. R.M. specimen No. P. 2723. × $^3/_2$. *B*, the same head-shield as in *A*, but in dorsal aspect. × $^3/_2$. *C*, a fairly complete flattened head-shield in dorsal aspect. R. M. specimen No. P. 2827. × 2.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; *ifc_1*, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nm*, obtected nuchal area; *nn*, nasal notch; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb.fen*, orbital fenestra; *plc*, postero-lateral (preobstantic) corner; *pr*, paranasal process; *pr.nm*, posterior median process of centro-nuchal plate; *ptoc*, postobstantic corner; *soa*, subobstantic area; *soc_2*, anterior median section of supraorbital sensory canal groove; *spg*, spiracular groove; *stc*, supratemporal (cross-commissural) pit-line groove; *vcp*, vertical pit-line groove of cheek.



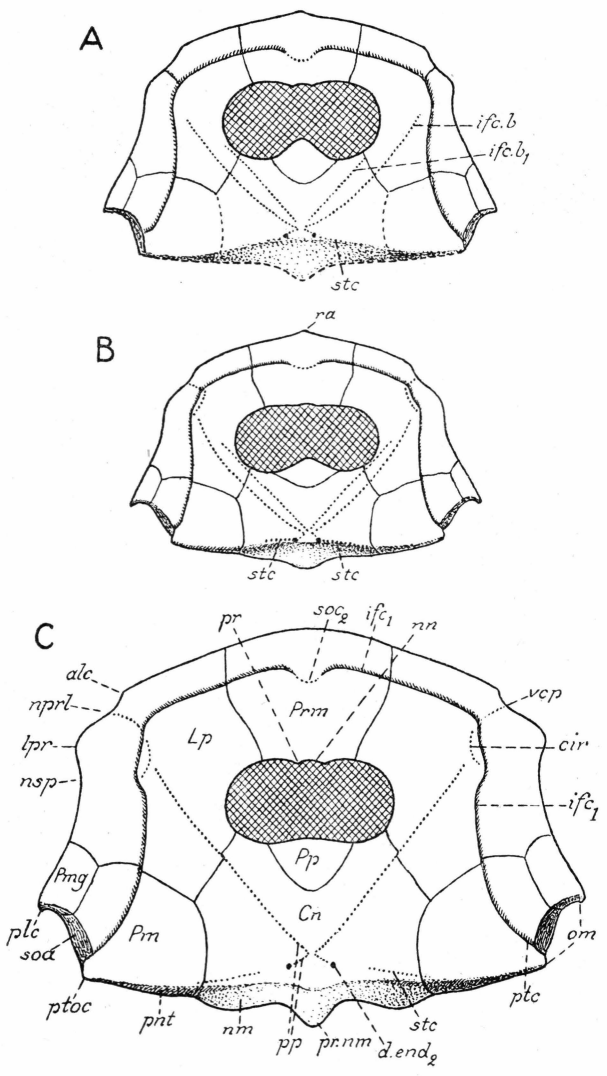
Text-fig. 82. *Bothriolepis canadensis*. Restorations of two fairly large head-shields in dorsal aspect. *A*, of the head-shield reproduced in text-fig. 76 A; *B*, of the head-shield reproduced in text-fig. 76 B. × $^{6}/_{5}$.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; *d.end*$_2$, external opening of canal for endolymphatic duct; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *ifc.b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *nn*, nasal notch; *nprl*, prelateral notch; *nsp*, supraspiracula notch; *om*, obstantic margin; *plc*, postero-lateral (preobstantic) corner; *pp*, posterior pit-line groove of skull-roof; *pr*, pa anasal p ocess; *pr.nm*, poste io median process of centro-nuchal plate; *pp*, posterior pit-line groove of skull-roof; *ptc*, cephalic division of main lateral line groove; *poc*, post-obstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median section of supraorbital sensory canal groove; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.



Text-fig. 83. *Bothriolepis canadensis*. Restorations of four head-shields. Dorsal aspect. The two shields in *B* and *D* of a comparatively broad and short type. *A–C*, × $^{6}/_{5}$. *D*, × $^{4}/_{5}$. *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-Shield; *cir*, semicircular pit-line groove; *d.end*$_2$, canal for ductus endolymphaticus; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nm*, obtected nuchal area; *nn*, nasal notch; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *om*, obstantic margin; *plc*, postero-lateral (preobstantic) corner; *pp*, posterior pit-line groove of skull-roof; *pr*, paranasal process; *pr.nm*, posterior median process of centro-nuchal plate; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median section of the supraorbital sensory canal groove, the anterior median pit-line; *stc*, supra-temporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

individuals it is either about equally broad as long, or else somewhat narrower than long. Its breadth : length ratio, which was worked out for about sixty cases, was found to range between 96–160. In very small individuals it is 106–160, but normally 120–150; in medium-sized individuals it is 92–120, but generally 100–120; and finally, in large individuals it is 90–114, but usually only 90–100. During its growth, however, the plate did not only decrease in breadth, but underwent also certain other changes. Thus, as has already been pointed out above (p. 44), the rostral angle normally became obscure or disappeared entirely. Moreover, the hindmost part of the plate did not increase proportionally as much in breadth as did the rostral part, on account of which the posterior dorsal and posterior ventral margins

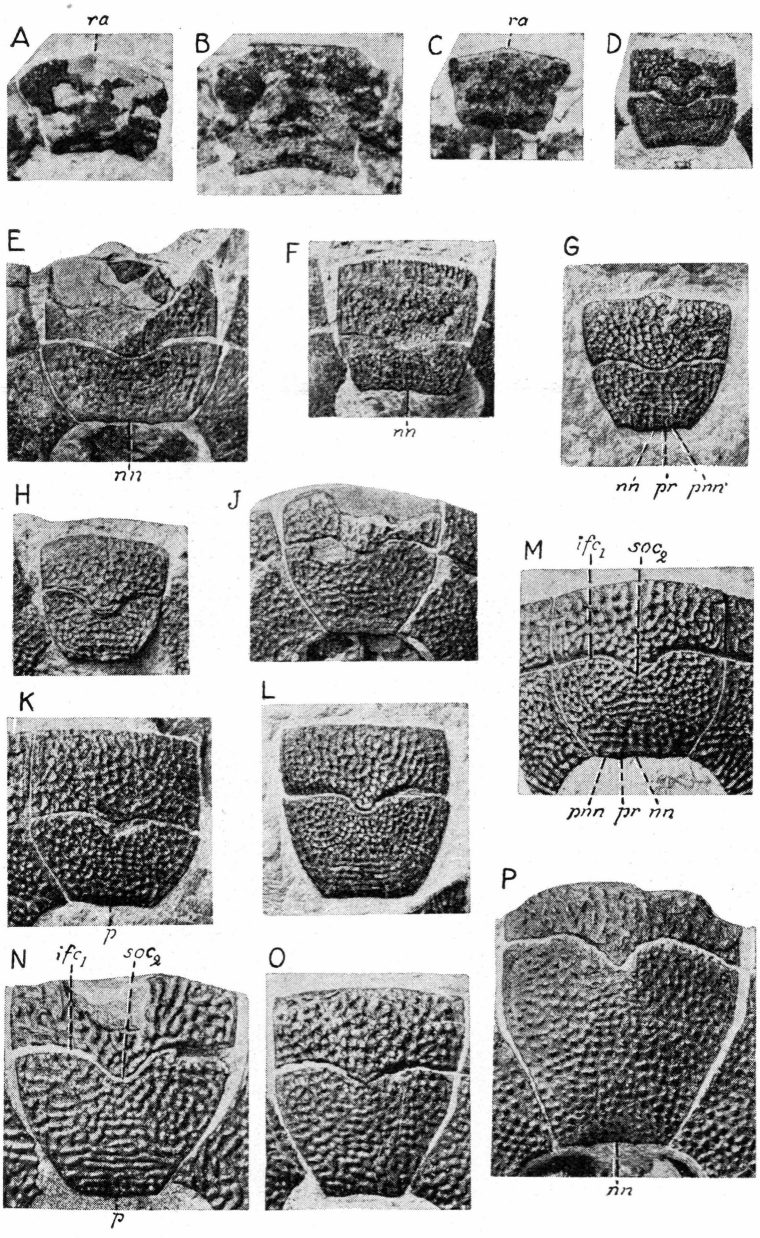


Text-fig. 84. *Bothriolepis canadensis*. Restorations of three head-shields in dorsal aspect *A*, of a small specimen (dorsal length of trunk-armour 3,3 cm). × $^{2}/_{1}$. *B*, also of a small specimen (dorsal length of trunk-armour about 3,6 cm). × $^{8}/_{5}$. *C*, of a large specimen (dorsal length of trunk-armour about 12-13 cm). × $^{4}/_{5}$.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; *d.end*$_2$, external opening of the canal for the endolymphatic duct; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *ifc.b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nm*, obtected nuchal area; *nn*, nasal notch; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *om*, obstantic margin; *plc*, postero-lateral (preobstantic) corner; *pnt*, paranuchal trochlea; *pp*, posterior pit-line groove of skull-roof; *pr*, paranasal process; *pr.nm*, posterior median process of centro-nuchal plate; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *ra*, rostral angle; *soa*, subobstantic area; *soc*$_2$, anterior median section of the supraorbital sensory canal groove, the anterior median pit-line; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-linegroove of cheek.

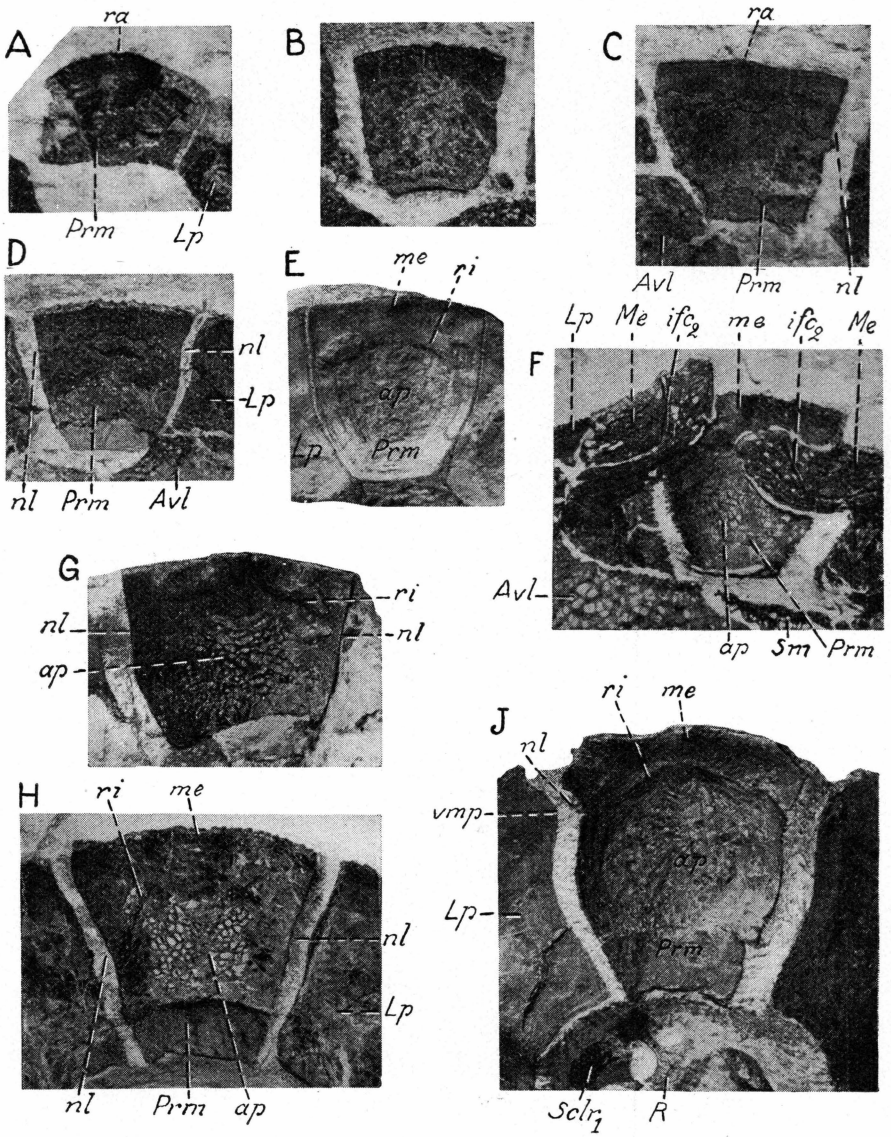
gradually became narrower in proportion to the rostral margin than what they are in young individuals. In small specimens the posterior dorsal margin is thus about three fourths of the length of the rostral margin, whereas in large specimens it is only about one half, or even somewhat less than one half, of the length of that margin. Finally, the poriferous area (*ap*, text-figs. 11, 12, 20B, 86) seems to be absent or indistinct in very small specimens, and it is likely, therefore, that it began to developed first in medium-sized individuals. The maximum breadth of the plate sometimes is at the rostral margin, sometimes about midway between the rostral margin and the posterior dorsal margin, but in most cases the plate is of a fairly uniform breadth throughout its whole anterior half (text-fig. 85). When the maximum breadth is midway, or about midway, between the rostral margin and the posterior dorsal margin the narrowing forwards takes place either very gradually (text-fig. 85K) or else suddenly at the upper infraorbital sensory canal groove (*ifc*$_1$, text-fig. 85D, E), so that there is a nick just behind this sensory canal groove, in front of which the breadth remains practically uniform forwards to the very rostral margin. This margin (text-figs. 85, 86) is mostly clearly convex, but may also sometimes be almost straight. The dorsal lateral margin (text-figs. 20B, 21C, 85) varies considerably in configuration. It may be convex throughout its extent; its anterior and posterior parts may meet at a more or less pronounced rounded angle; its anterior and posterior parts may both be convex or fairly straight; and, finally, its anterior parts may be convex or straight and its posterior parts a little concave. The dorsal posterior margin (text-figs. 20B, 21C, 85, 87D–F) is sometimes fairly straight or a little concave, or convex throughout its extent, but in most cases its configuration is clearly influenced by its position in relation to the nasal apertures. In the latter cases it is provided with a nasal process (*p*) or with a more or less well-marked nasal notch (*nn*), bounded on either side by a small paranasal process (*pr*). The ventral lateral margin (text-figs. 20B, 86) may be entirely devoid of a ventral lateral notch (text-fig. 86A, E), but in most cases it is provided with such a notch (*nl*). When present this notch lies far forwards, almost always in front of the middle of the plate and generally fairly close behind the rostral margin. The posterior longer part of the ventral lateral margin is more or less convex. The ventral posterior margin (text-figs. 11, 12, 20B, 86) may be fairly straight, a little convex or a little concave. On account of the position far forward of the ventral lateral notch (*nl*) the oblique premedian ridge (*ri*, text-figs. 11, 12, 20B, 86) is mostly situated fairly close to the rostral margin of the plate. A more or less distinct median elevation (*me*) is often to be noticed between the anteromedial ends of the oblique premedian ridges of both sides.

The rostral plate (*R*, text-figs. 4, 12, 21A–C, 77C, 86J, 87A, D, E, 90, 101, 111, 114) is somewhat longer than broad and considerably longer and narrower than in *B. panderi* (text-figs. 21D, 230). The nasal notch (*na*)

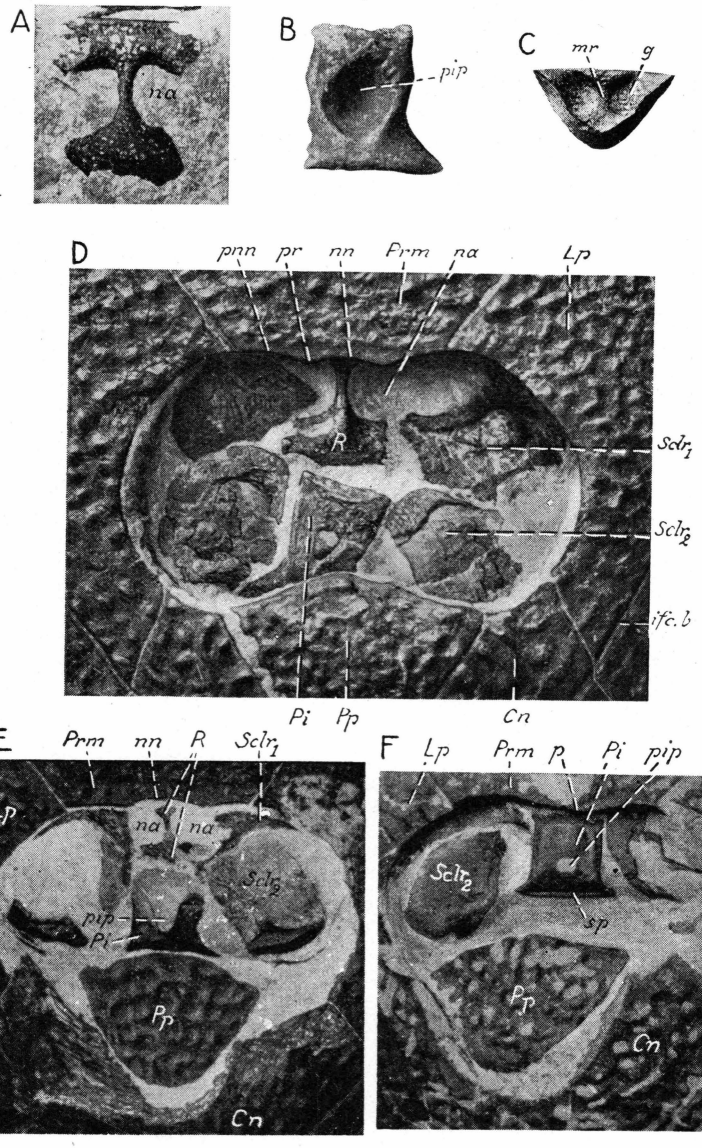


Text-fig. 85. *Bothriolepis canadensis*. A series of fifteen premedian plates illustrating the changes in the shape of the premedian plate during its growth. All the plates in dorsal aspect. *A*, of a very small specimen (dorsal length of trunk-armour about 1,85 cm). *P*, of a large specimen (dorsal length of trunk-armour about 12 cm). R. M. specimens Nos. P. 2747, 2499, 2403, 2448, 2258, 2174, 2138, 2534, 2630, 2679, 2138, 2723, 2781, 2784 and 2124 respectively. *A–C*, × 3.3; *D*, × 1.5; *E–P*. Nat. size

ifc_1, upper infraorbital sensory canal groove (foremost part); *nn*, nasal notch; *p*, nasal process; *pnn*, paranasal notch; *pr*, paranasal process; *ra*, rostral angle; soc_2, anterior median section of supraorbital sensory canal groove, the anterior median pit-line.

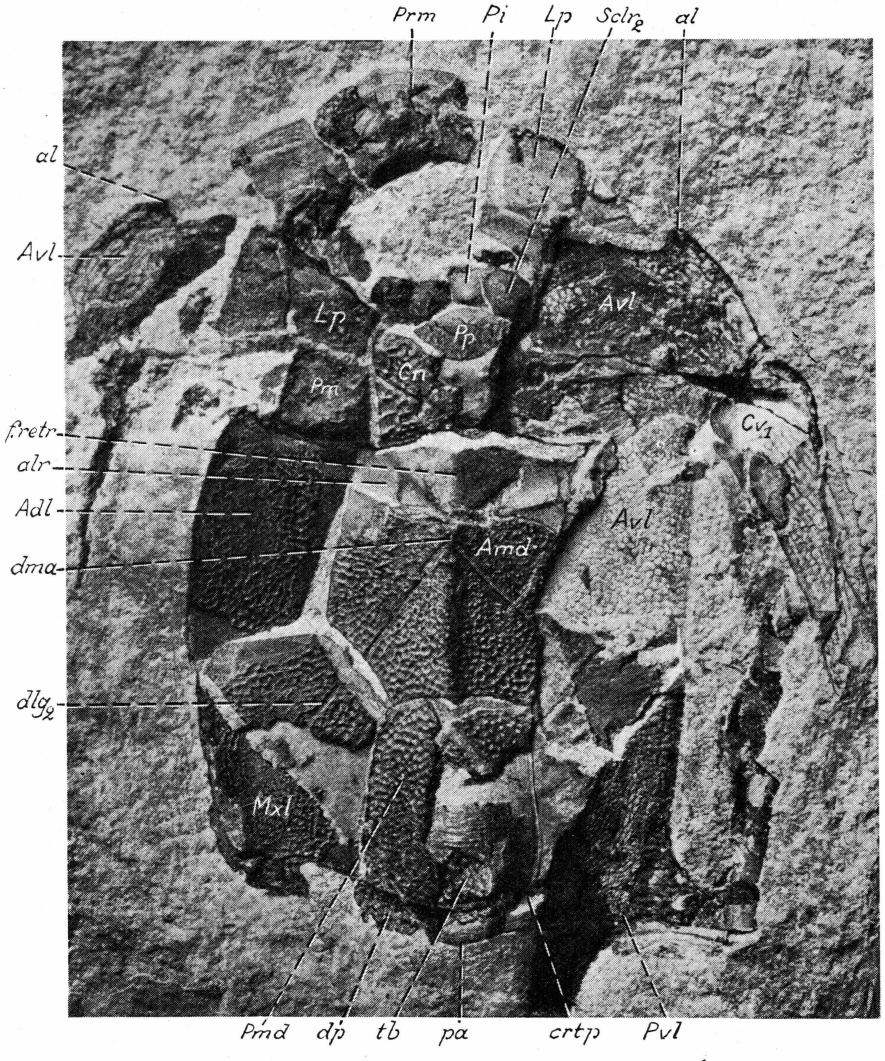


Text-fig. 86. *Bothriolepis canadensis*. A series of nine premedian plates in ventral aspect. *A*, of a very small specimen (dorsal length of trunk-armour about 1,85 cm); *J*, of a large specimen (dorsal length of trunk-armour about 12 cm). R. M. specimens Nos. P. 2747, 2238, 2295, 2268, 2833, 2179, 2129, 2221 and 2124 respectively. *A*, ×4; *B–J*, × 3/2.
Avl, anterior ventro-lateral plate; *Lp*, lateral plate; *Me*, mental plate; *Prm*, premedian plate; *R*, rostral plate; $Sclr_1$, anterior sclerotic plate; *Sm*, semilunar plate; *ap*, poriferous area; ifc_2, lower infraorbital sensory canal groove; *me*, elevation between the anterior ends of the ridges *ri*; *nl*, ventral lateral notch; *ra*, rostral angle; *ri*, oblique premedian ridge; *vmp*, ventral medial process (of lateral plate).



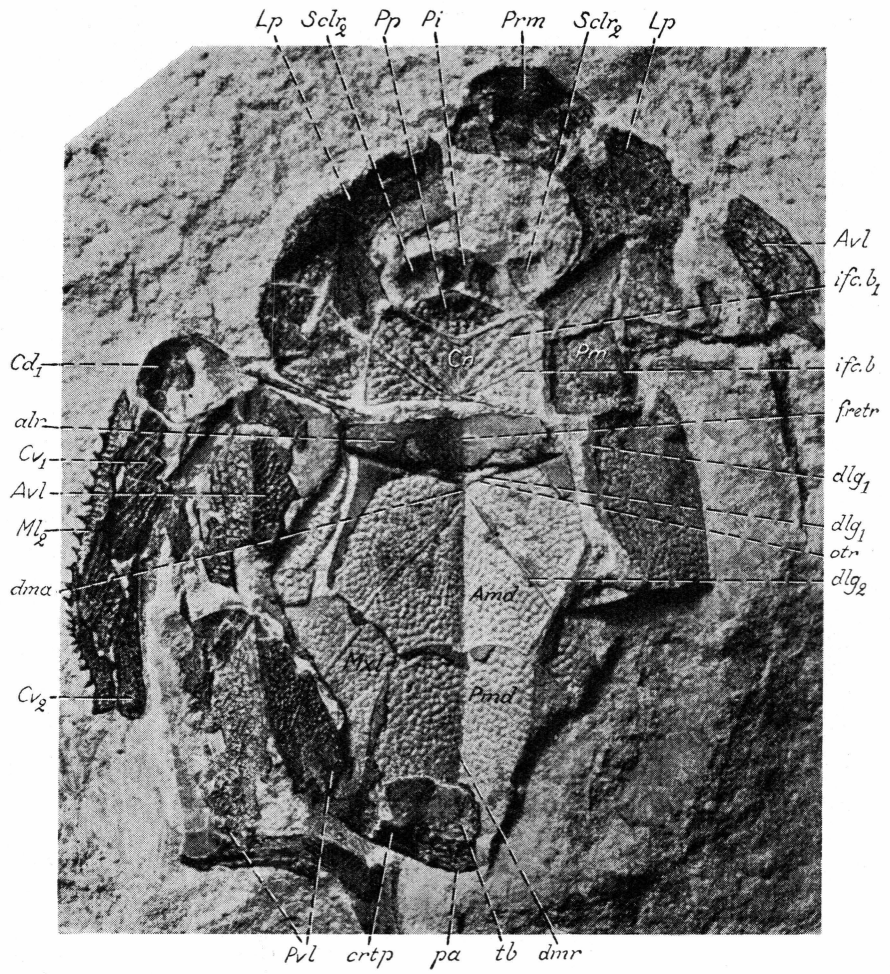
Text-fig. 87. *Bothriolepis canadensis*. *A*, a detached rostral plate in external aspect and with the rostral end downwards. R. M. specimen No. P. 2487. × 4. *B*, a pineal plate in ventral aspect. R. M. specimen No. P. 2323. × 4. *C*, a small postpineal plate in ventral aspect. R. M. specimen No. P. 2106. × 2. *D–F*, the dermal bones in and around the orbital fenestra in three different specimens. Dorsal aspect. R. M. specimens Nos. P. 2630, 2109 and 2348, respectively. *D*, × $^{9}/_{2}$. *E*, *F*, × 4.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pi*, pineal plate; *Pp*, postpineal plate; *Prm*, premedian plate; R, rostral plate; $Sclr_1$, anterior sclerotic plate; $Sclr_2$, postero-dorsal sclerotic plate; *g*, groove or pit on postpineal plate; *ifc.b*, posterior oblique cephalic pit-line groove; *mr*, median ridge on postpineal plate; *na*, nasal aperture or nasal notch (in rostral plate); *nn*, nasal notch (in premedian plate); *p*, nasal process; *pip*, pineal pit (in fig. *E*, preserved as impression, in fig. *F* the very dorsal tip exposed); *pnn*, paranasal notch; *pr*, paranasal process; *sp*, unornamented area along posterior margin of pineal plate.

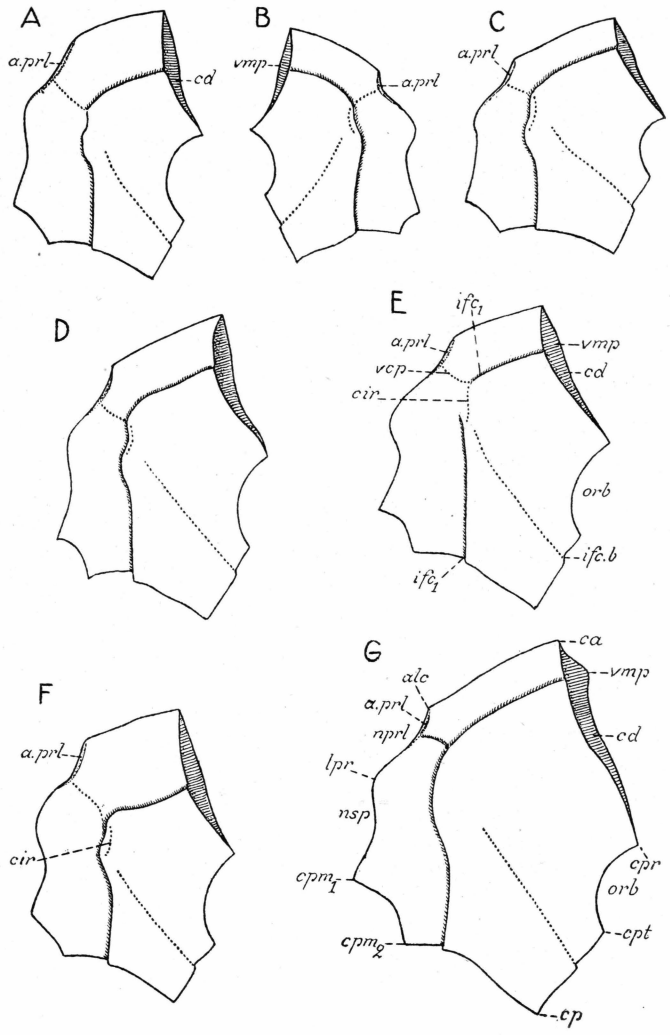


Text-fig. 88 *A. Bothriolepis canadensis*. A very small specimen (dorsal length of trunk-armour about 1,85 cm), much flattened and crushed and partly deficient. Dorsal aspect, but with considerable dorsal parts of the armour split off on the right side. R. M. specimen No. P. 2747. About × $^{10}/_{3}$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1, dorsal central plate 1; Cv_1, Cv_2, ventral central plates 1 and 2; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, lateral marginal plate 2; *Mxl*, mixilateral plate; *Pi*, pineal plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; $Sclr_2$, postero-dorsal sclerotic plate; *al*, antero-lateral corner of subcephalic division of anterior ventro-lateral plate; *alr*, postlevator thickening; *crtp*, crista transversalis interna posterior; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *dp*, groove above crista transversalis interna posterior; *f. retr*, levator fossa; *ifc. b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove; *otr*, oblique transverse ridge; *pa*, posterior angle of posterior median dorsal plate; *tb*, ventral tuberosity (on posterior median dorsal plate).

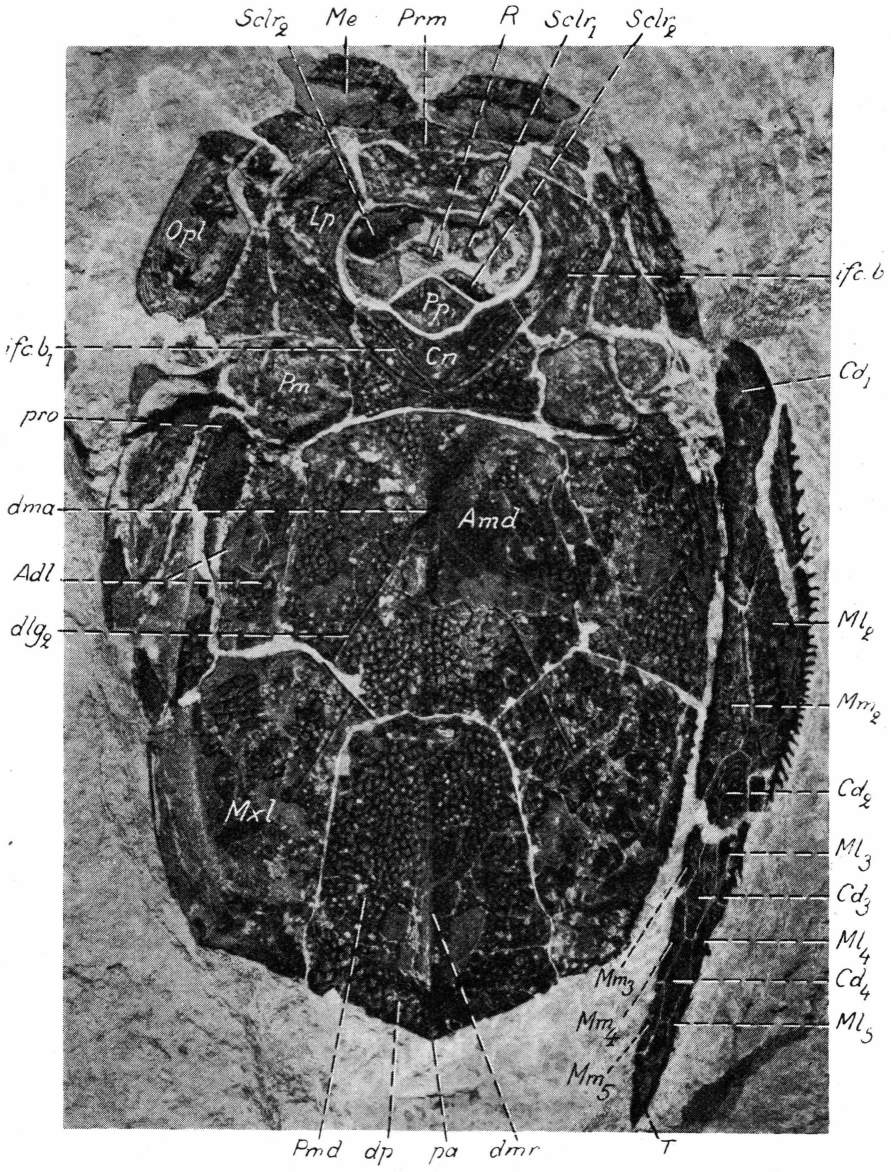


Text-fig. 88 B. *Bothriolepis canadensis*. Counterpart of the specimen reproduced in text-fig. 88 *A*. Several of the plates represented only by impressions of their upper sides. Approximately × $^{10}/_{3}$. For explanation of index letters see text-fig. 88 *A*.

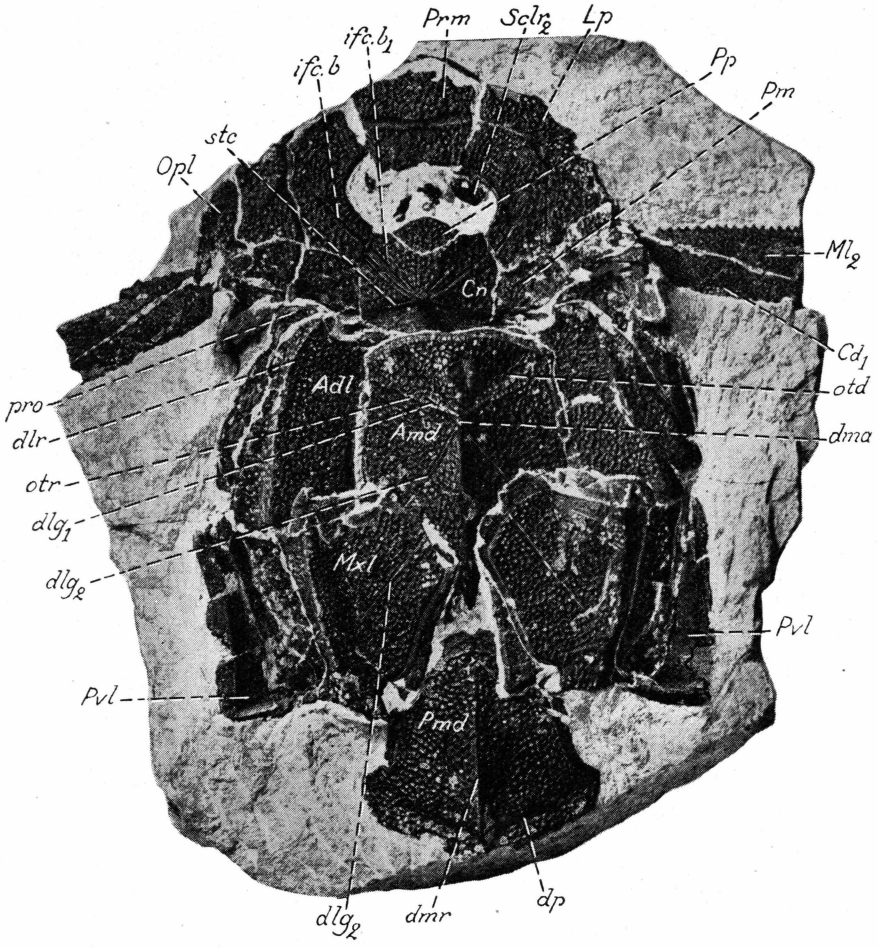


Text-fig. 89. *Bothriolepis canadensis*. Restorations of seven lateral plates in dorsal aspect. *A*, about × $^{3}/_{2}$. *B–G*, about × $^{9}/_{8}$.

alc, antero-lateral corner; *a. prl*, prelateral area, for the attachment of the prelateral plate; *ca*, antero-medial corner; *cd*, area overlapped by premedian plate; *cir*, semicircular pit-line groove; *cp*, posterior corner; cpm_1, cpm_2, anterior and posterior postmarginal corners respectively; *cpr*, preorbital corner; *cpt*, postorbital corner; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb*, orbital notch; *vcp*, vertical pit-line groove of the cheek; *vmp*, ventral medial process.

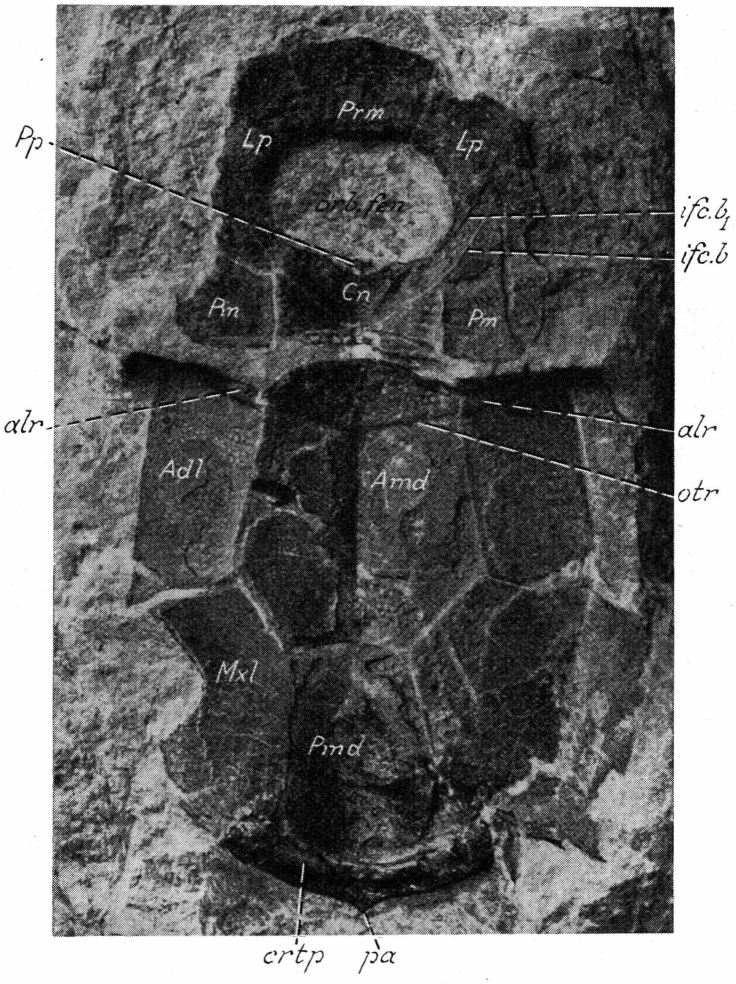


Text-fig. 90. *Bothriolepis canadensis*. A small dorso-ventrally flattened specimen in dorsal aspect (dorsal length of trunk-armour about 3 3 cm). R. M. specimen No. P. 2418. × 2.5. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Me*, mental plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *R*, rostral plate; $Sclr_1$, anterior sclerotic plate; $Sclr_2$, antero-dorsal sclerotic plate; *T*, terminal plate; dlg_2, posterior oblique abdominal pit-line groove; *dmr*, dorsal median ridge; *dma*, tergal angle; *dp*, depression or groove above the dorsal median part of the crista transversalis interna posterior; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *pa*, posterior corner or angle of the posterior median dorsal plate; *pro*, processus obstans.



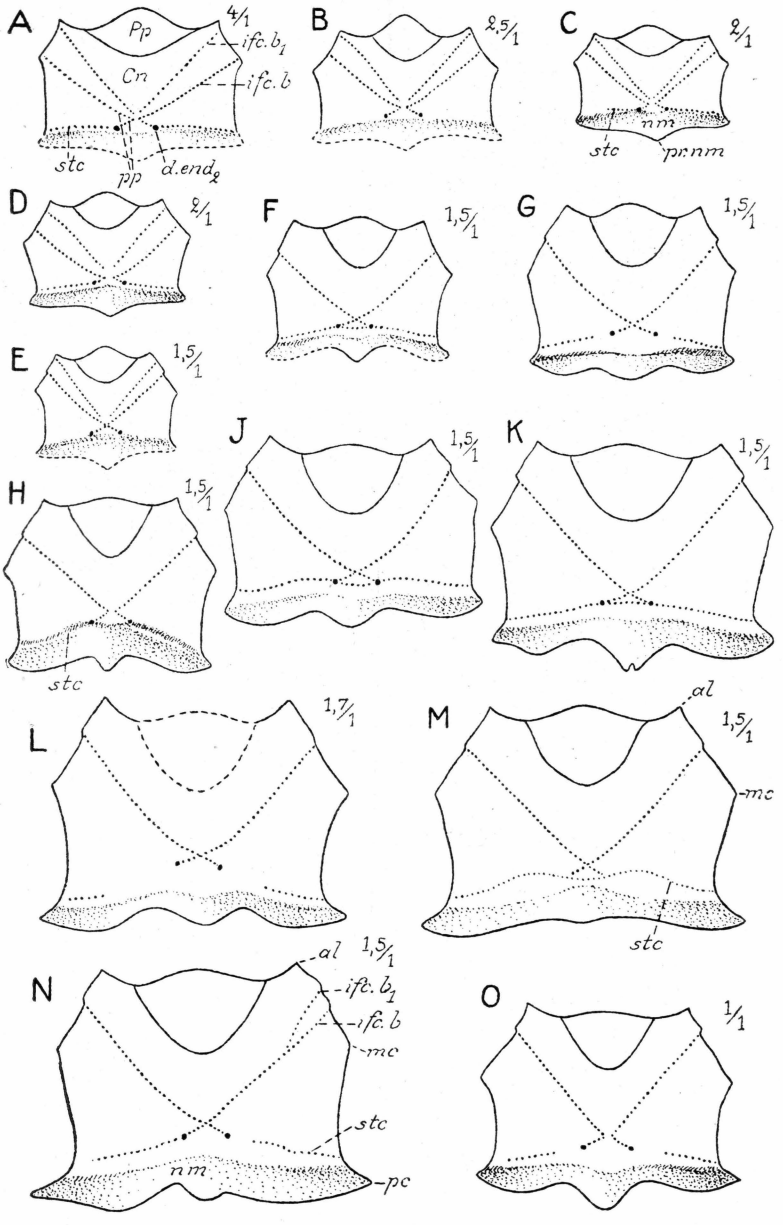
Text-fig. 91. *Bothriolepis canadensis*. A much crushed and flattened, small specimen in dorsal aspect (dorsal length of trunk-armour about 3,6 cm). R. M. specimen No. P. 2326. Approximately × $^{9}/_{5}$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, lateral marginal plate 2; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular plate); *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; $Sclr_2$ dorso-lateral sclerotic plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dlr*, dorso-lateral ridge; *dmr*, dorsal median ridge; *dp*, depression above the median dorsal part of the crista transversalis interna posterior; *ifc.b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove; *otd*, obliquely transverse depression above the postlevator thickening (*alr*); *otr*, oblique transverse ridge; *pro*, processus obstans; *stc*, supratemporal pit-line groove.



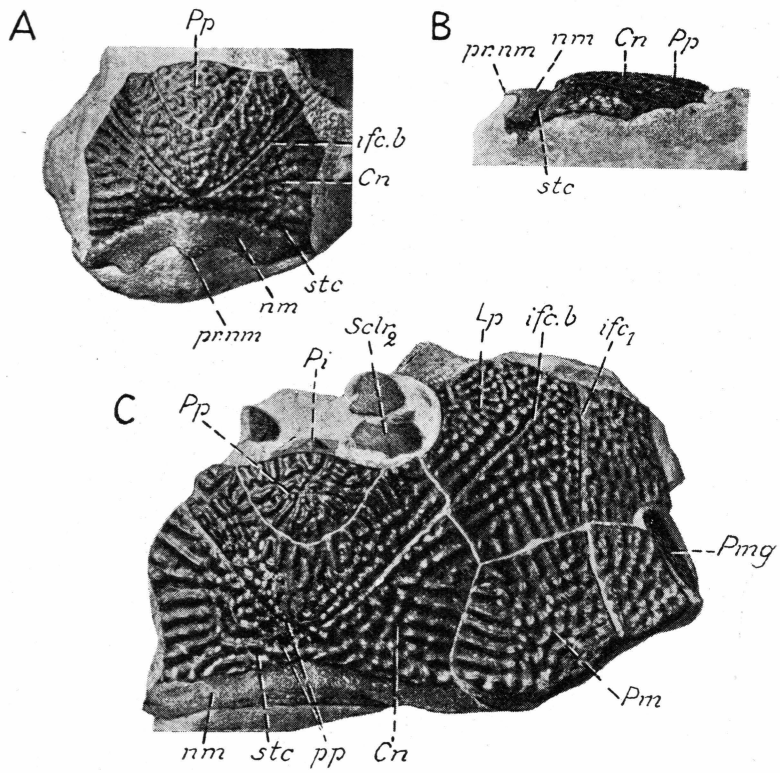
Text-fig. 92. *Bothriolepis canadensis*. Head-shield and dorsal wall of trunk-armour of a small specimen (dorsal length of trunk-armour about 2,4 cm). Ventral aspect R. M. specimen No. P. 2316. × 3.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate (fragment); *Prm*, premedian plate; *alr*, postlevator thickening (lateral part); *crtp*, crista transversalis interna posterior; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *otr*, oblique transverse ridge (impression) *pa*, posterior angle of posterior median dorsal plate.



Text-fig. 93. *Bothriolepis canadensis*. A series of fourteen centro-nuchal plates with attached postpineal plates. The series shows the changes in the characters of the centro-nuchal and postpineal plates during their growth. All the plates in dorsal aspect. *A–D*, of small specimens. *E*, of a somewhat small specimen. *F–O*, of medium-sized and large specimens.

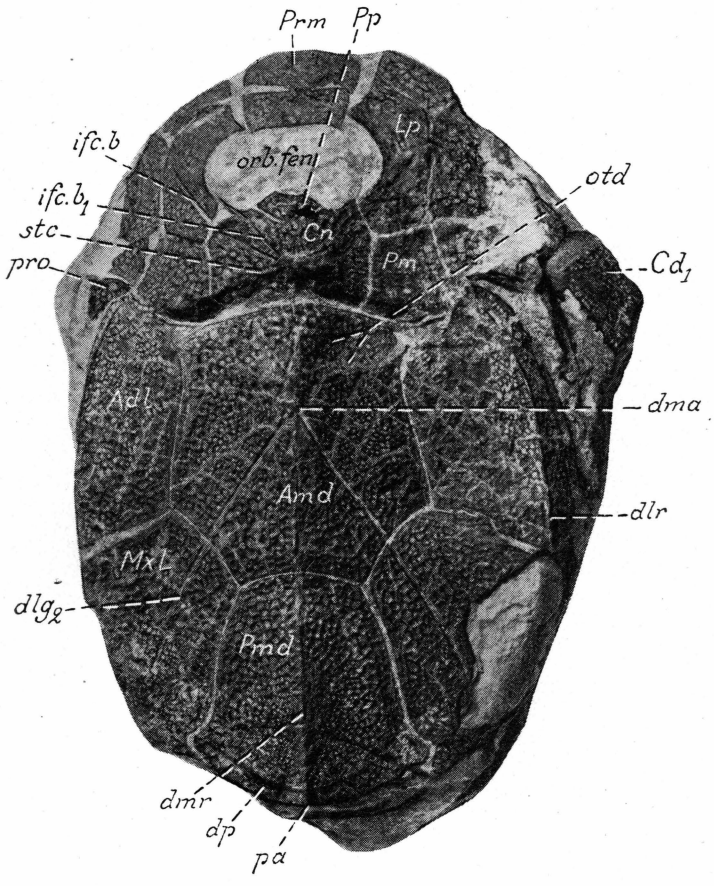
Cn, centro-nuchal plate; *Pp*, postpineal plate; *al*, antero-lateral corner; *d.end*$_2$, external opening of canal for endolymphatic duct; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc. b*$_1$, anterior oblique cephalic pit-line groove; *mc*, lateral corner; *nm*, obtected nuchal area; *pc*, postero-lateral corner; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process; *stc*, supratemporal pit-line groove.



Text-fig. 94. *Bothriolepis canadensis*. *A*, *B*, a centro-nuchal plate, with the premedian plate attached, in dorsal and right lateral aspects respectively. R. M. specimen No. P. 2322. × 1.5. *C*, certain posterior parts of a head-shield in dorsal aspect. R. M. specimen No. P. 2323. × 1.5. *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pi*, pineal plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Sclr*$_2$, postero-dorsal sclerotic plate; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *nm*, obtected nuchal area; *pp*, posterior pit-line groove of skull-roof; *pr.nm*, posterior median process; *stc*, supratemporal pit-line groove.

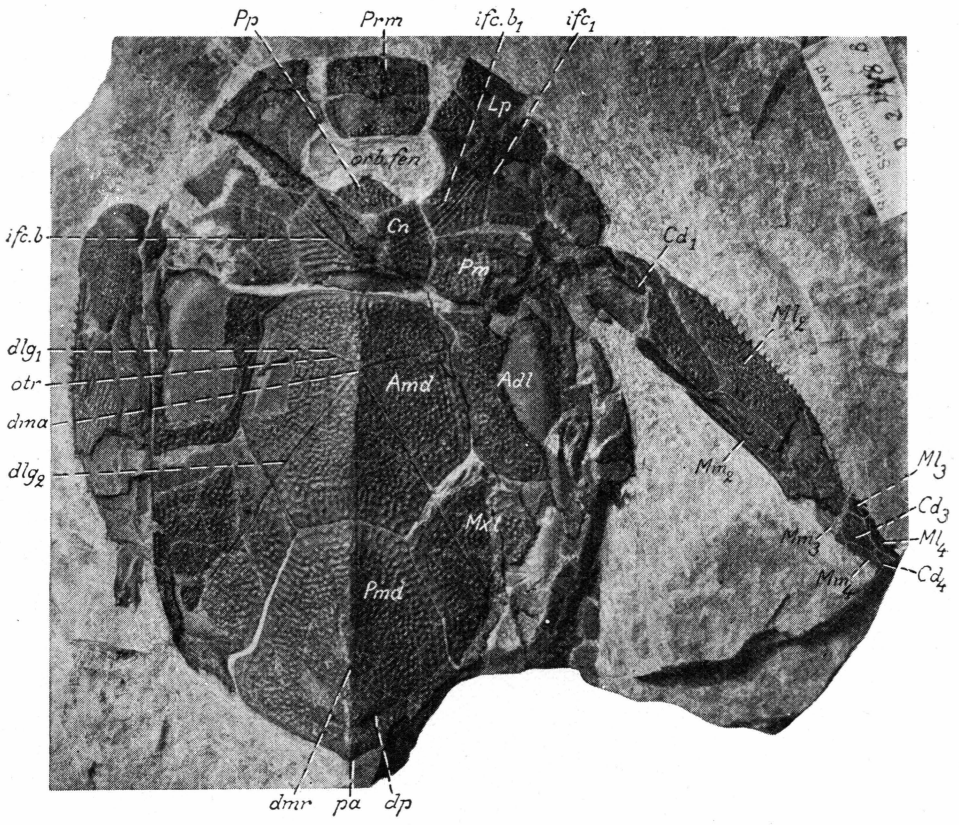
is deep and well developed. The prenasal division is expanded towards the sides and may sometimes be almost as broad as the postnasal division. Its anterior margin seems at least often to be concave. The internasal division is relatively long and always very narrow. And, finally, the postnasal division, which is the broadest one of all the three divisions of the bone, overlaps posteriorly the anterior end of the pineal plate. However, in spite of this overlapping, its attachment to the pineal plate was certainly only fairly loose.

The pineal plate (*Pi*, text-figs. 4, 12, 21C, 23A–D, 77C, 87B, D–F, 88, 94C, 101, 104, 114, 131, 163B) is four-sided and in general shape is nearest as in *B. cellulosa*. It differs, however, clearly from the corresponding plate in *B. cellulosa* in the following respects (cf. text-fig. 23E–G): 1) it is more



Text-fig. 95. *Bothriolepis canadensis*. Small deficient specimen in dorsal aspect (dorsal length of trunk-armour 3,4 cm). R. M. specimen No. P. 2719. × 2.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *dp*, depression above the median dorsal part of the crista transversalis interna posterior; *ifc.b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove; *orb.fen*, orbital fenestra; *otd*, obliquely transverse depression; *pa*, posterior corner of posterior median dorsal plate; *pro*, processus obstans; *stc*, supratemporal pit-line groove developed as an imperfect pit-line.

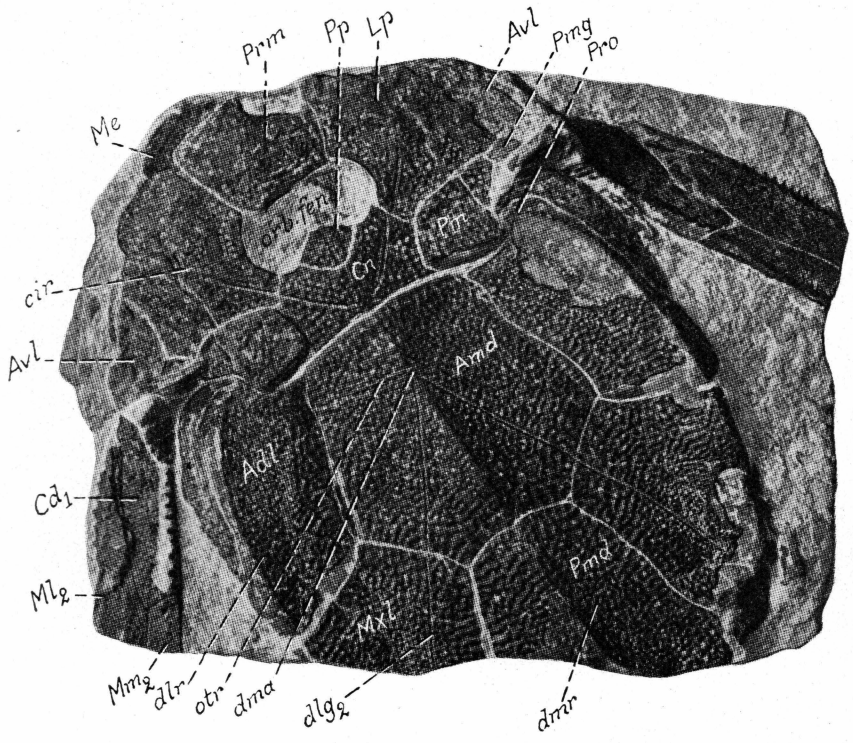
symmetric in shape; 2) it is normally broader than long; 3) its postero-lateral corner is much longer, and because of this its maximum breadth is larger than in *B. cellulosa*; 4) its anterior and posterior margins are more regular in their configuration, and the posterior margin is straight or a little concave, never somewhat convex; 5) there is no clearly defined unornamented area along the lateral and posterior margins; and, finally, 6) the pineal pit at least often is a little wider and, besides, lies somewhat further backwards than in *B. cellulosa*. As in *B. cellulosa*, the pineal pit, though extending far



Text-fig. 96. *Bothriolepis canadensis*. Small compressed but fairly complete specimen (dorsal length of trunk-armour 3,9 cm). Dorsal aspect. R. M. specimen No. P. 2448. $\times^{8}/_{5}$. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, Cd_3, Cd_4, dorsal central plates 1, 3, 4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, median marginal plates 2–4; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *dp*, depression above the median dorsal part of the crista transversalis interna posterior; ifc_1, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove; *orb.fen*, orbital fenestra; *otr*, oblique transverse ridge; *pa*, posterior angle of posterior median dorsal plate.

upwards into the plate, does not open outwards through a pineal foramen.

The lateral plate (*Lp*, text-figs. 4, 9–12, 24A, B, 34, 76–84, 90–92, 95–99, 101–103, 110–117, 127–134, 140, 147, 148, 154, 155, 157–159, 208, 209) is rather variable as to its proportions, its breadth across the anterior postmarginal corner (cpm_1) and the postorbital corner (*cpt*) ranging between 60–80% of the total length. The lateral margin of the plate seems mostly to be relatively longer in small and medium-sized specimens than in large specimens. The upper infraorbital sensory canal groove (ifc_1) passes in various specimens differently far from the lateral and rostral margins, and the lateral

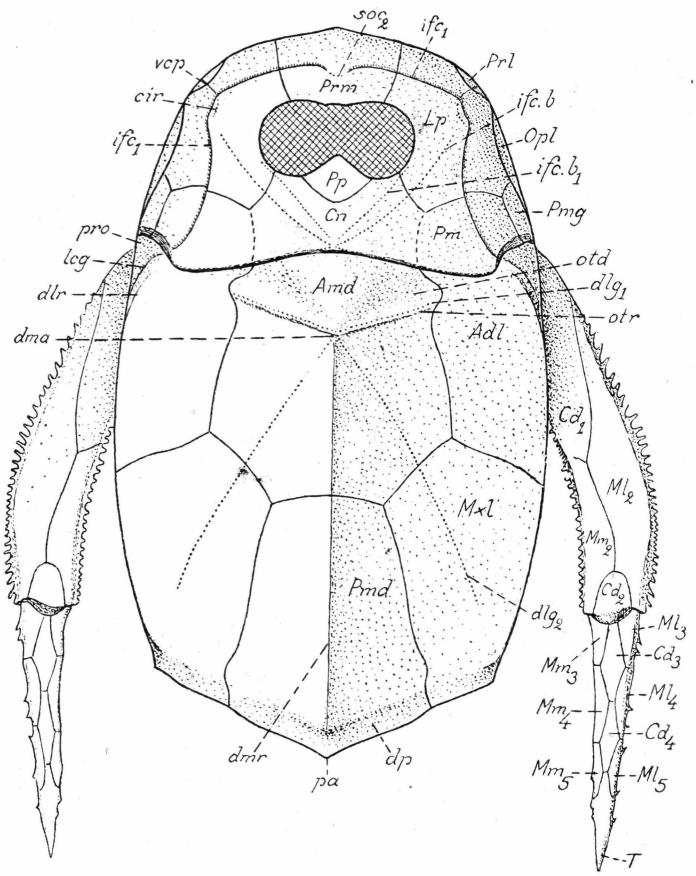


Text-fig. 97. *Bothriolepis canadensis.* Deficient, dorso-ventrally compressed specimen of fairly small size (dorsal length of trunk-armour about 4,5 cm) Dorsal aspect. R. M. No. P. 2153. × $^3/_2$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, foremost (subcephalic) part of left anterior ventro-lateral plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Me*, mental plate; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *cir*, semicircular pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *orb.fen*, orbital fenestra; *otr*, oblique transverse ridge; *pro*, processus obstans.

and medial divisins of the plate are, therefore, variable as to their breadth. The ventral medial process (*vmp*) which fits into the ventral lateral notch (*nl*) of the ventral lateral margin of the premedian plate is normally situated far forwards. This process, however, is often weakly developed or absent.

The postpineal plate (*Pp*, text-figs. 4, 9–11, 21 C, 76–84, 87 D–F, 88, 90–98, 101, 102, 106, 109, 114–117, 127–129, 131–133, 148, 154, 155, 157–159, 163 B, 203, 204, 206, 208, 209) increased during its growth considerably more in length than in breadth. Its length : breadth ratio is in small specimens only 47–55, but amounts in medium-sized and large specimens normally to



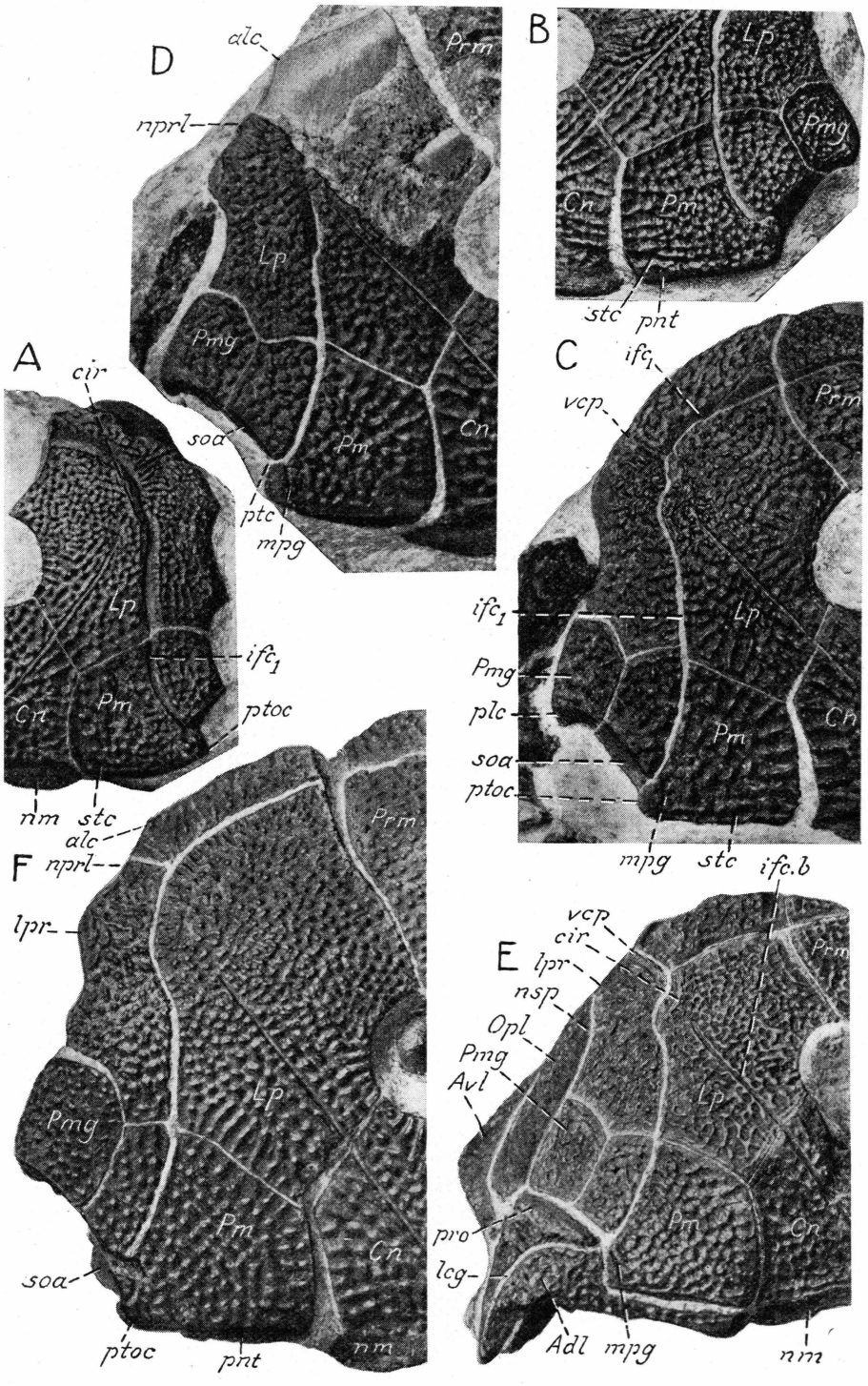
Text-fig. 98. *Bothriolepis canadensis*. Restoration of the armour of a small individual (dorsal length of trunk-armour 3,3 cm). Dorsal aspect. × 2.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_5, lateral marginal plates 2-5; Mm_2–Mm_5, medial marginal plates 2–5; *Mxl*, mixilateral plate; *Opl*, extralateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prl*, prelateral plate; *Prm*, premedian plate; *T*, terminal plate; *cir*, semicircular pit-line groove; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *dp*, depression above the median dorsal part of the crista transversalis interna posterior; ifc_1, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove, *otd*, anterior obliquely transverse depression above the postlevator thickening (*alr*); *otr*, oblique transverse ridge; *pa*, posterior angle of the posterior median dorsal plate; *pro*, processus obstans; soc_2, anterior median division of the supraorbital sensory canal groove, the anterior median pit-line; *vcp*, vertical pit-line groove of cheek.

between 63–70. In small specimens the plate with about one half of its length lies in front of the centro-nuchal plate, and consequently in such specimens projects fairly far forwards into the orbital fenestra. In medium-sized and large specimens, on the other hand, the plate almost in its entire rostro-caudal extent is embraced by the centro-nuchal plate, on account of which in specimens of these two categories of size it projects only fairly slightly

forwards beyond the centro-nuchal plate. Finally, the anterior (orbital) margin of the plate in small individuals is very strongly convex, sometimes even somewhat produced forwards into an anterior median angular process, whereas in medium-sized and large individuals it is only fairly slightly convex. On the other hand, this margin is never either straight or concave. The margin under consideration of the plate is thus always convex, but its degree of convexity is much stronger in small individuals than in medium-sized and large individuals.

The centro-nuchal plate (*Cn*, text-figs. 4, 9–12, 15A, B, 25, 26A, 76–84, 88, 90–92, 93–98, 101, 102, 106, 109, 114–117, 127–134, 140, 146–148, 154, 155, 157–159, 203–206, 208, 209) was carefully examined in a great number of specimens. It is now fully evident that this plate normally is somewhat shorter and broader in small individuals than in medium-sized and large individuals (text-fig. 93). Its length:breadth ratio is 65–83, but mostly ranges between 65–71 in small individuals, and between 71–83 in medium-sized and large individuals[1]). The paramedian length in small specimens is always somewhat smaller than the total median length, whereas in medium-sized and large specimens, on the other hand, it may often equal or exceed the total median length. The breadth across the postero-lateral corners (*pc*) may sometimes be a little smaller than the breadth across the middle corners, but mostly equals, or exceeds, the breadth across the said corners. The postpineal notch is shallow in small specimens, but fairly deep both in medium-sized and large specimens (text-fig. 93). In specimens of the latter two categories of size it is somewhat semicircular in outline. The anterior division of the lateral margin usually is shorter than the posterior one, but is generally somewhat shorter relatively in small individuals than in medium-sized and large ones. The posterior division of the lateral margin normally is rather slightly concave, and, the deepest part of its concavity mostly lies behind its middle or close to the postero-lateral corner (*pc*) of the plate. In its larger anterior part this division of the lateral margin is only directed slightly posteriorly. The posterior margin (text-fig. 93) in small individuals bears only a posterior median process (*pr.nm*), whereas in medium-sized and large individuals it is also provided with a paired more or less strong lateral convexity, bounded from the posterior median process by a paired more or les deep concavity or notch. This configuration of the posterior margin in medium-sized and large individuals is strikingly constant. The posterior median process of small individuals is broad and clearly angular, whereas that of medium-sized and large individuals is mostly narrower and rounded off. The length of the process is fairly variable. The obtected nuchal area (*nm*), extending underneath the anterior median dorsal plate, particularly in small specimens, is often somewhat de-

[1]) The length is here the total median length (see pp. 11-12, fig. 1B); the breadth is measured across the lateral corners (*mc*) of the plate.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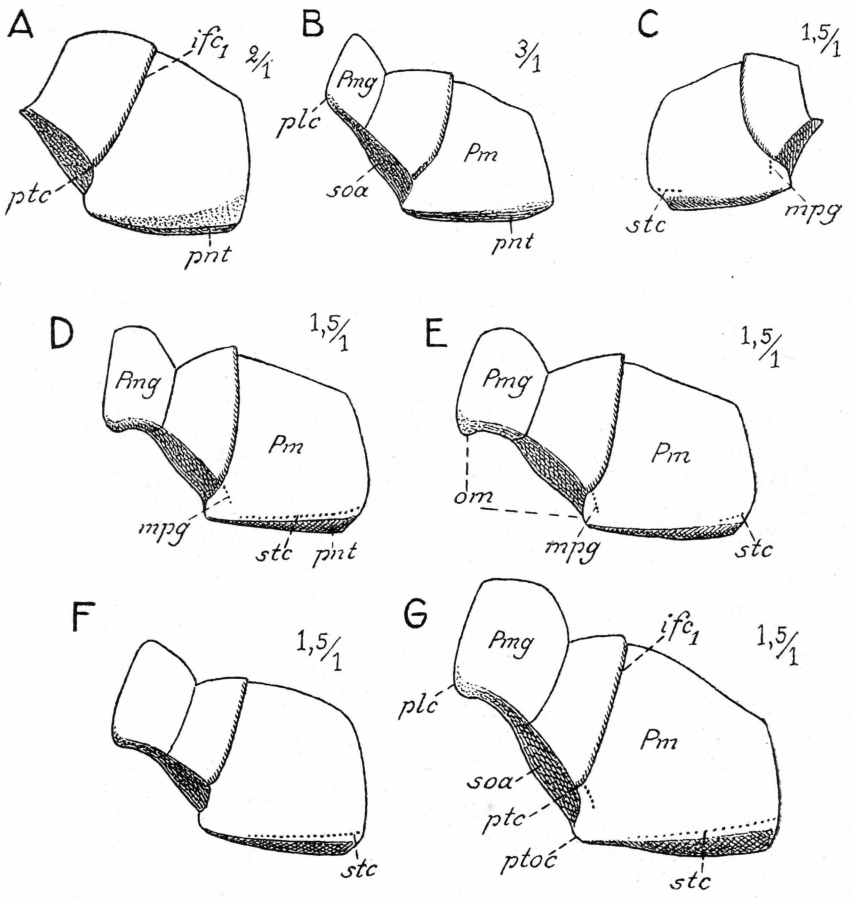


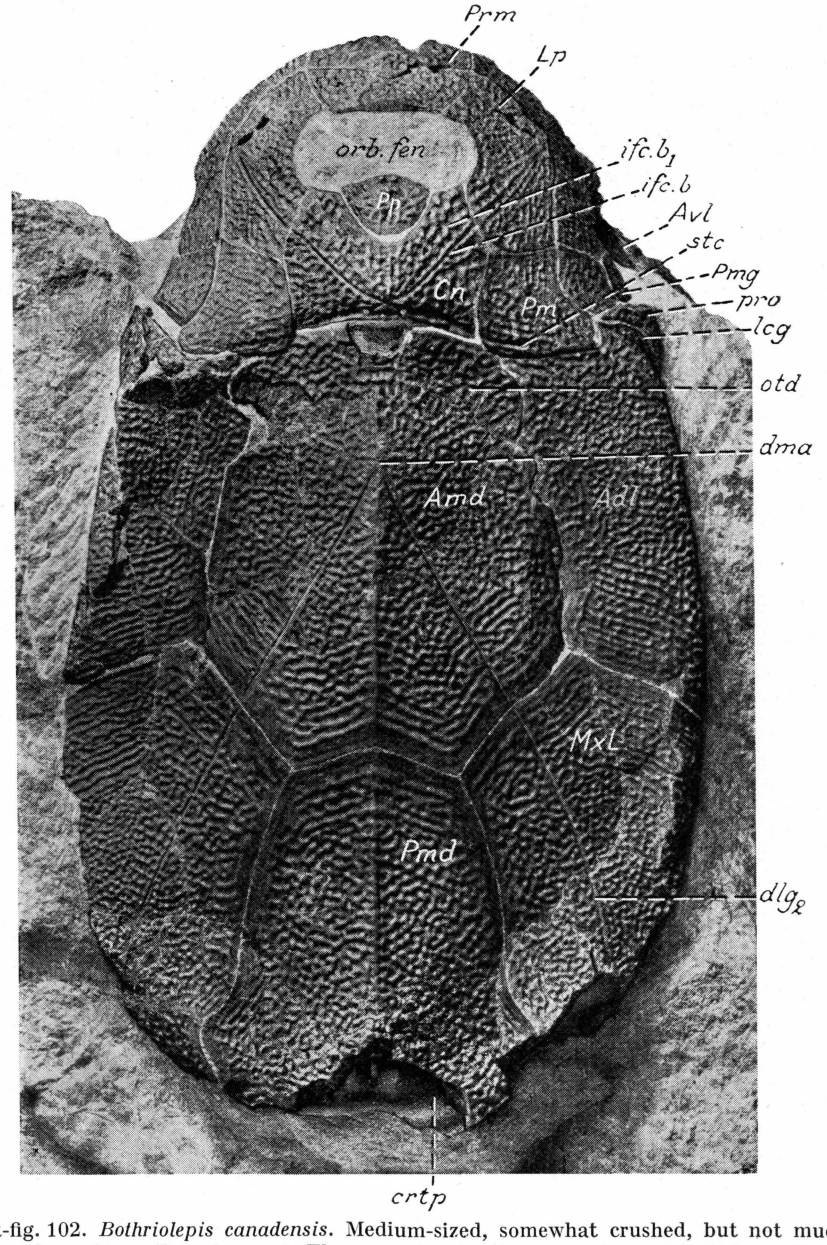
Text-fig. 100. *Bothriolepis canadensis*. A series of seven restored paranuchal-marginal plates. Five of these plates with the postmarginal plate attached.
Pm, paranuchal-marginal plate; *Pmg*, postmarginal plate; ifc_1, upper infraorbital sensory canal groove; *mpg*, middle pit-line groove of the skull-roof (lateral part); *om*, obstantic margin; *plc*, postero-lateral (preobstantic) corner; *pnt*, paranuchal trochlea; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area; *stc*, supratemporal pit-line groove.

Text-fig. 99. Lateral parts of five head-shields in dorso-lateral aspect. R. M. specimen Nos. P. 2667, 2318, 2679, 2107, 2124, and 2132 respectively. × 3/2.
Adl, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate (part of the subcephalic division); *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of lateral plate; *cir*, semicircular pit-line groove; ifc_1, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *lcg*, main lateral line); *nm*, obtectal nuchal area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *plc*, postero-lateral (preobstantic) corner; *pnt*, paranuchal trochlea; *pro*, processus obstans; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

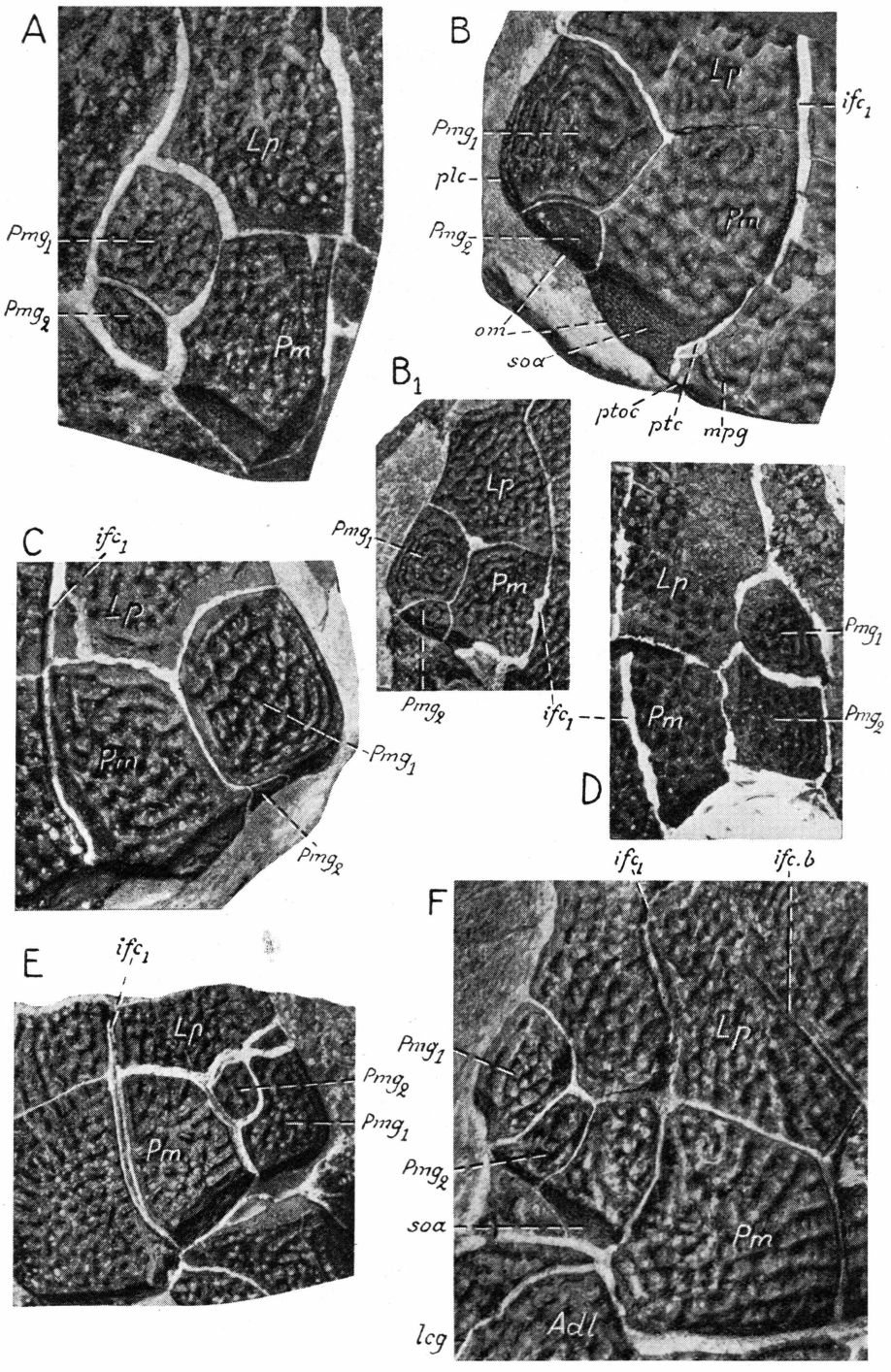


Text-fig. 101. *Bothriolepis canadensis*. Medium-sized, flattened specimen in dorsal aspect. R. M. specimen No. P. 3325 A. × $^3/_2$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Me*, mental plate; *Mxl*, mixilateral plate; *Pi*, pineal plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; Pmg_1, Pmg_2, post-marginal plates; *Pp*, postpineal plate; *Prm*, premedian plate; *R*, rostral plate; $Sclr_1$, anterior sclerotic plate; $Sclr_2$, postero-dorsal sclerotic plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *lcg*, main lateral line groove; *otr*, oblique transverse groove; *pro*, processus obstans.



Text-fig. 102. *Bothriolepis canadensis*. Medium-sized, somewhat crushed, but not much flattened specimen. Dorsal aspect. The areas devoid of ornament are zones of growth on which ornament was just beginning to develop. R. M. specimen No. P. 2837. × $^3/_2$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, foremost (subcephalic) part of right anterior ventro-lateral plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *crtp*, crista transversalis interna posterior (impression); dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *ifc.b*, posterior oblique cephalic pit-line groove; $ifc.b_1$, anterior oblique cephalic pit-line groove; *lcg*, main lateral line groove; *orb.fen*, orbital fenestra; *otd*, obliquely transverse depression above the postlevator thickening (*alr*); *pro*, processus obstans; *stc*, supratemporal pit-line groove.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Pmg1
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B
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Pmg1
plc
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Pm
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ptoc
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mpg
B1
Lp
Pmg1
Pm
Pmg2
C
ifc1
Lp
Pm
Pmg1
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D
Lp
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Pm
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soα
Pm
Adl
lcg

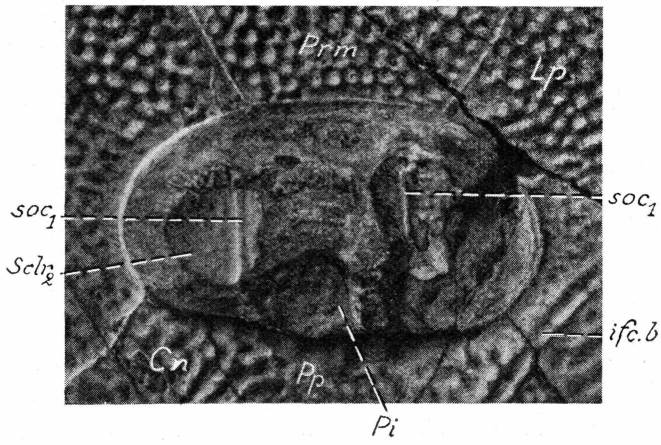
pressed in relation to the other more anteriorly situated parts of the upper face of the plate (text-figs. 91, 94A, B, 95). On the posterior face of the plate (text-figs. 11, 12, 19, 25B) we find the median occipital crest (*cr.o*) and the fossae (*fm*, fm_1) which probably served as insertion areas for certain parts of the levator muscles of the head.

The paranuchal-marginal plate (*Pm*, text-figs. 1C, D, 4, 9–12, 27, 28A, 29, 76–84, 88, 90–92, 94–103, 106, 109, 115–117, 127–134, 140, 147, 148, 154, 155, 157–159, 203, 208, 209) is broader than long, its length : breadth ratio ranging between 71–85. The plate is mostly fairly equally developed on the right and left sides of the head-shield, but may also often differ considerably in proportions on both sides of the head-shield. The medial division of the plate is usually about as long as broad, but may in some cases be a little longer than broad. The lateral division as a rule extends slightly forwards beyond the medial division and at its anterior end is generally bounded off from that division by a well-marked nick. Usually it is comparatively broad in smaller medium-sized specimens (text-figs. 84A, B, 99, 100), but decreased mostly in breadth during the growth of the paranuchal-marginal plate so that in large specimens it is often fairly narrow. More precisely its breadth in small individuals amounts to about two thirds (64%) of the breadth of the medial division, whereas its breadth in medium-sized and large individuals is mostly only about one half or less than one half of the breadth of the medial division. In very large individuals its breadth may even be considerably less than one half of the breadth of the medial division.

The postmarginal plate (*Pmg*, text-figs. 1D, 4, 9–12, 76, 77A, B, 78, 79C, 80A, B, 81–84, 94C, 97–99, 100B, D–G, 101–103, 106, 109, 114–116, 127–134, 147, 148, 154, 155, 157–159, 163, 203, 208, 209) is fairly variable as to its proportions, but is always longer than broad and four-sided in shape. The postero-lateral corner (*plc*) of the plate is normally extended backwards into a short process (text-figs. 29C, D, E, 82–84, 99, 100D–G) bearing the most antero-lateral part of the subobstantic area (*soa*), but in several cases it may also be rounded off, and be devoid of such a process (text-figs. 29A, B, F, 100A, 101, 103A, B, F). The plate projects always forwards beyond the lateral division of the paranuchal-marginal plate, but

Text-fig. 103. *Bothriolepis canadensis*. Seven cases in which the postmarginal plate is subdivided into two elements. *A*, R. M. specimen No. P. 2854. × 3; *B*, R. M. specimen No. P. 2731 (same specimen as in text-fig. 163 B), × 3; B_1, R. M. specimen No. P. 2867. × 2; *C*, R. M. specimen No. P. 2723. × 3; *D*, R. M. specimen No. P. 2780. × 2; *E*, R. M. specimen No. 2287. × 2; *F*, R. M. specimen No. P. 3325. × 3.

Adl, anterior dorso-lateral plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; Pmg_1, anterior postmarginal plate; Pmg_2, posterior post-marginal plate; ifc_1, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *lcg*, main lateral line groove; *mpg*, middle pit-line groove of the skull roof; *om*, obstantic margin; *plc*, postero-lateral (preobstantic) corner; *ptoc*, postobstantic corner; *ptc*, cephalic division of main lateral line groove; *soa*, subobstantic area.



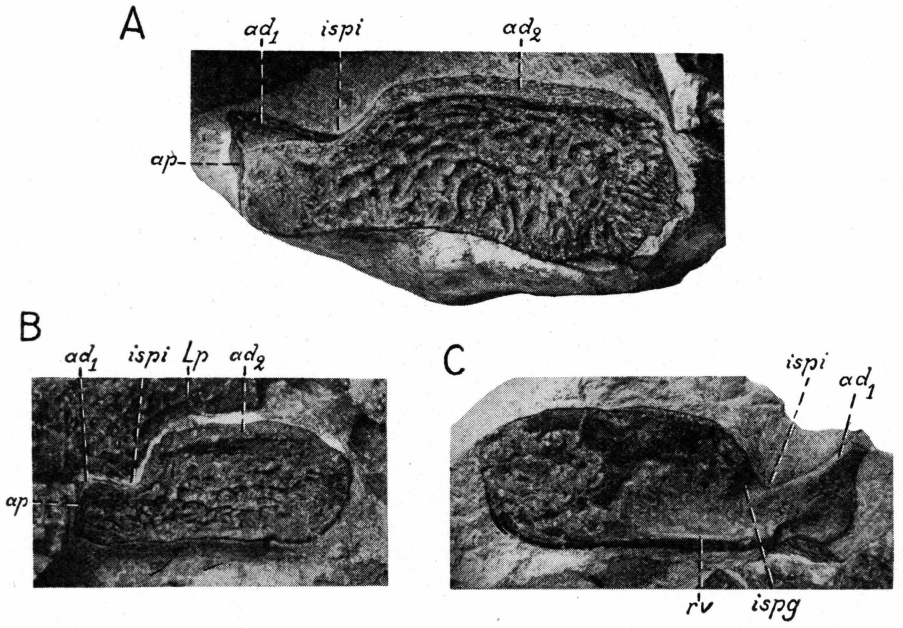
Text-fig. 104. *Bothriolepis canadensis.* Impression of the middle part of the upper side of a rather large head-shield. The posterior paired section of the supraorbital sensory canal groove clearly shown as impression. R. M. specimen No. P. 2282. × 5/2.
Cn, centro-nuchal plate; *Lp*, lateral plate; *Pi*, pineal plate; *Pp*, postpineal plate; *Prm*, premedian plate; $Sclr_2$, postero-dorsal sclerotic plate; *ifc.b*, posterior oblique cephalic pit-line groove; soc_1, posterior, paired section of the supraorbital sensory canal groove, developed as a pit-line groove on the postero-dorsal sclerotic plate.

only so slightly, however, that the suture between it and the lateral plate normally runs decidedly more in a transverse than in a rostro-caudal direction. Only exceptionally this suture is more rostro-caudalyy disposed so that it tends to pass somewhat as in *B. panderi* (text-fig. 229). In most of its characters the plate is much as in *B. cellulosa* (text-figs. 218, 219).

In several cases the postmarginal plate is subdivided into two elements, which according to their position have been termed the anterior and posterior postmarginal plates respectively (Pmg_1, Pmg_2, text-figs. 29, 103). These two elements vary considerably in their position, extent and shape (pp. 80–83; cf. also Gross 1942b, fig. 5, and pl. 11, fig. 2). Sometimes both the elements enter into the formation of the subobstantic area (*soa*), sometimes one of them, either the anterior or posterior one, may be situated so as to be entirely excluded from participating into the formation of that area. The posterior postmarginal plate (Pmg_2) may in some cases be as small as to be represented only by a splint of bone in the very suture between the anterior postmarginal (Pmg_1) and paranuchal-marginal plates.

The sclerotic ring (text-fig. 30) has been dealt with above (pp. 83–85), on account of which it is superfluous to enter upon its structure here. In this connection it may be mentioned, however, that the posterior paired section of the supraorbital sensory canal groove was sometimes situated in a well-marked groove (soc_1, text-fig. 104) on the postero-dorsal sclerotic plate.

The sclerotic plates seem mostly to be devoid of ornament. In certain cases, however, traces of ornament may be found on the anterior and postero-dorsal sclerotic plates (text-fig. 104).



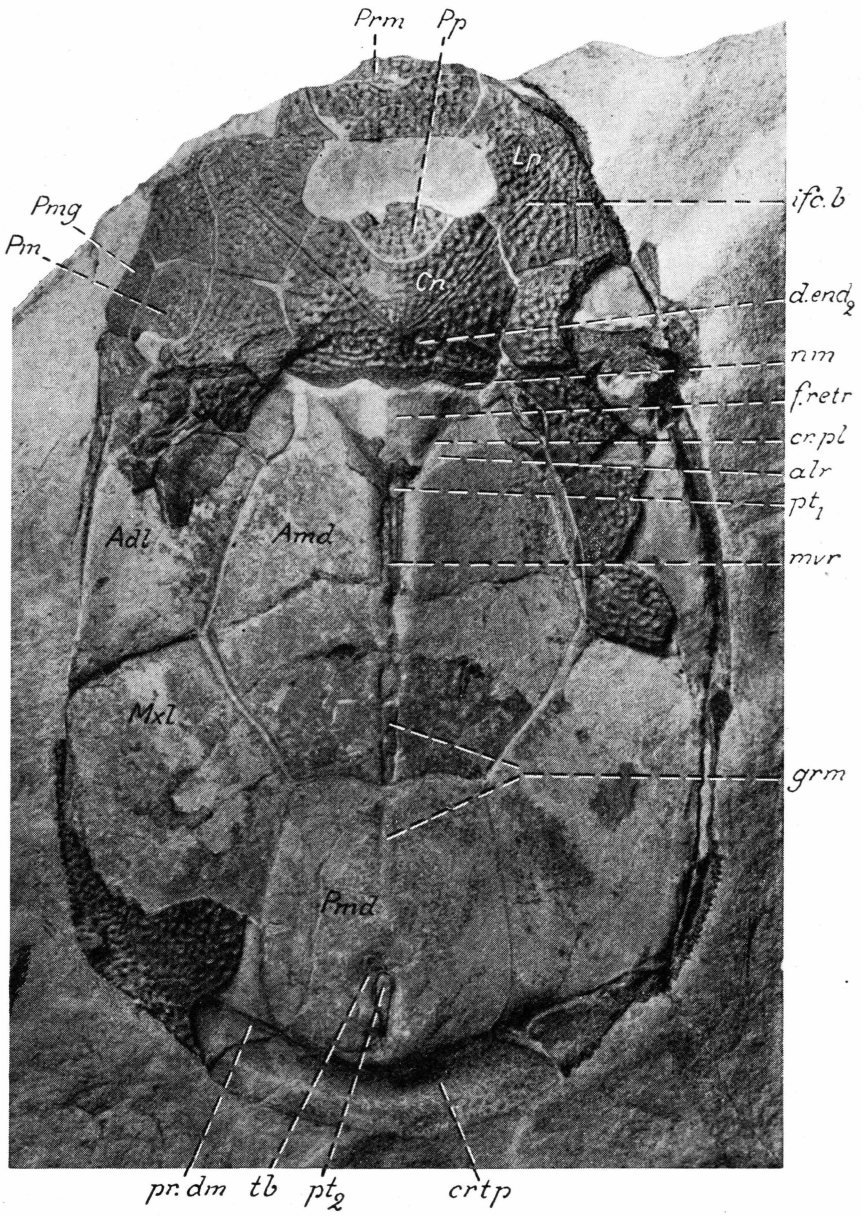
Text-fig. 105. *Bothriolepis canadensis*. Three left extralateral (opercular) plates. *A*, *B*, in external (lateral) aspect. *C*, in internal (medial) aspect. *A*, R. M. specimen No. P. 2781. × 2; *B*, R. M. specimen No. P. 2864. × 2; *C*, R. M. specimen No. P. 2696. × 2. *Lp*, lateral plate; ad_1, prespiracular area of attachment; ad_2, postspiracular area of attachment; *ap*, area overlapped by the prelateral plate *ispi*, infraspiracular notch; *ispg*, groove on the medial side of the extralateral plate leading to the infraspiracular notch; *rv*, ventral longitudinal crest on the medial side of the extralateral plate.

Dermal bones of the cheek and visceral skeleton.

The dermal bones developed on the cheek and in relation to the visceral arches are well preserved and lie more or less in their natural position in several of the specimens examined (text-figs. 80B, 110–113, 128, 129, 131, 132, 140, 148, 154, 160–162, 168, 169, 173, 176, 209), and their shape and position could, therefore, be fairly well ascertained (cf. pp. 21–24, 85–98, and text-figs. 4, 8, 31A, B, E, 32–34, 35A–C, 36A, B, 37, 83D, 98, 105, 107, 109, 114).

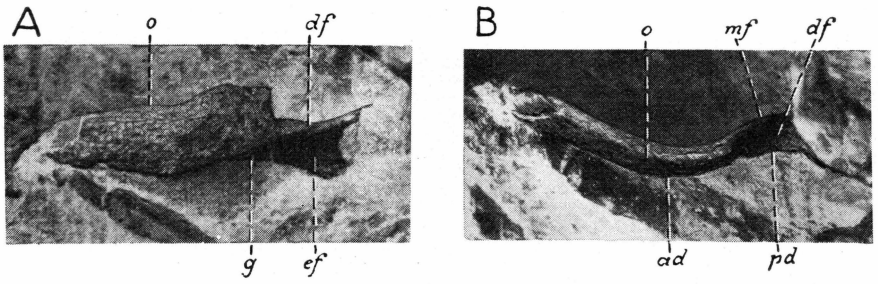
The labial bone (*Lb*, text-figs. 7, 8, 34) was found preserved only in a single very large specimen (text-fig. 111) where it is present on both the right and left sides. As has been pointed out (p. 36), it cannot be decided whether this bone is a dermal bone, developed in relation to a labial cartilage, or a substitution bone, developed in a labial cartilage.

The prelateral plate (*Prl*, text-figs. 4, 7, 8, 31A, B, 34, 65, 83D, 98, 110, 112C, 114, 131, 140; cf. also Stensiö 1931, text-fig. 22C) is four-sided in shape, but, as its dorsal margin is short and often not clearly defined, it usually tends to become somewhat triangular in outline. The plate is imperfectly known, but it is obvious that it is fairly variable both as to size and proportions.



Text-fig. 106. *Bothriolepis canadensis*. Medium-sized specimen in dorsal aspect. The bones of the dorsal wall of the trunk-armour represented mainly by impressions of their lower sides only. R. M. specimen No. P. 2867. × $^3/_2$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alr*, postlevator thickening (impression); *cr.pl*, postlevator crest (impression); *crtp*, crista transversalis interna posterior (impression); *d.end*$_2$, external opening of canal for endolymphatic duct; *f.retr*, levator fossa; *grm*, ventral median groove; *ifc.b*, posterior oblique cephalic pit-line groove; *mvr*, ventral median ridge (impression); *nm*, obtected nuchal area; *pr.dm*, medial dorsal process of mixilateral plate (impression); *pt*$_1$, *pt*$_2$, anterior and posterior ventral pits respectively (impression); *tb*, ventral tuberosity (impression).

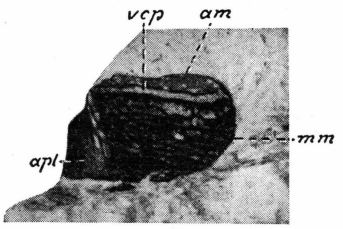


Text-fig. 107. *Bothriolepis canadensis*. Left inferognathal, deficient both anteriorly and posteriorly. *A*, in external, and *B*, in dorsal (labial) aspect. R. M. specimen No. 2114. × 4.
ad, anterior biting division; *df*, dorsal face of posterior, non-biting division; *ef*, external face of posterior, non-biting division (situated on medial side of Meckel's cartilage); *g*, groove at transition between anterior biting, and posterior non-biting, divisions (this groove occupied by the dorsal part of Meckel's cartilage); *mf*, medial free face of posterior non-biting division; *o*, oral margin of anterior, biting division; *pd*, posterior, non-biting division.

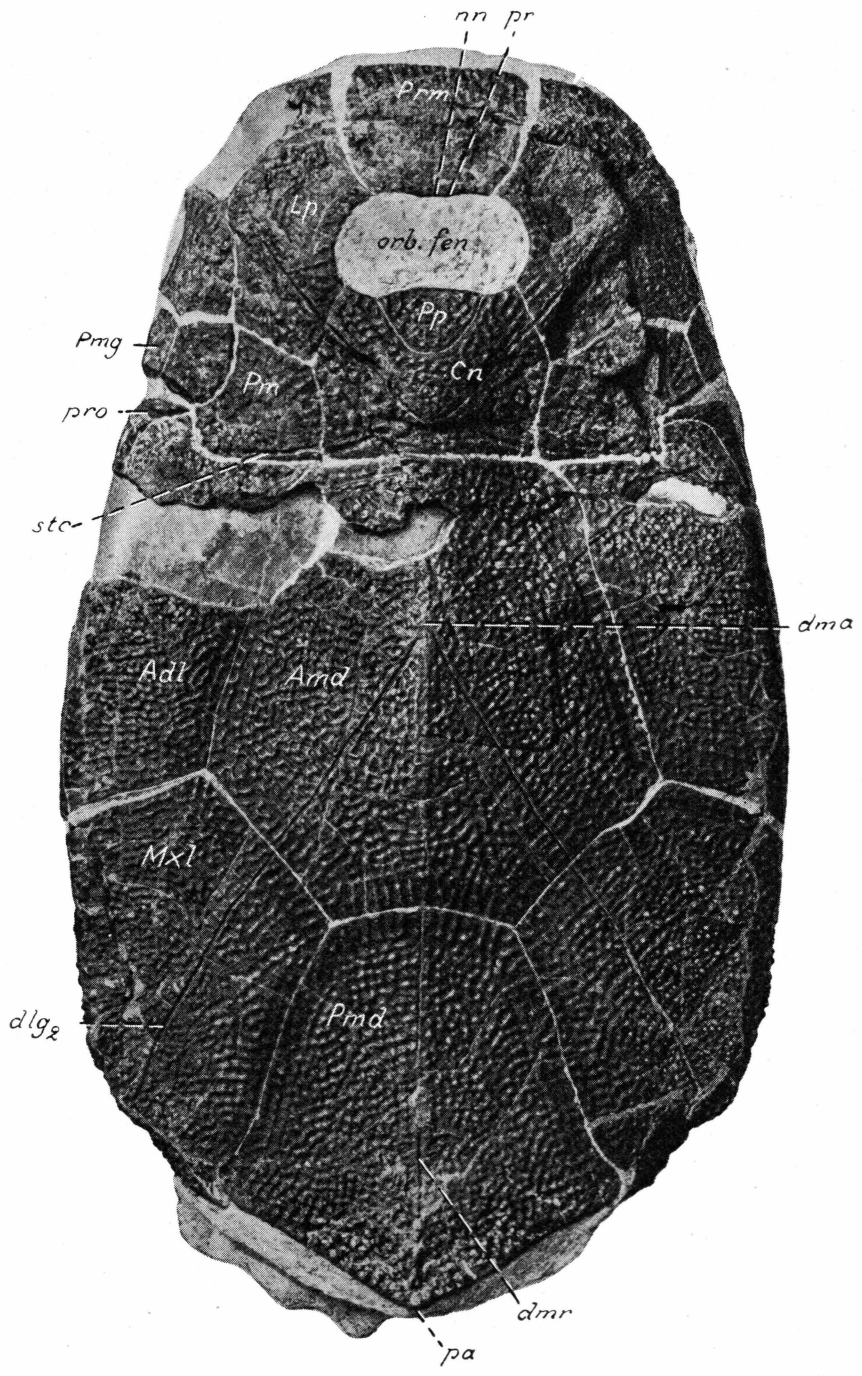
The extralateral (opercular) plate (*Opl*, text-figs. 4, 7, 8, 31E, 32, 34, 65, 83D, 98, 105, 110, 111, 112B, C, 114, 116, 128, 132, 140, 148, 154, 155, 157, 208) in its general shape is somewhat suggestive of the maxillary in the *Palaeonisciformes*. It is normally about two and a half to two and three fourths times as long as it is high, but may also sometimes be nearly three times as long as high. Its maximum height is across the posterior third. For further details concerning the development of the plate the reader is referred to the general part of this work (pp. 88–90).

The mental plate (*Me*, text-figs. 8, 34, 35A–C, 90, 101, 110, 111, 112B, 113A, 114, 131, 140, 160–162, 168, 169, 176) is fairly often preserved, but is nearly always in a poor state of preservation. Judging from a few specimens (text-fig. 35A–C) in which it is fairly complete, it is two and a half times as long as it is high or thereabouts. It is thus probably somewhat lower and longer than in *B. cellulosa* (text-fig. 35D, E). Its sensory canal component is normally provided with a delicate, more or less reticular ornament; its tooth-component bears small tooth-like cusps on the lower margin.

The infraprelateral plate (*Py*, text-figs. 8, 33, 34, 37, 108–114) is



Text-fig. 108. *Bothriolepis canadensis*. A right infraprelateral plate in external (ventral) aspect. R. M. specimen No. 2114. × 3.
am, anterior margin; *apl*, area attached to the prelateral and extra-lateral plates; *mm*, medial = morphologically ventral margin; *vcp*, vertical pit-line groove of cheek.



Text-fig. 109. *Bothriolepis canadensis*. Medium-sized flattened specimen in dorsal aspect. R. M. specimen No. 2664. × $^{3}/_{2}$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *dlg*$_2$, posterior oblique abdominal pitline groove; ; *dma*, tergal angle; *dmr*, dorsal median ridge; *nn*, nasal notch; *orb.fen*, orbital fenestra; *pa*, posterior angle of posterior median dorsal plate; *pr*, paranasal process; *pro*, processus obstans; *stc*, supra-temporal pit-line groove.

clearly fairly variable as to its size and proportions, but it is always morphologically higher than broad with a strongly convex ventral (medial) margin. In several cases it shows a delicate reticular ornament on its outside, behind the pit-line groove (*vcp*) passing along its anterior margin.

The inferognathal (*Ifg*, text-figs. 8, 34, 36A, B, 107, 110–114) is fundamentally as the similarly termed bone in the Euarthrodires. Its anterior biting division (*ad*) is fairly variable as to shape and proportions. The upper margin (*o*) of this division is often smooth, but may also show certain irregular cusps, probably representing teeth in a much reduced condition. At least in many cases the outside of the division in question presents indications of a delicate ornament more or less clearly reticular in disposition. For further details concerning the plate the reader is referred to pp. 93 and 96 above.

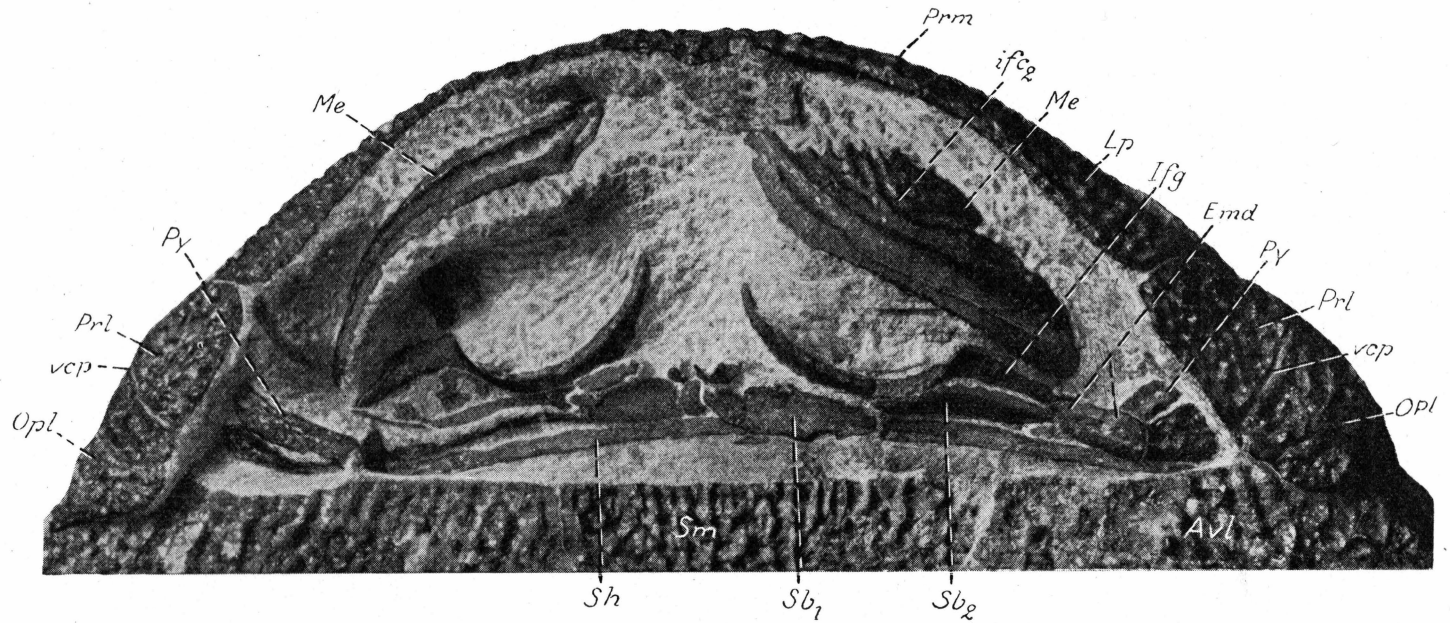
The submandibular series of bones (*Sbm*, Sb_1, Sb_2, text-figs. 8, 34, 37, 110, 111, 112, 113B, C) varies considerably in its development in different specimens. It may be developed in the following ways: 1) it may be represented only by one fairly short element, Sb_2, situated below the posterior part of the lower jaw (text-figs. 8, 34, 37C, 111); 2) in front of the element Sb_2 there may be another element, Sb_1, so that the series is composed of two elements, anterior and posterior (text-figs. 37B, 110, 112B, C, 113B); 3) the elements Sb_1 and Sb_2 may be fused into one single long plate ($Sb_1 + Sb_2$, text-figs. 37A, 112A); 4) at least in certain cases there is also a median unpaired element (*Sbm*, text-figs. 37A, 112A) situated below and behind the symphysial parts of the lower jaws. – The plates of this series exhibit often a vestigial reticular ornament.

The subhyoideal series of bones (*Sh*, *Shm*, Sh_1, Sh_2, text-figs. 8, 34, 37, 110–112, 113B, C) may consist of a single long element (*Sh*), or else it may be subdivided into one median element (*Shm*) and one or two lateral elements (Sh_1, Sh_2) of varying length. Sometimes a paired element is segmented off on one side only ($Sh_1 r$, $Sbm + Sh_1 l$, text-fig. 113B). The subhyoideal bone series is often straight throughout its extent, but in several cases the lateral parts arch backwards. The bone or bone series in question is sometimes broad (in a direction from in front backwards), sometimes comparatively narrow. It shows no traces of ornament.

Trunk-armour or exoskeletal shoulder-girdle.

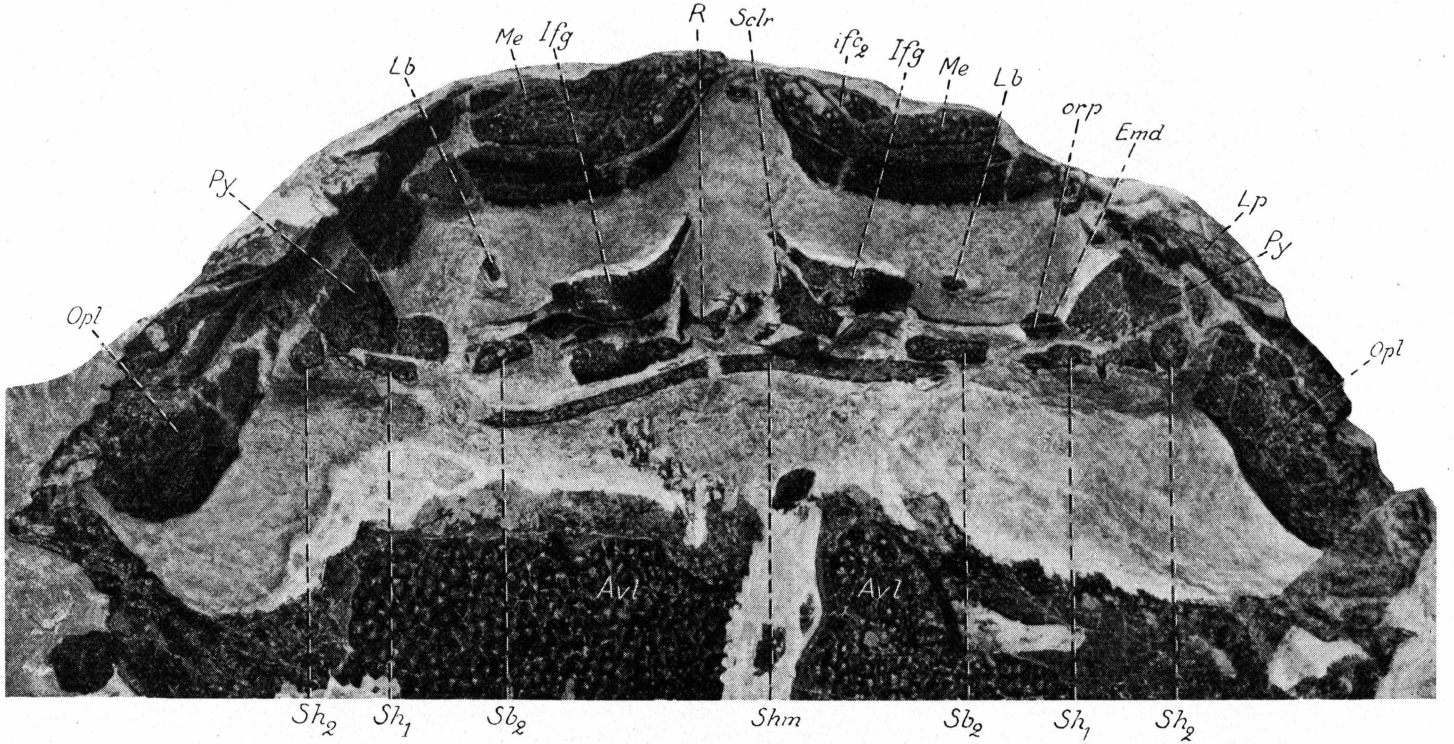
The trunk-armour as to its extent and proportions has been dealt with above (pp. 229–230) and little remains, therefore, to be added concerning its general characters.

The tergal angle (*dma*, text-figs. 38, 39A, B, 40, 43A, B, 88, 90, 91, 95–98, 101, 102, 109, 114, 115–124, 127, 128, 140–143, 146, 154–157, 179–183, 202, 204, 206, 210) is situated close in front of, or near behind, the transition between the anterior and middle thirds of the anterior median dorsal plate.



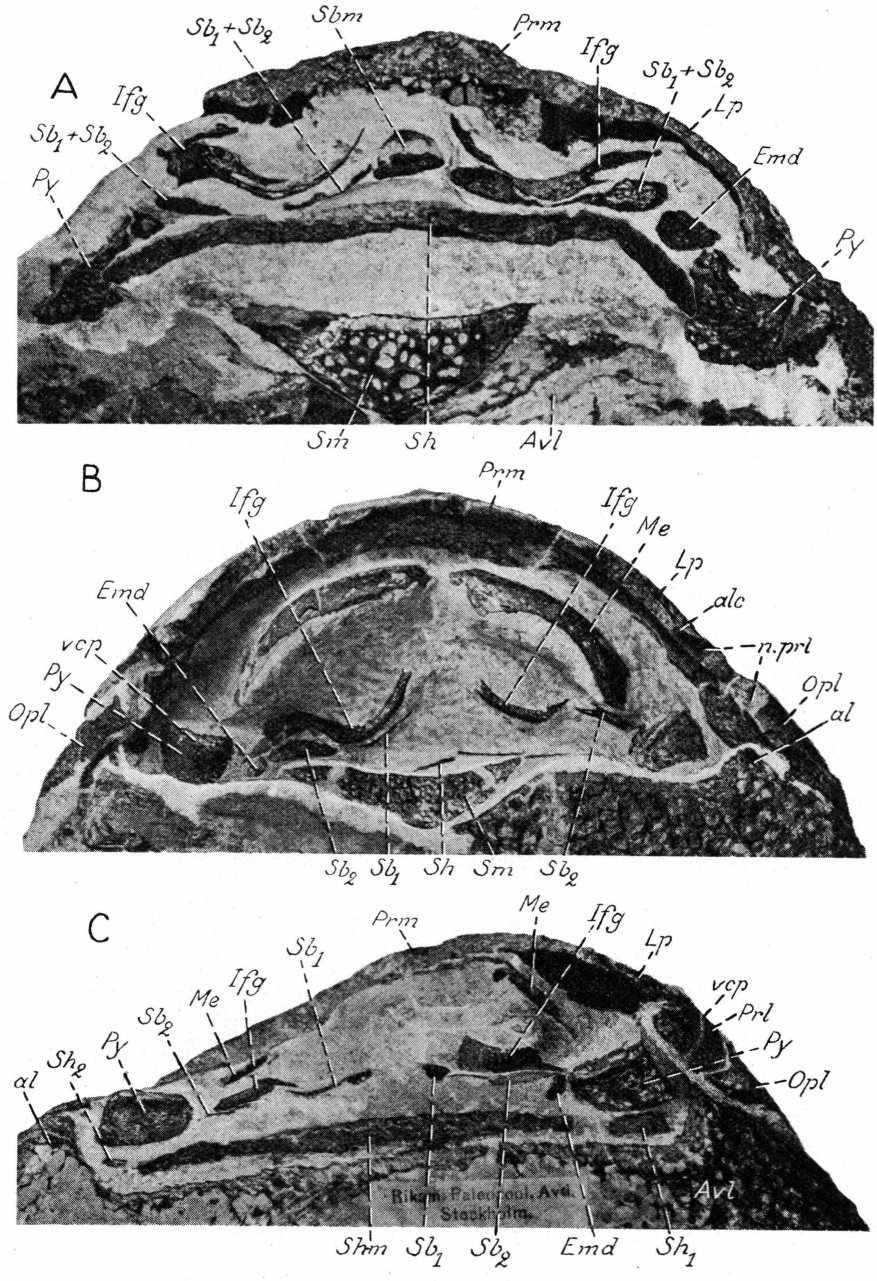
Text-fig. 110. *Bothriolepis canadensis*. Head in ventral aspect, showing the dermal bones of the cheek and visceral skeleton. R. M. specimen No. P. 834. Approximately × 2.

Avl, anterior ventro-lateral plate; *Emd*, extramandibular plate; *Ifg*, inferognathal; *Lp*, lateral plate; *Me*, mental plate; *Opl*, extralateral plate, *Prl*, prelateral plate; *Prm*, premedian plate; *Py*, infraprelateral plate; Sb_1, Sb_2, paired lateral submandibular plates; *Sh*, subhyoideal bone; *Sm*; semilunar plate; ifc_2, lower infraorbital sensory canal groove; *vcp*, vertical pit-line groove of cheek.

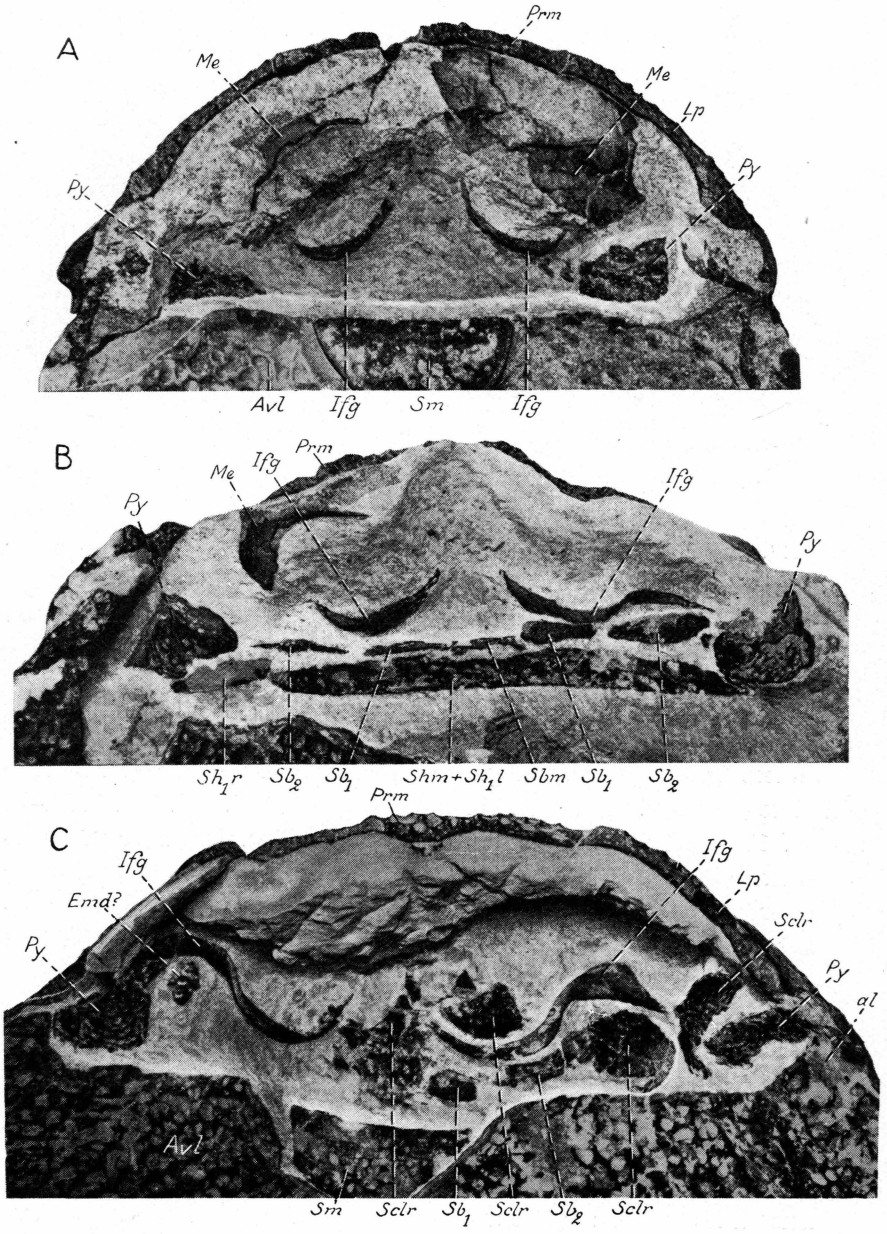


Text-fig. 111. *Bothriolepis canadensis*. Lower side of the head of a very large specimen R. M. specimen No. 2130 (also reproduced by Stensiö in 1931, text-fig. 27, but the ventral dermal bones have now been a little more exposed by preparation). This specimen reproduced from the dorsal side in text-fig. 159. Somewhat more than × 1.5.

Avl, anterior ventro-lateral plate; *Emd*, extramandibular plate; *Ifg*, inferognathal; *Lb*, labial bone; *Lp*, lateral plate; *Me*, mental plate; *Opl*, extra-lateral plate; *Py*, infraprelateral plate; *R*, rostral plate; Sb_2, paired lateral element of the submandibular series; *Sclr*, sclerotic plate; Sh_1, Sh_2, *Shm*, elements of the subhyoideal bone-series; ifc_2, lower infraorbital sensory canal groove; *orp*, oral pit-line groove.

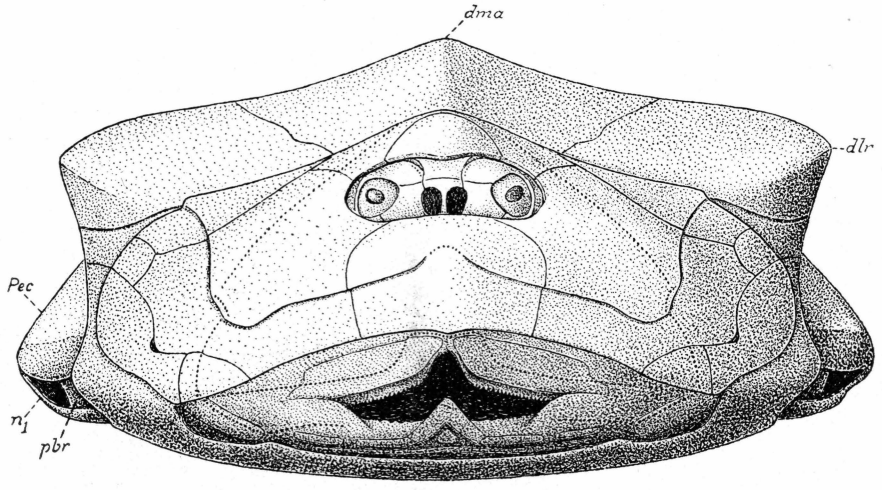


Text-fig. 112. *Bothriolepis canadensis*. Lower side of the head of three specimens. *A*, R. M. specimen No. 2109 (also reproduced by Stensiö in 1931 in text-fig. 25). About × $^{7}/_{2}$. *B*, R. M. specimen No. 2854. × $^{11}/_{5}$. *C*, R. M. specimen No. 2132. Slightly less than × 2. *Avl*, anterior ventro-lateral plate; *Emd*, extramandibular plate; *Ifg*, inferognathal; *Lp*, lateral plate; *Me*, mental plate; *Opl*, extralateral plate; *Prl*, prelateral plate; *Prm*, premedian plate; *Py*, infraprelateral plate; Sb_1, Sb_2, submandibular plates 1 and 2; $Sb_1 + Sb_2$, plate equivalent to the plates Sb_1 and Sb_2; *Sbm*, unpaired median submandibular plate; *Sh*, subhyoideal bone; Sh_1, Sh_2, *Shm*, elements of the subhyoideal series; *Sm*, semilunar plate; *al*, antero-lateral corner of subcephalic division of anterior ventro-lateral plate; *alc*, antero-lateral corner of lateral plate and of head-shield as a whole; *nprl*, prelateral notch; *vcp*, vertical pit-line groove of cheek.



Text-fig. 113. *Bothriolepis canadensis*. Lower side of three heads. *A*, R. M. specimen No. P. 2837. × $^{7}/_{3}$. *B*, R. M. specimen No. P. 2867. × $^{7}/_{3}$. *C*, R. M. specimen No. 2773. Approximately × $^{7}/_{3}$.

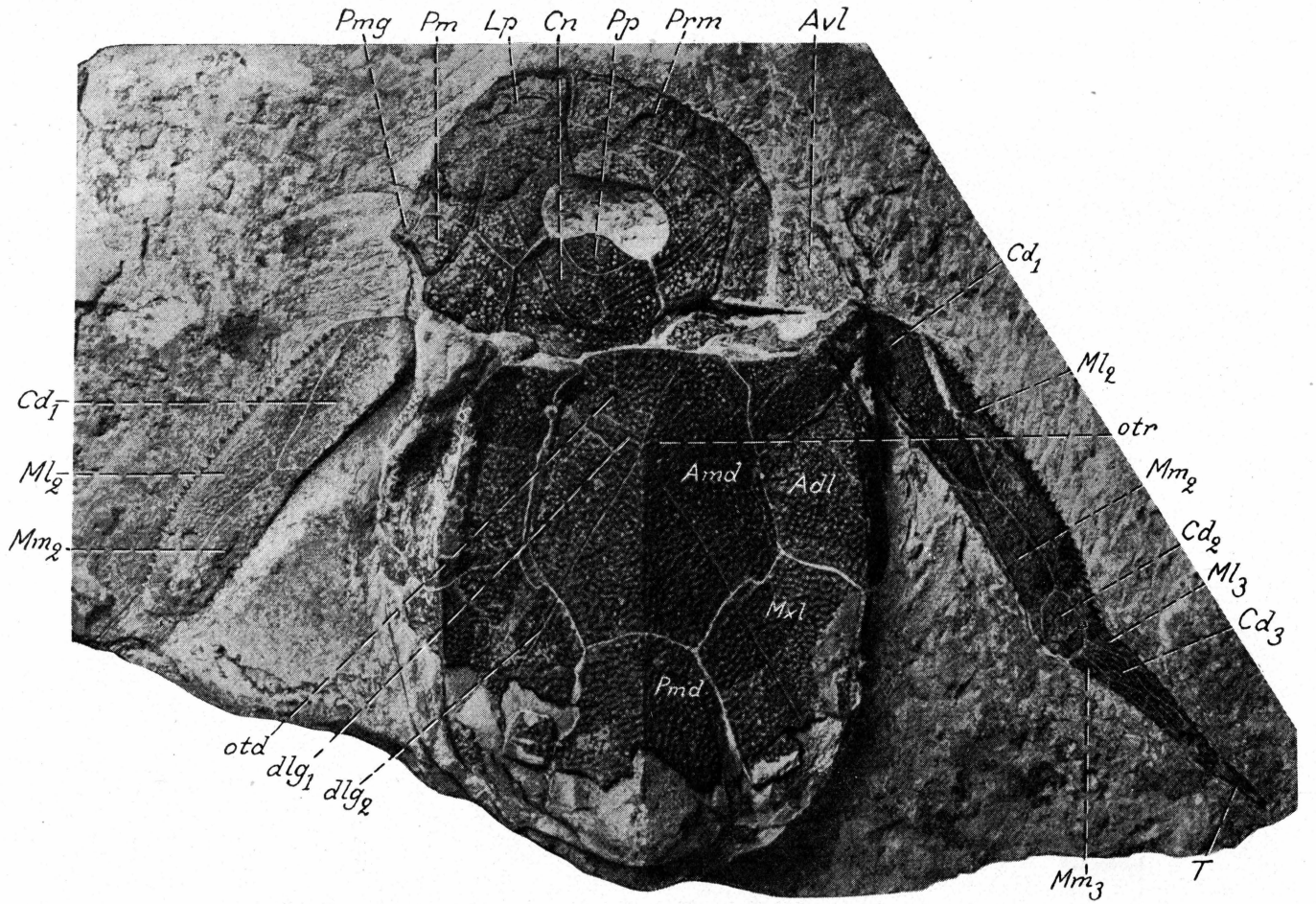
Avl, anterior ventro-lateral plate; *Emd?*, perhaps an extramandibular plate; *Ifg*, inferognathal; *Lp*, lateral plate; *Me*, mental plate; *Prm*, premedian plate; *Py*, infraprelateral plate; Sb_1, *Sb*, submandibular plates, representing both the plate Sb_1 and the plate Sb_2; *Sbm*, probably median unpaired submandibular plate; *Sclr*, sclerotic plates; Sh_1r, independent paired lateral subhyoideal plate; $Shm + Sh_1l$, subhyoideal bone, representing both a median and a left lateral element; *Sm*, semilunar plate; *al*, antero-lateral corner of the subcephalic division of the anterior ventro-lateral plate.



Text-fig. 114. *Bothriolepis canadensis*. Attempted restoration of the head and trunk-armour in anterior aspect. Approximately × $^3/_2$.
Pec, pectoral fin; *dlr*, dorso-lateral ridge of trunk-armour; *dma*, tergal angle; n_1, lateral corner of proximal brachial aperture; *pbr*, processus brachialis of anterior ventro-lateral plate.

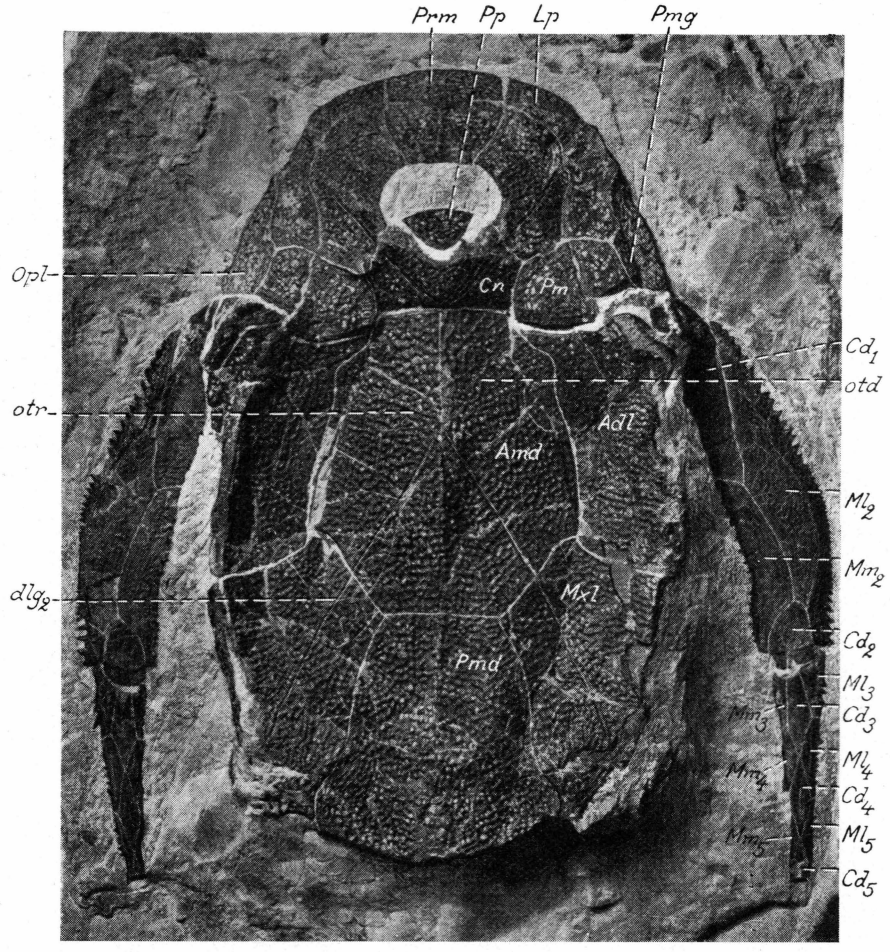
The median dorsal ridge (*dmr*) in small and smaller medium-sized individuals usually is sharp-edged and well developed from the tergal angle backwards to, or almost to, the posterior angle or corner (*pa*) of the posterior median dorsal plate (text-figs. 39A, 43A, 88B, 90, 91, 95–98, 115, 118, 121, 135A–E, 136A, D, 138A–M, 142, 149, 179, 199–202, 204–206). In larger medium-sized and above all in large individuals, on the other hand, this ridge is mostly more rounded off, less well-marked, and often much reduced or entirely absent in its middle part (text-figs. 39B, 43B, 101, 102, 109, 116, 117, 119, 120, 122–124, 127–134, 135G, 136F, 137C, 138N–R, 139–141, 143, 146, 147, 154–159, 180–183). The dorso-lateral ridge (*dlr*) and the ventro-lateral ridge (*vlr*) are both present, but vary much as to their development in that they may either be sharp-edged and well defined, or else more or less strongly rounded off and less clearly pronounced.

In very small individuals in which it does not exceed a length of 4 cm, the dorsal wall of the trunk-armour normally presents the following four formations on its outside: 1) the anterior oblique abdominal pit-line groove (dlg_1); 2) the oblique transverse ridge (*otr*), forming the posterior boundary of the anterior oblique abdominal pit-line groove; 3) the oblique transverse depression (*otd*) above the postlevator thickening; and 4) the groove or depression (*dp*) above the median part of the crista transversalis interna posterior (text-figs. 43A, 45A, 88, 90, 91, 95–98, 121A–D, 179A–C, 199, 201, 202, 204). These four formations may often persist to some extent also in smaller medium-sized individuals in which the dorsal length of the trunk-armour



Text-fig. 115. *Bothriolepis canadensis*. Flattened and somewhat crushed specimen of fairly small size. Dorsal aspect. R. M. specimen No. P. 2853 (the head-shield of this specimen reproduced in text-fig. 80 A). × 1.5.

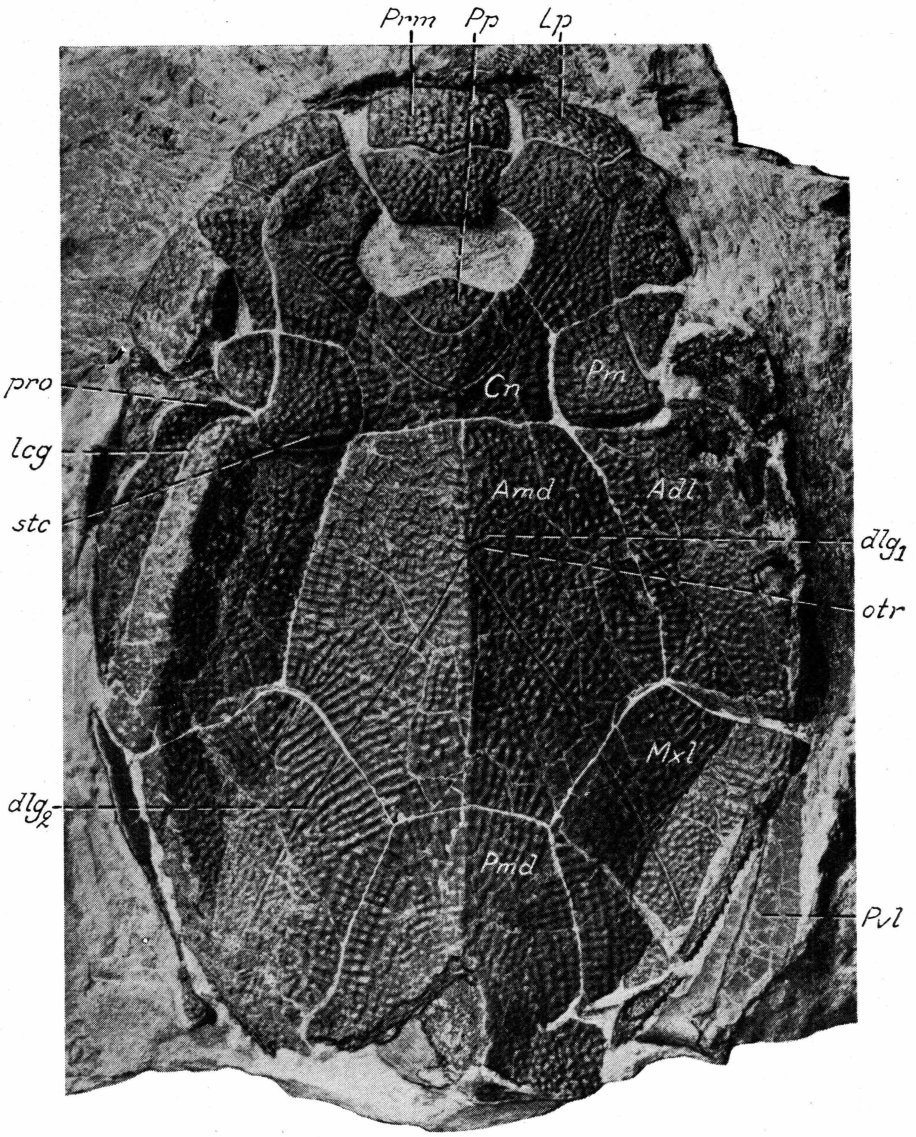
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, foremost (subcephalic) part of right anterior ventro-lateral plate; Cd_1–Cd_3, dorsal central plates 1–3; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, Ml_3, lateral marginal plates 2, 3; Mm_2–Mm_3, medial marginal plates 2, 3; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *T*, terminal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *otd*, obliquely transverse depression above postlevator thickening (*alr*); *otr*, oblique transverse ridge.



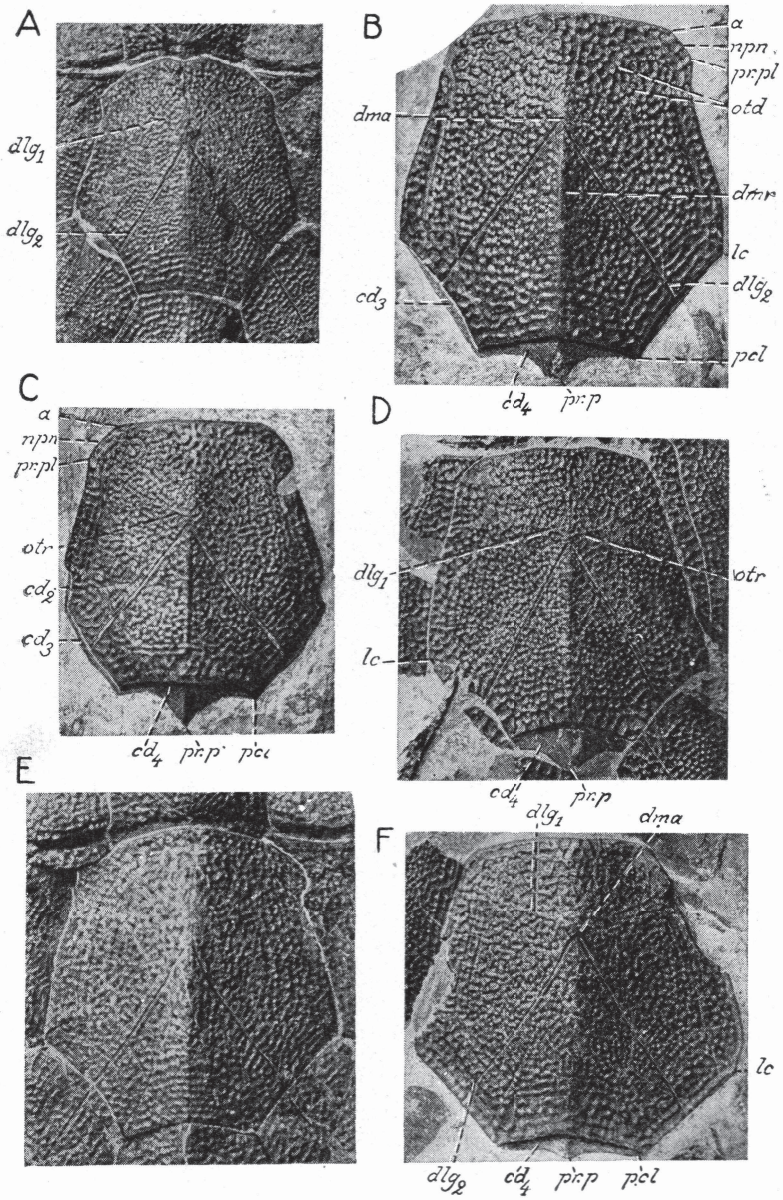
Text-fig. 116. *Bothriolepis canadensis*. Somewhat flattened and crushed, but almost complete medium-sized specimen in dorsal aspect. R. M. specimen No. P. 2756. Slightly magnified.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_5, dorsa central plates 1–5; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *Mxl*, mixilateral plate; *Opl*, extralateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *otd*, obliquely transverse depression above postlevator thickening (*alr*); *otr*, oblique transverse ridge.

amounts to about 4–7 cm, but occur more rarely in larger medium-sized individuals, and are normally absent in large individuals in which the dorsal length of the trunk-armour exceeds 10 cm (text-figs. 43B, 45B, C, 101, 109, 115–120, 121E–M, 122–124, 127–135, 140–143, 146–149, 154–159, 179D–F, 180–183). Most persistent of the formations in question are the depression (*otd*) above the postlevator thickening and the depression or groove (*dp*) above the median dorsal part of the crista transversalis interna posterior,

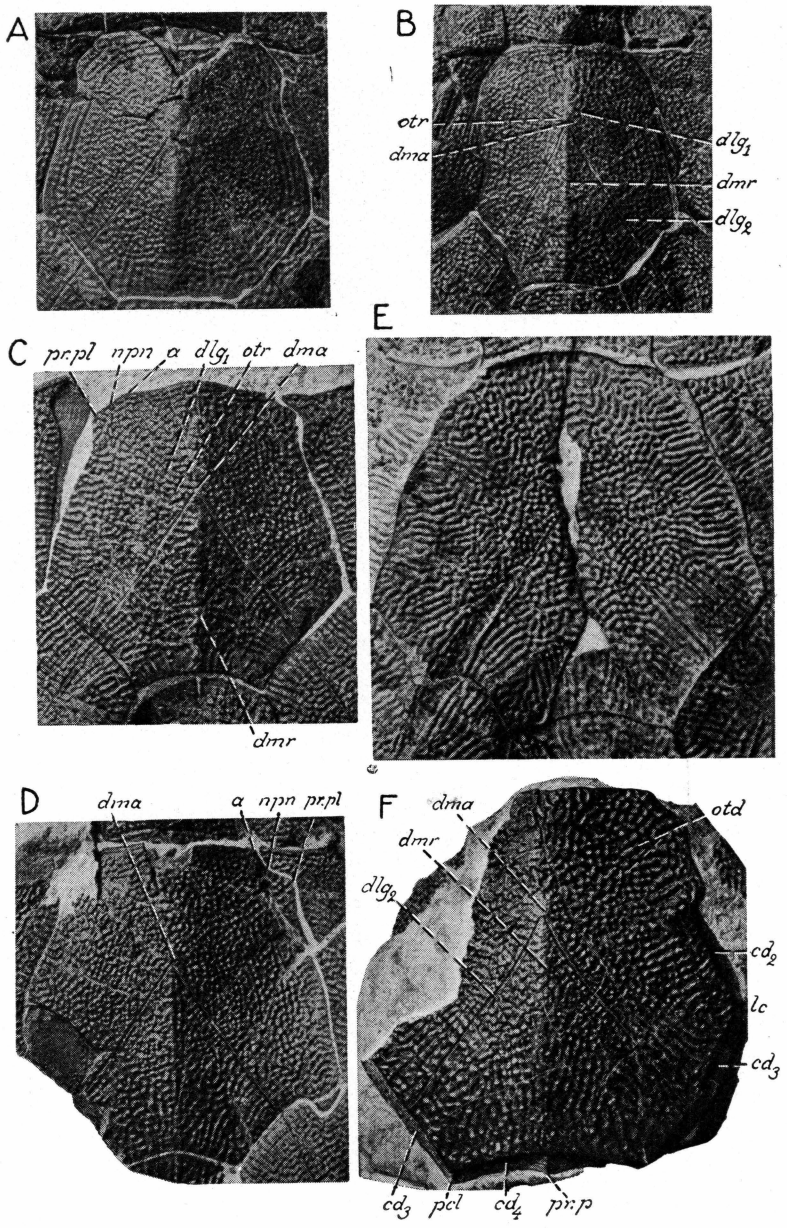


Text-fig. 117. *Bothriolepis canadensis*. Medium sized specimen in dorsal aspect. The specimen dorso-ventrally flattened and partly crushed. R. M. specimen No. P. 2762. × 3/2.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranùchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *lcg*, main lateral line groove of trunk; *otr*, oblique transverse ridge; *pro*, processus obstans; *stc*, supratemporal cross-commissural pit-line groove.

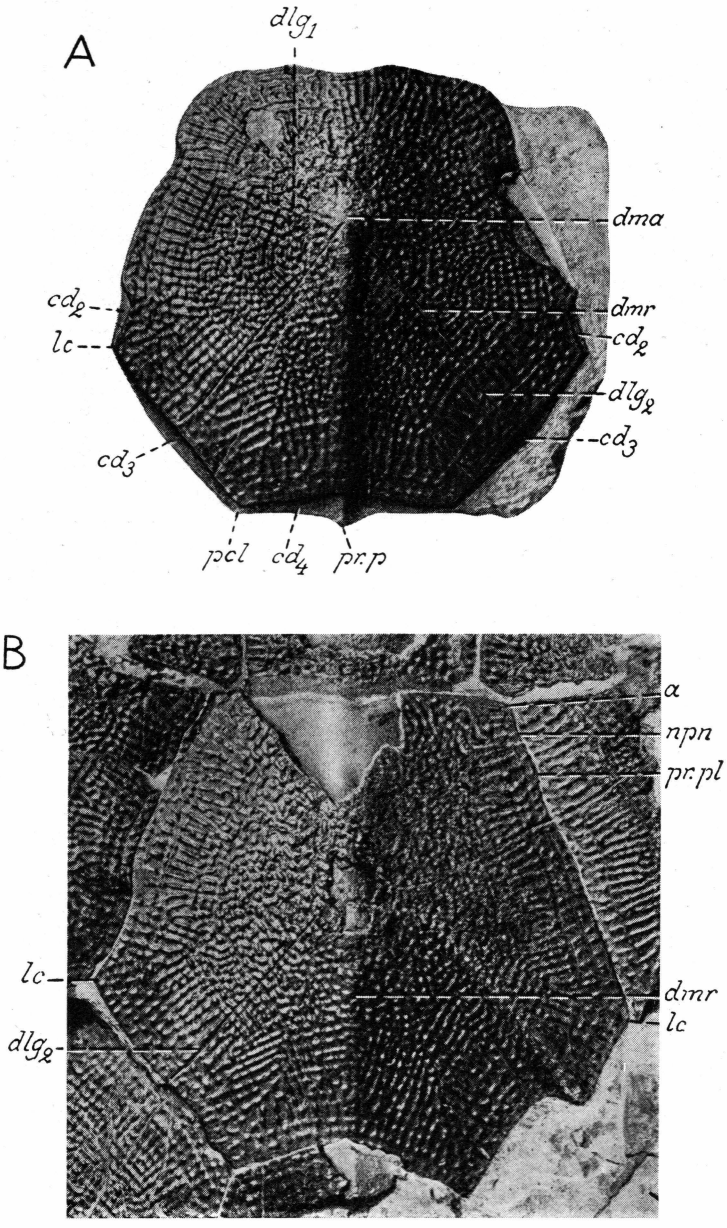


Text-fig. 118. *Bothriolepis canadensis*. *A–F*, six anterior median dorsal plates in dorsal aspect. *A*, of a small individual (dorsal length of trunk-armour about 4,9 cm). *B–F*, small medium-sized individuals. R. M. specimens Nos. P. 2699, 2661, 2159, 3323, 2534, 2255 respectively. *A*, *C–F*, × 2,5; *B*, × 1,6.

a, antero-lateral corner; cd_2, area overlapped by anterior dorso-lateral plate; cd_3, area overlapped by mixilateral plate; cd_4, area overlapped by posterior median dorsal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *lc*, lateral corner; *npn*, postnuchal notch; *otd*, oblique transverse depression above postlevator thickening (*alr*); *otr*, oblique transverse ridge (behind pit-line groove dlg_1); *pcl*, postero-lateral corner; *pr.p*, posterior median process; *pr.pl*, external postlevator process.



Text-fig. 119. *Bothriolepis canadensis*. *A–F*, six anterior median dorsal plates of medium-sized and somewhat large individuals. Dorsal aspect. R. M. specimens Nos. P. 2163, 2526, 2572, 2233, 2282, 2133 respectively. *A*, nat. size; *B–F*, diminished.
For explanation of index letters see text-fig. 118.



Text-fig. 120. *Bothriolepis canadensis*. *A*, *B*, two anterior median dorsal plates of large individuals. Dorsal aspect. R. M. specimens Nos. P. 2744, 2805. Nat. size.
For explanation of index letters see text-fig. 118.

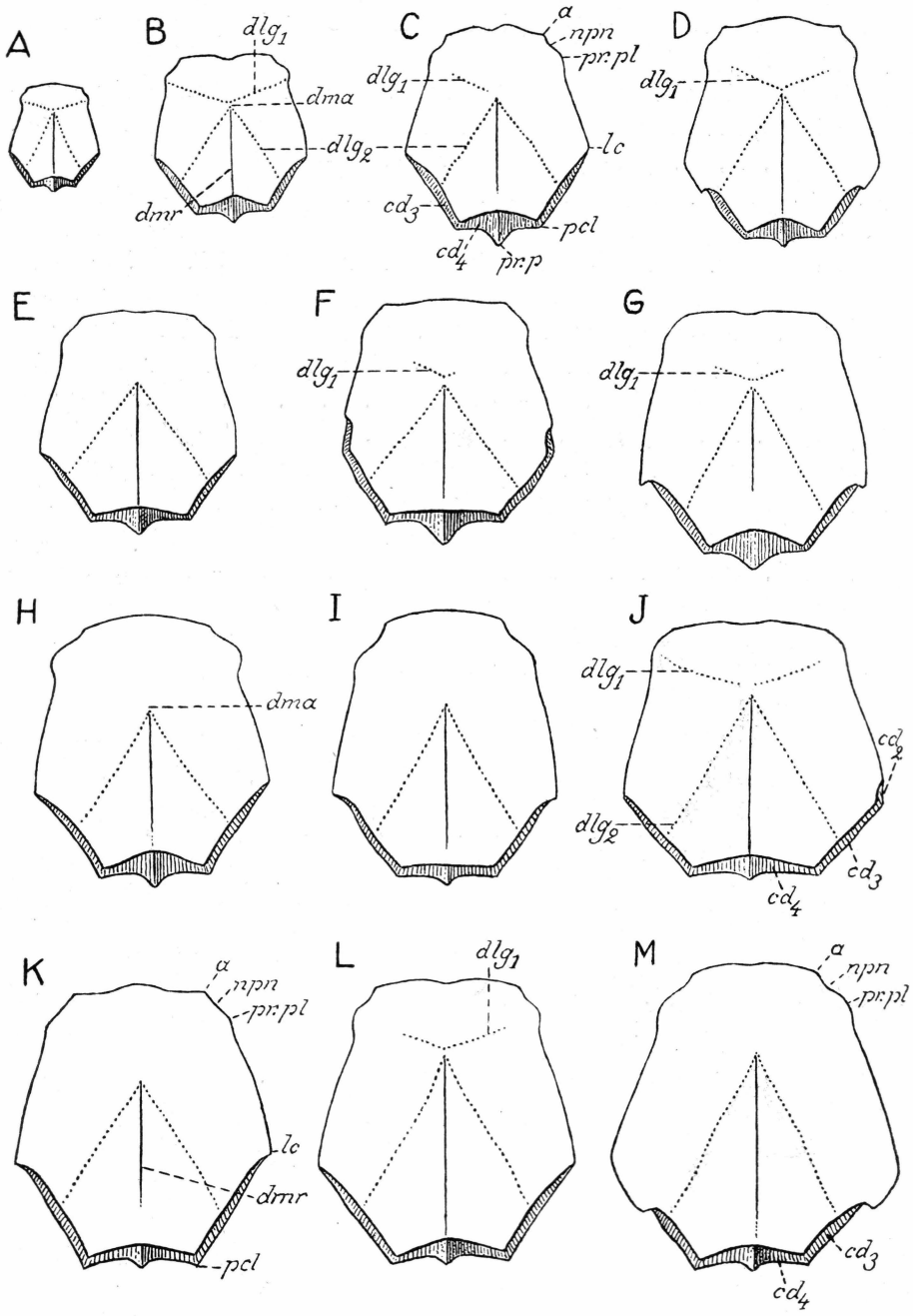
which may sometimes be found in a vestigial condition still in very large individuals.

The posterior margin of the dorsal wall of the armour normally is produced into a marked posterior median angle or short process (*pa*, text-figs. 38, 39A, B, 40, 98, 129, 135, 136, 138, 139, 179–183), but may also exceptionally exhibit a more or less marked median concavity or notch (text-fig. 137A, B).

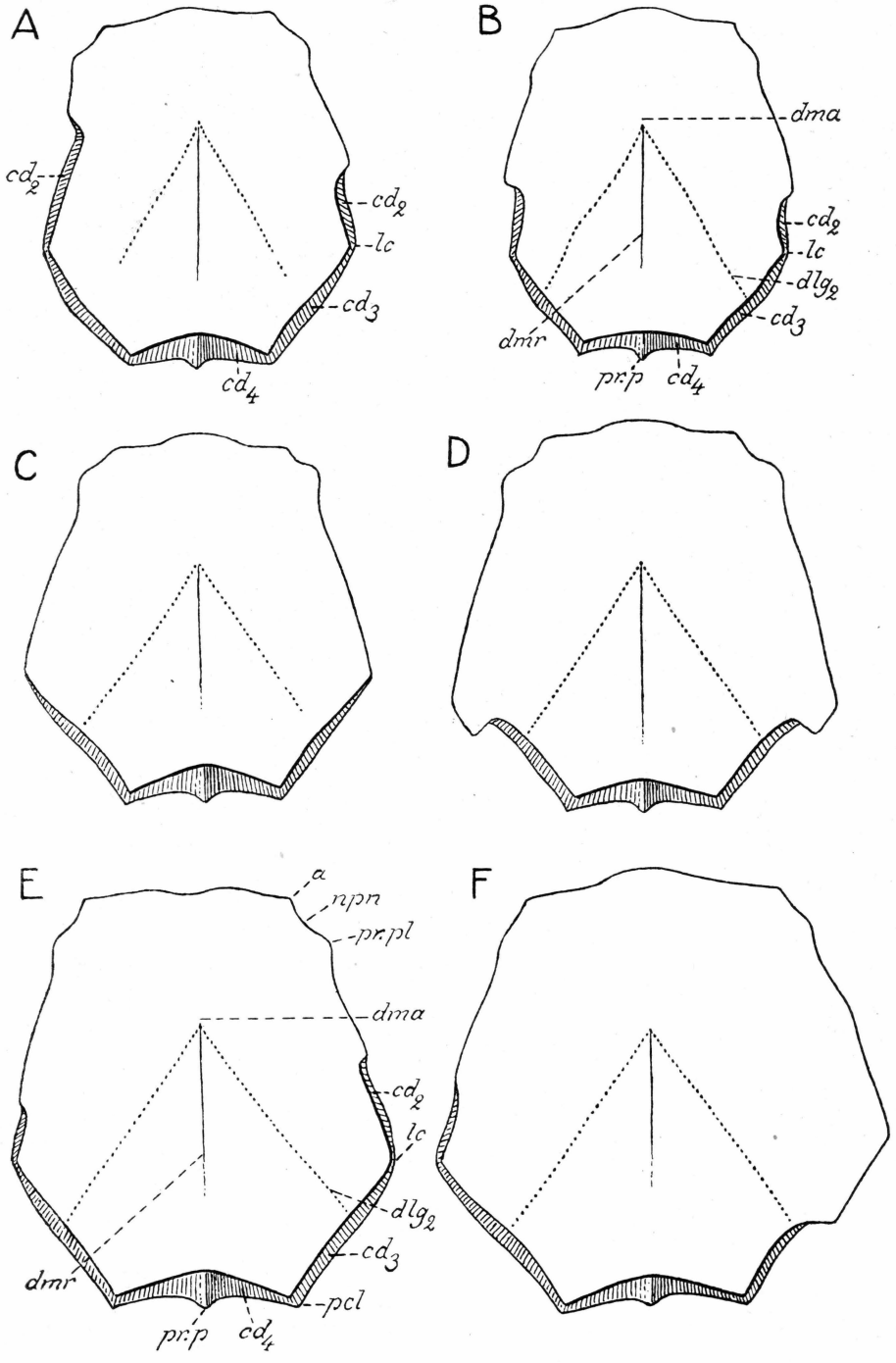
The crista transversalis interna anterior (*cit*, cit_1, text-figs. 48A, B, 51A, 144, 145A, 151, 152, 163A, 164A, 165F, 166E, F, 169) is well developed, but is represented ventrally, on the ventral wall, only by its anterior branch, the postbranchial crest (cit_1). The crista transversalis interna posterior (*crtp*, text-figs. 46, 47A, 88, 92, 106, 125F, 136, 137A, B, 143, 146, 150, 151B, 152, 156, 158, 172C, 173) is strongly developed in its median dorsal part situated on the posterior median dorsal plate. The area on the lower side of the posterior median dorsal plate nearest behind the crista transversalis interna posterior, that is to say the posterior marginal area (*pma*), is very variable as to its extent both in rostro-caudal and transverse directions (text-figs. 136, 137A, B).

The levator fossa (*f.retr*) varies in length, but normally it is somewhat long (text-figs. 44A, 88A, B, 106, 125, 126, 148, 151B, 158, 199). The postlevator thickening (*alr*) is always fairly conspicuous (text-figs. 44A, 125, 126). Besides by that thickening, the levator fossa is often bounded posteriorly also by a postlevator crest (*cr.pl*, text-figs. 44A, 125, 126), which usually, however, occurs more frequently and is stronger developed in small than in larger individuals. The anterior (pt_1) and posterior (pt_2) ventral pits are present even in very small individuals (text-figs. 44A, 46, 47A, 125, 126, 136, 137A, B) and so is also the ventral tuberosity (*tb*) on the posterior median dorsal plate (text-figs. 46, 47A, 88A, B, 125F, 136, 137A, B). This tuberosity (*tb*) normally is rather pronounced and often also well defined. The ventral median ridge (*mvr*) in small and smaller medium-sized individuals is developed only nearest in front of, and somewhat behind, the anterior ventral pit (pt_1), where, however, it is thick and strong (text-figs. 92, 125, 136A–C). In larger medium-sized and large individuals, on the other hand, this ridge has a much greater extent, reaching backwards as far as to close in front of the ventral tuberosity (*tb*) and, besides, often also far forwards into the levator fossa (text-figs. 44A, 47A, 106, 126, 136E, 137B, 148, 151B, 158). The ventral median groove (*grm*) is absent in small individuals and developed first as late as in connection with the appearance of the posterior parts of the ventral median ridge. The presence of a fully developed ventral median ridge and ventral median groove thus is a character distinctive of larger medium-sized and large individuals.

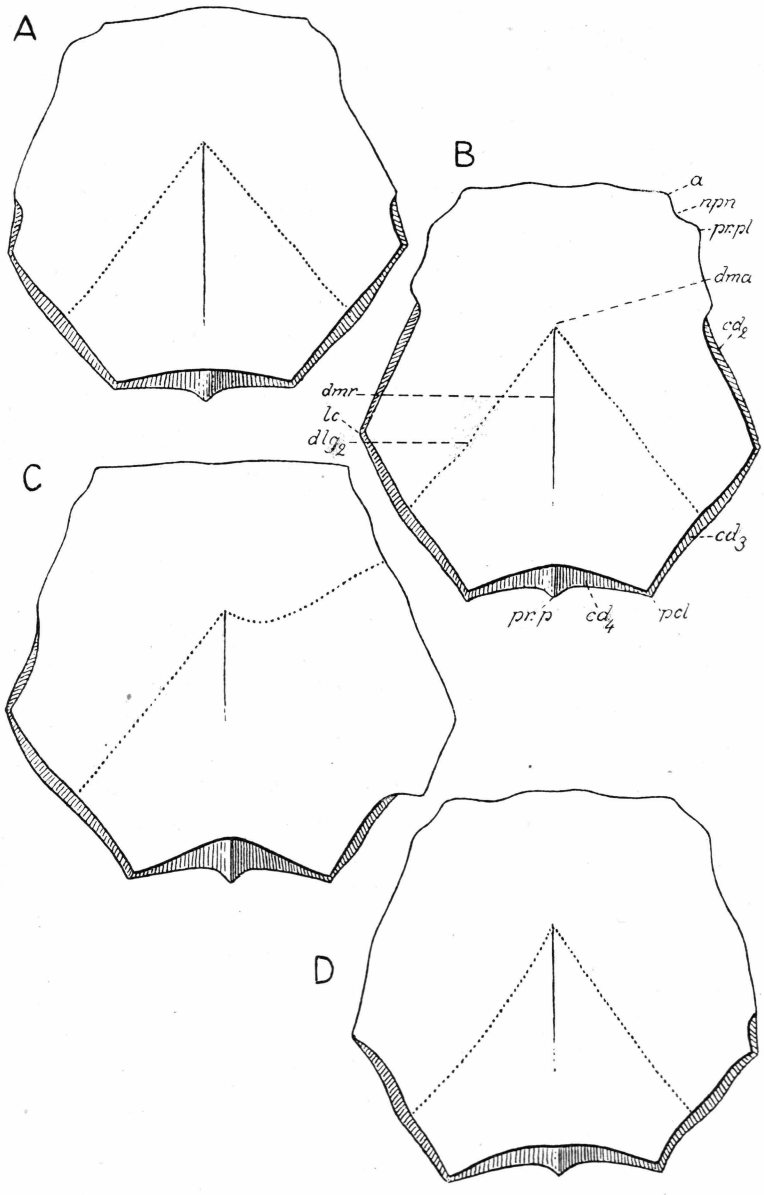
Finally, it deserves to be mentioned here that the supranuchal area (*sna*) is absent as a rule in small and smaller medium-sized individuals (text-fig.



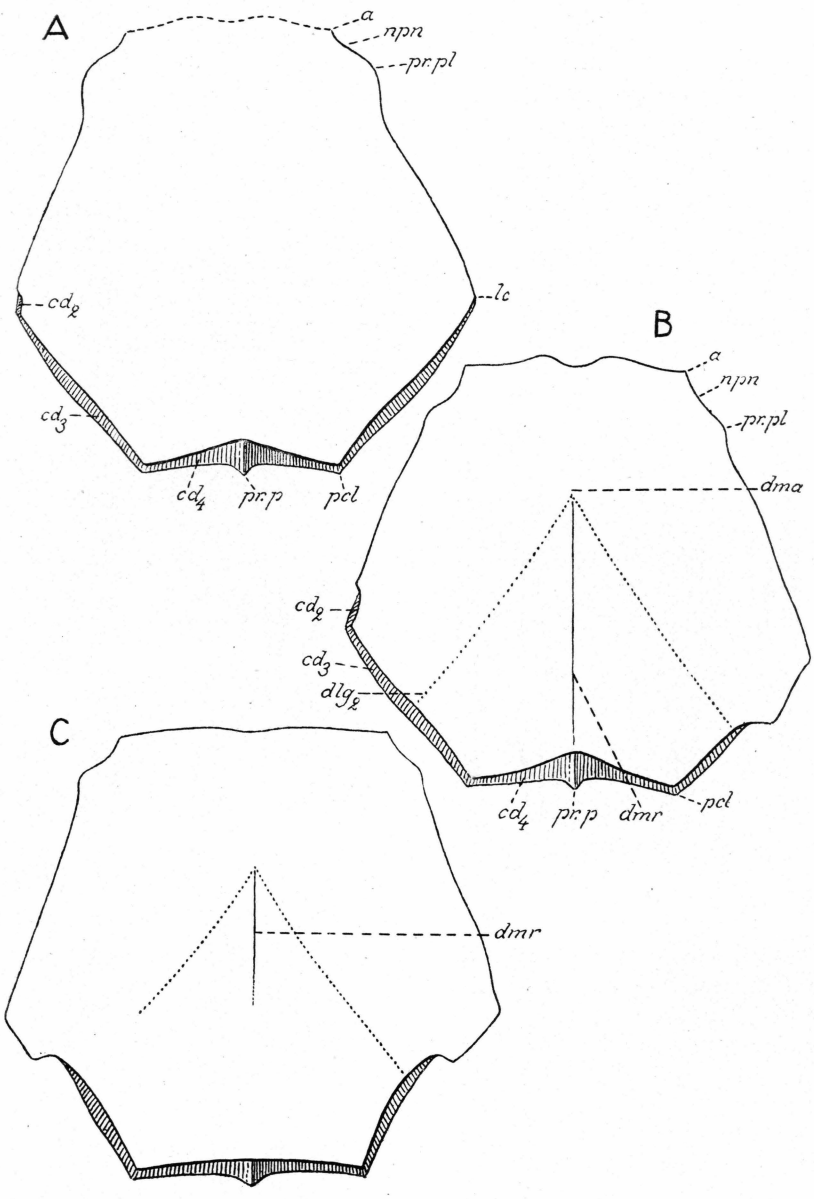
Text-fig. 121. *Bothriolepis canadensis. A–M,* restorations of thirteen anterior median dorsal plates of small and smaller medium-sized individuals. Dorsal aspect. Nat. size. *a,* antero-lateral corner; cd_2, area overlapped by anterior dorso-lateral plate; cd_3, area overlapped by mixilateral plate; cd_4, area overlapped by posterior median dorsal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma,* tergal angle; *dmr,* dorsal median ridge; *lc,* lateral corner; *npn,* post-nuchal notch; *pcl,* postero-lateral corner; *pr. p,* posterior median process; *pr. pl,* external postlevator process.



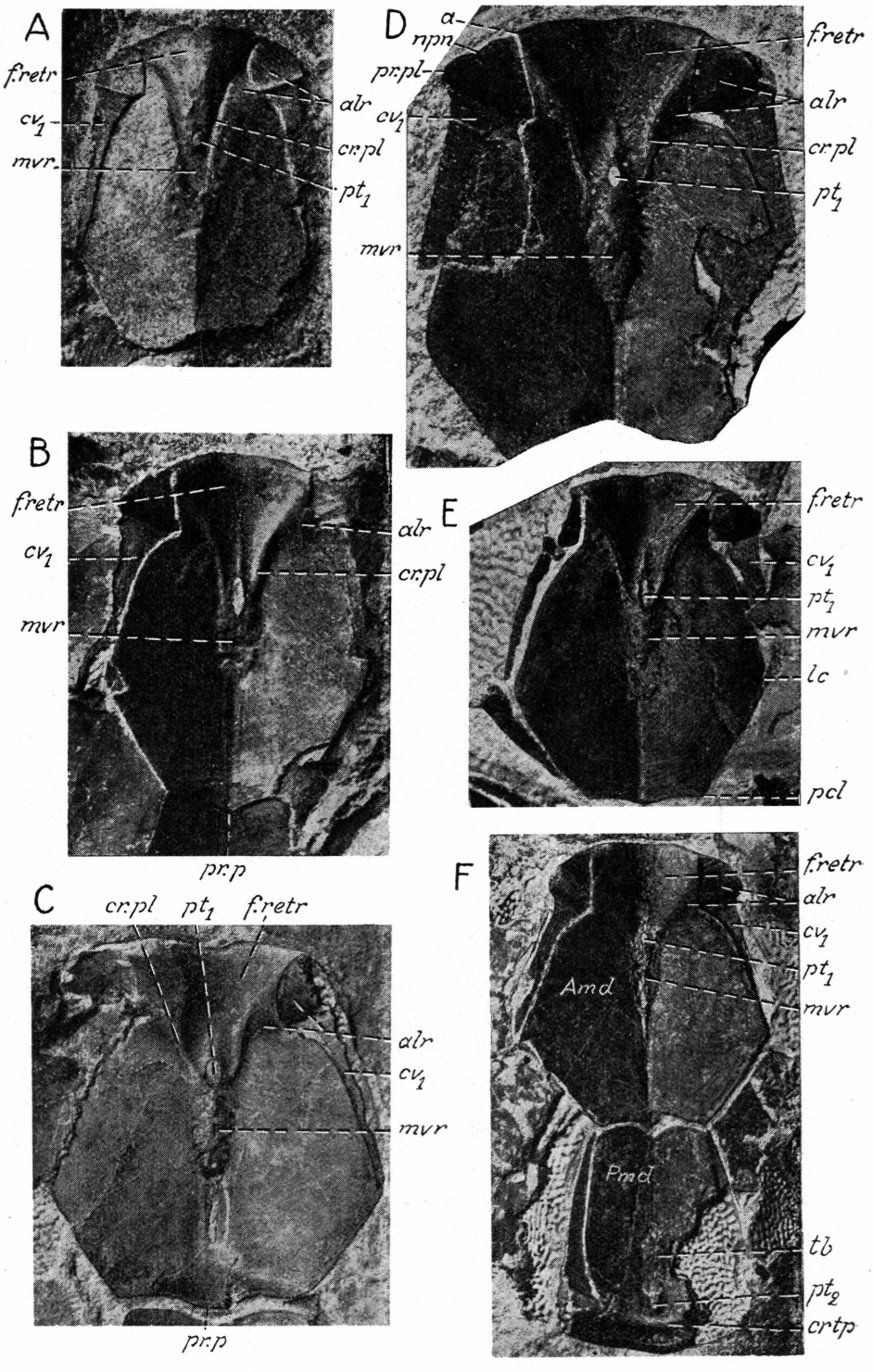
Text-fig. 122. *Bothriolepis canadensis*. *A–F*, restorations of six anterior median dorsal plates of medium-sized and large individuals. Dorsal aspect. Nat. size.
For explanation of index letters see text-fig. 121.



Text-fig. 123. *Bothriolepis canadensis*. *A–D*, restorations of four anterior median dorsal plates of large individuals. Dorsal aspect. × $^{5}/_{6}$.
For explanation of index letters see text-fig. 121.



Text-fig. 124. *Bothriolepis canadensis*. *A–C*, three anterior median dorsal plates of very large individuals. Dorsal aspect. × $^{5}/_{6}$.
For explanation of index letters see text-fig. 121.


A
f.retr
cv1
mvr
alr
cr.pl
pt1
D
a-
npn
pr.pl
cv1
mvr
f.retr
alr
cr.pl
pt1
B
f.retr
cv1
mvr
alr
cr.pl
pr.p
E
f.retr
cv1
pt1
mvr
lc
pcl
C
cr.pl
pt1
f.retr
alr
cv1
mvr
pr.p
F
f.retr
alr
cv1
pt1
mvr
Amd
Pmd
tb
pt2
crtp

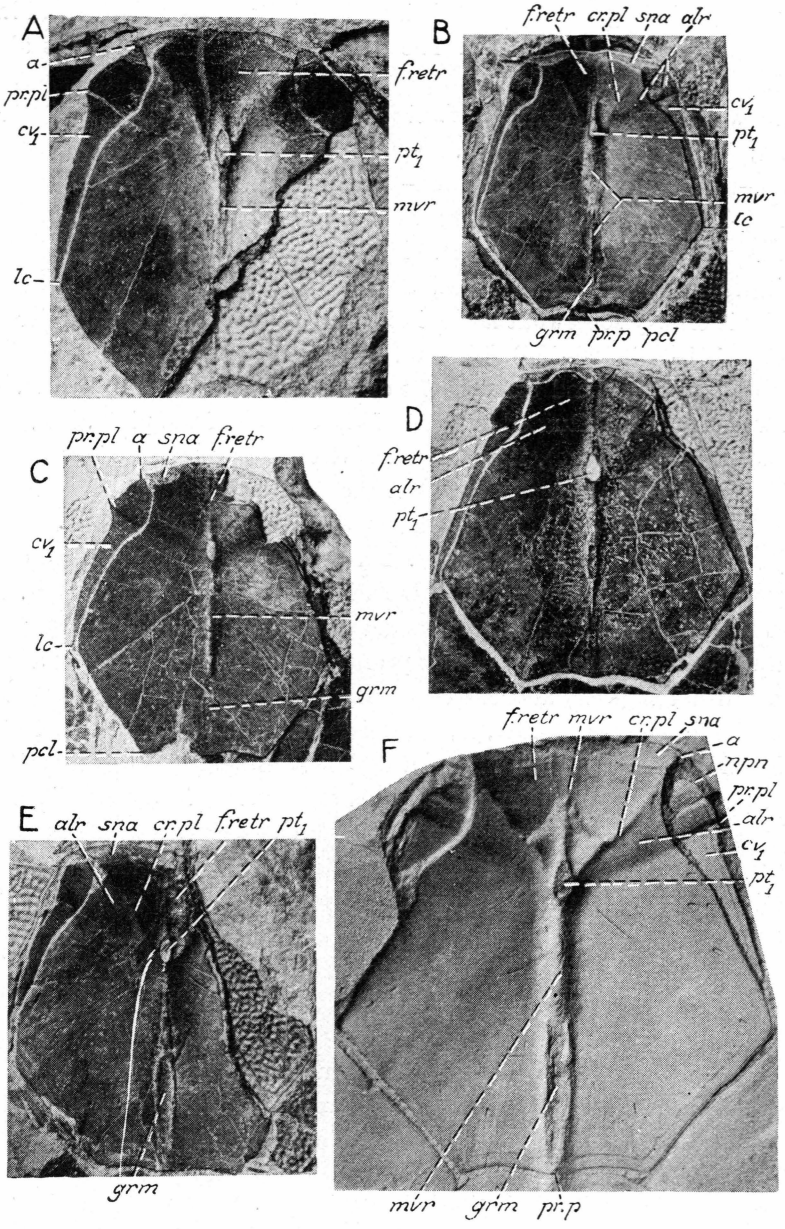
125), whereas it is generally well defined in larger medium-sized and large individuals (text-figs. 44A, 126). The presence of this area is thus also a sign of maturity.

The anterior median dorsal plate (*Amd*, text-figs. 38, 39A, B, 40, 43A, B, 44A, 88A, B, 90–92, 95–98, 101, 102, 106, 109, 114–128, 130–134, 140–143, 146–149, 151, 152, 154–159, 179–183, 199, 200, 202, 204–206, 207, 210) is fairly variable in several of its characters. The breadth : length ratio has a total range of variation of 76–112. It is mostly 80–100 in small and medium-sized individuals and 90–105 in large individuals, and thus normally is clearly somewhat larger in large individuals than in smaller ones (text-figs. 121–126, 179–183). We find, therefore, that during its growth the plate as a rule increased somewhat more in breadth than in length. The tergal angle (*dma*) is situated in front of the middle of the plate, but, as we have seen (p. 269 above), it varies somewhat in its position. The anterior margin of the plate is usually of about the same breadth as the underlying part of the centro-nuchal plate, but in certain cases it is a little broader than that part of the centro-nuchal plate. This margin normally is more or less clearly convex, but may also sometimes be nearly straight (text-figs. 121–125). In many cases it exhibits a median more or less well-marked notch. The antero-lateral corner (*a*) is well pronounced and so are mostly also the postnuchal notch (*npn*) and the external postlevator process (*pr.pl*) of the lateral margin (text-figs. 43A, B, 44A, 118–126). The posterior part of the anterior division of the lateral margin that follows behind the external postlevator process, between it and the lateral corner (*lc*) of the plate, is always clearly concave anteriorly, whereas further backwards it may be somewhat convex, nearly straight, or slightly undulating. The posterior margin may be straight or little concave. The posterior median process (*pr.p*) is broader and longer relatively in small than in medium-sized and large specimens (text-figs. 118–126). The overlapped areas (cd_2, cd_3, cd_4) are all comparatively narrow. The overlapping areas (cv_1, cv_2), on the other hand, are fairly broad (text-figs. 44A, 125, 126).

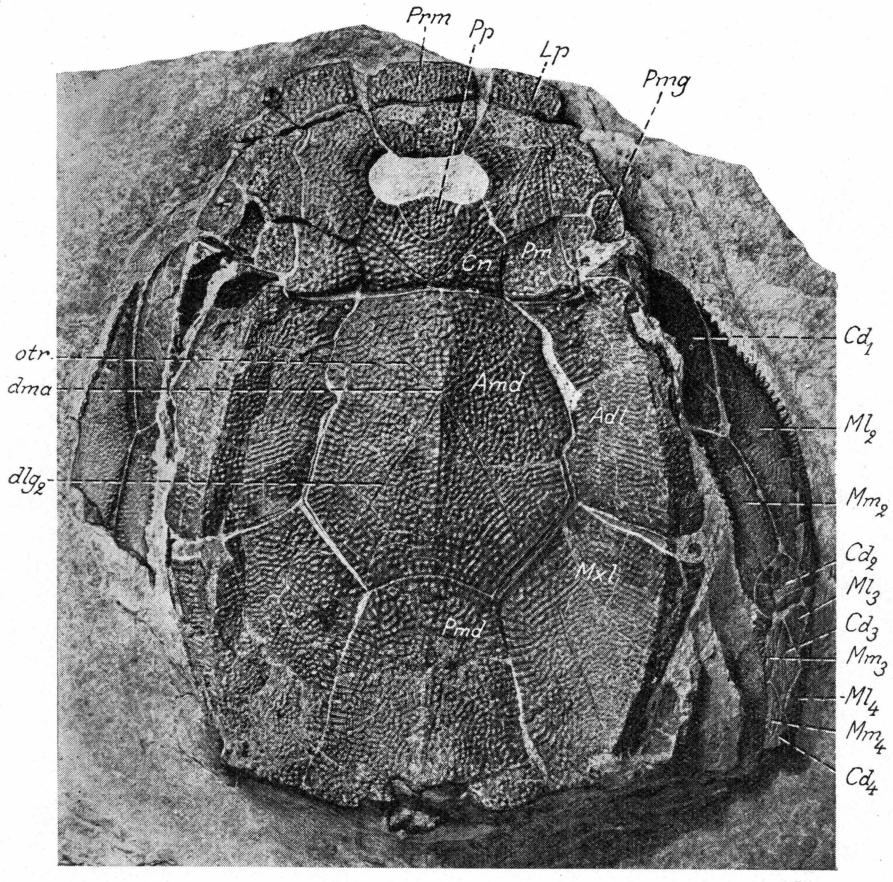
The sutural connection of the anterior median dorsal plate with the anterior dorso-lateral and mixilateral plates were thoroughly examined in 130 specimens of all orders of size. It was of the normal type, characteristic of

Text-fig. 125. *Bothriolepis canadensis*. *A*, impression of the lower side of a very small anterior median dorsal plate. *B–E*, five anterior median dorsal plates of small and small medium-sized individuals in ventral aspect. In *F*, also the posterior median ventral plate shown from the ventral side. R. M. specimens Nos. P. 2825, 2201, 3224, 2315a, 2315b, 2730. *A*, × $^7/_2$; *B–D*, × 3; *E*, × 2; *F*, × $^5/_4$.

Amd, anterior median dorsal plate; *Pmd*, posterior median dorsal plate; *a*, antero-lateral corner; *alr*, postlevator thickening; *cr. pl*, postlevator crista; *crtp*, crista transversalis interna posterior; cv_1, area overlapping anterior dorso-lateral plate; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *pcl*, postero-lateral corner; *pr. p*, posterior median process; *pr. pl*, external postlevator process; pt_1, pt_2, anterior and posterior ventral pits respectively; *sna*, supranuchal area; *tb*, ventral tuberosity (of posterior median dorsal plate).

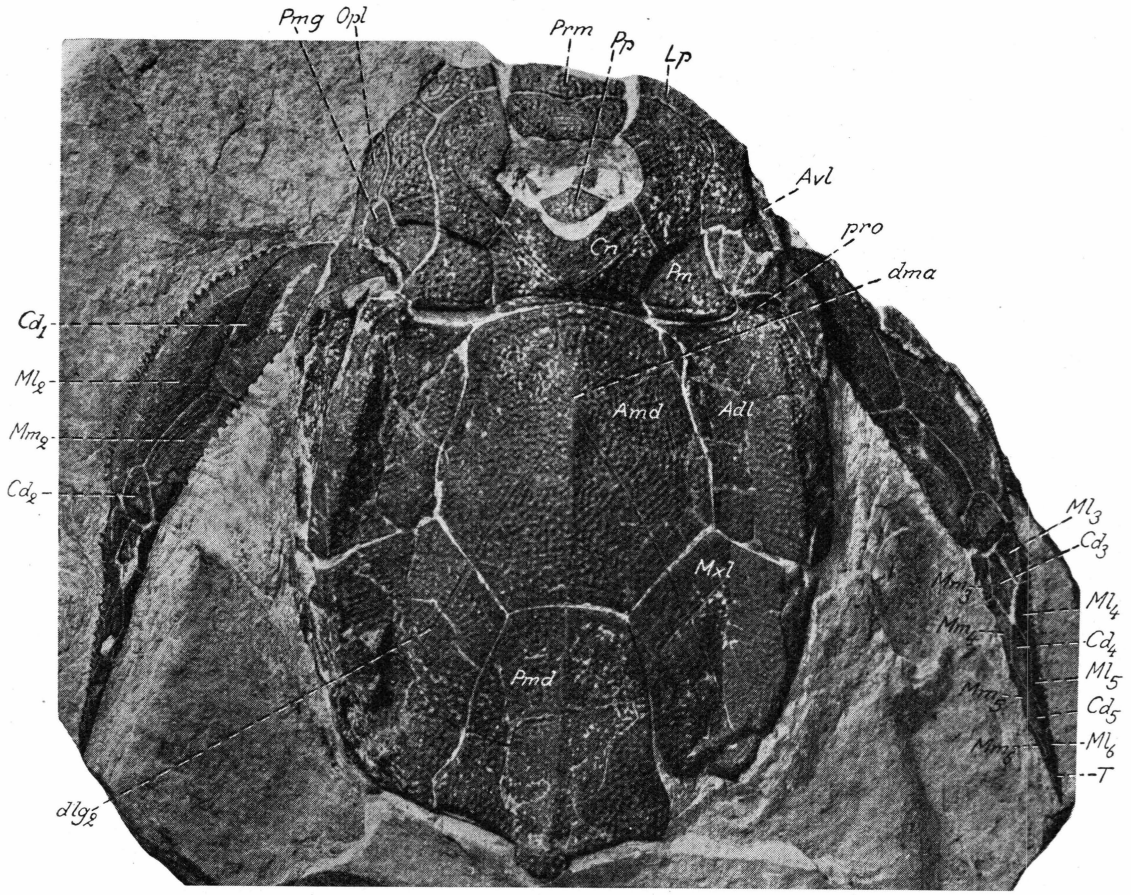


Text-fig. 126. *Bothriolepis canadensis*. *A–F*, six anterior median dorsal plates of medium-sized and large individuals. Ventral aspect. R. M. specimens nos. P. 2315, 2245, 2484, 2278, 2800, 2349. Diminished.
For explanation of index letters see text-fig. 125.



Text-fig. 127. *Bothriolepis canadensis*. Medium-sized fairly complete specimen, much crushed and flattened. Dorsal aspect. R. M. specimen No. P. 2488. Slightly diminished. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2-Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, medial marginal plates 2–4; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *otr*, oblique transverse ridge.

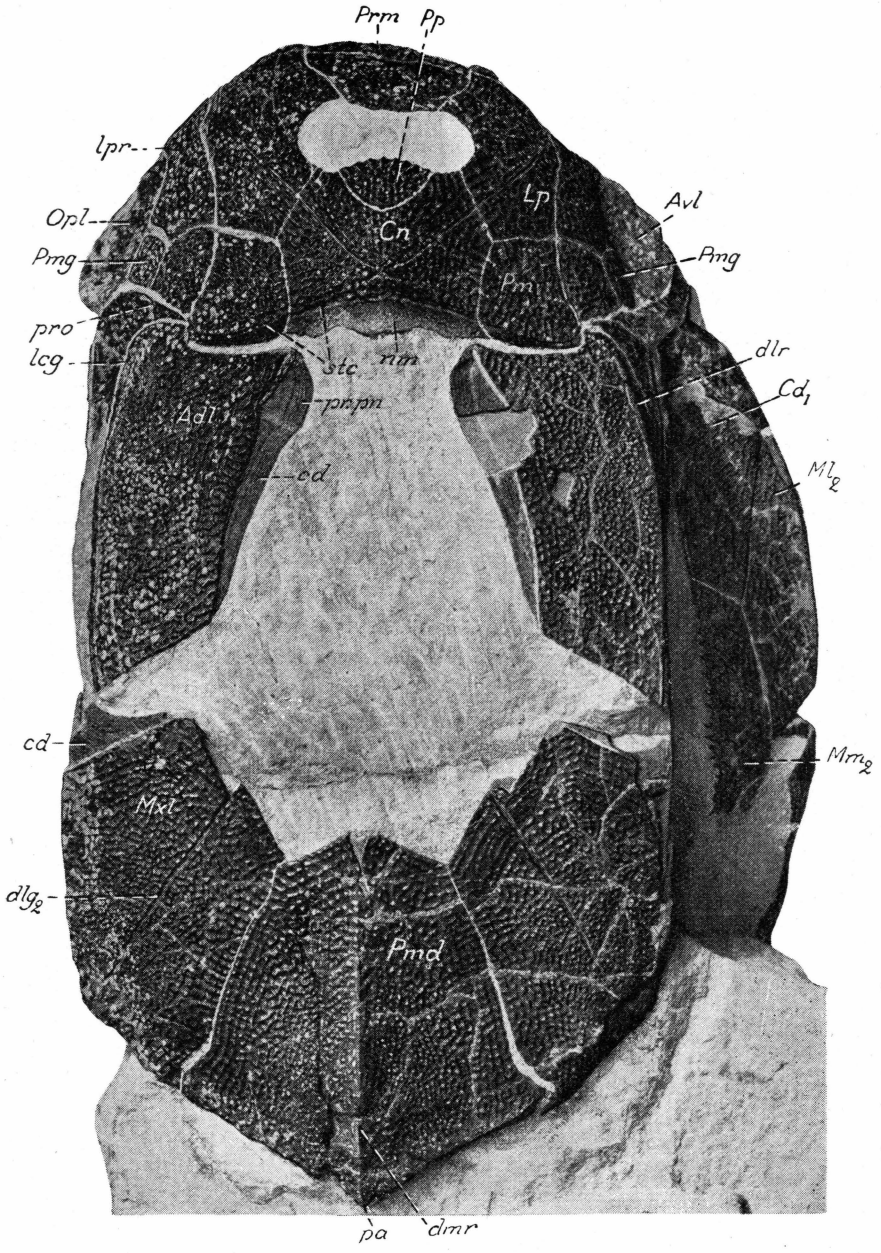
the genus, in 83 specimens, and thus in about 64% of the material, whereas it was of abnormal types in 48 specimens, that is to say in about 36% of the material. Abnormal types of this sutural connection thus are much more frequent than what could be expected. As to the development of the sutural connection in question in various stages of growth the following could be established. In very small individuals in which the dorsal wall of the trunk-armour is 1,85–4,5 cm long the connection seems practically always to be of the normal type characteristic of the genus. At any event no distinct abnormalities in this respect were to be detected among individuals



Text-fig. 128. *Bothriolepis canadensis*. Medium-sized specimen, flattened and somewhat crushed, but almost complete. Dorsal aspect. R. M. specimen No. P. 2607. Approximately. $\times$ $^7/_5$.

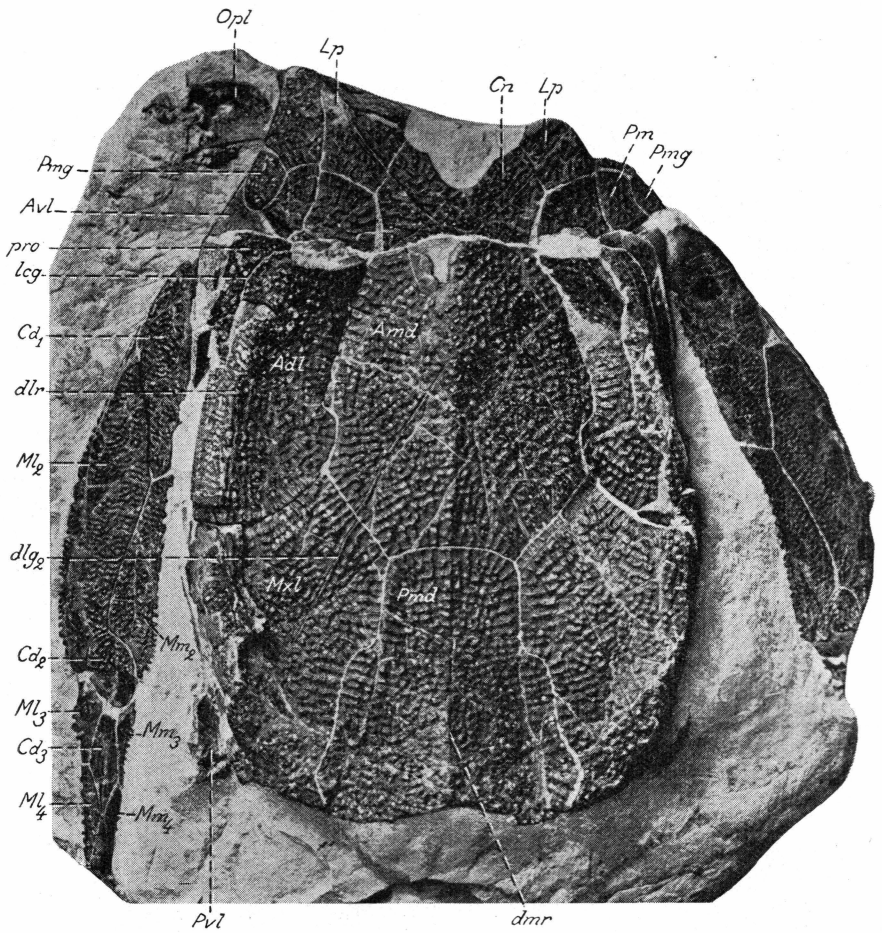
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1–Cd_5, dorsal ventral plates 1–5; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_6, lateral marginal plates 2–6, Mm_2–Mm_6, medial marginal plates 2–6; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *T*, terminal plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *pro*, processus obstans.

of this category of size. In medium-sized and large individuals, thus in individuals in which the dorsal wall of the trunk-armour is 4,5–13 cm long, the normal type of the sutural connection in question always predominates, but abnormal types are also often met with and seem to have become more frequent with the increase in size of the individuals. Everything seems thus to show: 1) that the sutural connection under discussion was generally normal in small individuals; 2) that abnormal types of this sutural connection generally arose first in small medium-sized individuals; and 3) that



Text-fig. 129. *Bothriolepis canadensis*. Slightly flattened, medium-sized specimen in dorsal aspect. Anterior median dorsal plate and left pectoral fin missing. R. M. specimen No. 2773. Approximately $\times$ $^3/_2$.

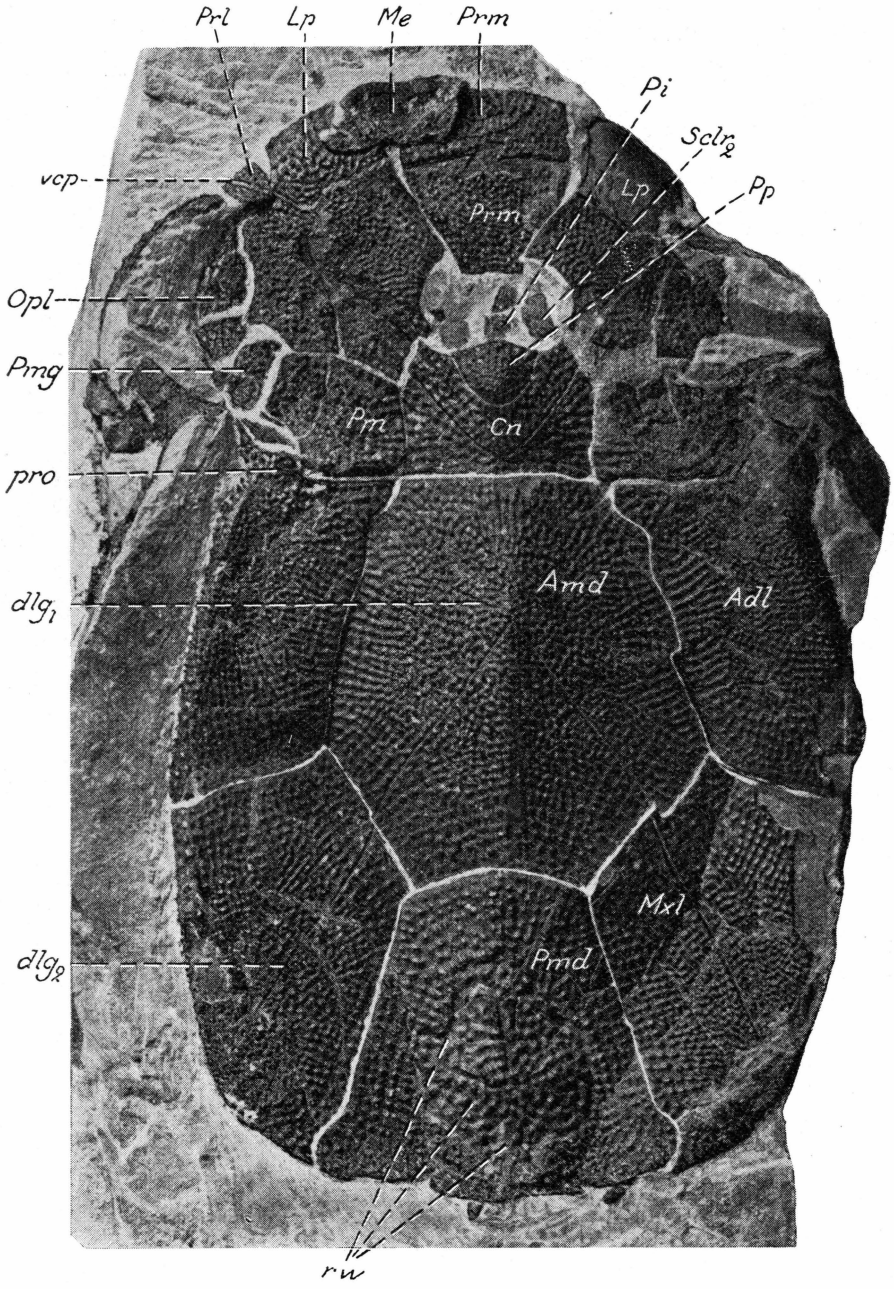
Adl, anterior dorso-lateral plate; *Avl*, foremost (subcephalic) part of right anterior ventro-lateral plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *cd*, overlapped areas; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dmr*, median dorsal ridge; *lcg*, main lateral line-groove; *lpr*, supraspiracular process; *nm*, obtected nuchal area; *pa*, posterior corner of posterior median dorsal plate; *pro*, processus obstans; *pr. pn*, internal postlevator process; *stc*, supratemporal cross-commissural pit-line groove.



Text-fig. 130. *Bothriolepis canadensis.* Medium-sized specimen in dorsal aspect. Considerable anterior parts of the head-shield and a short posterior median part of the dorsal wall of the trunk-armour missing. R M. specimen No. P. 2696. Slightly diminished.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, foremost (subcephalic) part of left anterior ventro-lateral plate; Cd_1–Cd_3, dorsal central plates 1–3; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, medial marginal plates 2–4; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pvl*, posterior ventro-lateral plate; dlg_2, posterior oblique abdominal pitline groove; *dlr*, dorso-lateral ridge; *dmr*, dorsal median ridge; *lcg*, main lateral linegroove; *pro*, processus obstans.

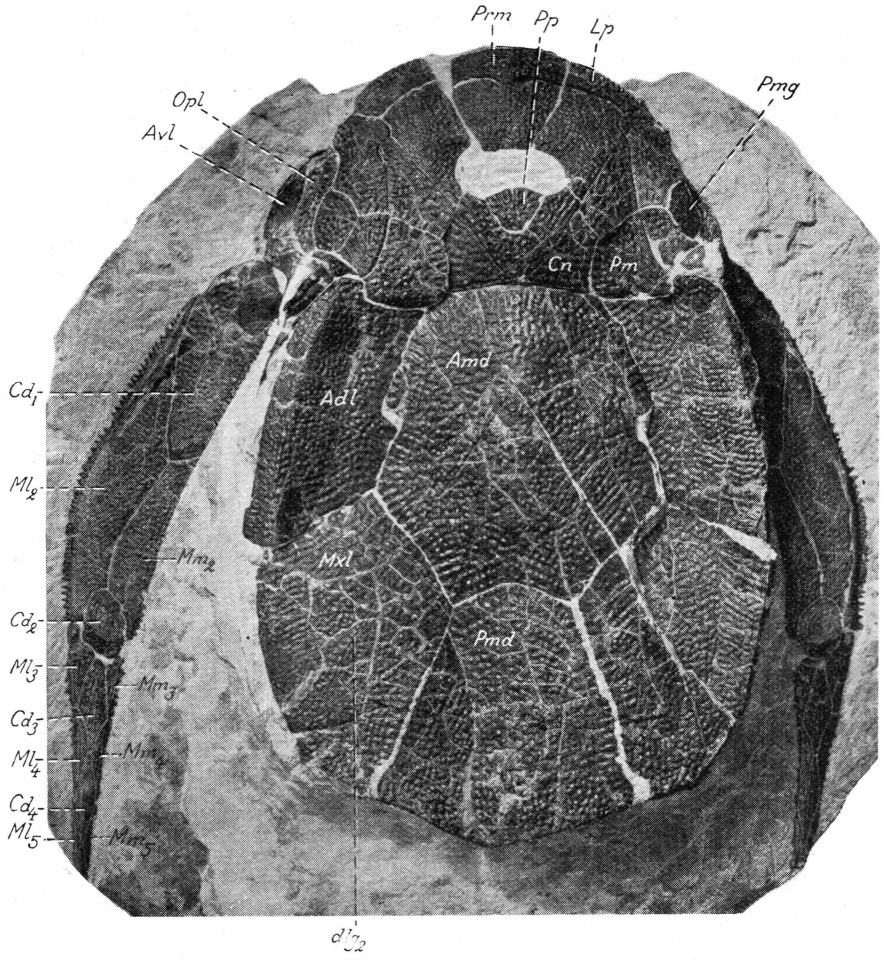
abnormal types of the sutural connection occurred most frequently in large individuals.

The following anomalous types of the sutural connection of the anterior median dorsal plate (*Amd*) with the anterior dorso-lateral (*Adl*) and mixilateral (*Mxl*) plates have been observed hitherto. 1) The *Amd*-plate overlaps an anterior part of the *Adl*-plate, but is overlapped by the latter plate on one or on both sides nearest in front of its lateral corner (*lc*). Its connec-



Text-fig. 131. *Bothriolepis canadensis*. Somewhat large, flattened specimen in dorsal aspect. R. M. specimen No. P. 2260. Nat. Size.

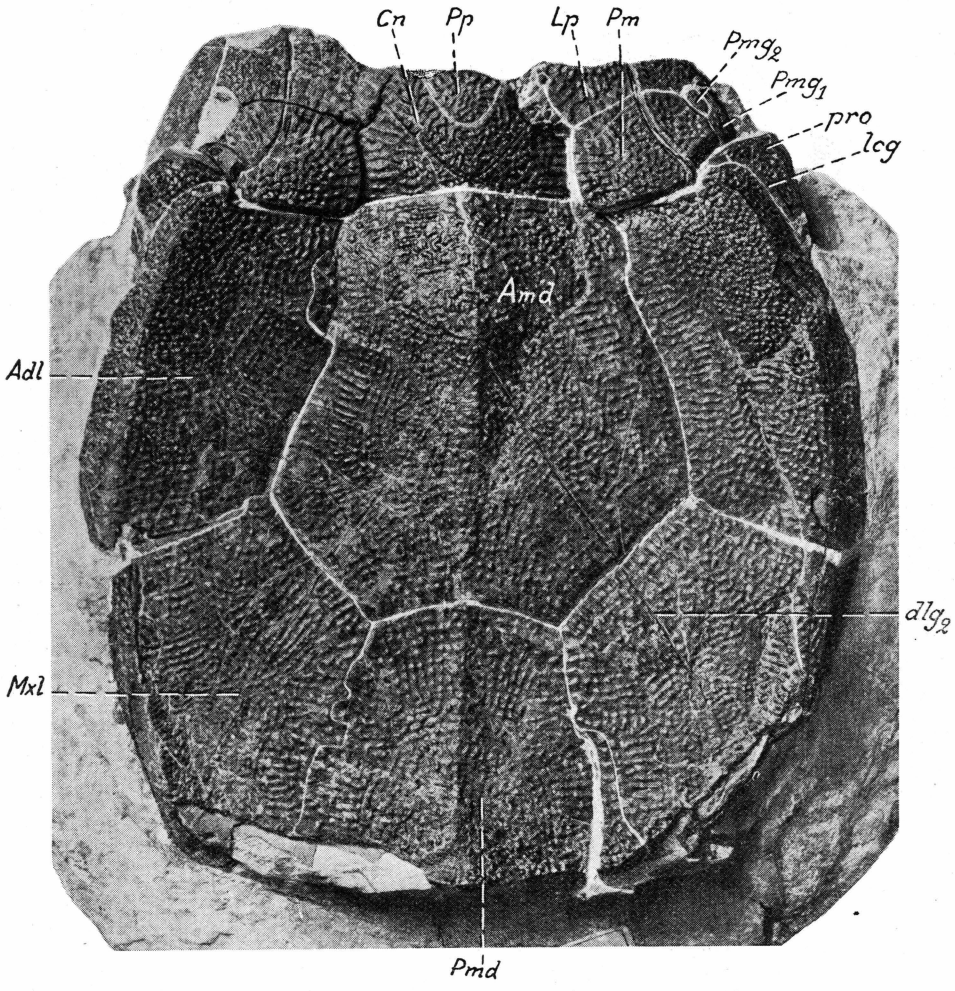
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Sclr*$_2$, postero-dorsal sclerotic plate; *dlg*$_1$, anterior oblique abdominal pit-line *Pi*, pineal plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prl*, prelateral plate; *Prm*, premedian plate; *Sclr*$_2$, postero-dorsal sclerotic plate; *dlg*$_1$, anterior oblique abdominal pit-line groove; *dlg*$_2$, posterior oblique abdominal pit-line groove; *pro*, processus obstans; *rw*, area representing a healed wound in the posterior median dorsal plate (the bone regenerated at this place); *vcp*, vertical pit-line groove of cheek.



Text-fig. 132. *Bothriolepis canadensis*. Fairly large flattened specimen in dorsal aspect. R. M. specimen No. P. 2784. × 4/5.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove.

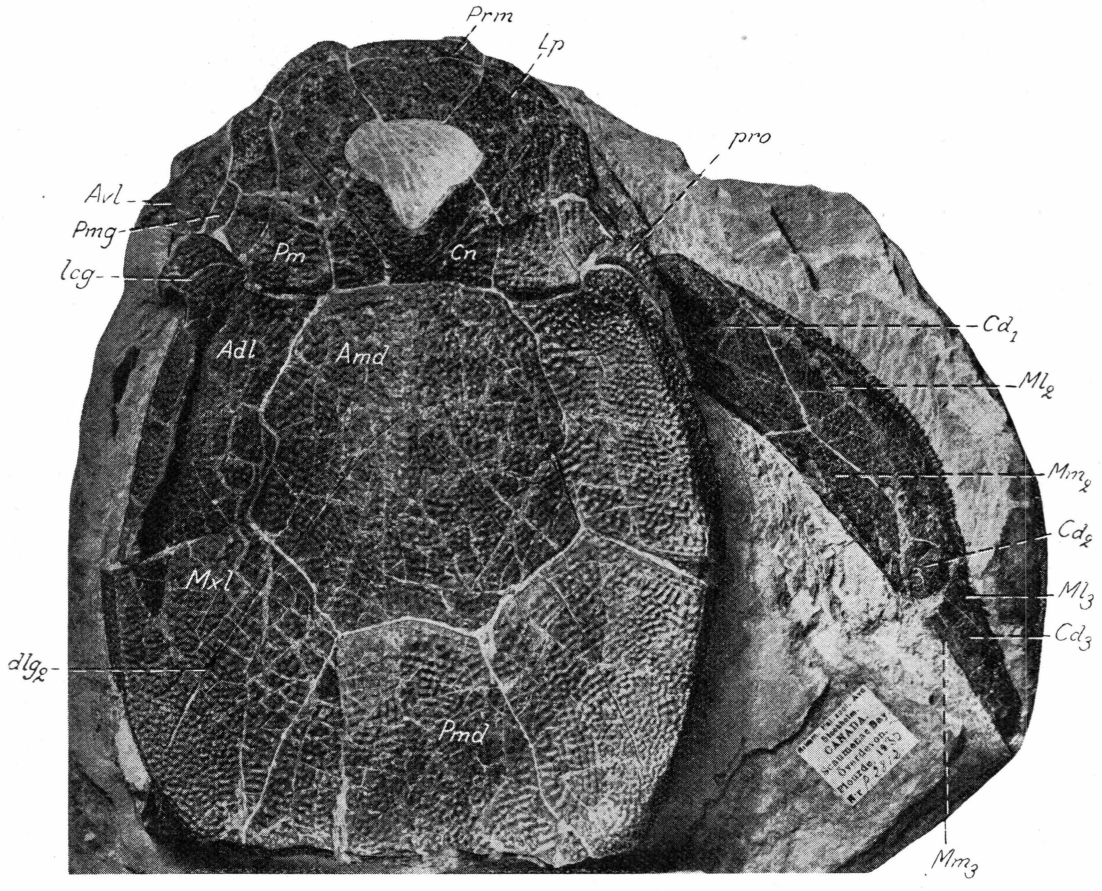
tion with the *Mxl*-plate is as normally in the genus (text-figs. 43B, 118C, 119E, F, 120A, 121F, J, 122A, B, E, 123A, B, D, 124A, 127, 130, 132–134, 147, 155, 157, 180B, 181A, C, D, 183A–C). This abnormal type is the most common one, occuring in about 22% of the specimens examined. 2) The *Amd*-plate overlaps the *Adl*-plate in the normal way, but in addition behind its lateral corner, on one or on both sides, it overlaps also an anterior part of the *Mxl*-plate. Most posteriorly, however, it is always overlapped by the *Mxl*-plate (text-figs. 101, 109, 115, 118D, 119B, E, 121D, M, 122D,



Text-fig. 133. *Bothriolepis canadensis*. Fairly large flattened specimen in dorsal aspect. A large anterior part of the head-shield and a posterior part of the dorsal wall of the trunk-armour missing. R. M. specimen No. P. 2287. Same specimen as in text-figs. 55, 56, 59, 60 and 175. Nat. size.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; Pmg_1, anterior postmarginal plate; Pmg_2, posterior postmarginal plate; *Pp*, postpineal plate; dlg_2, posterior oblique abdominal pit-line groove; *lcg*, main lateral line groove; *pro*, processus obstans.

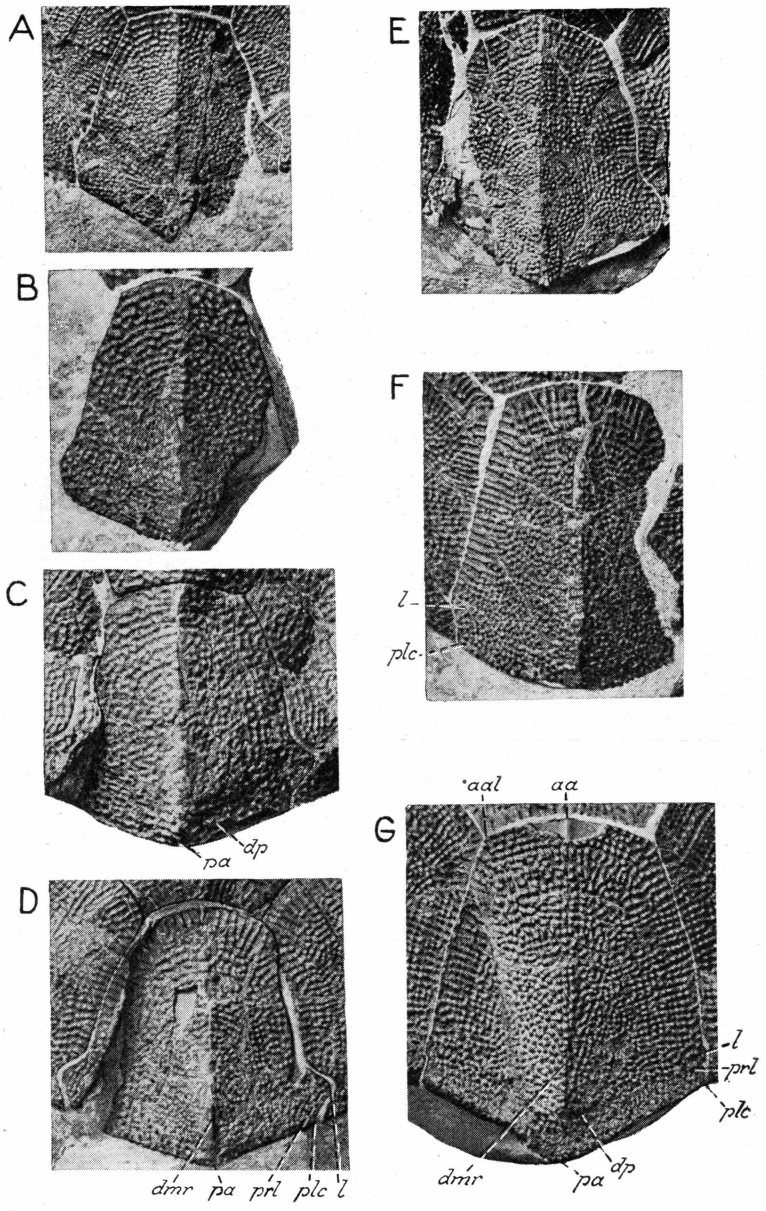
124C, 151B, 159, 179F, 180C, 183D). This type is found in at least 10% of the specimens examined. 3) The anomalous types 1 and 2 occur combined (text-figs. 44A, 122F, 123C, 124B, 126F, 131, 156, 182, 185). Only in one case (text-fig. 131) both these anomalies are found on the same side. In all other cases they are combined in such a way that the anomaly of type 1 is found on one side and the anomaly of type 2 on the opposite side.



Text-fig. 134. *Bothriolepis canadensis*. Somewhat large, dorso-ventrally compressed specimen. R. M. specimen No. P. 2812. Approximately × $^{9}/_{10}$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1–Cd_3, dorsal central plates 1–3; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, Ml_3, lateral marginal plates 2 and 3 respectively; Mm_2, Mm_3, medial marginal plates 2 and 3 respectively; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *lcg*, main lateral line groove; *pro*, processus obstans.

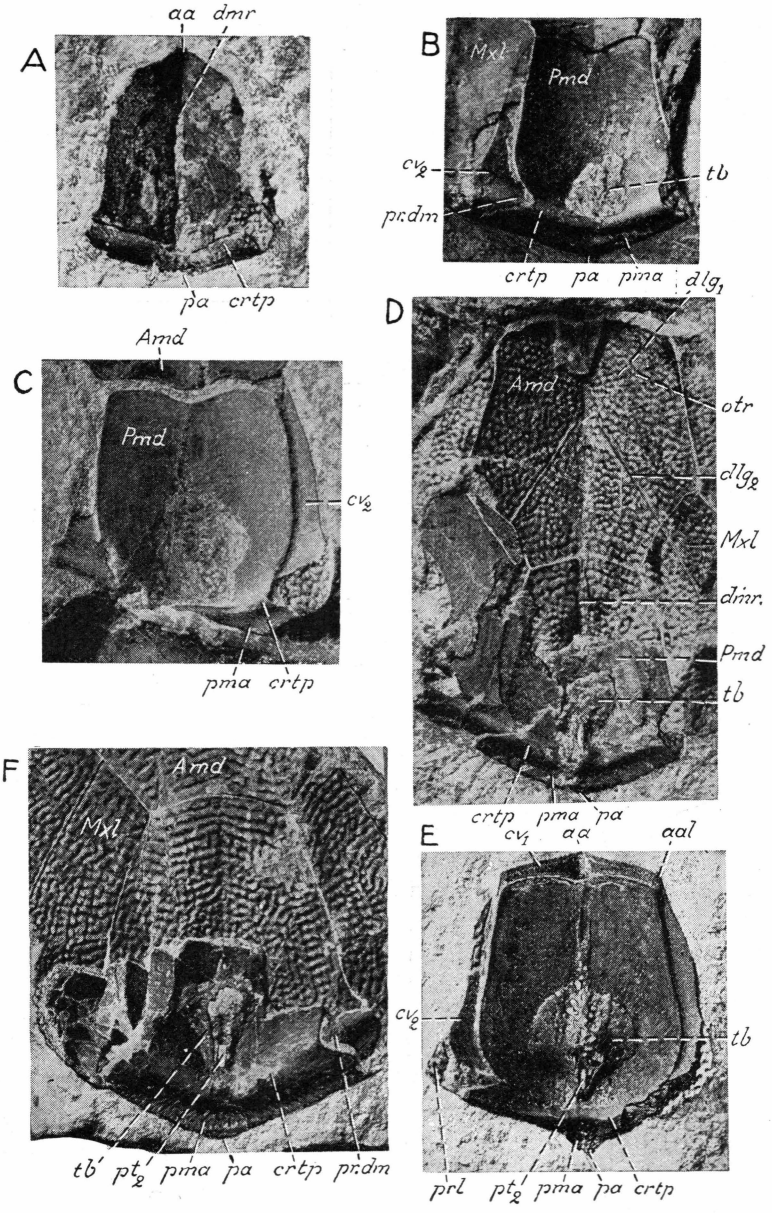
Type 3 as here defined is rather rare, being met with only in about 4% of the specimens examined.

Finally, it is worthy of notice in this connection that in several cases when it must be considered as normal, the sutural connection of the *Amd*-plate with the *Adl*-plate nevertheless may exhibit a certain trend of development towards the anomalous type 2 as above defined. This trend, which may be found even in small specimens, appears in such a way that the lateral corner of the *Amd*-plate is a little produced into a small postero-lateral process (text-figs. 88A, 95, 117, 118D, 121G, I, K).



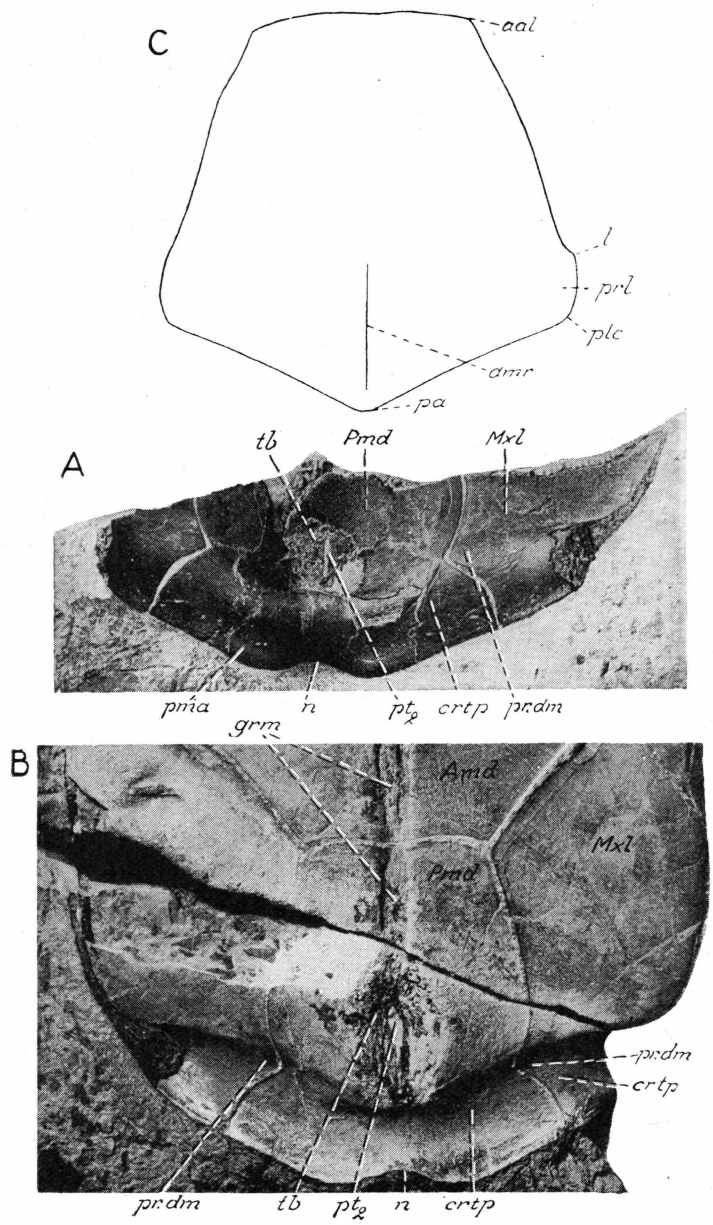
Text-fig. 135. *Bothriolepis canadensis*. Series of seven posterior median dorsal plates in dorsal aspect. *A*, R. M. specimen No. P. 2699. × 5/4. *B*, R. M. specimen No. P. 2396. × 5/4. *C*, R. M. specimen No. P. 2534. × 5/4. *D–G*, R. M. specimens Nos. P. 2572, 2474, 2638, and 2712 respectively. Diminished.

aa, anterior angle or corner; *aal*, antero-lateral corner; *dmr*, dorsal median ridge; *dp*, groove above crista transversalis interna posterior; *l*, lateral corner or angle; *pa*, posterior corner or angle; *plc*, postero-lateral corner; *prl*, lateral process.

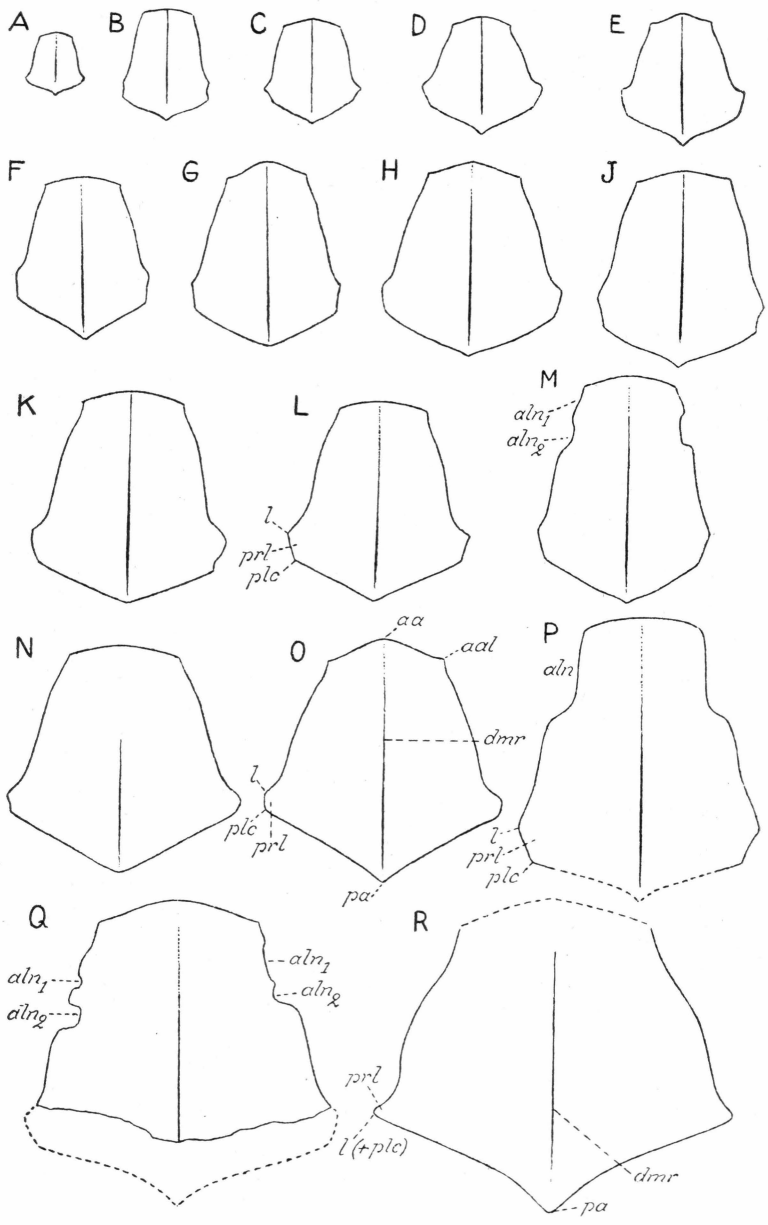


Text-fig. 136. *Bothriolepis canadensis*. *A–F*, six posterior median dorsal plates in ventral aspect. All the plates deficient and some of them partly represented by impressions of their upper side. *A–D*, of small specimens. R. M. specimens Nos. P. 2825, 2201, 3324, and 2772 respectively. *A*, about × 3. *B*, *C*, × 2.5. *D*, No. P. 2772, × 1.6. *E*, *F*, of medium-sized specimens. R. M. specimens Nos. P. 2808, 2834, respectively. × 1.3.

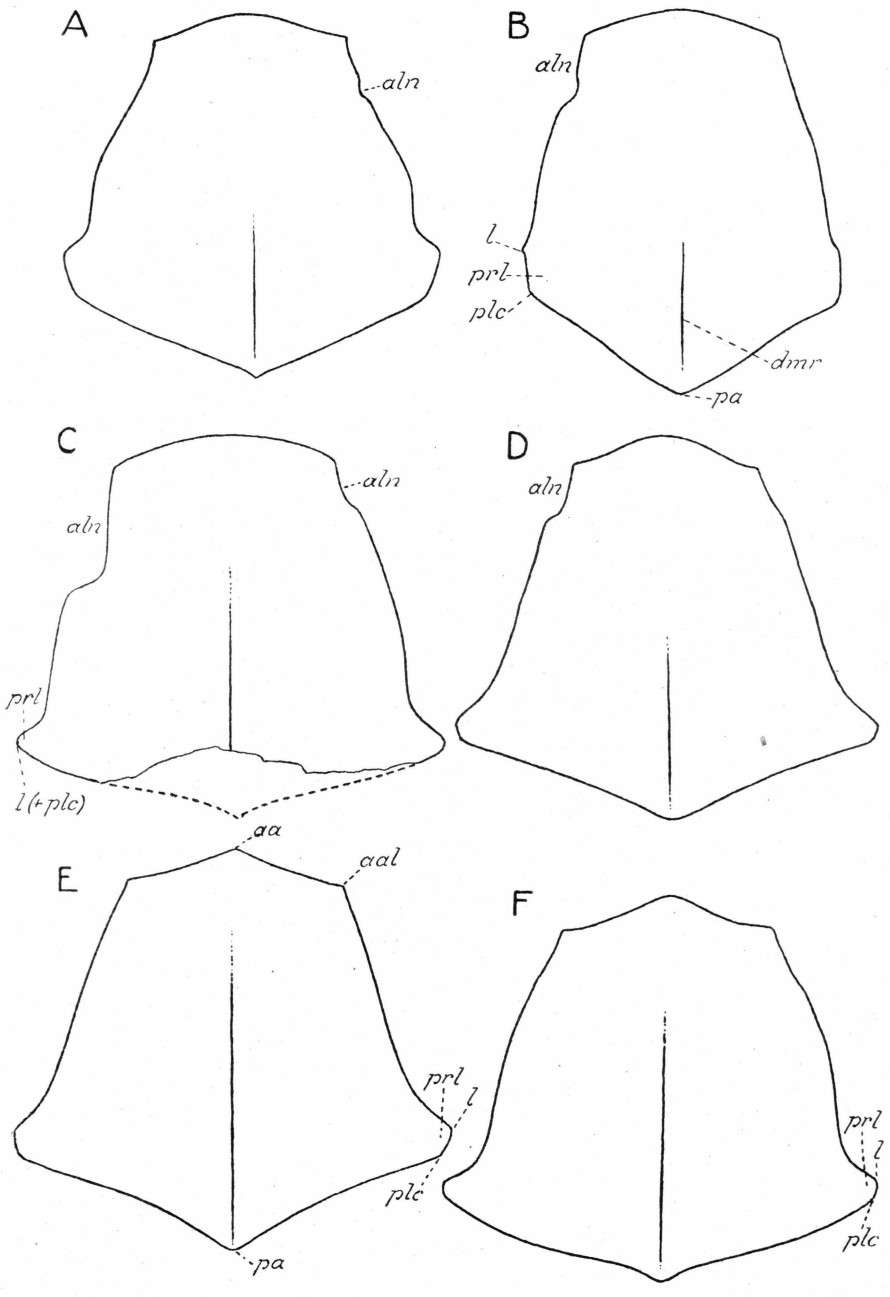
Amd, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *aa*, anterior angle or corner; *aal*, antero-lateral corner; *crtp*, crista transversalis interna posterior; dlg_1, anterior oblique abdominal pit-line groove (impression); dlg_2, posterior oblique abdominal pit-line groove (impression); cv_1, area overlapping anterior median dorsal plate; cv_2, area overlapping mixilateral plate; *dmr*, dorsal median ridge (impression); *otr*, oblique transverse ridge (impression); *pa*, posterior angle or process; *pma*, posterior marginal area; *pr. dm*, medial dorsal process (of mixilateral plate); *prl*, lateral process; pt_2, posterior ventral pit; *tb*, ventral tuberosity.



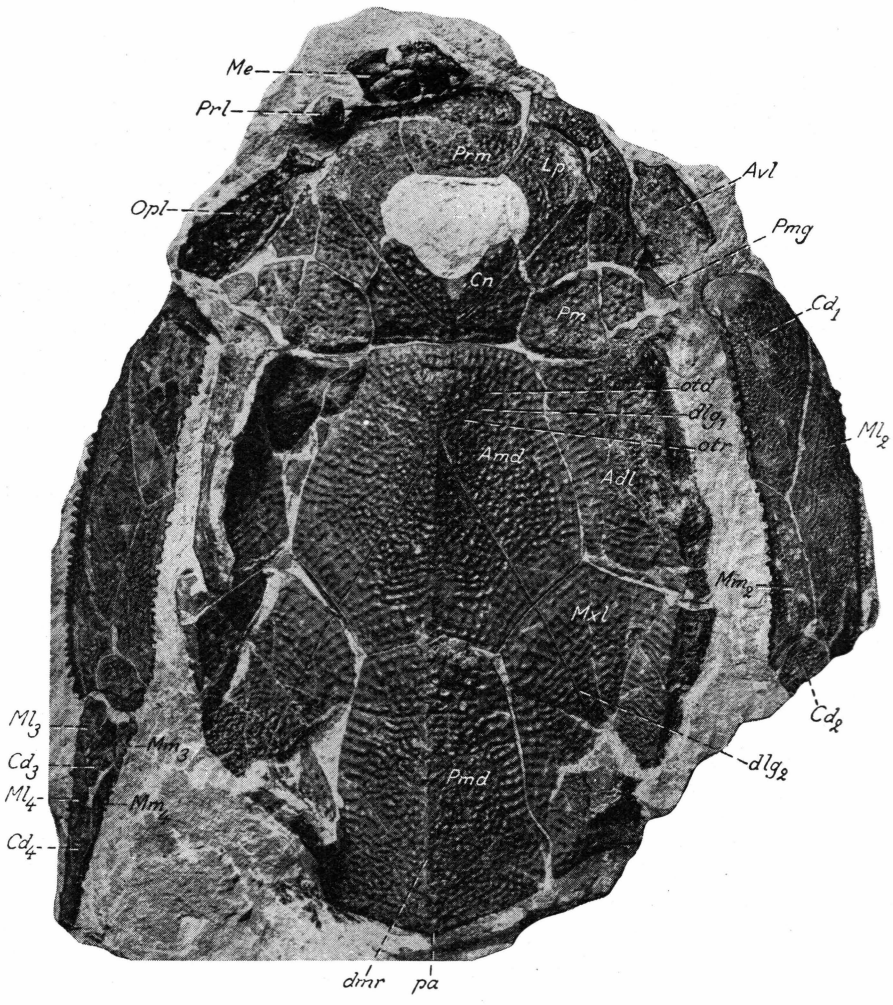
Text-fig. 137. *Bothriolepis canadensis*. *A*, the hindmost part of the dorsal wall of a trunk-armour in ventral aspect. R. M. specimen No. P. 2349. *B*, impression of the lower side of the posterior half of a trunk-armour. Same specimen as in *A*. *C*, restoration of a posterior median dorsal plate of a very large specimen. *A–C*, diminished.
Amd, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *aal*, antero-lateral corner; *crtp*, crista transversalis interna posterior (in *B* preserved as impression); *dmr*, dorsal median ridge; *grm*, ventral median groove (impression); *l*, lateral corner; *n*, median notch in posterior margin of *Pmd*-plate; *pa*, posterior median angle or corner; *plc*, postero-lateral corner; *pma*, posterior marginal area; *pr. dm*, medial dorsal process (of *Mxl*-plate); *prl*, lateral process; pt_2, posterior ventral pit; *tb*, ventral tuberosity (mainly impression).



Text-fig. 138. *Bothriolepis canadensis*. *A–R*, restorations of seventeen posterior median dorsal plates of small and medium-sized individuals. *A–E*, of small individuals (dorsal length of trunk-armour 1,85–3,8). *F–M*, of small medium-sized individuals (dorsal length of trunk-armour 4,9–7 cm). *N–R*, of medium-sized and somewhat large individuals (dorsal length of trunk-armour 7,5–10,3 cm). Diminished.
aa, anterior angle or corner; *aal*, antero-lateral corner; *aln*, mixilateral notch; aln_1, aln_2, mixilateral notches; *dmr*, dorsal median ridge; *l*, lateral corner or angle; *l* (+ *plc*), lateral corner coincident with postero-lateral corner; *pa*, posterior median corner or process; *plc*, postero-lateral corner; *prl*, lateral process.

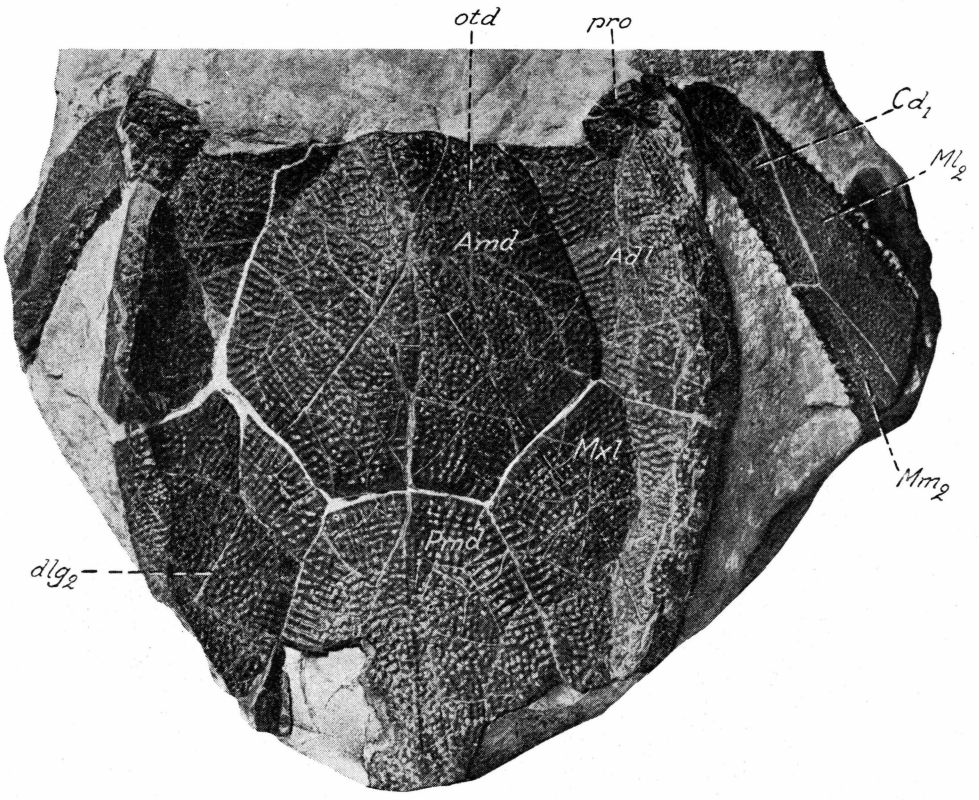


Text-fig. 139. *Bothriolepis canadensis*. *A–F*, restorations of six posterior median dorsal plates of large individuals. Dorsal aspect. Slightly diminished.
For explanation of index letters see text-fig. 138.



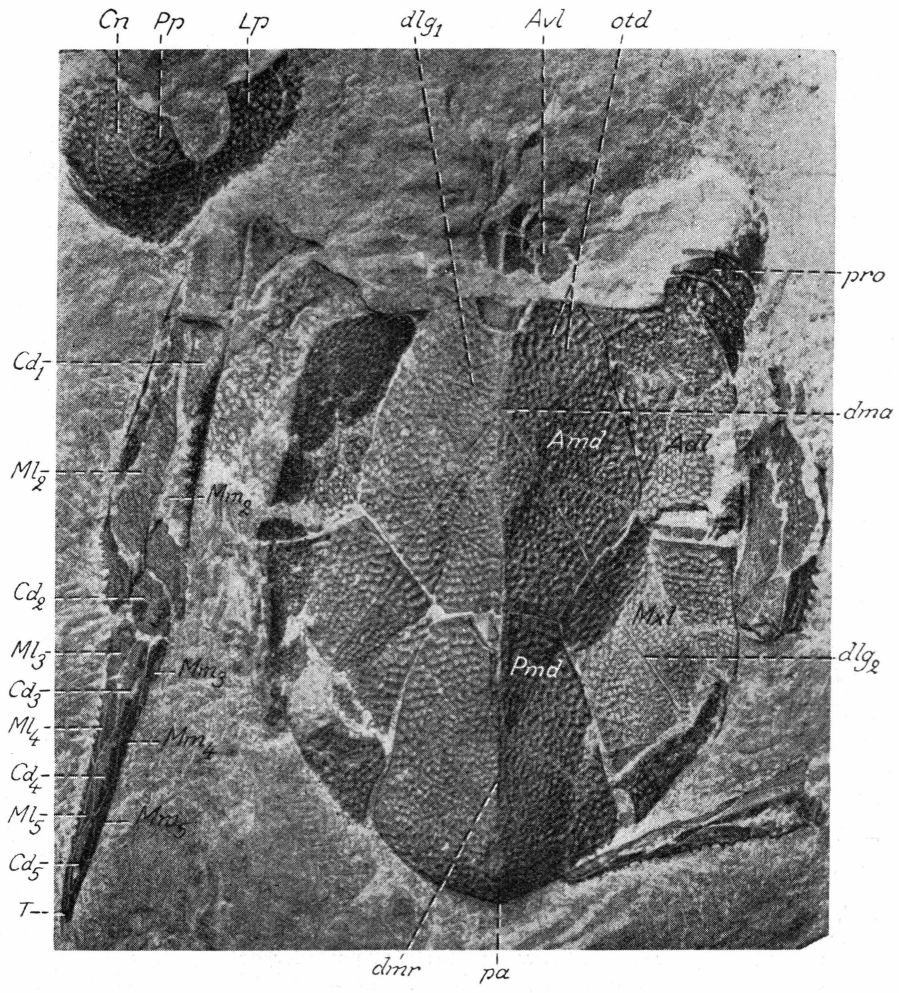
Text-fig. 140. *Bothriolepis canadensis*. Medium-sized specimen, flattened and crushed. Dorsal aspect. R. M. specimen No. 2493. Approximately × $^{11}/_{10}$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, medial marginal plates 2–4; *Me*, mental plate; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, para-nuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Prl*, prelateral plate; *Prm*, premedian plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dmr*, dorsal median ridge; *otd*, depression above postlevator thickening; *otr*, oblique transverse ridge; *pa*, posterior angle.

The posterior median dorsal plate (*Pmd*, text-figs. 39A, B, 40, 45A–C, 47A, 88A, B, 90–92, 95–98, 101, 102, 106, 109, 115–117, 125F, 127–143, 146–149, 150D, 151B, 152, 154–159, 179–183, 199–201, 204–206) does not narrow particularly much anteriorly in front of its lateral processes (*prl*) and is, therefore, comparatively broad anteriorly. As the anterior median



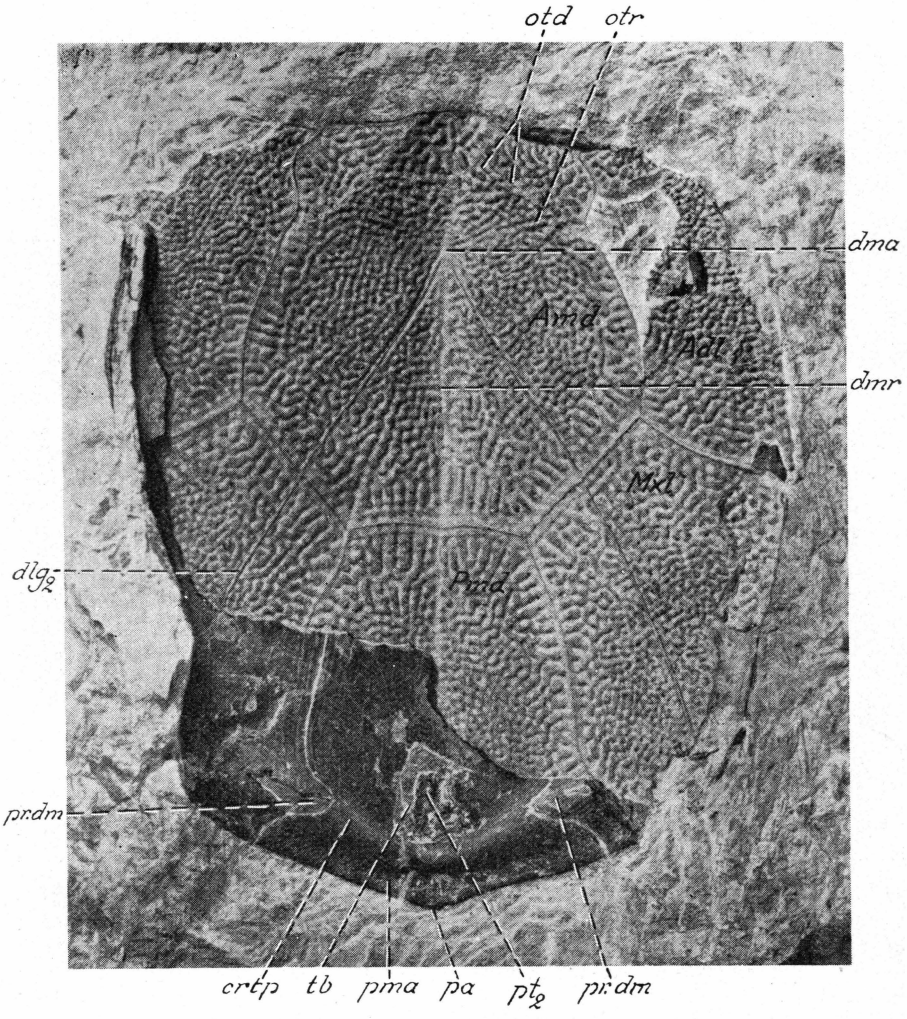
Text-fig. 141. *Bothriolepis canadensis*. Trunk-armour with proximal parts of the pectoral fins of a medium-sized specimen. The trunk-armour flattened and crushed. Dorsal aspect. R. M. specimen No. P. 2189. Nat. size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, dorsal central plate 1; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_2, posterior oblique abdominal pit-line groove; *otd*, oblique transverse depression above postlevator thickening (*alr*); *pro*, processus obstans.

dorsal plate, it generally increased proportionally more in breadth than in length during its growth, and hence in large individuals it is normally broader than in medium-sized and small individuals. Its breadth : length ratio ranges between 77–117. In small and medium-sized individuals that ratio is mostly 80–100, but it may exceptionally be as much as 117; in large individuals it generally exceeds 100. The anterior margin of the plate (text-figs. 45A–C, 47A, 127–143, etc.) is mostly a little produced into an obtuse median angle or corner (*aa*), but in many cases it is devoid of such a corner, being slightly convex or almost straight. The lateral process (*prl*) is generally well developed (text-figs. 135A–E, 136, 137C, 138, 139A, C–F), but may exceptionally be small or absent (text-figs. 135F, G, 139B). This process is mostly broad distally and of such a shape that it exhibits both a well-marked lateral



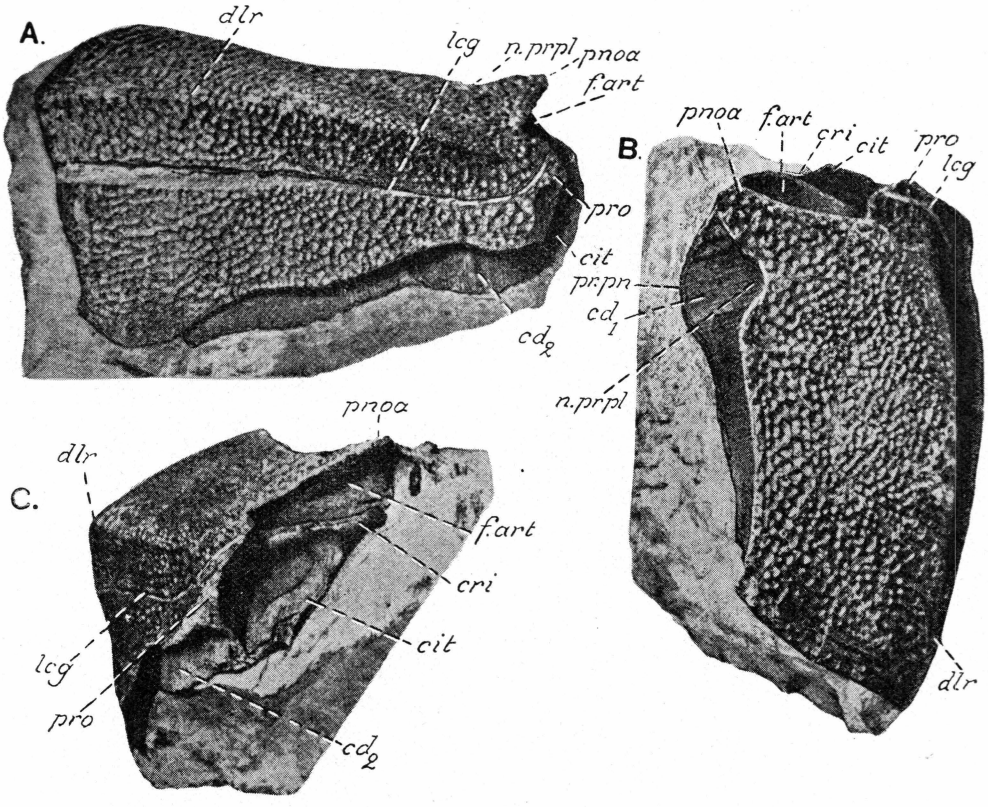
Text-fig. 142. *Bothriolepis canadensis*. Trunk-armour with pectoral fins of a medium-sized specimen. The trunk-armour and partly also the pectoral fins much flattened and crushed. Dorsal aspect. R. M. specimen No. P. 2104. × $^4/_3$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1–Cd_5, dorsal central plates 1–5; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *otd*, depression above postlevator thickening (*alr*); *pa*, posterior angle of posterior median dorsal plate; *pro*, processus obstans.

margin of a varying configuration and a more or less pronounced lateral corner (*l*, text-figs. 137C, 138B–P, 139A, B). In several cases, however, the lateral process is narrow and more or less strongly rounded off distally so that it is fairly pointed and without a distinct lateral margin (text-figs. 138A, R, 139C–F). In the latter cases the lateral (*l*) and postero-lateral (*plc*) corners



Text-fig. 143. *Bothriolepis canadensis*. Deficient dorsal wall of a trunk-armour of a medium-sized specimen. Ventrel aspect. The larger part of the wall preserved as an impression of its upper side. R. M. specimen No. P. 2753. × $^3/_2$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *crtp*, crista transversalis interna posterior; dlg_2, posterior oblique abdominal pit-line groove (impression); *dma*, tergal angle (impression); *dmr*, dorsal median ridge (impression); *otd*, depression above postlevator thickening (impression); *otr*, oblique transverse ridge (impression); *pa*, posterior median corner; *pma*, posterior marginal area; *pr. dm*, medial dorsal process (of *Mxl*-plate); pt_2, posterior ventral pit; *tb*, ventral tuberosity.

of the plate may coincide with each other [*l* (+ *plc*), text-figs. 138R, 139C]. The part of the lateral margin of the plate situated in front of the lateral process is mostly somewhat concave most posteriorly, a little convex at the middle, and a little concave most anteriorly nearest to the antero-lateral corner (*aal*). However, the anterior half of this part of the lateral margin

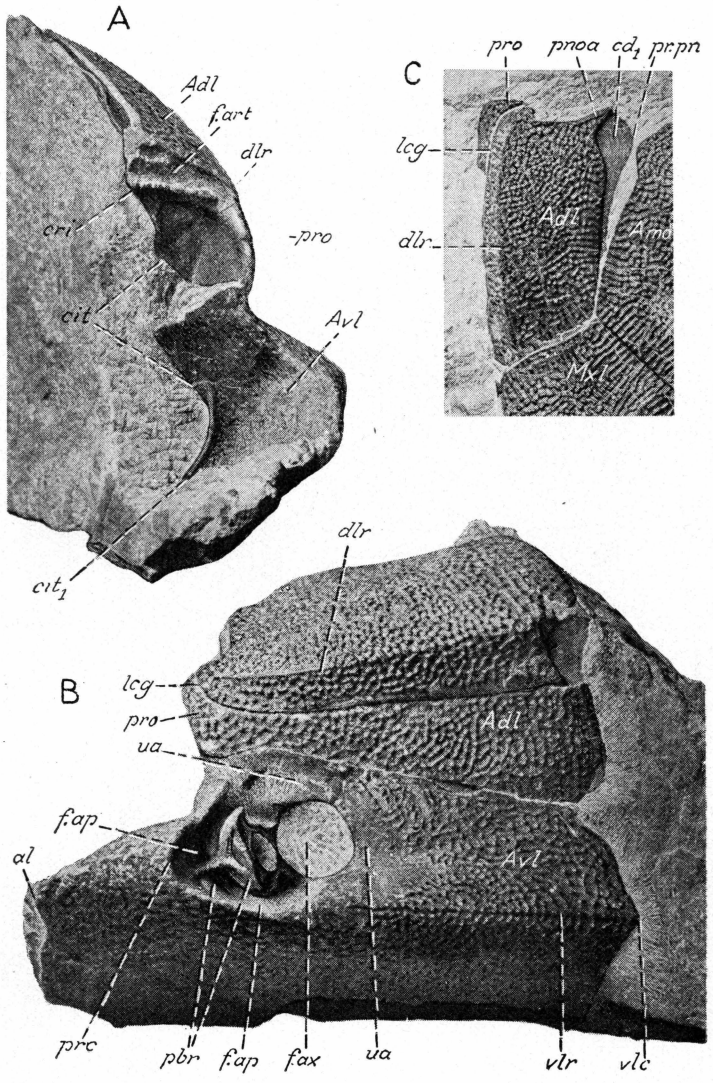


Text-fig. 144. *Bothriolepis canadensis*. A right anterior dorso-lateral plate of a medium-sized specimen. *A*, in lateral, *B*, in dorsal, and *C*, in anterior aspects. R. M. specimen No. P. 2134. × $^3/_2$.

cd_1, area overlapped by anterior median dorsal plate; cd_2, area overlapped by anterior ventro-lateral plate; *cit*, crista transversalis interna anterior (lateral, vertical part); *cri*, infraarticular crest; *dlr*, dorso-lateral ridge; *f. art*, articular fossa (for paranuchal trochlea); *lcg*, main lateral line groove; *n. prpl*, notch in dorsal margin of ornamented area, for external postlevator process (*pr. pl*) of anterior median dorsal plate; *pnoa*, postnuchal ornamented corner; *pro*, processus obstans; *pr. pn*, internal postlevator process.

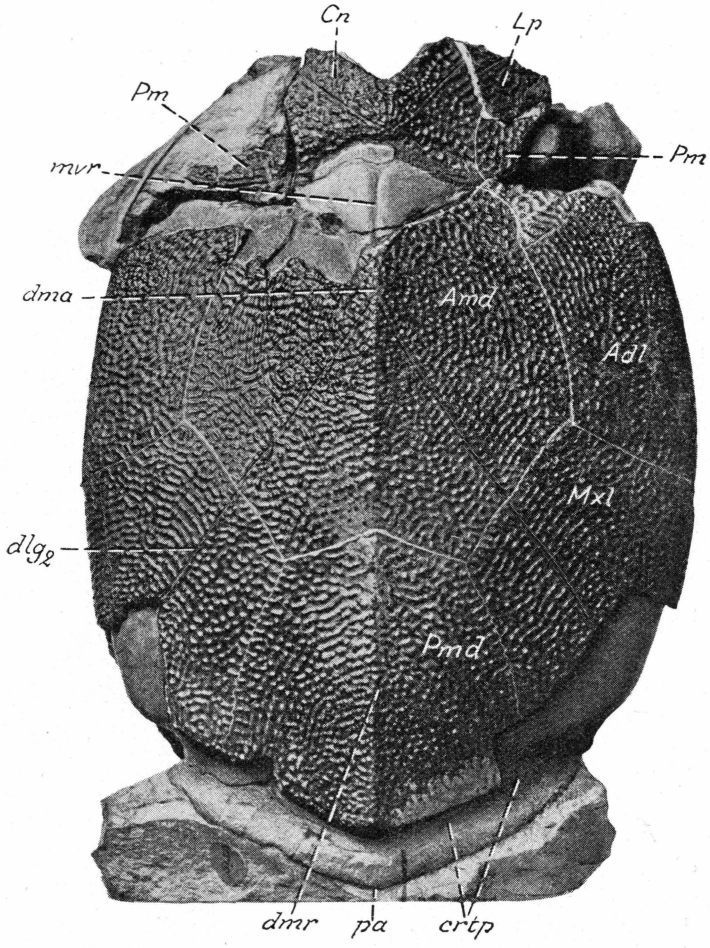
may in several cases present a more or less large mixilateral notch (*aln*, text-figs. 130, 138P, 139A–D, 157), or even two such notches (aln_1, aln_2 text-figs. 101, 133, 138M, Q). The posterior margin practically always is produced into a median posterior corner or short process (*pa*). In a single case, however, this margin shows a median notch (*n*, text-fig. 137A, B) instead of the median corner or process.

The posterior median dorsal plate overlaps both the anterior median dorsal plate and the mixilateral plate. In those cases when it has one or two mixilateral notches it is probably also overlapped at that or those notches by the mixilateral plate, and hence at this or these places it is presumably wedged in between a dorsal and a ventral lamina of the mixilateral plate, quite as is often the case in medium-sized and large individuals of *B. groen-*



Text-fig. 145. *Bothriolepis canadensis*. *A*, left anterior dorso-lateral plate somewhat disconnected from the anterior ventro-lateral plate of the same side. Anterior aspect. *B*, the same two plates in lateral aspect. *A*, *B*, R.M. specimen No. P. 2121. × slightly magnified. *C*, part of the dorsal wall of a trunk-armour in which the anterior dorso-lateral plate is somewhat disconnected from the anterior median dorsal plate so that it shows its dorsal margin and the area overlapped by the anterior median dorsal plate. Dorsal aspect. R. M. specimen No. P. 2572. Diminished.

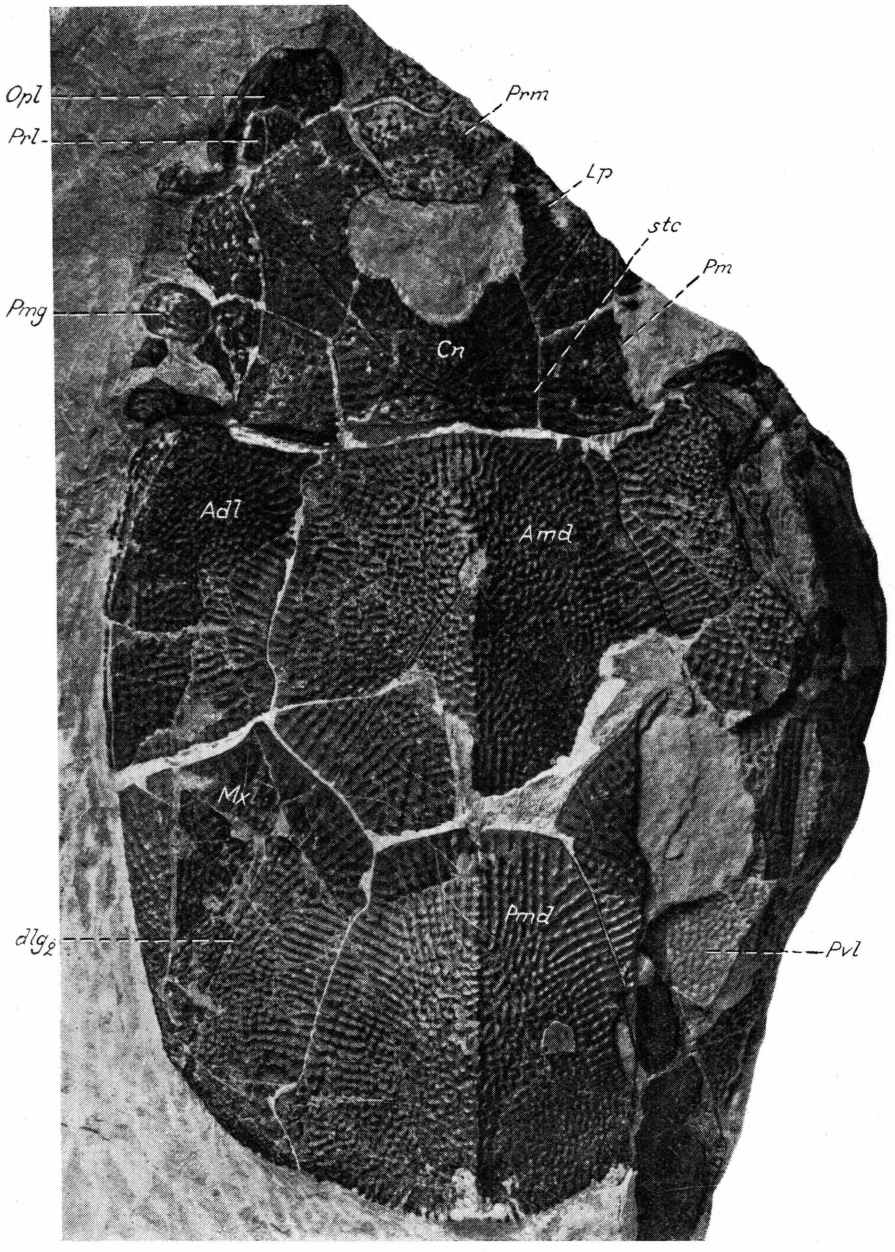
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; *Mxl*, mixilateral plate; *al*, antero-lateral corner of subcephalic division of anterior ventro-lateral plate; cd_1, area overlapped by anterior median dorsal plate; *cit*, cit_1, crista transversalis interna anterior and postbranchial crest respectively; *dlr*, dorso-lateral ridge; *f. ap*, fossa articularis pectoralis; *f. art*, articular fossa for paranuchal trochlea; *f. ax*, foramen axillare; *lcg*, main lateral line grove; *pbr*, processus brachialis; *pnoa*, postnuchal ornamented area; *prc*, prepectoral corner; *pro*, processus obstans; *pr. pn*, internal postlevator process; *ua*, unornamented zone around the foramen axillare; *vlc*, postero-ventral corner of anterior ventro-lateral plate; *vlr*, ventro-lateral ridge.



Text-fig. 146. *Bothriolepis canadensis.* Trunk-armour and certain posterior parts of a head-shield in dorsal aspect. The trunk-armour deficient both anteriorly and posteriorly, but only slightly dorso-ventrally compressed anteriorly and almost uncrushed. R. M. specimen No. P. 2114 (same specimen as in text-fig. 150 D and 173). Nat. size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *crtp*, crista transversalis interna posterior (impression); dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *mvr*, ventral median ridge (impression of foremost part, extending into levator fossa *f. retr*); *pa*, posterior corner or angle of posterior median dorsal plate (impression).

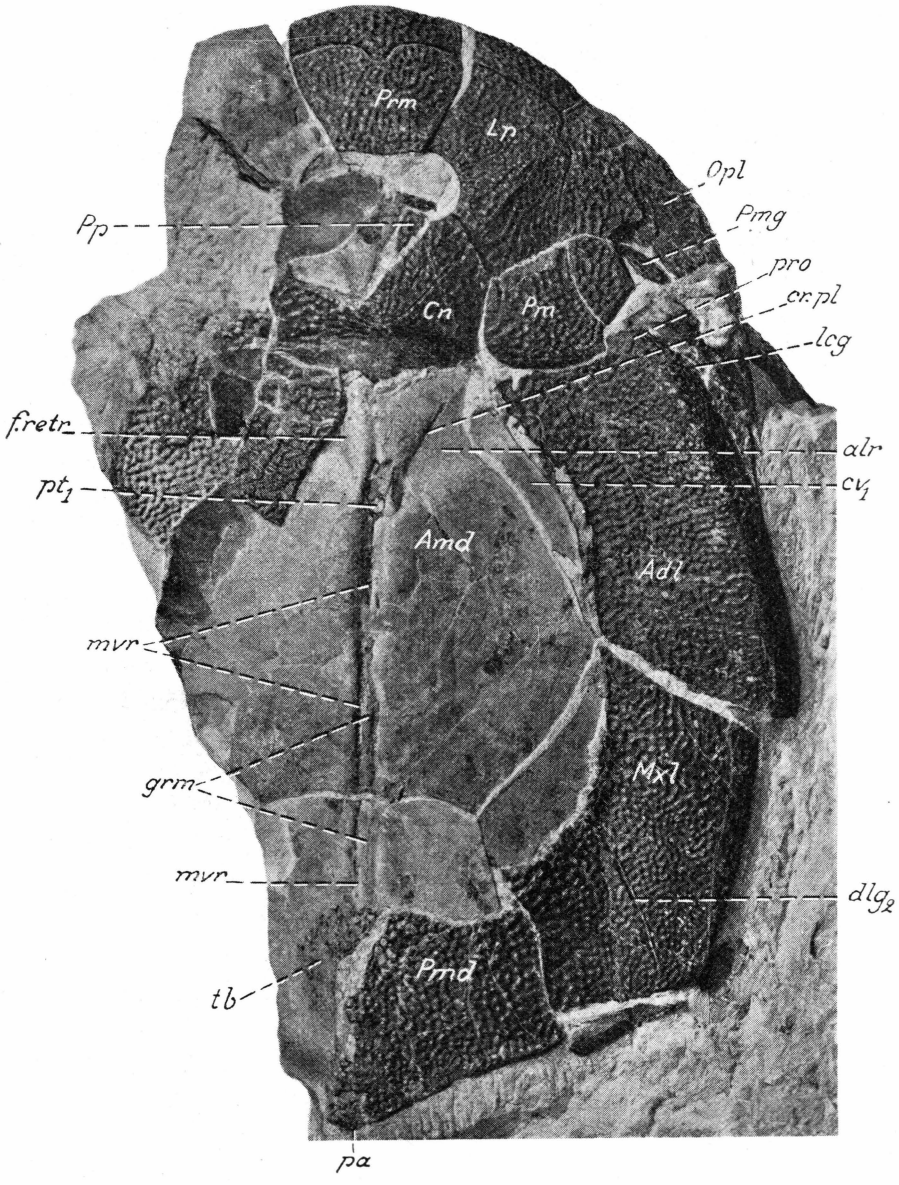
landica (text-fig. 286 F). In certain cases it is also not impossible that it may have abutted anteriorly against the mixilateral plate with its very edge only, and thus without overlapping the mixilateral plate or being overlapped by that plate.

The anterior dorso-lateral plate (*Adl*, text-figs. 38, 39 A, B, 40, 48 A–C, 88, 90–92, 95–98, 101, 102, 106, 109, 114–117, 127–134, 140–140, 150 D, 151, 152, 154–159, 179–183) is rarely complete so as to show both its



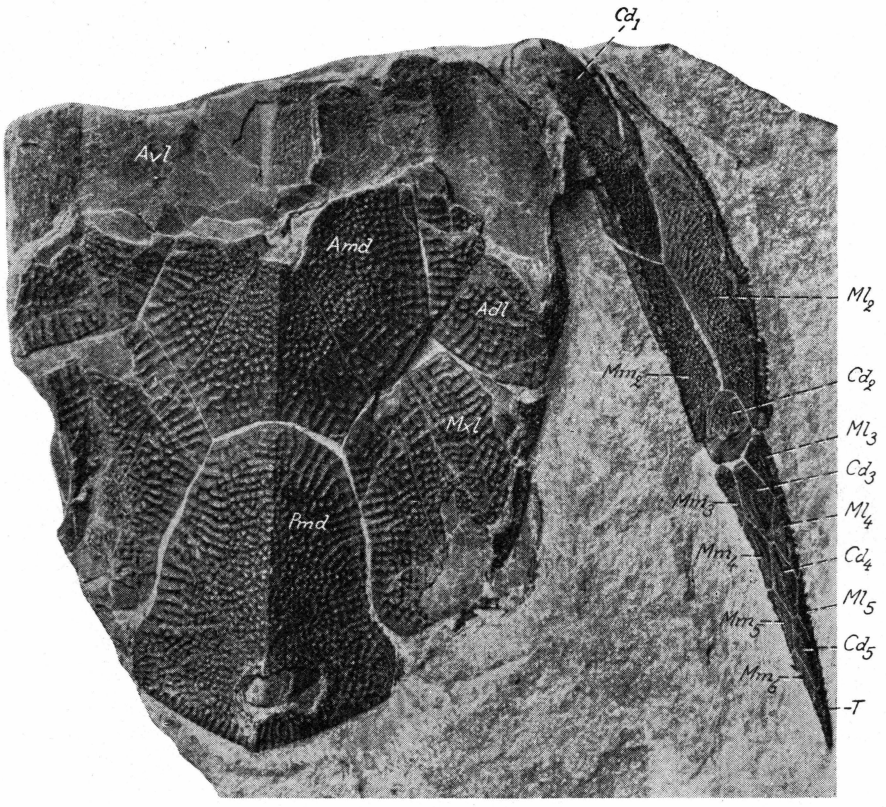
Text-fig. 147. *Bothriolepis canadensis*. Medium-sized specimen in dorsal aspect. Both the head-shield and trunk-armour flattened and crushed. R. M. specimen No. P. 2644. Slightly more than $^5/_4$ of the nat. size.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Opl*, extralateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Prl*, prelateral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; dlg_2, posterior oblique abdominal pit-line groove; *stc*, supratemporal pit-line groove.



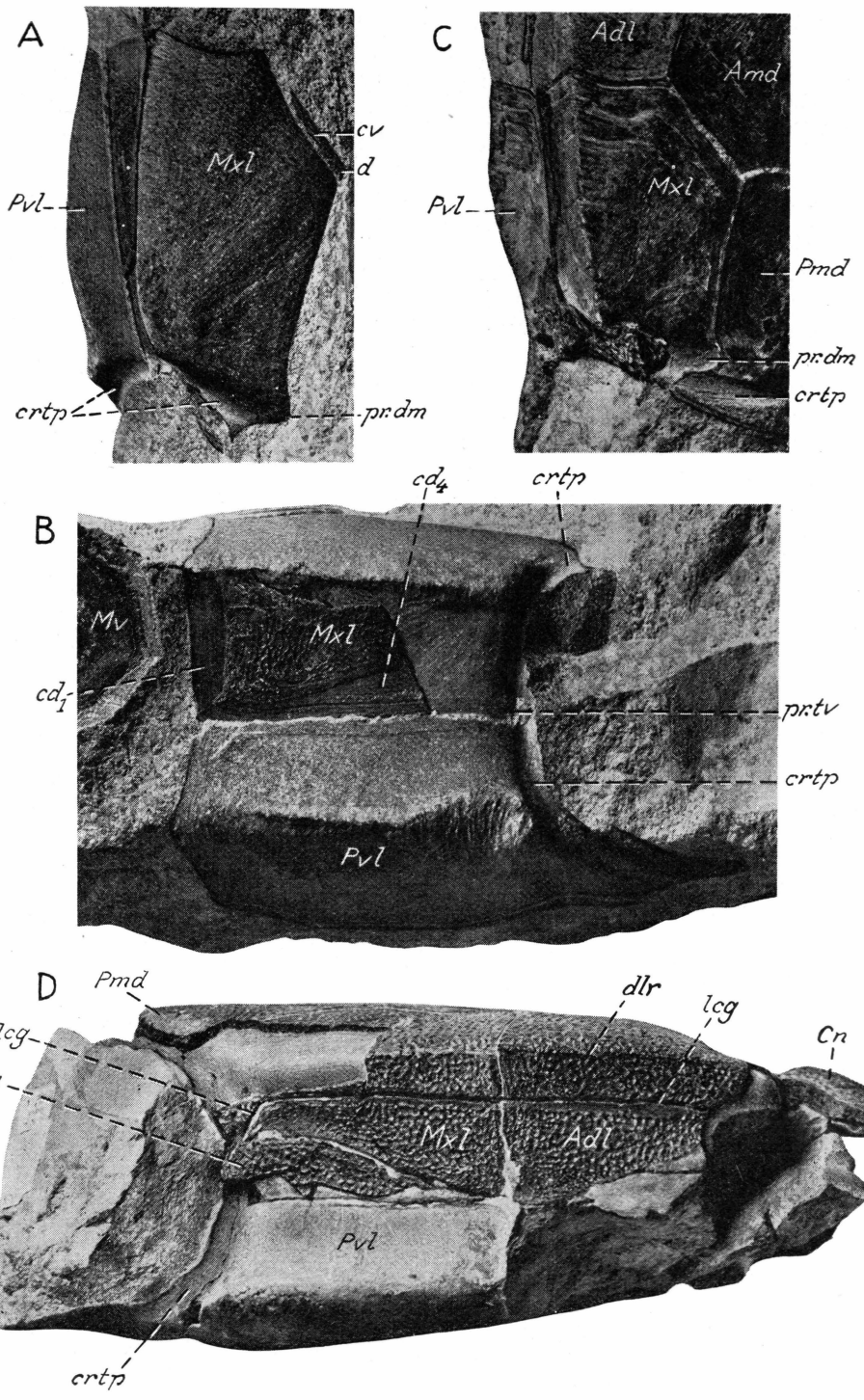
Text-fig. 148. *Bothriolepis canadensis*. Dorsal aspect of a deficient, flattened, fairly large specimen. Several of the bone-plates partly or mainly represented by impressions of their lower (internal) sides. R. M. specimen No. P. 2129. Nat. size.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alr*, postlevator thickening (impression); *cr. pl*, postlevator crest (impression); cv_1, area of *Amd*-plate overlapping *Adl*-plate (impression); dlg_2, posterior oblique abdominal pit-line groove; *f. retr*, levator fossa; *grm*, ventral median groove (impression); *lcg*, main lateral line groove; *mvr*, ventral median ridge (impression); *pa*, posterior angle or corner of *Pmd*-plate; *pa*, posterior corner or angle; *pro*, processus obstans; pt_1, anterior ventral pit; *tb*, ventral tuberosity.



Text-fig. 149. *Bothriolepis canadensis.* Deficient trunk-armour with the right pectoral fin of a fairly small medium-sized specimen. Dorsal aspect. An anterior part of the dorsal wall of the trunk-armour missing. R. M. specimen No. P. 2447. Approximately × $^3/_2$. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1–Cd_5, dorsal central plates 1–5; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_6, medial marginal plates 2–6; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *T*, terminal plate.

dorsal and lateral laminae. The lateral lamina is mostly either missing, or else is crushed and damaged to such an extent that its proportions cannot be ascertained. Taken as a whole the plate is comparatively low and normally about equally long as, or a little longer than, the mixilateral plate. In consequence of the fact that it meets the lateral lamina at an almost straight angle the dorsal lamina with its medial part lies only fairly little above the level of the dorso-lateral ridge (text-figs. 40, 48C, 114, 144A, C, 145A, B, 150D, 151A, 152) or at least not nearly as high up as for instance in *B. maxima* (pp. 450–451), *B. groenlandica* (text-figs. 283D, 287B, 288) and *B. jarviki* (text-fig. 304). This lamina is mostly about twice as long as broad. The lateral lamina is usually only somewhat more than twice as long as high and thus is comparatively high, much higher than in several other species,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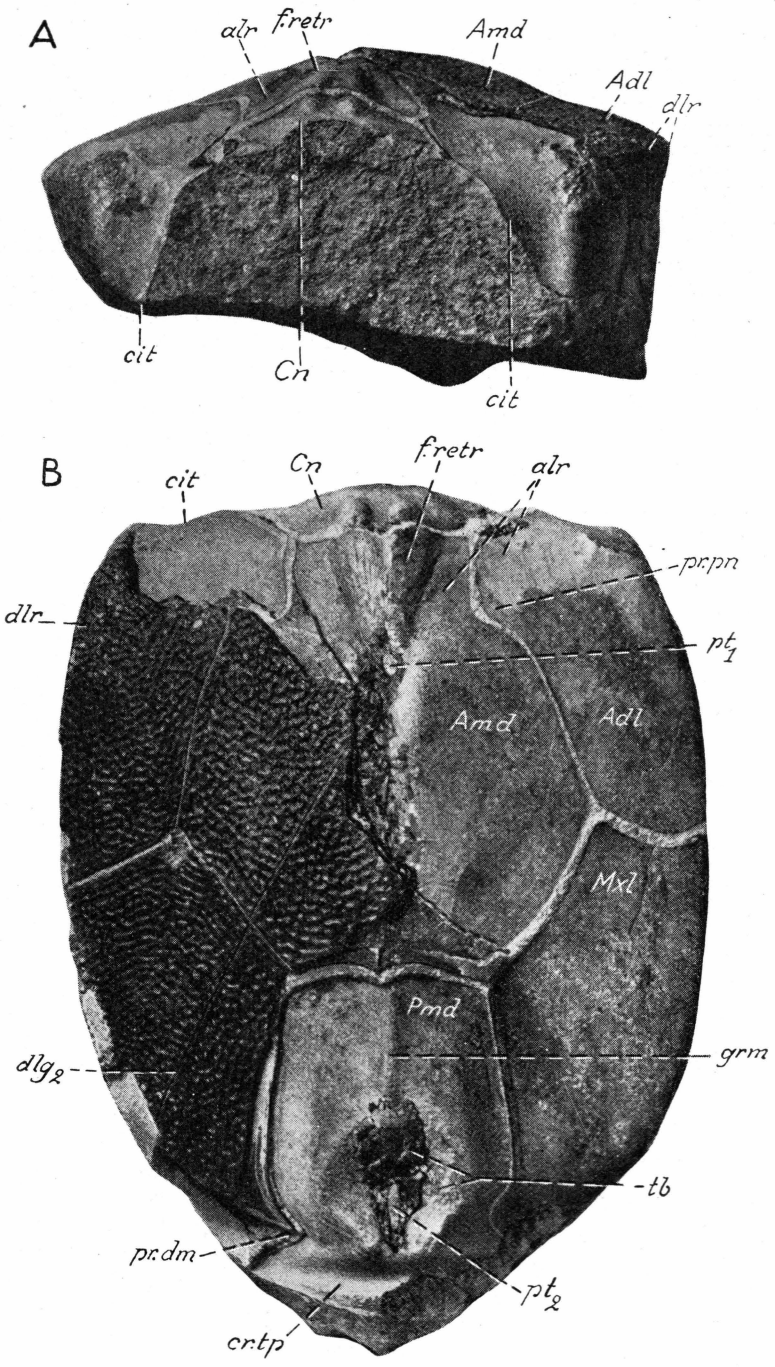
Mxl
Adl
Pvl
crtp

e.g. *B. maxima*, *B. gigantea* and *B. groenlandica* (cf. pp. 450, 488, 561; cf. also text-figs. 287B, 288). The processus obstans (*pro*) is well developed. The articular fossa (*f.art*, text-figs. 48A–C, 144B, C, 145A) for the paranuchal trochlea is bounded below by a well developed infraarticular crest (*cri*), whereas a supraarticular crest seems normally to be absent. The various margins of the plate are developed as follows. The dorsal (dorso-medial margin is always convex anteriorly, where it forms the usually broad and well rounded off internal postlevator process (*pr.pn*), but generally somewhat concave further backwards. The anterior margin is strongly convex on the processus obstans, whereas, on the other hand, it is fairly straight or a little concave dorsally (dorso-medially) to that process. The ventral margin is imperfectly known, but is probably slightly undulating. Finally, the posterior margin is somewhat produced into a posterior corner at the dorso-lateral ridge (*dlr*). Dorsally to that corner, that is to say on the dorsal lamina, it may be either somewhat convex or a little undulating, whereas ventrally to the same corner, and thus on the lateral lamina, it is as a whole a little concave. At the postero-ventral corner, there is sometimes a postero-ventrally facing short margin, by means of which the plate abutted against the anterior dorsal corner of the posterior ventro-lateral plate of its side (text-figs. 38, 40). The notch or emargination (*n.prpl*) in the upper (dorso-medial) margin of the ornamented area of the plate that is developed for the external postlevator process of the anterior median dorsal plate normally is somewhat deep and well-marked, and because of this the postnuchal ornamented corner (*pnoa*) of the plate is generally well pronounced (text-figs. 39A, B, 48A, B, 98, 144B, 145C, 179–183). As has already been pointed out, this corner, when the plate is in its natural connection with the anterior median dorsal plate, conveys the apparent impression of being an antero-medial process.

The plate mostly has its normal sutural connections with the adjacent plates. However, in several cases, as we have seen (pp. 118–121, 130, 293–303), it is both overlapped by and itself overlaps the anterior median dorsal

Text-fig. 150. *Bothriolepis canadensis*. *A*, impression of the inner side of a left mixilateral plate attached to the posterior ventro-lateral plate of the same side. Dorsal aspect. R. M. specimen No. P. 2116. × $^3/_2$. *B*, the same specimen as in fig. *A*, but in lateral aspect. A detached median ventral plate also shown. *C*, posterior left part of the dorsal wall of a trunk-armour preserved as an impression of its internal side. Dorsal aspect. R. M. specimen No. P. 2110. × $^3/_2$. *D*, deficient trunk-armour seen from the right side. Some of the plates to a certain extent or entirely represented by impressions of their internal sides. R. M. specimen No. P. 2114. Same specimen as in text-fig. 146. Nat. size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Mxl*, mixilateral plate; *Mv*, median ventral plate; *Pmd*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; cd_1, area overlapped by anterior dorso-lateral plate; cd_4, area overlapped by posterior ventro-lateral plate; *cv*, area overlapping anterior median dorsal plate (impression); *crtp*, crista transversalis interna posterior (impression); *cu*, postero-ventral corner of ornamented area of *Mxl*-plate; *d*, dorsal (dorso-medial) corner of *Mxl*-plate; *dlr*, dorso-lateral ridge; *lcg*, main lateral line groove; *pr. dm*, medial dorsal process (situated underneath lateral part of *Pmd*-plate); *pr. tv*, postero-ventral process (covered from outside by posterior ventro-lateral plate).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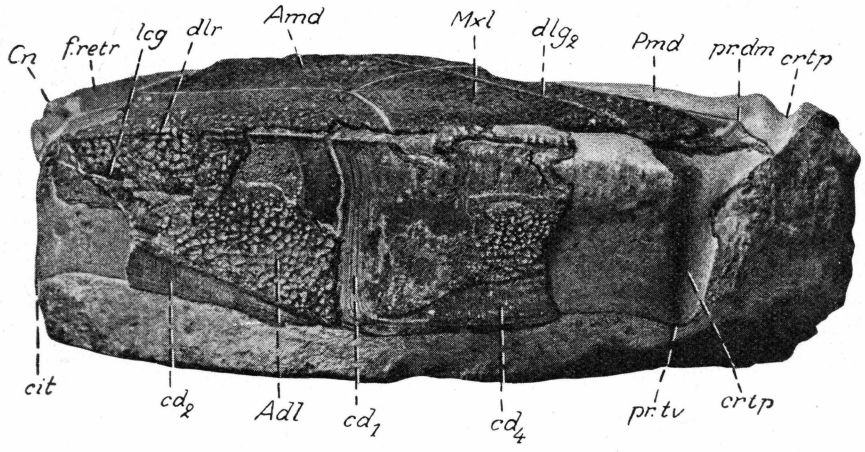
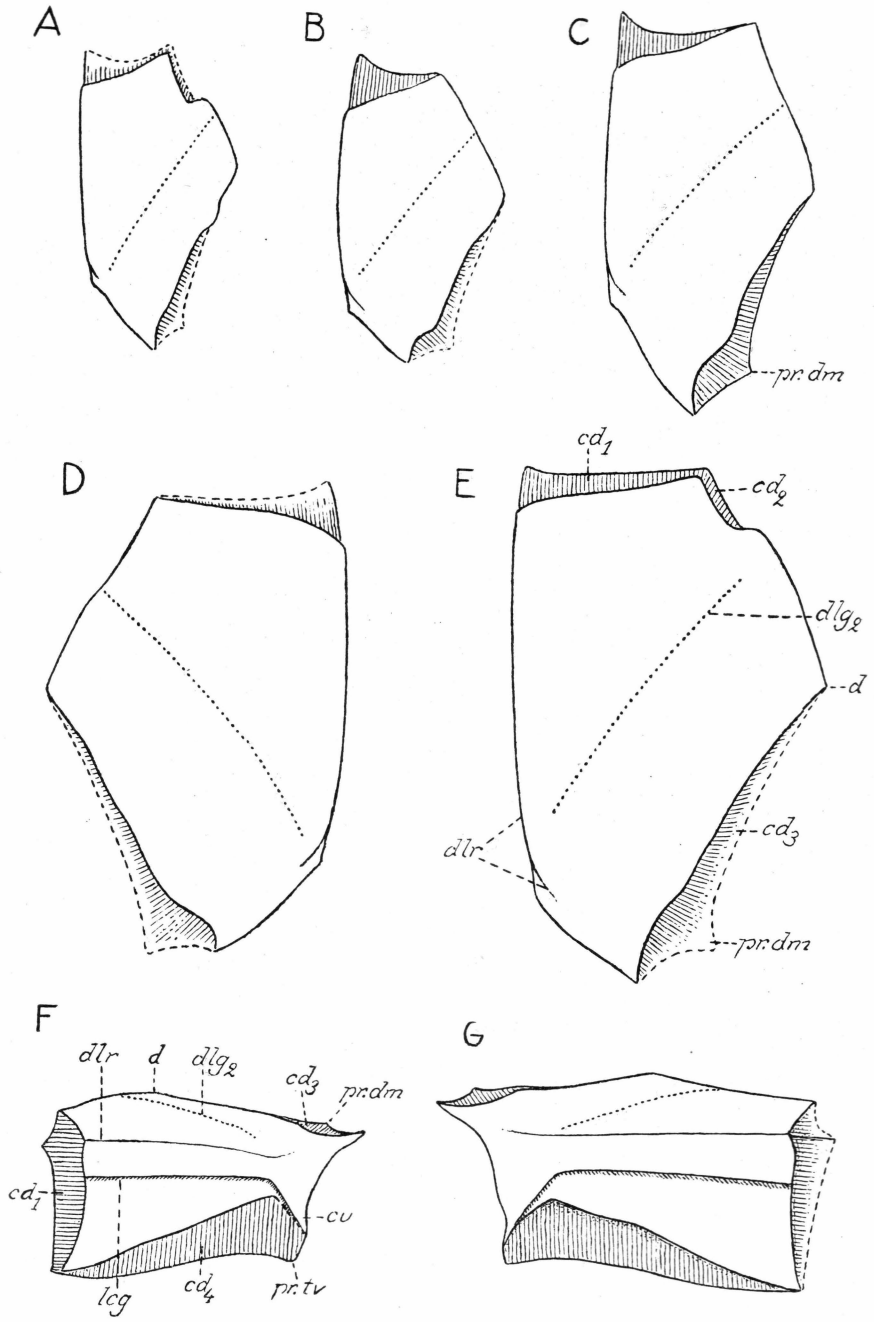


Text-fig. 152. *Bothriolepis canadensis*. Dorsal part of a trunk-armour seen from the left side. Same specimen as in text-fig. 152. × $^3/_2$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate, represented by an impression of its posterior face; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; cd_1, area overlapped by anterior dorso-lateral plate; cd_2, area overlapped by anterior ventro-lateral plate; cd_4, area overlapped by posterior ventro-lateral plate; *cit*, crista transversalis interna anterior (impression of the posterior face); *crtp*, crista transversalis interna posterior (impression); dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *f. retr*, levator fossa (impression); *lcg*, main lateral line groove; *pr. dm*, medial dorsal process of mixilateral plate, covered by lateral part of posterior median dorsal plate (impression); *pr. tv*, postero-ventral process of mixilateral plate.

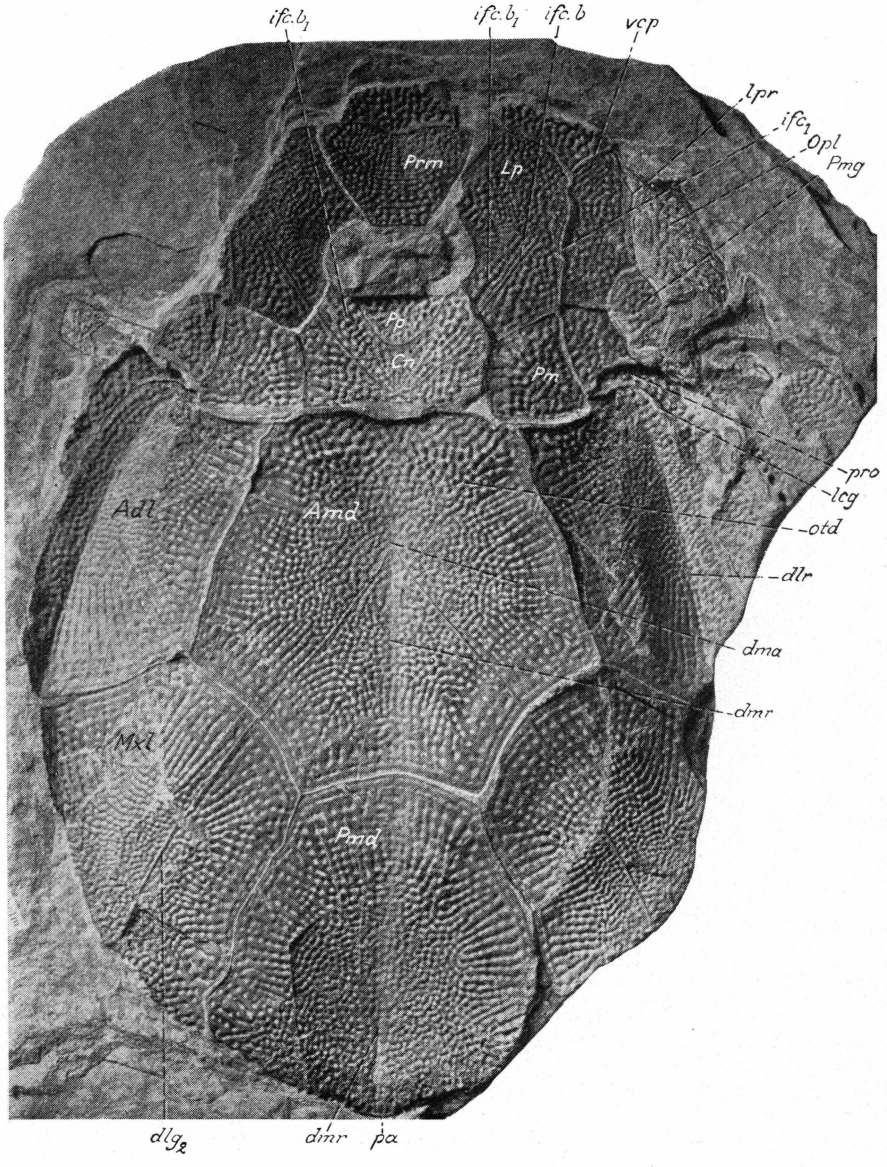
plate. Moreover, it is not only overlapped by the anterior ventro-lateral plate, but also overlaps that plate, at least anteriorly In certain cases it embraces the dorsal parts of the anterior ventro-lateral plate almost to the same extent as it does in *B groenlandica* (text-fig 288). Finally, it is also obvious that the plate with its posterior ventro-lateral corner may sometimes abut against the antero-dorso-lateral corner of the posterior ventro-lateral plate

The mixilateral plate (*Mxl*, text-figs. 38, 39A, B, 40, 50A, B, 88, 90–92, 95–98, 101, 102, 106, 109, 115–117, 127–134, 137A, B, 140, 143, 146–159, 179–183, 199, 200, 204–206) is mostly represented only by its dorsal

Text-fig. 151. *Bothriolepis canadensis*. Dorsal parts of a medium-sized trunk-armour. Several of the bone plates entirely or to a large extent represented by impressions of their inner sides. *A*, seen straight from in front. *B*, in dorsal aspect. R. M. specimen No. P. 2792 (the specimen shown in lateral aspect in text-fig. 152). × $^3/_2$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate, represented by an impression of its posterior face; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *alr*, postlevator thickening (impression); *cit*, crista transversalis interna anterior (impression of its posterior face); *crtp*, crista transversalis interna posterior (impression); dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *f. retr*, levator fossa (impression); *grm*, ventral median groove; *pr. dm*, medial dorsal process of mixilateral plate, covered by lateral part of posterior median dorsal plate (impression); *pr. pn*, internal postlevator process of anterior dorso-lateral plate (impression); pt_1, pt_2, anterior and posterior ventral pits respectively; *tb*, ventral tuberosity of *Amd*-plate (mainly impression).

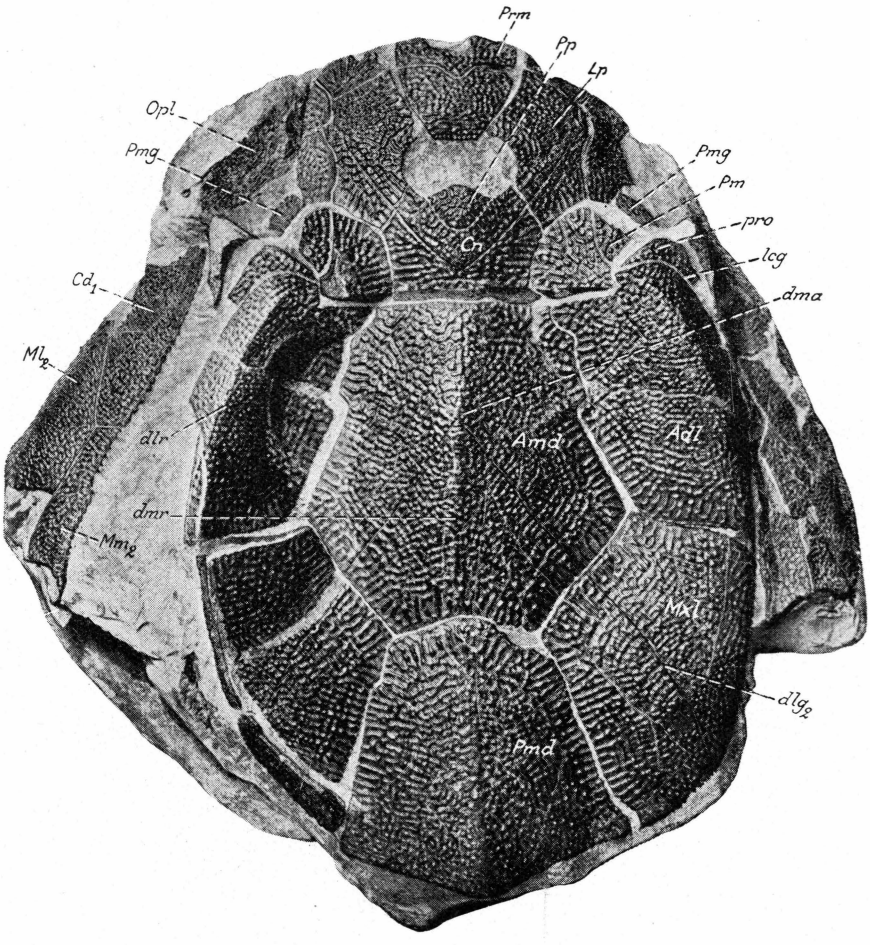


Text-fig. 153. *Bothriolepis canadensis*. *A–E*, restorations of five mixilateral plates in dorsal aspect. *A–C*, *E*, left plates; *D*, a right plate. Nat. size. *F*, *G*, restorations of a left and a right mixilateral plate respectively. Both the latter plates in lateral aspect. Nat. size. cd_1, area overlapped by anterior dorso-lateral plate; cd_2, area overlapped by anterior median dorsal plate; cd_3, area overlapped by posterior median dorsal plate; cd_4, area overlapped by posterior ventro-lateral plate; *cu*, postero-ventral ornamented corner; *d*, dorsal corner; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *lcg*, main lateral line groove; *pr. dm*, medial dorsal process; *pr. tv*, postero-ventral process.



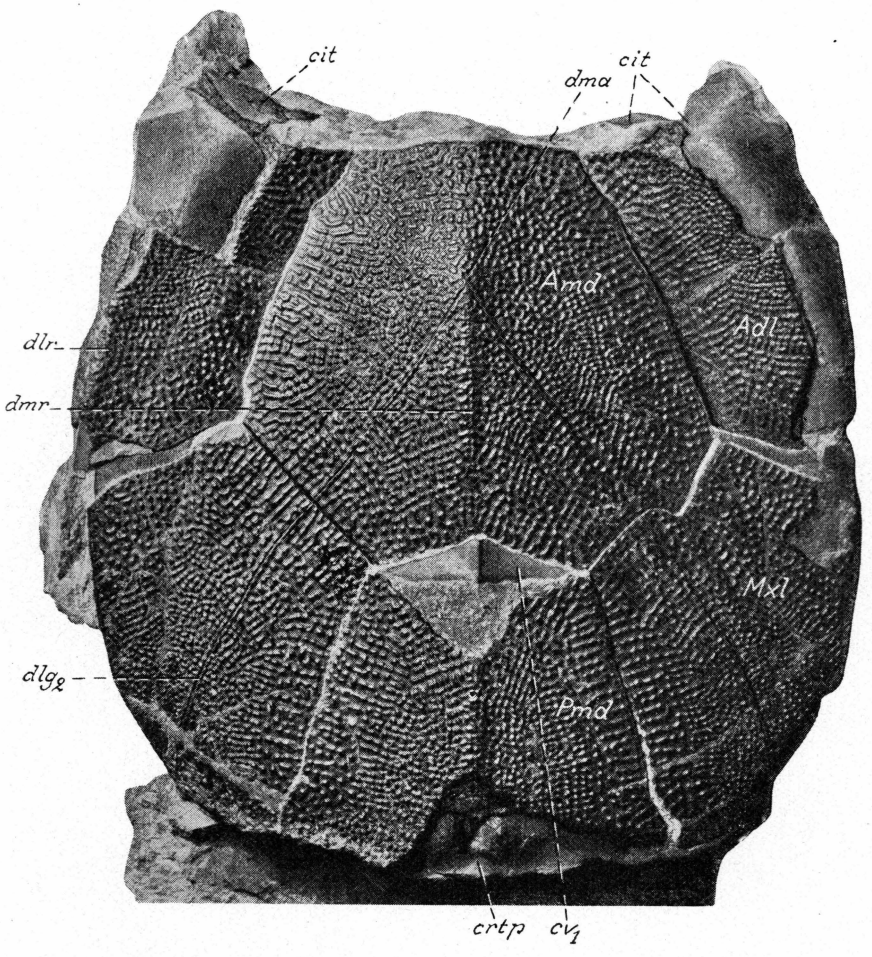
Text-fig. 154. *Bothriolepis canadensis*. Somewhat deficient impressions of the dorsal side of a head-shield and of the dorsal side of a trunk-armour. Both head-shield and trunk-armour much flattned. R. M. Specimen No. P. 2714. Approximately × $^{9}/_{10}$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *lcg*, main lateral line groove; *lpr*, supraspiracular process; *otd*, oblique transverse depression above postlevator thickening (*alr*); *pa*, posterior corner; *pro*, processus obstans; *vcp*, vertical pit-line groove of cheek.



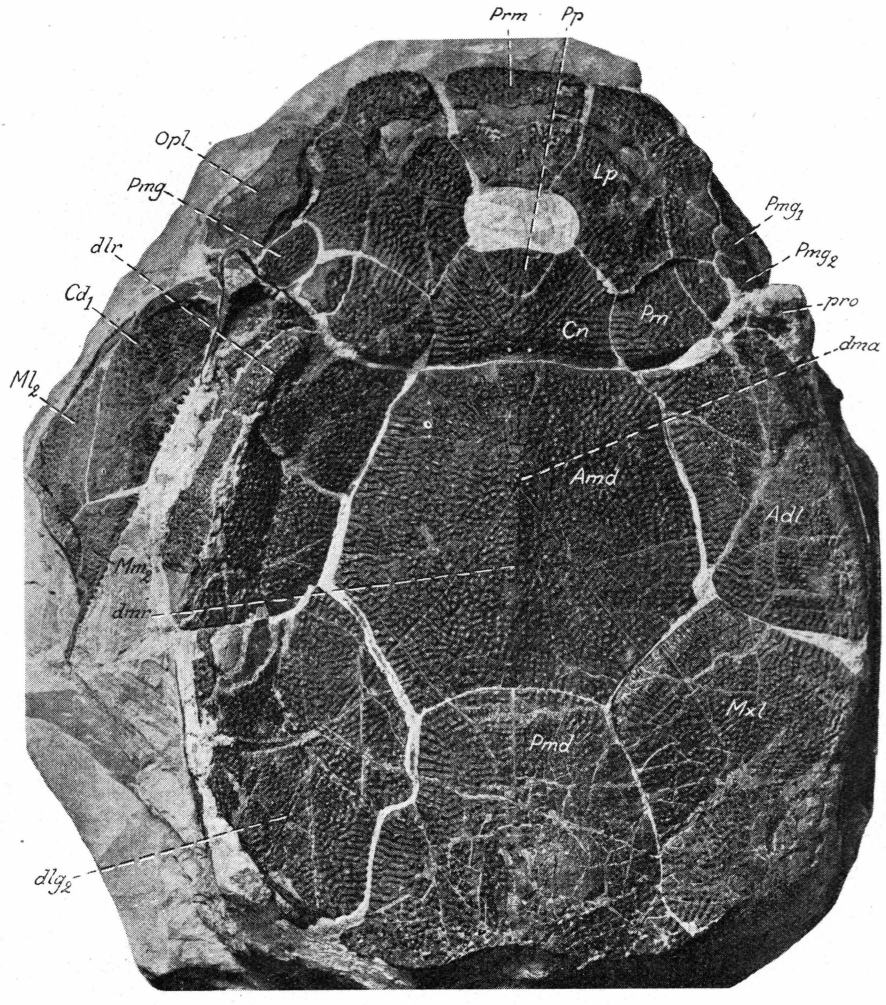
Text-fig. 155. *Bothriolepis canadensis*. Large, somewhat deficient specimen in dorsal aspect. The armour flattened and partly crushed. R. M. specimen No. P. 2781. Approximately $\times$ $^3/_4$. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *lcg*, main lateral line groove; *pro*, processus obstans.

lamina, whereas its lateral lamina is missing, much crushed, compressed or damaged in other ways, Its two laminae, as those of the anterior dorso-lateral plate, meet at nearly right angles, and on account of this its dorsal lamina rises only comparatively little above the level of the dorso-lateral ridge (text-figs 38, 40, 150B, D, 152, 153F, G). In lateral aspect the dorsal lamina, therefore, is lower than in several other species, such as. *B maxima*, *B turanica*, *B. alvesiensis*?, *B. gigantea*, *B. obesa*, *B. groenlandica* and *B. jarviki* (text-figs. 251, 256, 259B, 287B, 289, 304). This lamina varies much as to



Text-fig. 156. *Bothriolepis canadensis*. Somewhat deficient trunk-armour of a large specimen. Dorsal aspect. R. M. specimen No. 2124 (same specimen as in text-figs. 10, 12, 185, 186 B, 187 A, 189 D, 190 A, B). Approximately × $^{9}/_{10}$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *cit*, crista transversalis interna anterior (impression); *crtp*, crista transversalis interna posterior (impression); cv_1, area (of posterior median dorsal plate) overlapping anterior median dorsal plate (impression); dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge.

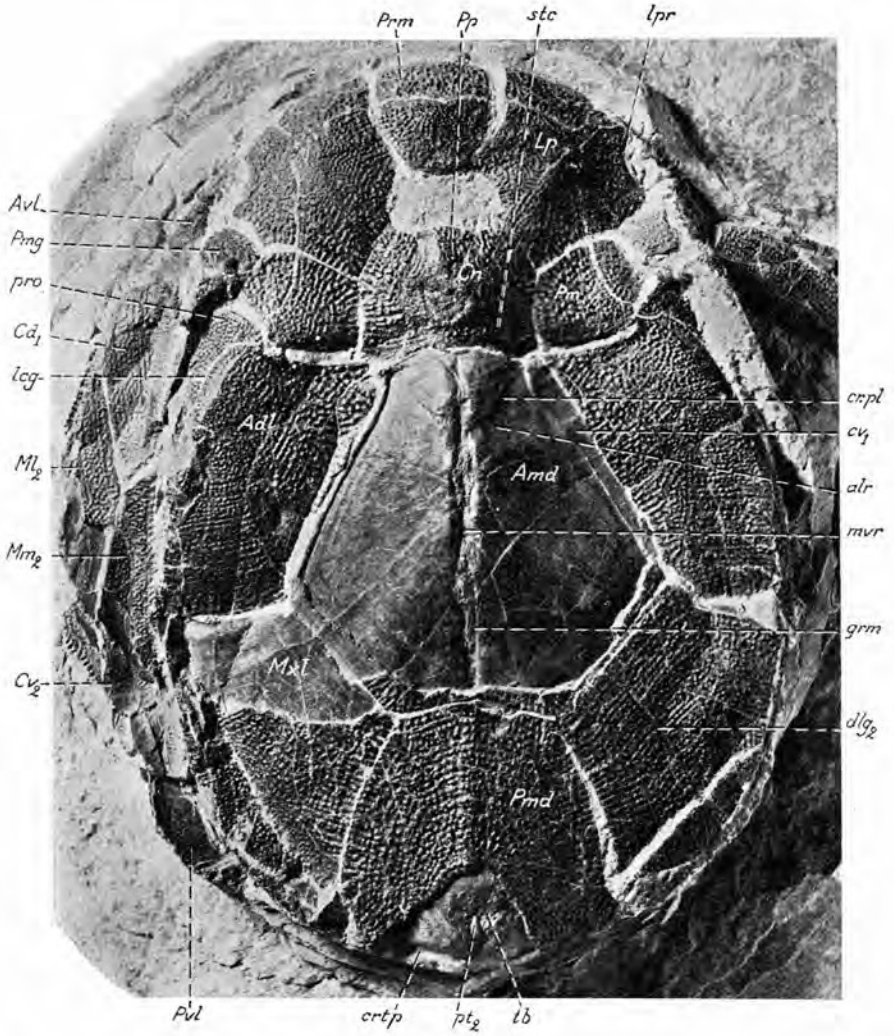
its relative proportions, being from about one and a half times to twice as long as broad. The lateral lamina is from about two and a fourth to about two and a third times as long as high and thus is relatively short and high, considerably higher than for instance in *B. maxima*, *B. gigantea* and *B. groenlandica* (text-figs. 256, 287B, 289). The dorsal (dorso-medial) corner (*d*) is always well defined. The anterior division of the dorsal (dorso-medial) margin may be convex throughout its extent, or else it is somewhat concave in its anterior part and somewhat convex further backwards. The posterior



Text-fig. 157. *Bothriolepis canadensis*. Large somewhat deficient armour in dorsal aspect. Both the head-shield and trunk-armour flattened and crushed. R. M. specimen No. P. 2780. About $^3/_4$ of the nat. size.

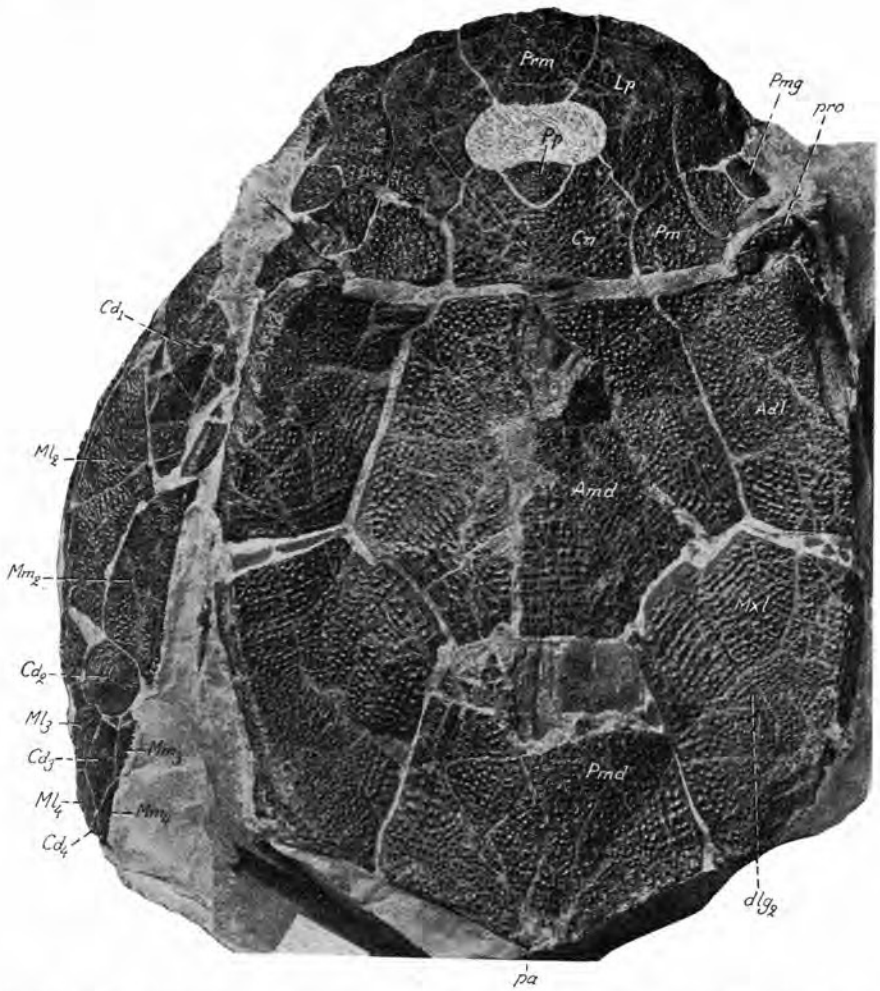
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; Pmg_1, Pmg_2, anterior and posterior postmarginal plates respectively; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *pro*, processus obstans.

division of the same margin is always produced into a distinct mostly angular posterior median process (*pr. dm*, text-figs. A, 50B, 137A, B, 150A, C, 151B, 153), situated underneath the posterior lateral part of the posterior median dorsal plate. The anterior margin shows nothing of any particular interest to us in this connection. The ventral margin is imperfectly known.



Text-fig. 158. *Bothriolepis canadensis*. Large, somewhat deficient specimen in dorsal aspect. The specimen much flattened, and some of the plates of the trunk-armour mainly or to some extent represented by impressions of their lower sides. Specimen in the possession of the Palaeontological Institute of the University of Uppsala. About $^{7}/_{10}$ of the natural size.

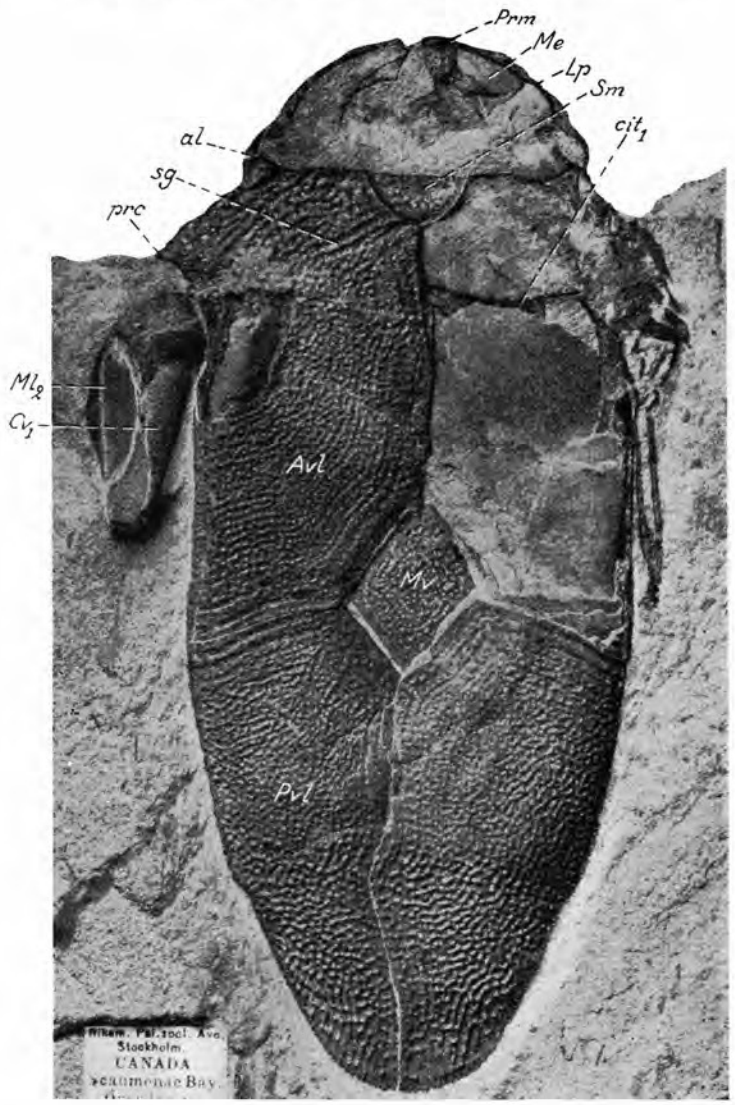
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1, dorsal central plate 1; *Cn*, centro-nuchal plate; Cv_2, ventral central plate 2; *Lp*, lateral plate; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *alr*, postlevator thickening; *cr. pl*, postlevator crest (impression); *crtp*, crista transversalis interna posterior (impression); cv_1, area of anterior median dorsal plate overlapping anterior dorso-lateral plate (impression); dlg_2, posterior oblique abdominal pit-line groove; *grm*, ventral median groove (impression); *lcg*, main lateral line groove; *lpr*, supraspiracular process; *mvr*, ventral median ridge (impression); *pro*, processus obstans; pt_2, posterior ventral pit; *stc*, supratemporal pit-line groove; *tb*, ventral tuberosity of posterior median dorsal plate.



Text-fig. 159. *Bothriolepis canadensis*. Very large specimen in dorsal aspect. Armour much compressed and crushed. R. M. specimen No. P. 2130 (same specimen as in text-fig. 111). About $^2/_3$ of the natural size.

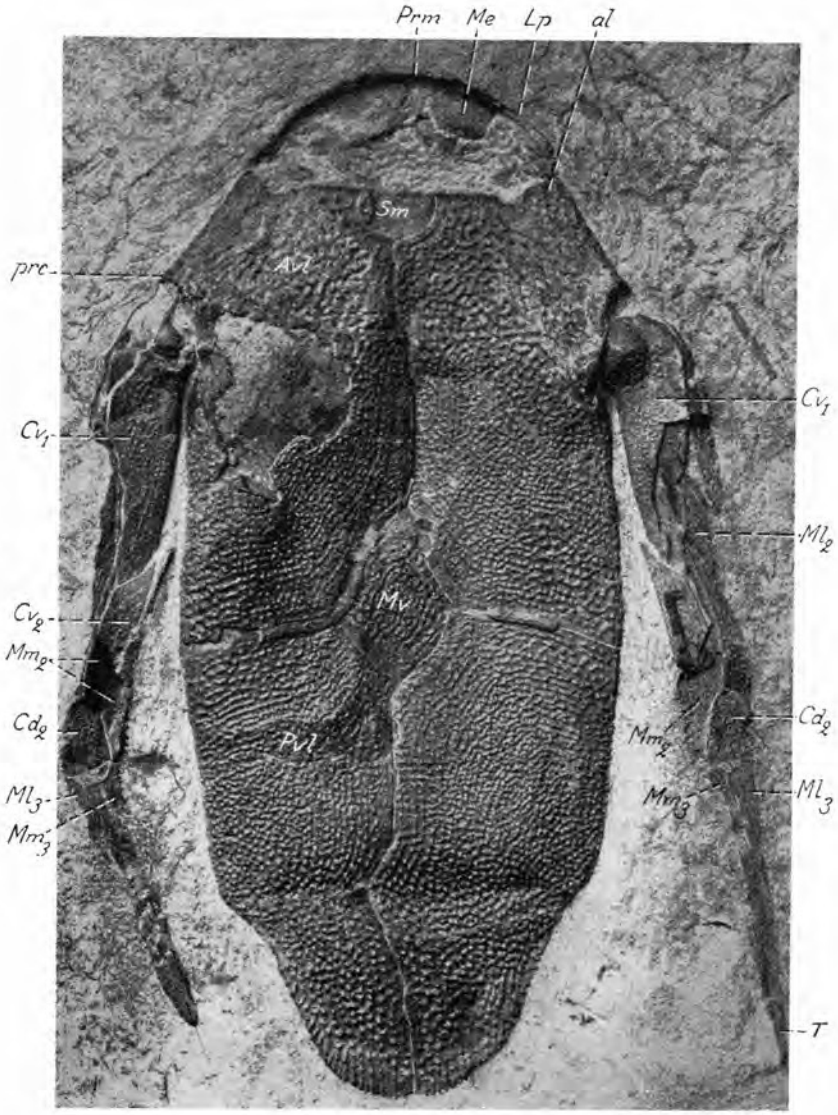
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, medial marginal plates 2–4; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *pa*, posterior angle of posterior median dorsal plate; *pro*, processus obstans.

It seems mostly to be somewhat concave throughout its extent and to have the deepest part of its concavity behind its middle, but sometimes it may be a little convex in its foremost part and concave in its posterior longer part. The postero-ventral corner (*pr. tv*) is slightly produced downwards, but is often somewhat angular and comparatively distinct. Finally, the posterior margin is clearly concave, as normally in the *Antiarchi*. The postero-



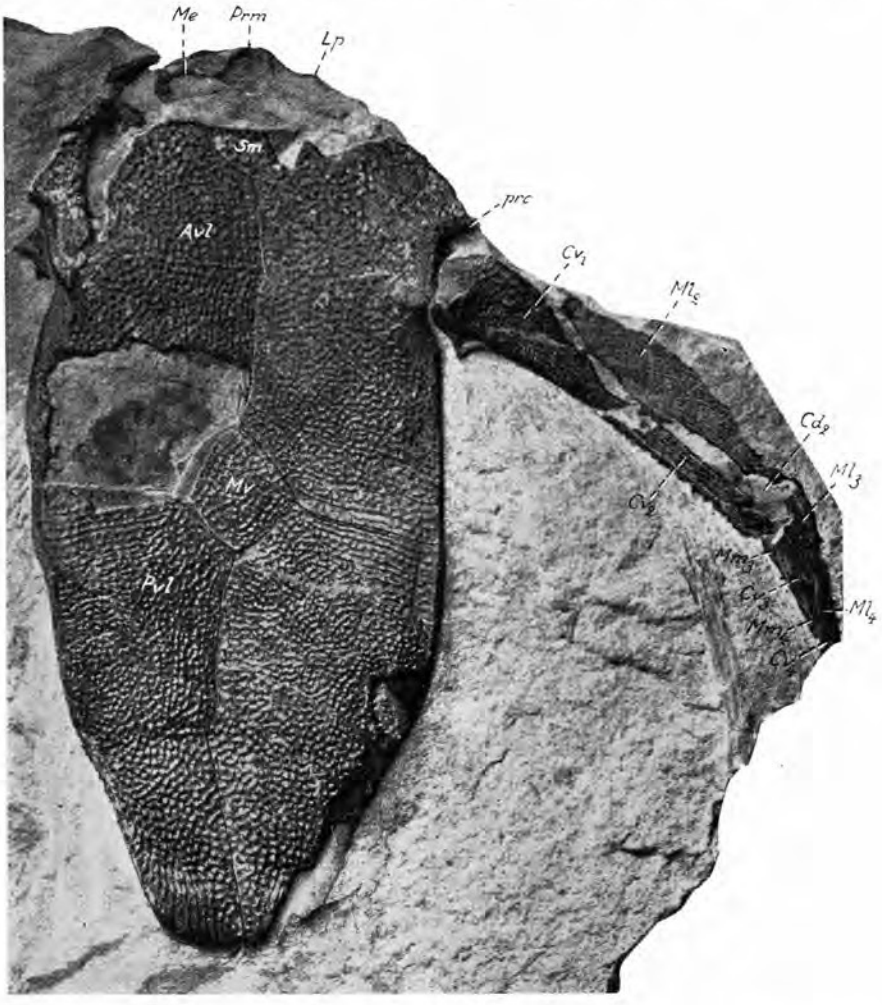
Text-fig. 160. *Bothriolepis canadensis*. Medium-sized specimen, showing the head and trunk-armour in ventral aspect. The left anterior ventro-lateral plate represented by an impression of its internal side. R. M. specimen No. P. 2837. $^5/_4$ of the natural size. *Avl*, anterior ventro-lateral plate; Cv_2, ventral central plate 2; *Lp*, lateral plate; *Me*, mental plate (impression); Ml_2, lateral marginal plate 2 (fragment); *Mv*, median ventral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *al*, antero-lateral corner of ventral lamina of anterior ventro-lateral plate; *cit*, post-branchial crest (= ventral anterior branch of crista transversalis interna anterior); *prc*, prepectoral corner; *sg*, subcephalic abdominal pit-line groove.

ventral corner (*cu*) of the ornamented area extends downwards as an apparent process behind the dorsal corner of the posterior ventro-lateral plate (text-figs. 38, 40, 150D, 153F, G).



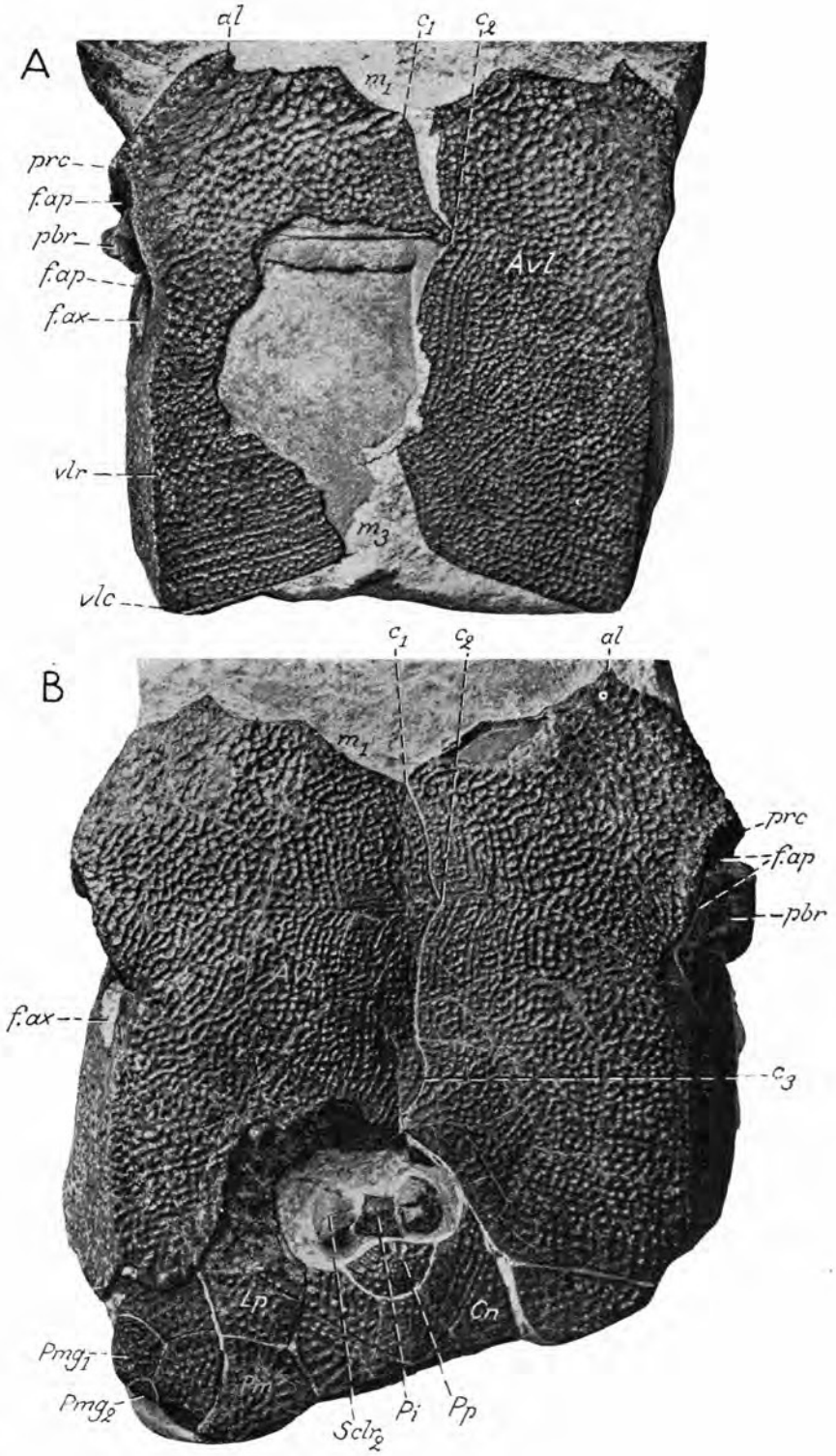
Text-fig. 161. *Bothriolepis canadensis*. Medium-sized, fairly complete specimen in ventral aspect. The pectoral fins crushed and to a considerable extent preserved as impressions of their dorsal side. R. M. specimen No. 2681. $^5/_4$ of the natural size.
Avl, anterior ventro-lateral plate; Cd_2, dorsal central plate 2 (impression); Cv_1, Cv_2, ventral central plates 1 and 2; *Lp*, lateral plate; *Me*, mental plate (impression); Ml_2, Ml_3, lateral marginal plates 2 and 3 respectively; Mm_2, Mm_3, medial marginal plates 2 and 3 respectively; *Mv*, median ventral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *T*, terminal plate; *al*, antero-lateral corner of ventral lamina of anterior ventro-lateral plate; *prc*, prepectoral corner.

The mixilateral plate normally overlaps the anterior median dorsal plate on an area extendending from the lateral corner (*lc*) backwards to the postero-lateral corner (*plc*, text-figs. 121 A–J, K, L, 122 C). As has been pointed out



Text-fig. 162. *Bothriolepis canadensis*. Medium-sized specimen in ventral aspect. R. M. specimen No. P. 2867. About $^5/_4$ of the natural size.
Avl, anterior ventro-lateral plate; Cd_2, dorsal central plate 2 (impression); Cv_1–Cv_4, ventral central plates 1–4; *Lp*, lateral plate; *Me*, mental plate (fragment); Ml_2–Ml_4, lateral marginal plates 2–4; Mm_3, Mm_4, median marginal plates 3 and 4 respectively; *Mv*, median ventral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *prc*, prepectoral corner.

(pp. 118–121, 133, 295–303), the plate in several cases is abnormal in its sutural connection with the anterior median dorsal plate in that it is overlapped by that plate on an area along the anterior part of its dorsal (dorsomedial) margin (cd_2, tex-fig. 153A, E). It is generally overlapped by the posterior median dorsal plate in the normal way, but may sometimes also be overlapped by that plate anteriorly or abut against that plate anteriorly only with its very edge. Along its ventral margin it seems always to be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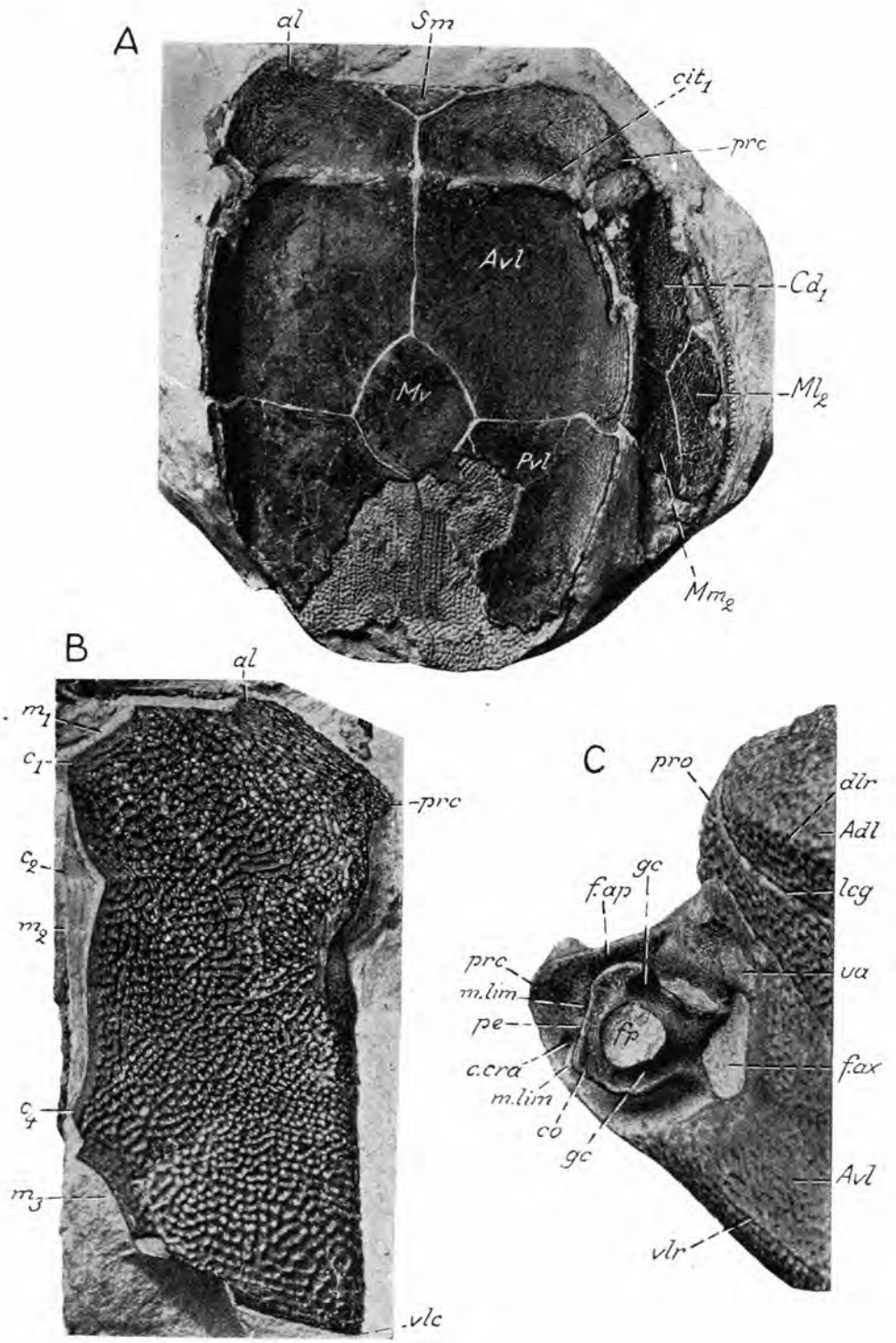
overlapped by the posterior ventro-lateral plate. Its anterior ventro-lateral corner may sometimes be completely separated from the postero-dorso-lateral corner of the anterior ventro-lateral plate by the anterior dorso-lateral and posterior ventro-lateral plates (text-figs. 38, 40, 150D).

The anterior ventro-lateral plate (*Avl*, text-figs. 38, 40, 41A, B, 51, 145A, B, 160–169, 173, 175–178) was rather exhaustively described by the writer at an earlier occasion (Stensiö 1931, pp. 89–102, text-figs. 38, 40, 43–48), on account of which it will be briefly dealt with here. The plate varies somewhat in relative length. In certain cases it is thus about equally long as the posterior ventro-lateral plate, whereas in other cases it is either longer or shorter than that plate. The lateral lamina (text-figs. 38, 40, 51A, 145B, 164C, 165A, C–F, 166E, F) is from about two and a half to nearly three times as long as high, and the ventral lamina (text-figs. 41A, B, 51B, C, 166A–D) from about one and a half to about two and a fourth times as long as broad. The subcephalic division constitutes from about 20–30% of the total length of the ventral lamina. The anterior free margin of the lateral lamina is more or less concave and well bounded off dorsally by the antero-dorsal corner (*adc*), which often is somewhat produced forwards so that it forms a short anteriorly, or somewhat antero-dorsally, pointing process. The dorsal margin of the lamina normally is little concave anteriorly between the antero-dorsal (*adc*) and dorsal (*de*) corners. Behind the last-mentioned corner it slopes gradually somewhat backwards and may there be practically straight, slightly convex, or slightly concave. The postero-dorsal corner is obtuse, but is always somewhat clearly marked. The posterior margin of the lamina may be practically straight, a little convex, a little concave, and sometimes even undulating. The free lateral margin of the ventral lamina (text-figs. 40, 41A, B, 51, 160–164, 165A, B, D–F, 166–169, 175, 176, 178), that is to say the lateral margin of the subcephalic division of the ventral lamina, may be fairly differently shaped in different specimens. It may thus be a little concave, practically straight, more or less convex, or convex as a whole, but with a more or less marked lateral corner or angle somewhat in front of its middle. The antero-lateral corner (*al*) is always present and is also normally well developed. In many cases it points forwards and more

Text-fig. 163. *Bothriolepis canadensis*. *A*, two anterior ventro-lateral plates, somewhat apart, but still not completely detached. Ventral aspect. R. M. specimen No. P. 2810. $\times$ $^3/_2$. *B*, two anterior ventro-lateral plates in natural connection with one another. Ventral aspect. A part of a head-shield also shown. R. M. specimen No. P. 2731. $\times$ $^5/_4$.
Avl, anterior ventro-lateral plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pi*, pineal plate; *Pm*, paranuchal marginal plate; Pmg_1, Pmg_2, anterior and posterior postmarginal plates; *Pp*, postpineal plate; $Sclr_2$, postero-dorsal sclerotic plate; *al*, antero-lateral corner of *Avl*-plate; c_1–c_3, corners of medial margin of *Avl*-plate; *f.ap*, fossa articularis pectoralis; *f.ax*, foramen axillare; m_1, anterior division of medial margin of the ventral lamina of the anterior ventro-lateral plate (for attachment of semilunar plate); m_3, posterior division of medial margin of ventral lamina of anterior ventro-lateral plate (for attachment of median ventral plate); *pbr*, processus brachialis; *prc*, prepectoral corner; *vlc*, posterior ventro-lateral corner of anterior ventro-lateral plate; *vlr*, ventro-lateral ridge.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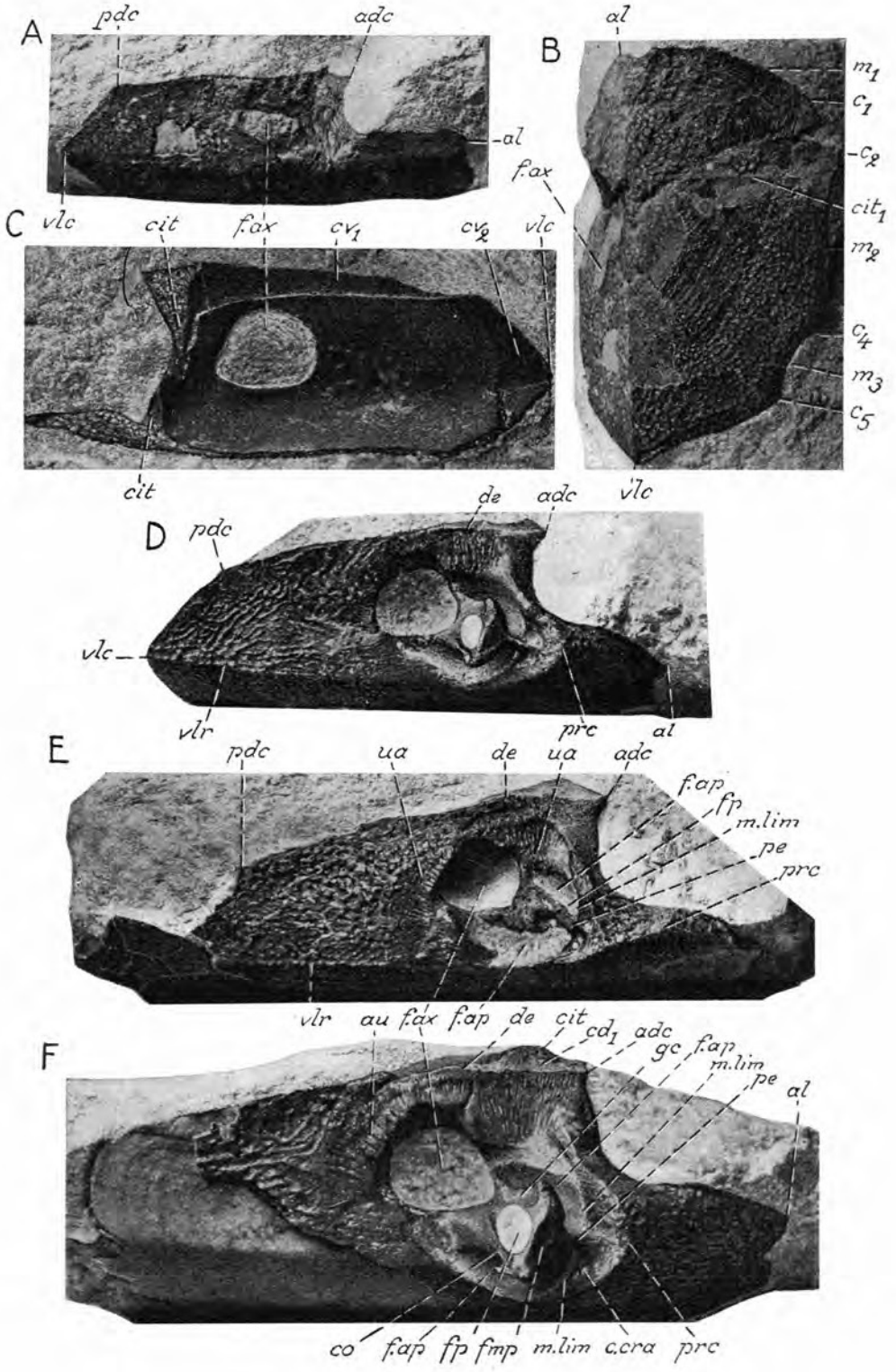
or less medially, but in several cases it may also be directed straight forwards. The anterior margin of the lamina under consideration, thus the anterior margin of the subcephalic division, as a whole generally is somewhat convex or straight, more rarely a little concave. In its most lateral part, just medially to the antero-lateral corner (*al*) it frequently shows a more or less well defined notch, but it may also not rarely be completely devoid of such a notch. The medial margin of the lamina as normally presents three divisions, an anterior (m_1), a middle (m_2) and a posterior (m_3), connected with the semilunar plate, the anterior ventro-lateral plate of the opposite side, and the median ventral plate respectively. The middle one (m_2) of these divisions is provided with one or two median angles or processes (c_2, c_3) which usually are more pronounced on the right than on the left plate. This division of the right plate often exhibits irregular small corners and notches, whereas the corresponding division of the left plate is more regular and straighter. Finally, the posterior margin of the ventral lamina mostly is a little convex in its medial part and a little concave in its lateral part, but may also be developed in the reverse way; sometimes it may be almost straight, or a little concave, or convex throughout its extent. The posterior ventro-lateral corner of the plate is always well-marked. The foramen axillare (*f.ax*, text-figs. 40A, 51A, 145B, 164C, 165, 166E, F, 191D) generally is about as high as it is long and fairly rounded, but may also sometimes be lower than long and oval in outline. The fossa axillaris (*f. ax*), the margo limitans (*m.lim*) of that fossa, and the different formations of the processus brachialis (*co, pe, fp, fmp, gc*) all are well shown in several of the specimens (text-figs. 40A, 51A, 145B, 164C, 165D, F, 166E, F). The fossa articularis pectoralis is well bounded off anteriorly towards the lateral face of the subcephalic division of the plate.

Text-fig. 164. *Bothriolepis canadensis*. *A*, ventral wall of a trunk-armour seen from the inner (dorsal) side. The posterior ventro-lateral plates partly represented by impressions of their outer (lower) side. On the right side the proximal segment of the pectoral fin exposed from the dorsal side. R. M. specimen No. P. 2705. Nat. size. *B*, a left anterior ventro-lateral plate in ventral aspect. R. M. specimen No. P. 2139. × $^3/_2$. *C*, the fossa articularis pectoralis and the processus brachialis in postero-lateral aspect. R. M. specimen No. P. 2121 (same specimen as in Text-fig. 145 A, B). × 2.

Adl, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; Cd_1, dorsal central plate 1; Ml_2, lateral margin plate 2; Mm_2, medial marginal plate 2; *Mv*, median ventral plate; *Sm*, semilunar plate; *al*, antero-lateral corner of anterior ventro-lateral plate; c_1–c_3, corners of the medial margin of the anterior ventro-lateral plate; cil_1, postbranchial crest (anterior one of the two ventral crests in which the crista transversalis interna anterior divides ventrally); *co*, pars condyloidea of processus brachialis; *c.cra*, opening of a canal; *dlr*, dorso-lateral ridge; *f.ap*, fossa articularis pectoralis; *f.ax*, foramen axillare; *fp*, funnel pit; *gc*, groove dorsally and ventrally to funnel pit; *lcg*, lateral line groove; m_1, m_2, m_3, anterior, middle and posterior divisions of medial margin of ventral lamina of anterior ventro-lateral plate (for attachment of semilunar plate, anterior ventro-lateral plate of opposite side, and median ventral plate respectively); *m.lim*, dorsal and ventral margo limitans, in all probability developed for attachment of articular capsule of pectoral joint; *pe*, pars pedalis of processus brachialis; *prc*, prepectoral corner; *ua*, unornamented area dorsally to fossa articularis pectoralis and around foramen axillare; *vlc*, ventro-lateral corner of anterior ventro-lateral plate; *vlr*, ventro-lateral ridge.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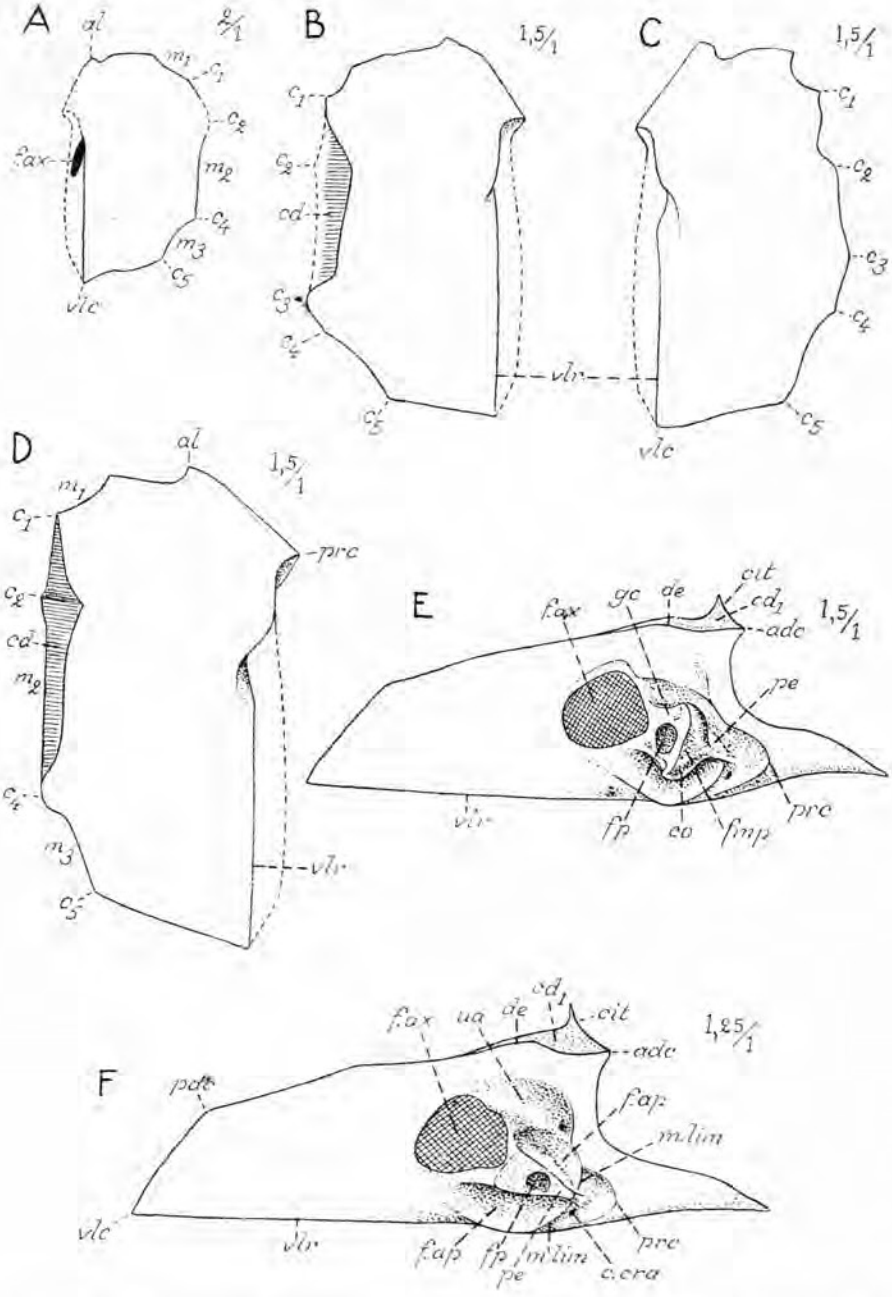
The plate here under consideration does not only overlaps the anterior dorso-lateral plate, but is also always to some extent overlapped by it. Generally it is overlapped by the said plate only on an area most anteriorly (cd_1, text-figs. 51A, 165D–F, 166E, F), but sometimes it may also be overlapped almost along its entire dorsal margin. In the latter cases it is thus embraced by the anterior dorso-lateral plate almost to the same extent as in *B. groenlandica* (text-fig. 288). In several cases the plate does not abut against the anterior ventro-lateral corner of the mixilateral plate, but is entirely separated from that corner by the anterior dorso-lateral and posterior ventro-lateral plates (text-fig. 40).

The posterior ventro-lateral plate (*Pvl*, text-figs. 38, 40, 41A, B, 53A, B, 160–162, 164A, 167–178) is rarely complete, its lateral lamina generally being absent, or else compressed, crushed and much damaged. This lamina is from about somewhat less than twice to about two and a half times as long as high. The ventral lamina is from not fully twice to about two and a third times as long as it is broad. The length of the subanal division mostly seems to be between one fourth and one third of the total length of the ventral lamina. The anterior margin of the lateral lamina usually is somewhat concave. The antero-dorsal corner (*ad*) is well pronounced, and just behind it there is sometimes a special short margin (text-fig. 40; *mda*, text-fig. 174E) by means of which the plate abutted against the anterior dorso-lateral plate of its side. The dorsal corner (*dc*) generally is obtuse and slightly pronounced (text-fig. 174E, F), but may sometimes also be somewhat more pointed and well-marked (text-fig. 53A). The anterior division

Text-fig. 165. *Bothriolepis canadensis*. *A*, *B*, a small deficient right anterior ventro-lateral plate in lateral and ventral aspects respectively. R. M. specimen No. P. 2741. × 2. *C*, a deficient right anterior ventro-lateral plate, seen from the medial side. R.M. specimen No. P. 2214. × $^3/_2$. *D–F*, three right anterior ventro-lateral plates in lateral aspect. In the plate shown in *E* the processus brachialis is broken off near its base. R. M. specimen Nos. P. 2180, 2731 (same as in text-fig. 163 B), and 2868 respectively. *D*, × $^3/_2$. *E*, × $^4/_5$. *F*, × 2. *adc*, antero-dorsal corner of lateral lamina; *al*, antero-lateral corner of subcephalic division of ventral lamina; c_1, corner between anterior (m_1) and middle (m_2) divisions of medial margin of ventral lamina; c_2, corner on middle division (m_2) of ventral lamina; c_4, corner between middle (m_2) and posterior (m_3) divisions of medial margin of ventral lamina; c_5, posterior medial corner of ventral lamina (= posterior ventro-medial corner of the plate as a whole); cd_1, area overlapped by anterior dorso-lateral plate; *cit*, crista transversalis interna anterior (vertical portion); cit_1, postbranchial crest (= anterior ventral branch of crista transversalis interna anterior); *co*, pars condyloidea of processus brachialis; cv_1, area overlapping anterior dorso-lateral plate; cv_2, area overlapping posterior ventro-lateral plate; *c.cra*, opening of a canal; *de*, dorsal corner or angle; *f.ap*, fossa articularis pectoralis; *f.ax*, foramen axillare; *fmp*, protractor area; *fp*, funnel pit; m_1, anterior division of medial margin of ventral lamina, connected with semilunar plate; m_2, middle division of medial margin of ventral lamina, connected with anterior ventro-lateral plate of opposite side; m_3, posterior division of medial margin of ventral lamina, connected with median ventral plate; *m.lim*, dorsal and ventral margo limitans, in all probality developed for the attachment of the articular capsule of the pectoral joint; *pdc*, postero-dorsal corner of lateral lamina; *pe*, pars pedalis of processus brachialis; *prc*, prepectoral corner of lateral lamina; *pe*, pars pedalis of processus brachialis; *prc*, prepectoral corner; *ua*, unornamented area postero-dorsally to fossa articularis pectoralis and around foramen axillare; *vlc*, posterior ventro-lateral corner; *vlr*, ventro-lateral ridge.



Text-fig. 166. *Bothriolepis canadensis*. *A–D*, restorations of four anterior ventro-lateral plates in ventral aspect. *A*, *C*, two right, and *B*, *D*, two left plates. *E*, *F*, restorations of two right anterior ventro-lateral plates in lateral aspect. In *F*, the pars condyloidea of the processus brachialis removed.

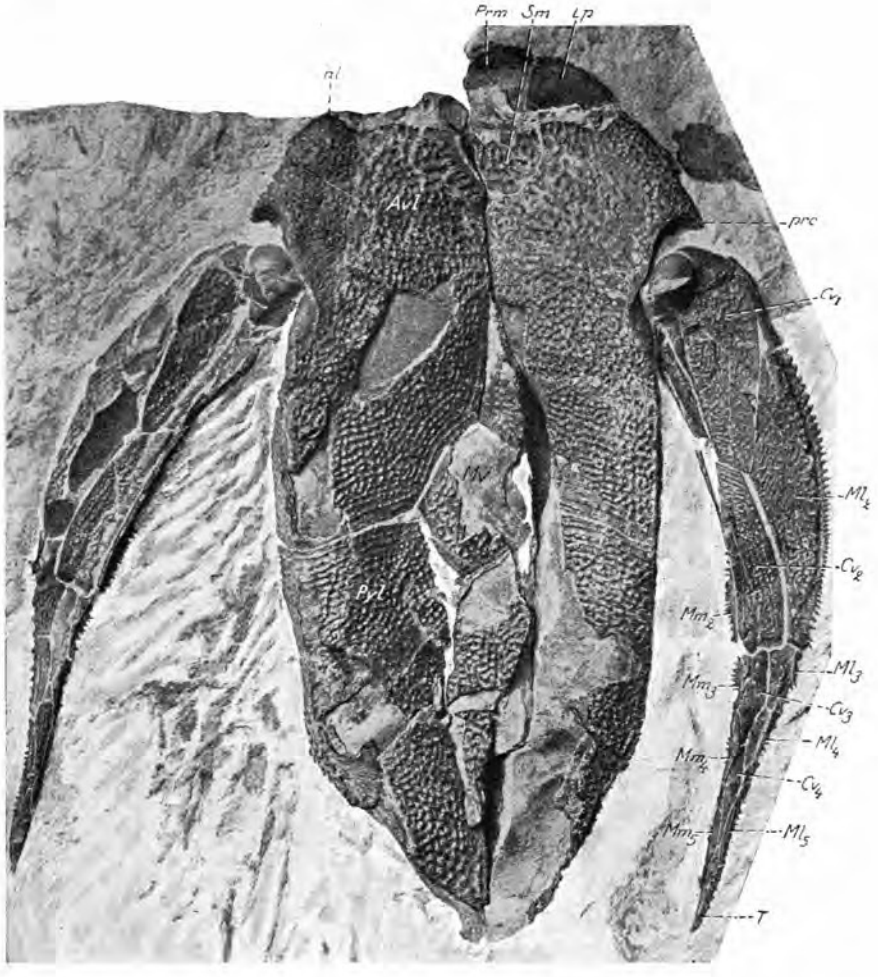
adc, antero-dorsal corner of lateral lamina; *al*, antero-lateral corner of the subcephalic division of the ventral lamina; c_1, corner between anterior(m_1) and middle (m_2) divisions

of the dorsal margin that lies in front of the dorsal corner mostly is a little concave or slightly undulating, whereas the posterior division of the same margin is straight or a little convex. The postero-dorsal corner (*pdlc*) is obtuse and often very obscure. The anterior margin of the ventral lamina may be straight or a little concave. The anterior division (ma_1) of the medial margin of the ventral lamina is generally shorter than the anterior margin of the same lamina, but may in certain cases be equally long as, or even longer than, that margin (text-figs. 172A, D, 174D). The posterior division division (ma_2) of the medial margin of the ventral lamina mostly is somewhat undulating, particularly on the left plate. It is characterized above all by the presence of a medial posterior corner or convexity (cm_3), situated a little behind its middle, a corner or convexity which on the left plate is always broad and rounded off, whereas on the right plate it may often be slightly developed and at least sometimes clearly angular. Finally, the free lateral margin of the subanal division of the ventral lamina always is strongly convex, particularly in its posterior part. In front of the ventral division of the crista transversalis interna posterior (*crtp*) there is normally a low broad transversalis thickening on the inner side of the ventral lamina (*tv*, text-figs. 172C, 173). This thickening begins at the lower end of the vertical division of the crista transversalis interna posterior and, running in a straight medial direction, meets the corresponding thickening of the opposite side in the median line. It increases often clearly in breadth in a medial direction.

The plate may sometimes abut against the anterior dorso-lateral plate with a short margin developed just behind its anterior dorsal corner. The sutural connections of the plate are otherwise as normally, with the exception, however, that in certain cases the right plate may overlap the left one for a short distance (*cd*, text-figs. 172D, 174D) just behind the posterior corner (cm_3).

The semilunar plate (*Sm*, text-figs. 8, 12, 34, 41A, B, 110, 112A, B, 113A, C, 160–162, 164A, 167–169, 176) is very variable as to proportions and shape. Its length ranges from about one half to about a fourth of its

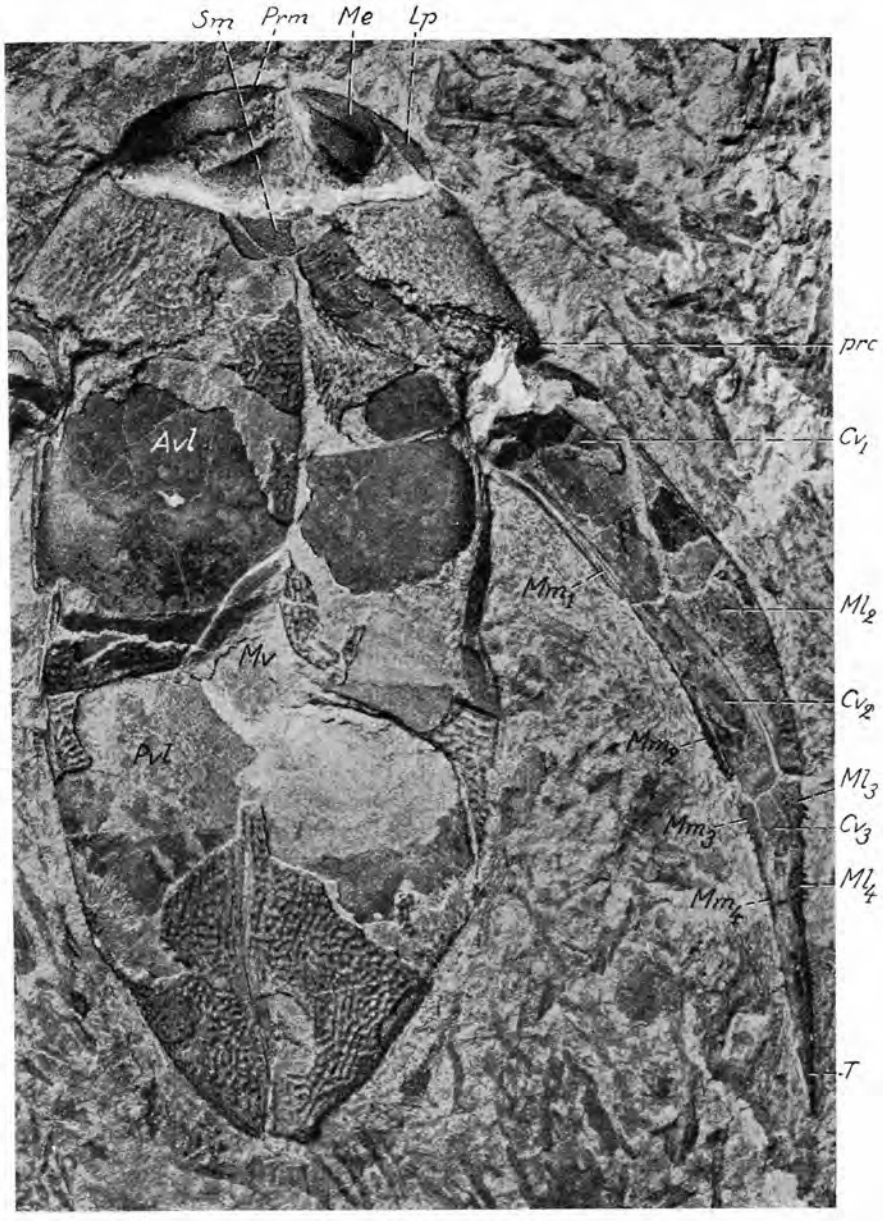
of medial margin of ventral lamina; c_2, c_3, corners on middle division (m_2) of ventral lamina; c_4, corner between middle (m_2) and posterior (m_3) divisions of medial margin of ventral lamina; c_5, posterior medial corner of ventral lamina (= posterior ventro-medial corner of the plate as a whole); *cd*, area overlapped by right anterior ventro-lateral plate; cd_1, area overlapped by anterior dorso-lateral plate; *cit*, crista transversalis interna anterior; *co*, pars condyloidea of processus brachialis; *c.cra*, opening of a canal; *de*, dorsal corner or angle; *f.ap*, fossa articularis pectoralis; *f.ax*, foramen axillare; *fmp*, protractor area; *fp*, funnel pit; *gc*, groove dorsally and ventrally to funnel pit; m_1, anterior division of medial margin of ventral lamina, connected with semilunar plate; m_2, middle division of medial margin of ventral lamina, connected with anterior ventro-lateral plate of opposite side; m_3, posterior division of medial margin of ventral lamina, connected with median ventral plate; *m.lim*, dorsal and ventral margo limitans, in all probality developed for the attachment of the articular capsule; *pdc*, postero-dorsal corner of lateral lamina; *pe*, pars pedalis of processus brachialis; *prc*, prepectoral corner; *ua*, unornamented area postero-dorsally to fossa articularis pectoralis and around foramen axillare; *vlc*, posterior ventro-lateral corner; *vlr*, ventro-lateral ridge.



Text-fig. 167. *Bothriolepis canadensis*. Medium-sized specimen in ventral aspect. Trunk-armour much flattened and crushed. R. M. specimen No. P. 2675. Slightly diminished. *Avl*, anterior ventro-lateral plate; Cv_1–Cv_4, ventral central plates 1–4; *Lp*, lateral plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *Mv*, median ventral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *T*, terminal plate; *al*, antero-lateral corner of ventral lamina of anterior ventro-lateral plate; *prc*, prepectoral corner.

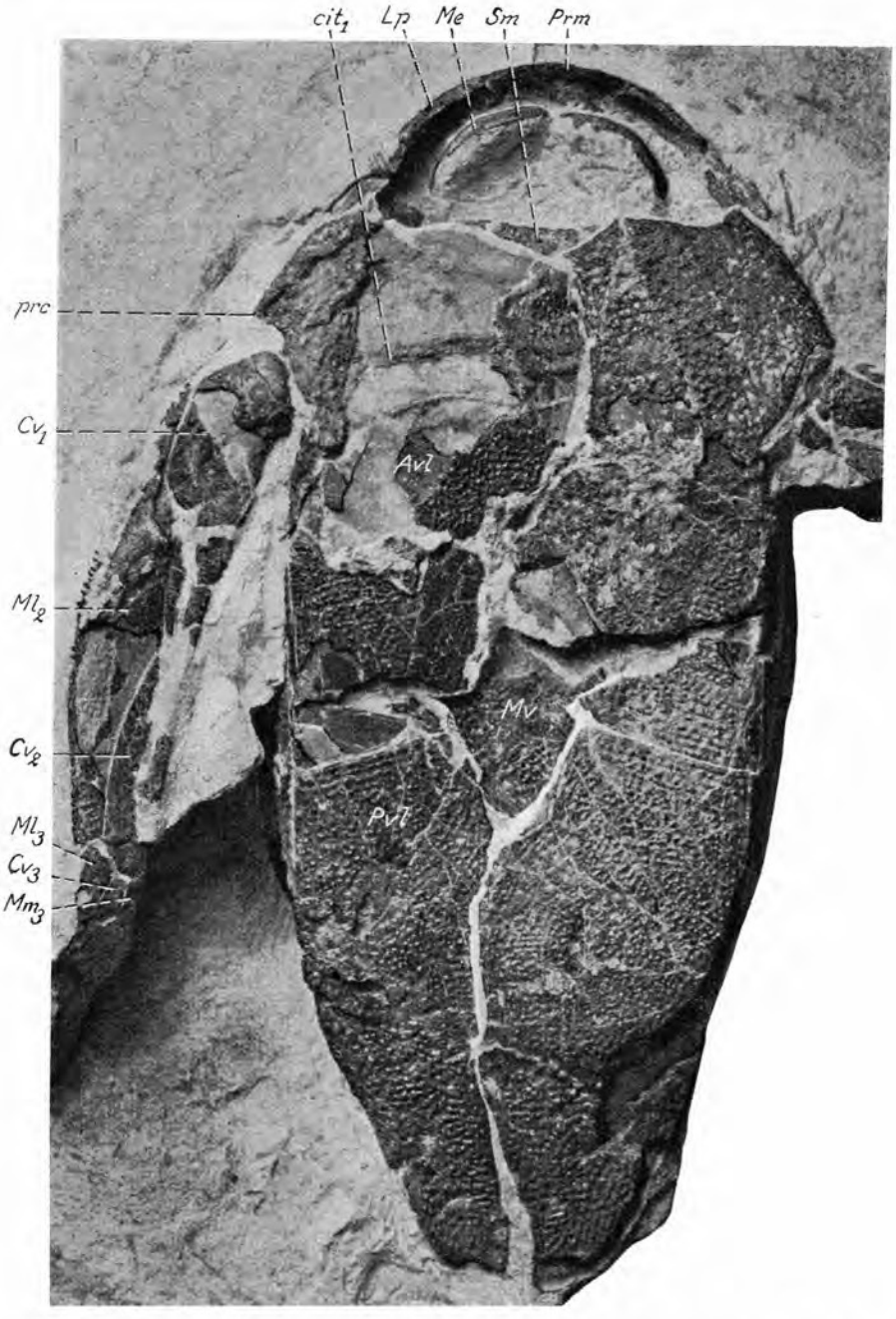
breadth. The plate in some cases is decidedly triangular, in other cases semilunar in outline. At least sometimes it is clearly overlapped by the anterior ventro-lateral plates.

Although it varies somewhat in relative size the median ventral plate (*Mv*, text-figs. 41A, B, 150B, 160–162, 164A, 167–169, 171B, 173, 175–178) is comparatively small in proportion to the size of the ventral wall of the trunk-armour. The plate is longer than broad, but sometimes the



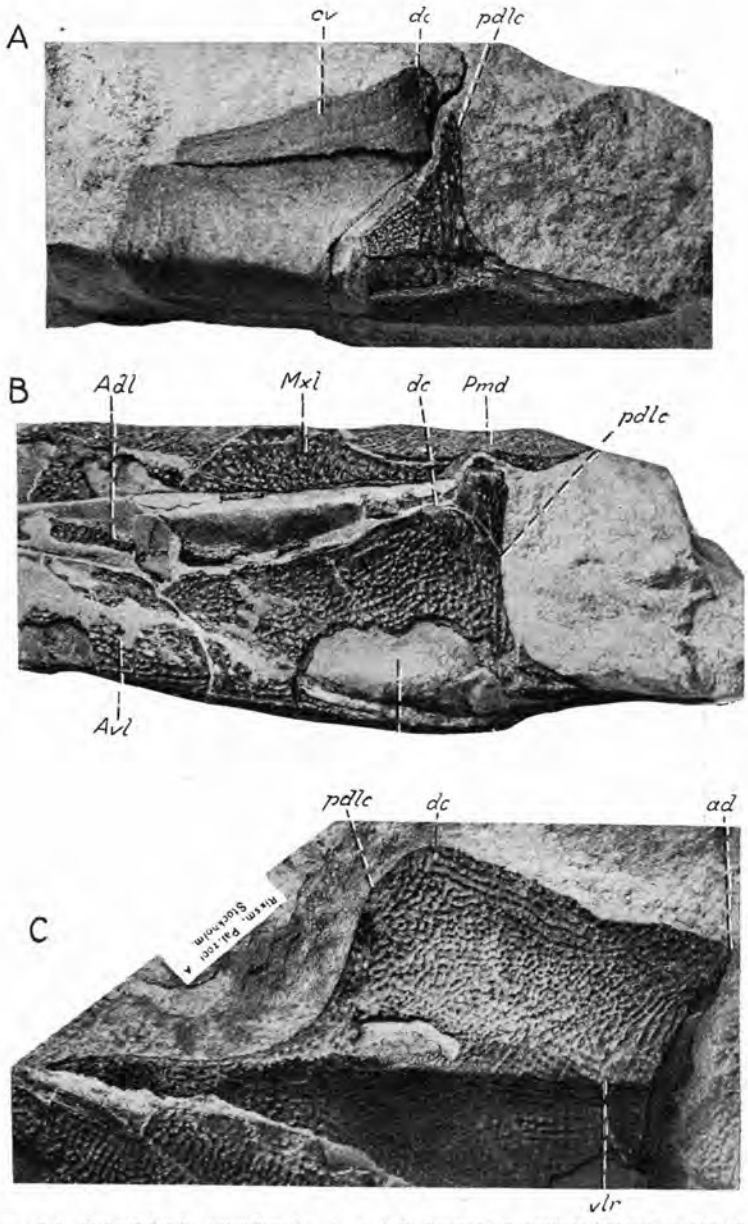
Text-fig. 168. *Bothriolepis canadensis*. Medium-sized specimen in ventral aspect, but with the right pectoral fin omitted. The plates of the trunk-armour and pectoral fin to a large extent preserved as impressions of their inner sides. R. M. specimen No. P. 2783. Somewhat less than 1.5 of the natural size.

Avl, anterior ventro-lateral plate; Cv_1–Cv_3, ventral central plates 1–3; *Lp*, lateral plate; *Me*, mental plate (impression); Ml_2–Ml_4, lateral marginal plates 2–4; Mm_1–Mm_4, medial marginal plates 1–4; *Mv*, median ventral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *T*, terminal plate; *prc*, prepectoral corner.



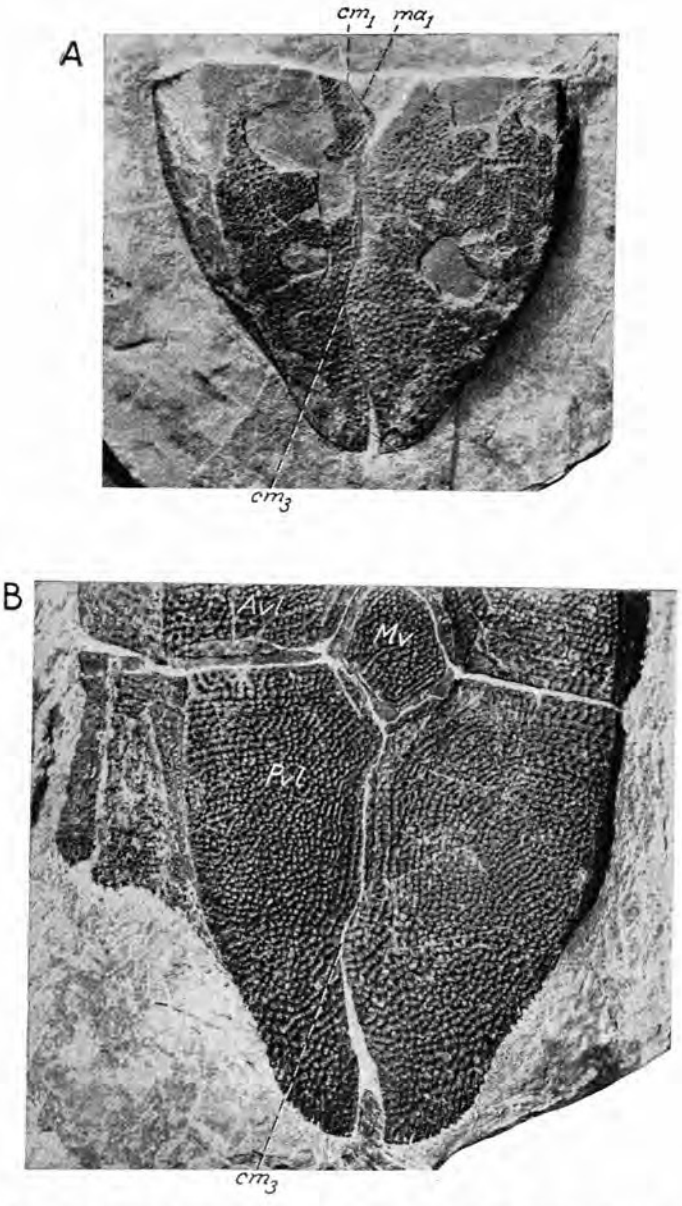
Text-fig. 169. *Bothriolepis canadensis*. Medium-sized specimen, somewhat crushed and compressed. Ventral aspect. R. M. specimen No. 2854 (same specimen as in text-figs. 80 B and 170 B. About $^5/_4$ of the natural size.

Avl, anterior ventro-lateral plate; Cv_1–Cv_3, ventral central plates 1–3; *Lp*, lateral plate; *Me*, mental plate (labial part); Ml_2–Ml_3, lateral marginal plates 2 and 3 respectively; Mm_3, medial marginal plate 3; *Mv*, median ventral plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; cit_1, postbranchial crest; *pre*, pre-pectoral corner.



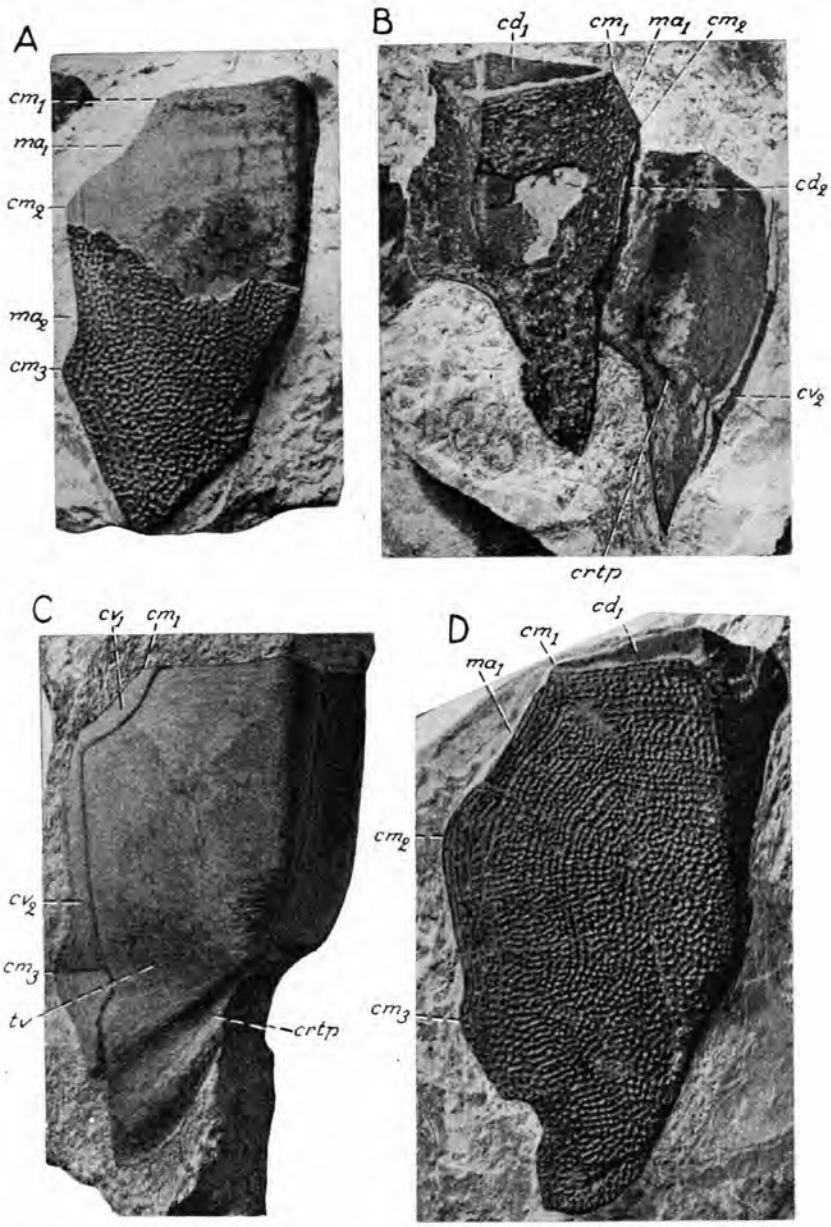
Text-fig. 170. *Bothriolepis canadensis*. *A*, a left posterior ventro-lateral plate in lateral aspect. The plate to a large extent preserved as impression of its internal side. R. M. specimen No. P. 2338. × 1.75. *B*, posterior part of a dorso-ventrally compressed trunk-armour seen from the left side and showing somewhat well the lateral lamina of the posterior ventro-lateral plate. R. M. specimen No. P. 2854 (same specimen as in text-figs. 80 B and 169). × 1.3. *C*, somewhat flattened posterior ventro-lateral plate in lateral aspect. R. M. specimen No. P. 2679. × 1.3.

Adl, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; *ad*, antero-dorsal corner of lateral lamina of *Pvl*-plate; *cv*, area overlapping mixilateral plate (impression); *dc*, dorsal corner (of lateral lamina and of *Pvl*-plate); *pdlc*, postero-dorsal corner of lateral lamina of *Pvl*-plate; *vlr*, ventro-lateral ridge.



Text fig. 171. *Bothriolepis canadensis*. *A*, *B*, two posterior ventro-lateral plates in their natural connection with one another. Ventral aspect. R. M. specimens Nos. 2115 and P. 2179. Nat. size.

Avl, anterior ventro-lateral plate; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; cm_1, antero-medial corner of ventral lamina of *Pvl*–plate; cm_3, posterior corner or convexity on posterior division of medial margin of ventral lamina of *Pvl*-plate; ma_1, anterior division of medial margin of lateral lamina of *Pvl*-plate (this division connected with median ventral plate).



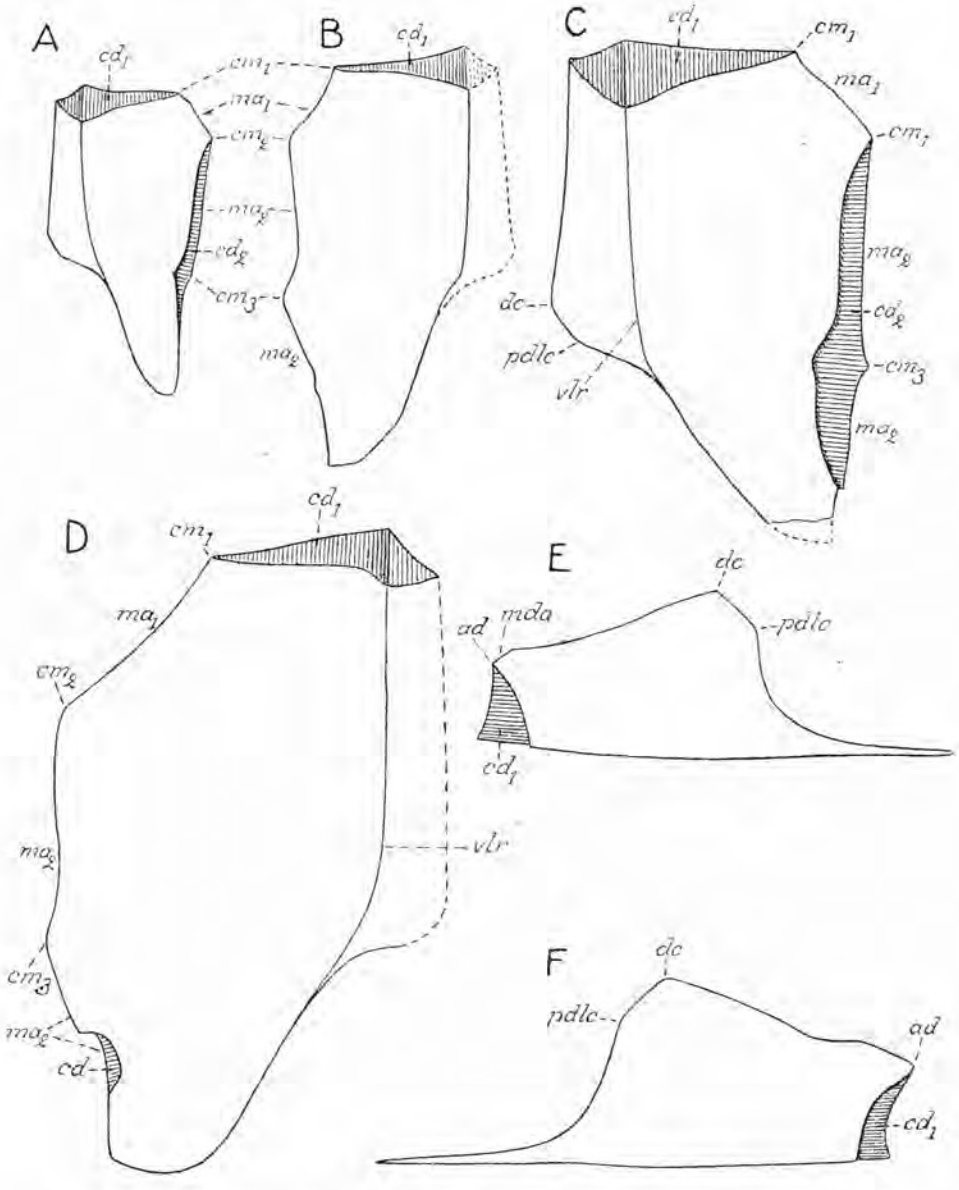
Text-fig. 172. *Bothriolepis canadensis*. *A*, left posterior ventro-lateral plate in ventral aspect. Partly preserved as an impression of its inner side. R. M. specimen No. P. 2756. Nat. size. *B*, two small detached posterior ventro-lateral plates, both somewhat flattened. The right plate seen mainly from below, the left plate from the medial side. R. M. specimen No. P. 2748. × 1,3. *C*, impression of the internal side of a left posterior ventro-lateral plate. Ventral aspect. R. M. specimen No. P. 2116. × 1,3. *D*, left posterior ventro-lateral plate in ventral aspect. R. M. specimen No. P. 2805. Diminished.

cd_1, area overlapped by anterior ventro-lateral plate; cd_2, area overlapped by left posterior ventro-lateral plate; cm_1, antero-medial corner of ventral lamina; cm_2, middle corner of

ventral lamina just behind median ventral plate; cm_3, posterior corner of ventral lamina; *crtp*, crista transversalis interna posterior; cv_1, area overlapping median ventral plate (impression); cv_2, area overlapping right posterior ventro-lateral plate; ma_1, anterior division of medial margin of ventral lamina, connected with median ventral plate; ma_2, posterior division of medial margin of ventral lamina, connected with the corresponding division of the medial lamina of the posterior ventro-lateral plate of the opposite side; *tv*, transverse thickening in front of the ventral horizontal part of the crista transversalis interna posterior (impression).

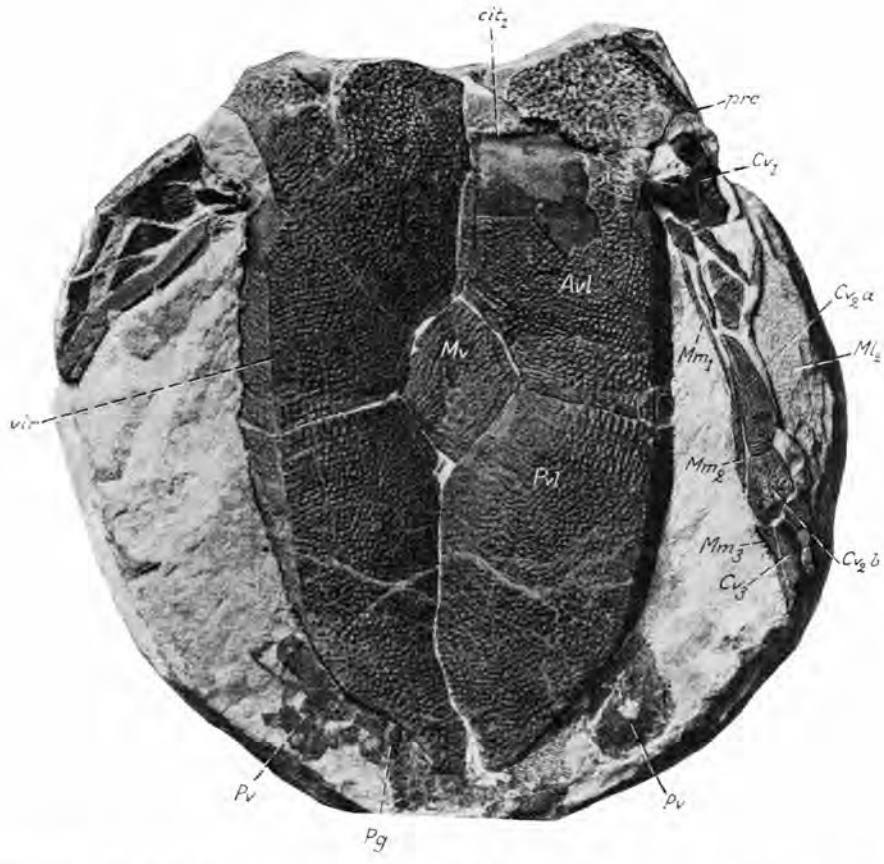


Text-fig. 173. *Bothriolepis canadensis*. Deficient specimen in ventral aspect. Parts of the head and the ventral wall of the trunk-armour shown. The ventral wall of the trunk-armour preserved mainly as an impression of its internal side. R. M. specimen No. P. 2114 (same specimen as in text-figs. 107, 108, 146 and 150 D). Nat. size.
Avl, anterior ventro-lateral plate; *Cn*, centro-nuchal plate; *Ifg*, inferognathal; *Mv*, median ventral plate; *Prl*, prelateral plate; *Py*, infraprelateral plate; *Pvl*, posterior ventro-lateral plate; *Sb*, submandibular series of bones; cit_1, postbranchial crest; *crtp*, crista transversalis interna posterior (impression); *tv*, transverse thickening in front of the ventral part of the crista transversalis interna posterior (impression).



Text-fig. 174. *Bothriolepis canadensis*. *A–D*, restorations of four posterior ventro-lateral plates. Ventral aspect. *A*, *C*, right plates; *B*, *D*, left plates; *E*, *F*, restorations of two posterior ventro-lateral plates, a left and a right one respectively, in lateral aspect. *A–E*, nat. size.

ad, antero-dorsal corner of lateral lamina; *cd*, area overlapped by right posterior ventro-lateral plate; cd_1, area overlapped by anterior ventro-lateral plate; cd_2, area overlapped by left posterior ventro-lateral plate; cm_1, antero-medial corner of ventral lamina; cm_2, middle corner of ventral lamina just behind median ventral plate; cm_3, posterior corner of ventral lamina; *dc*, dorsal corner of lateral lamina; ma_1, anterior division of medial margin of ventral lamina, connected with median ventral plate; ma_2, posterior division of medial margin of ventral lamina, connected with the corresponding division of the medial lamina of the posterior ventro-lateral plate of the opposite side; *mda*, short margin, connected with anterior dorso-lateral plate; *pdlc*, postero-dorsal corner of lateral lamina; *vlr*, ventro-lateral ridge.

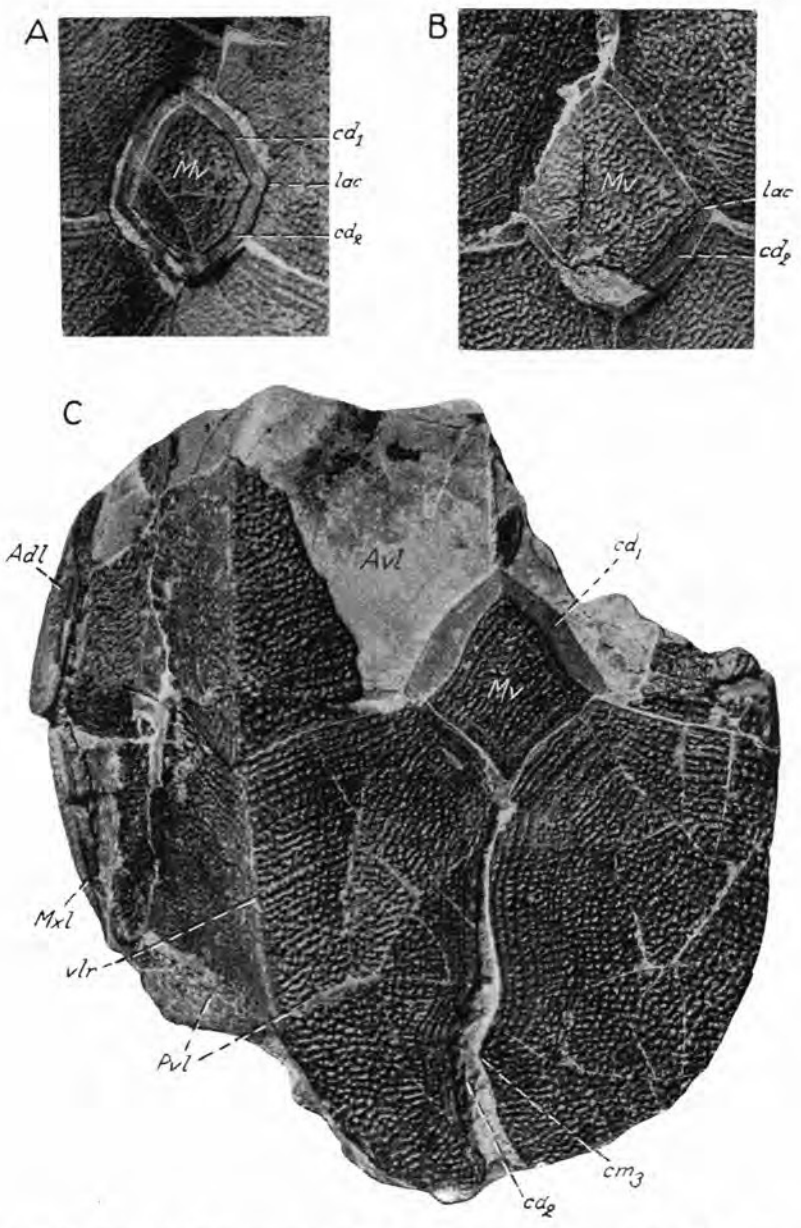


Text-fig. 175. *Bothriolepis canadensis*. Somewhat deficient trunk-armour with parts of the pectoral fins in ventral aspect. Laterally to, and behind, the subanal division of the ventral wall of the trunk-armour there are remains of the pelvic fins (*V*) and of the scale covering of the trunk. Worthy of notice is also that the ventral central plate of the left pectoral fin is divided into an anterior and a posterior element. R. M. specimen No. P. 2287 (same specimen as in text-figs. 55, 56, 59, 60 and 133). Approximately $^3/_4$ of the natural size. *Avl*, anterior ventro-lateral plate; Cv_1, ventral central plate1; Cv_2a, Cv_2b, anterior and posterior ventral central elements 2; Cv_3, ventral central plate 3; Ml_2, lateral marginal plate 2; Mm_1–Mm_3, medial marginal plates 1–3; *Mv*, median ventral plate; *Pg*, bone-element conceivably belonging to pelvic fin; *Pv*, pelvic fin; *Pvl*, posterior ventro-lateral plate; cit_1, postbranchial crest (impression); *prc*, prepectoral corner; *vlr*, ventro-lateral ridge.

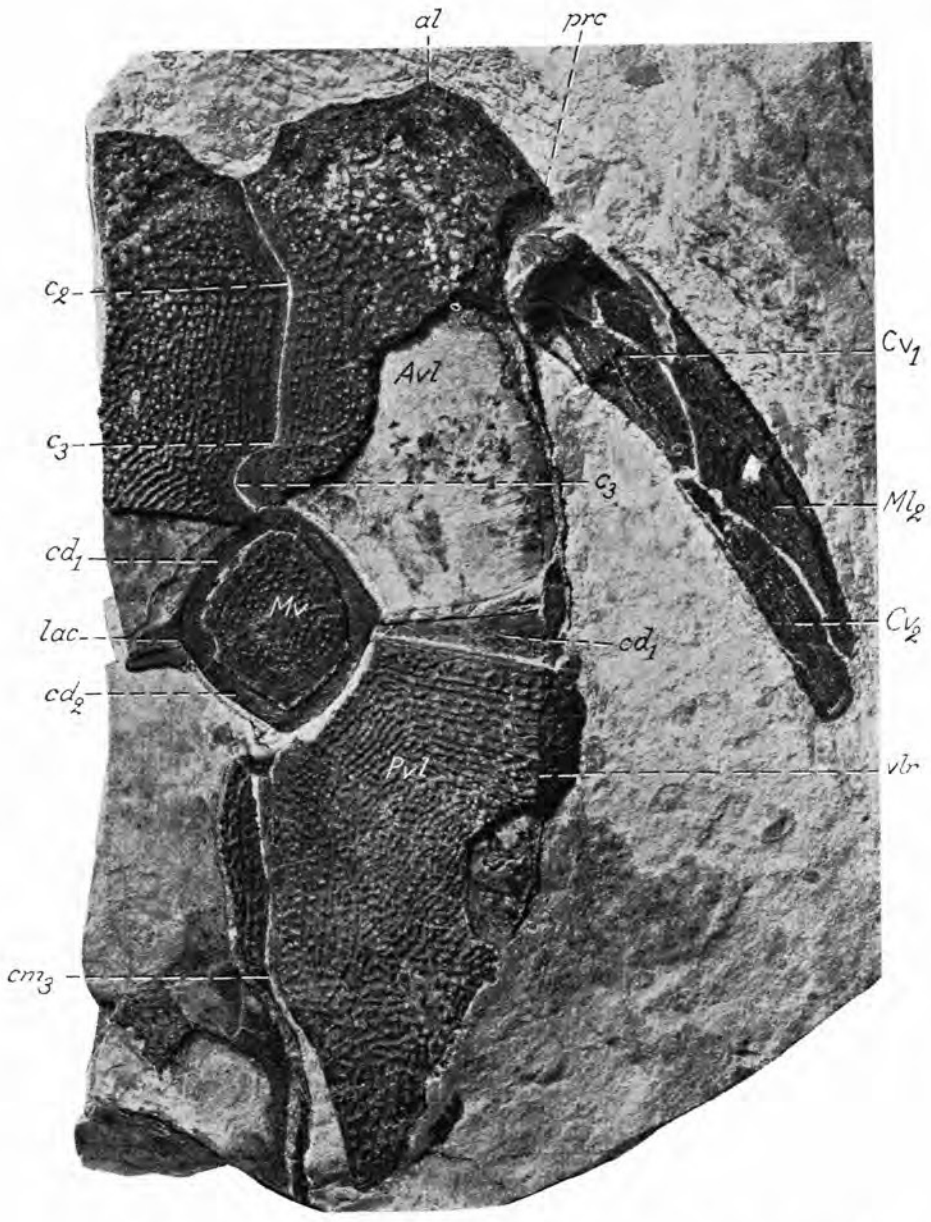
length is only slightly greater the breadth. The anterior division of the plate, situated in front of the lateral corners (*lac*), is longer than the posterior division, situated behind the said corners; and in this special feature the plate clearly differs from the corresponding plate both in *B. cellulosa* and *B. groenlandica* (cf. p. 141, and pp. 421–569 below). The breadth of the exposed ornamented area of the plate is from about one fourth to about one third of the maximum breadth of the ventral wall of the trunk-armour; the length of this area ranges from about one eighth to about almost one fifth of the



Text-fig. 176. *Bothriolepis canadensis*. Deficient trunk-armour with parts of the pectoral fins. Ventral aspect. R. M. specimen No. P. 2415. About $^5/_4$ of the natural size.
Avl, anterior ventro-lateral plate; Cv_1–Cv_3, ventral central plates 1–3; Ml_2, lateral marginal plate 2; Mm_3, medial marginal plate 3; *Me*, mental plate; *Mv*, median ventral plate; *al*, antero-lateral corner of subcephalic division of anterior ventro-lateral plate; c_2, corner on middle division (m_2) of ventral lamina of the *Avl*-plate; cm_3, posterior corner of ventral lamina of the *Pvl*-plate; *prc*, prepectoral corner.

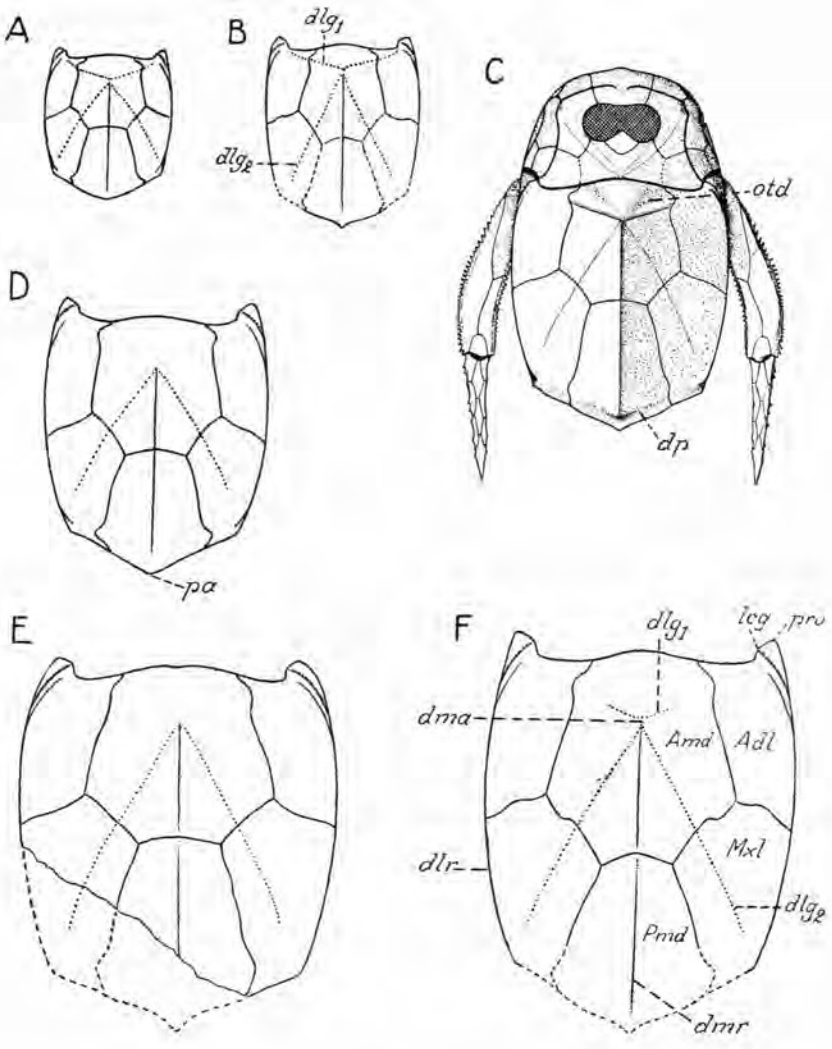


Text-fig. 177. *Bothriolepis canadensis*. *A–B*, median parts of ventral wall of two trunk-armours, showing the median ventral plate. External aspect. R.M. specimens Nos. P. 2177 and 2565 respectively. × 1.2. *C*, posterior parts of a somewhat flattened and crushed trunk-armour in ventral aspect. R. M. specimen No. P. 2629. Natural size.
Adl, anterior dorso-lateral plate; *Avl*, anterior ventro-lateral plate; *Mv*, median ventral plate; *Mxl*, mixilateral plate; *Pvl*, posterior ventro-lateral plate; cd_1, area overlapped by anterior ventro-lateral plate; cd_2, areas overlapped by posterior ventro-lateral plate; cm_3, posterior corner of ventral lamina of *Pvl*-plate; *lac*, lateral corner of *Mv*-plate; *vlr*, ventro-lateral ridge.



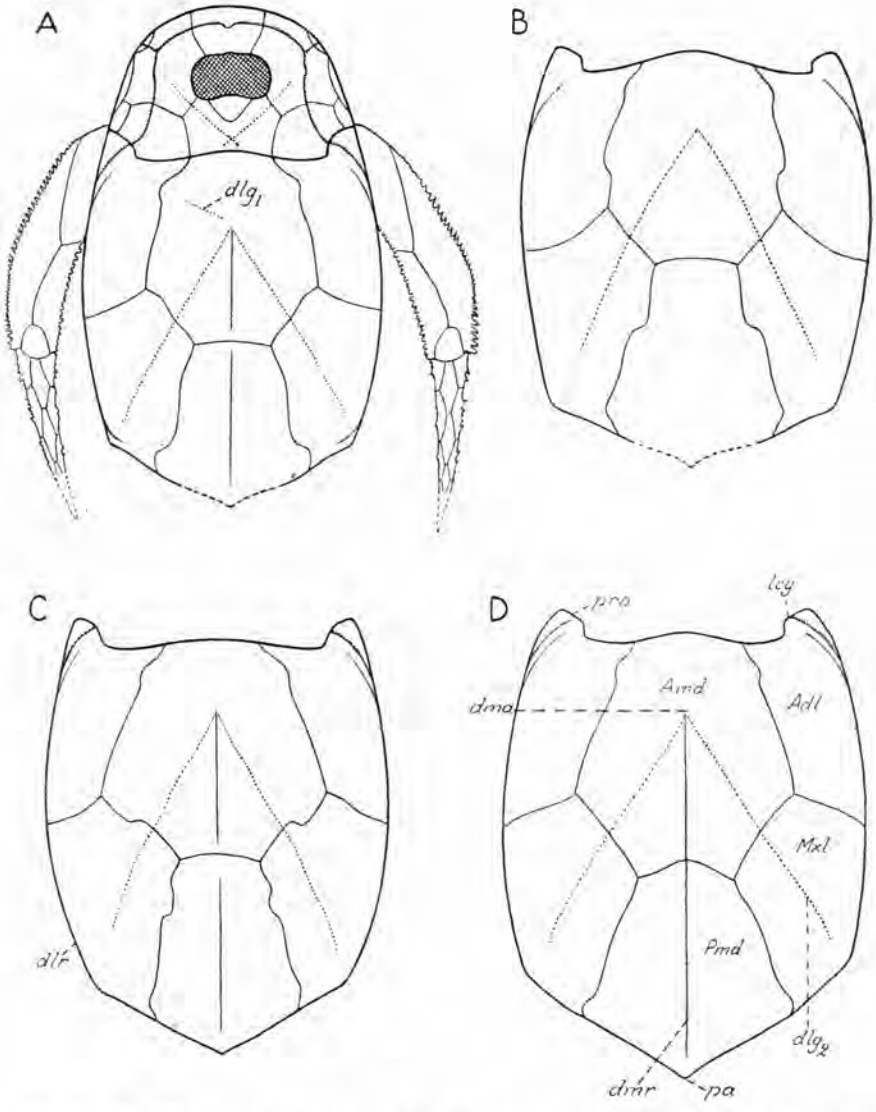
Text-fig. 178. *Bothriolepis canadensis*. Deficient ventral wall of a trunk-armour and a proximal segment of a left pectoral fin in ventral aspect. Certain of the plates of the ventral wall of the trunk-armour partly or mainly represented by impressions of their internal sides. R. M. specimen No. P. 2788. × $^3/_2$.

Avl, anterior ventro-lateral plate; Cv_1, Cv_2, ventral central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; *al*, antero-lateral corner of subcephalic division of *Avl*-plate; c_2, c_3, convexities or corners on the middle division of the medial margin of the ventral lamina of the *Avl*-plate; cd_1, cd_2, overlapped areas; cm_3, posterior corner of ventral lamina of *Pvl*-plate; *lac*, lateral corner of median ventral plate; *prc*, prepectoral corner.

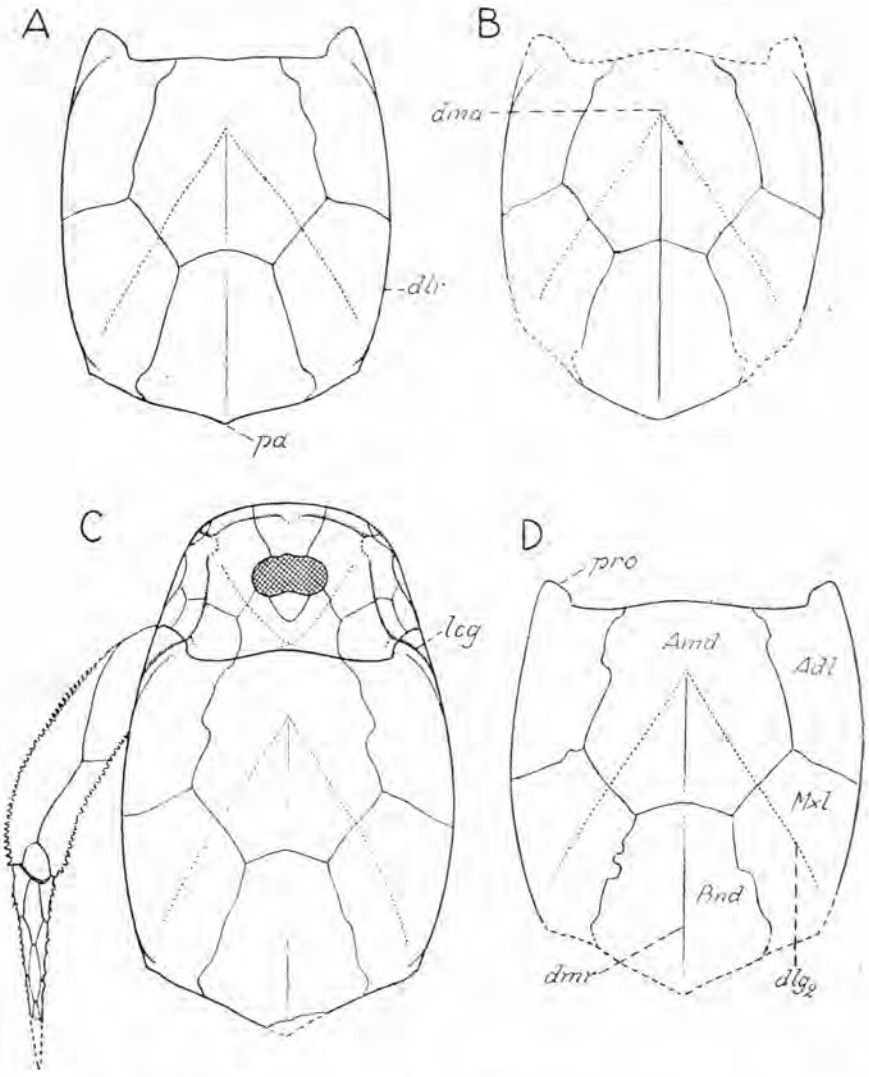


Text-fig. 179. *Bothriolepis canadensis*. *A–F*, restorations of six small trunk-armours in dorsal aspect. In *C* also the head-shield and pectoral fins restored. *A–D*, of four very small specimens (length of dorsal wall 1,85, 2,4, 3,3 and 3,4 cm respectively). *E*, *F*, of two somewhat larger specimens (length of dorsal wall 4,66 and 5 cm respectively). Approximately natural size.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior mediandorsal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *dp*, depression above median dorsal part of crista transversalis interna posterior; *leg*, main lateral line groove; *otd*, oblique transverse depression above postlevator thickening (*alr*); *pa*, posterior angle of posterior median dorsal plate; *pro*, processus obstans.

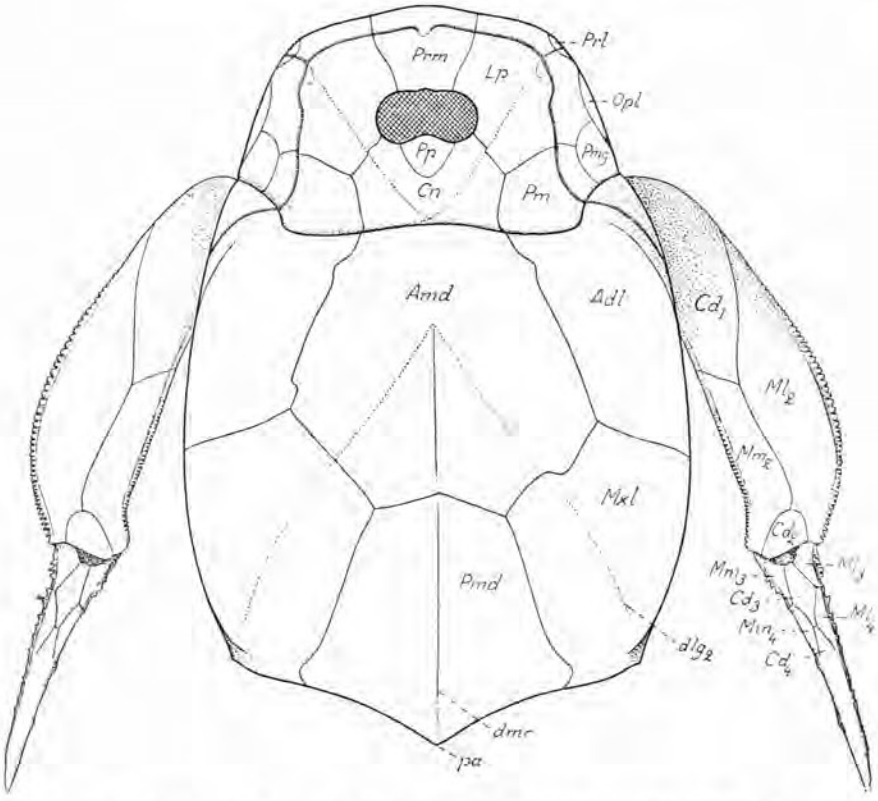


Text-fig. 180. *Bothriolepis canadensis*. *A–D*, restorations of four medium-sized trunk-armours in dorsal aspect. In *A*, also the head-shield and pectoral fins restored. (Dorsal wall of trunk-armour 6–7,6 cm long). About $^3/_4$ of the natural size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *lcg*, main lateral line groove; *pa*, posterior angle of posterior median dorsal plate; *pro*, processus obstans.



Text-fig. 181. *Bothriolepis canadensis*. *A–D*, restorations of four large medium-sized and large trunk-armours in dorsal aspect. In *C* also the head-shield and the left pectoral fin restored. (Dorsal wall of trunk-armour 9,6–10,4 cm long). Approximately × $^1/_2$ of the natural size.

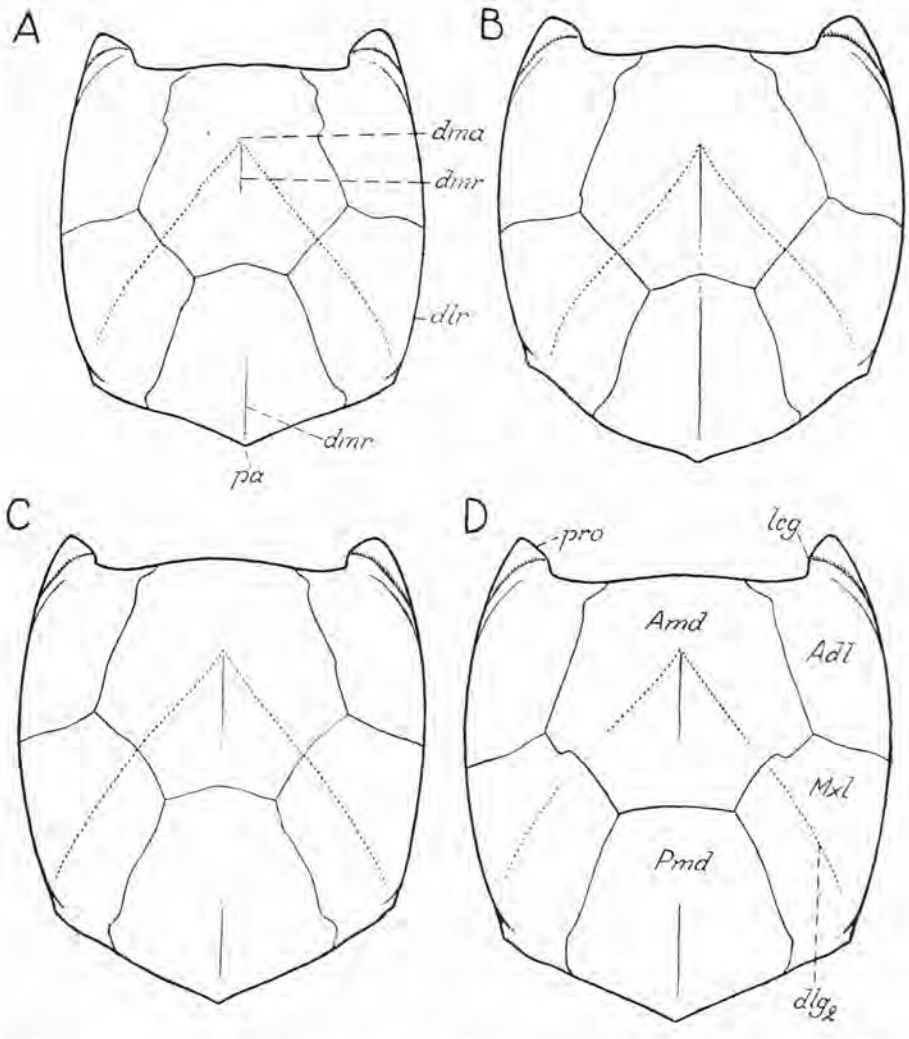
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *lcg*, main lateral line groove; *pa*, posterior angle of posterior median dorsal plate; *pro*, processus obstans.



Text-fig. 182. *Bothriolepis canadensis*. Restoration of the armour of a large individual. Dorsal aspect. Considerably diminished (slightly more than ½ of the natural size). *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_4, dorsal central plates 1–4 respectively; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, medial marginal plates 2–4; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prl*, prelateral plate; *Prm*, premedian plate; dlg_2, posterior oblique abdominal pit-line groove; *dmr*, dorsal median ridge; *pa*, posterior angle of postero-median dorsal plate.

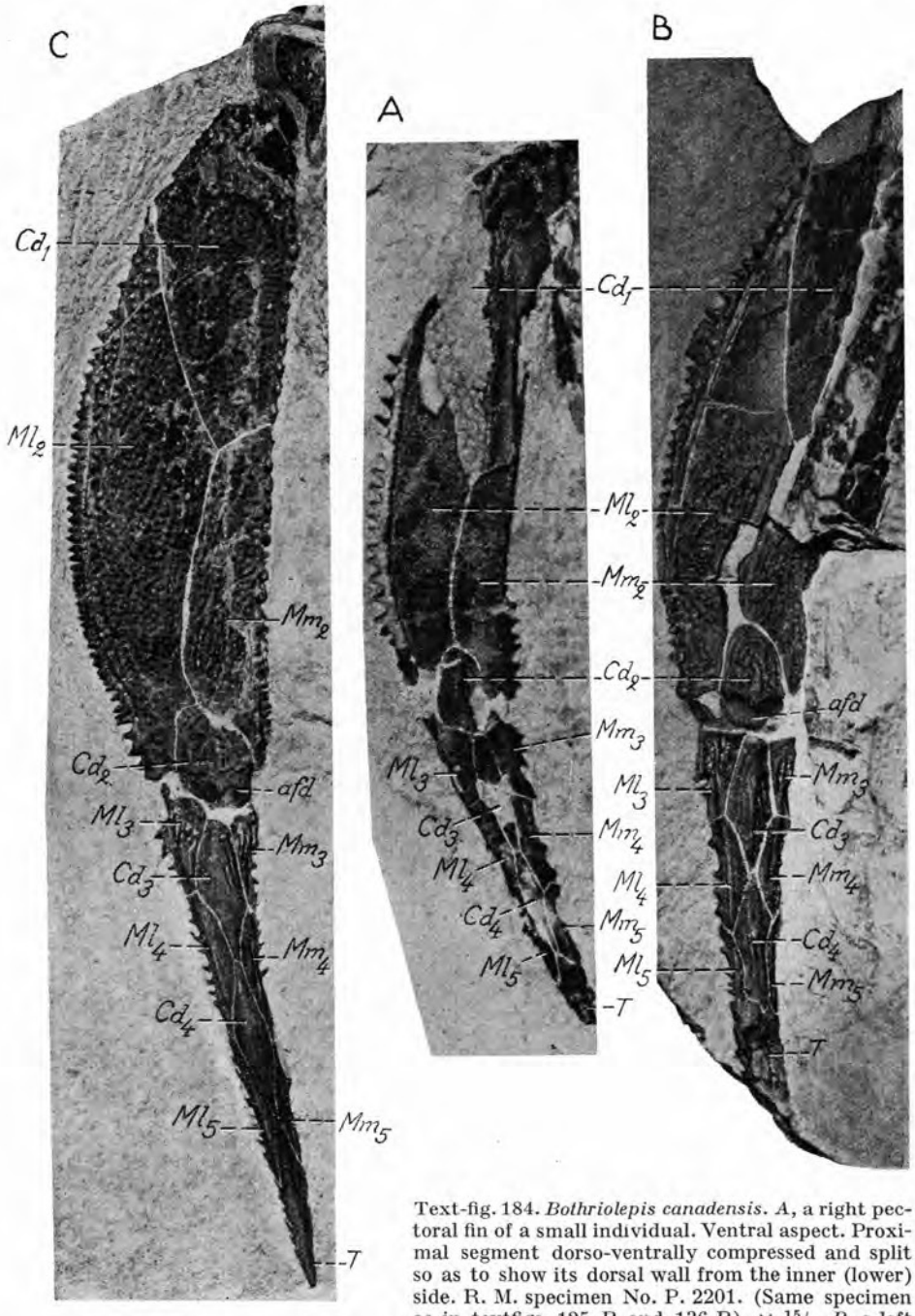
length of the ventral wall of the trunk-armour. The margins of the plate usually are a little convex. The anterior and posterior overlapped areas are mostly of a somewhat uniform breadth (text-figs. 177, 178), but in certain cases the anterior ones of these areas (cd_1) are clearly broader than the posterior ones (cd_2). In a single specimen recently described by Gross (1942, figs. 1, 2; pl. 11, fig. 2; pl. 12, fig. 1) the plate is doubble and asymmetrically developed.

A series of restorations of the trunk-armour in dorsal aspect is given in text-figs. 179–183. This series of restorations includes trunk-armours of all the stages of growth available, from those stages in which the dorsal wall is only 1,85 cm long (text-fig. 179A) up to those stages in which the dorsal wall is nearly 13 cm long (text-fig. 183D). In four cases (text-figs. 179C,

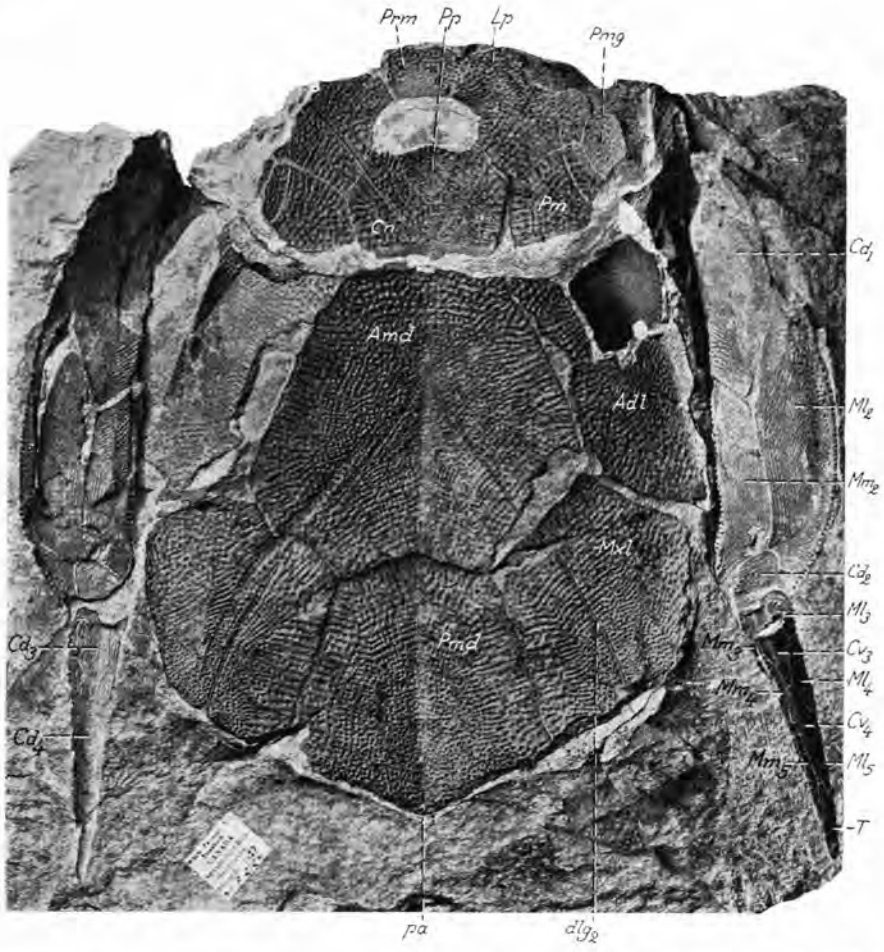


Text-fig. 183. *Bothriolepis canadensis*. *A–D*, restorations of four trunk-armours of large individuals. Dorsal aspect. Somewhat less than one half of the natural size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *lcg*, main lateral line groove; *pa*, posterior angle of posterior median dorsal plate; *pro*, processus obstans.

180 A, 181 C, 182) the head-shield and pectoral fins have also been restored. The series clearly illustrates the increase of the relative breadth of the dorsal wall during the growth of the trunk-armour and gives also an idea of the changes which took place in several of the plates during their proceeding growth. Moreover, it gives also an idea of certain other changes which took place during the growth of the individuals, e.g. the increase in breadth of



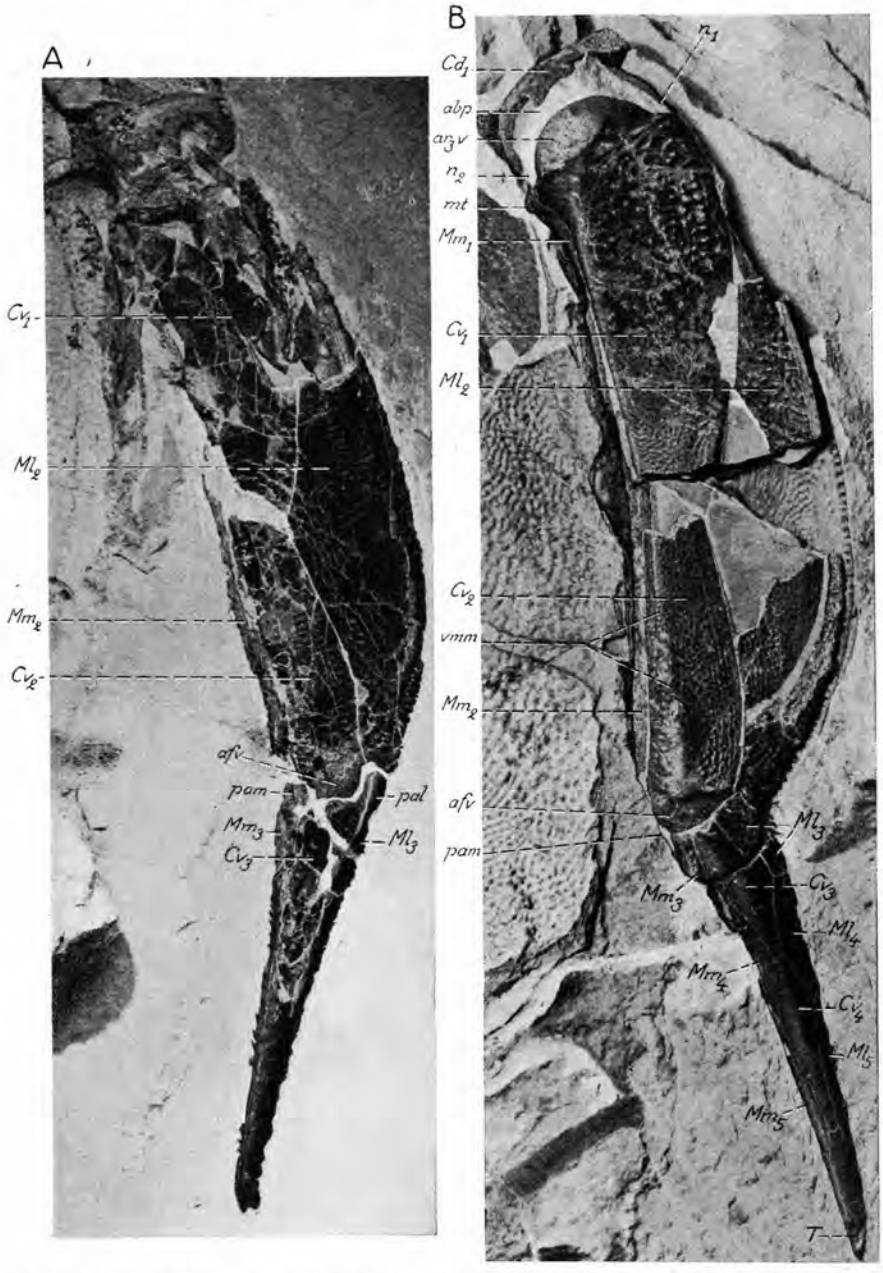
Text-fig. 184. *Bothriolepis canadensis*. *A*, a right pectoral fin of a small individual. Ventral aspect. Proximal segment dorso-ventrally compressed and split so as to show its dorsal wall from the inner (lower) side. R. M. specimen No. P. 2201. (Same specimen as in textfigs. 125 B and 136 B). × $^{15}/_{4}$. *B*, a left pectoral fin of a medium-sized specimen. Dorsal aspect. Plates of proximal segment somewhat detached and partly deficient, the distal segment wanting its most distal part. R. M. specimen No. P. 2163 (same specimen as in text-fig. 119 A). × 2. *C*, a left pectoral fin of a somewhat large specimen. Dorsal aspect. Proximal segment compressed from the lateral sides in its proximal part. R. M. specimen. No. P. 2192. × $^{3}/_{2}$.
Cd_1–Cd_4, dorsal central plates 1–4; M_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *T*, terminal plate (in *B* abnormally developed); *afd*, external articular area of plate Cd_2.



Text-fig. 185. *Bothriolepis canadensis*. Impression of the dorsal side of the armour of a large specimen. The larger part of the distal segment of the left pectoral fin present and shown in ventral aspect. R. M. specimen No. P. 2124 (same specimen as in text-figs. 10, 12, 156, 186 B, 187 A, 189 D, 190 A, B). Diminished.

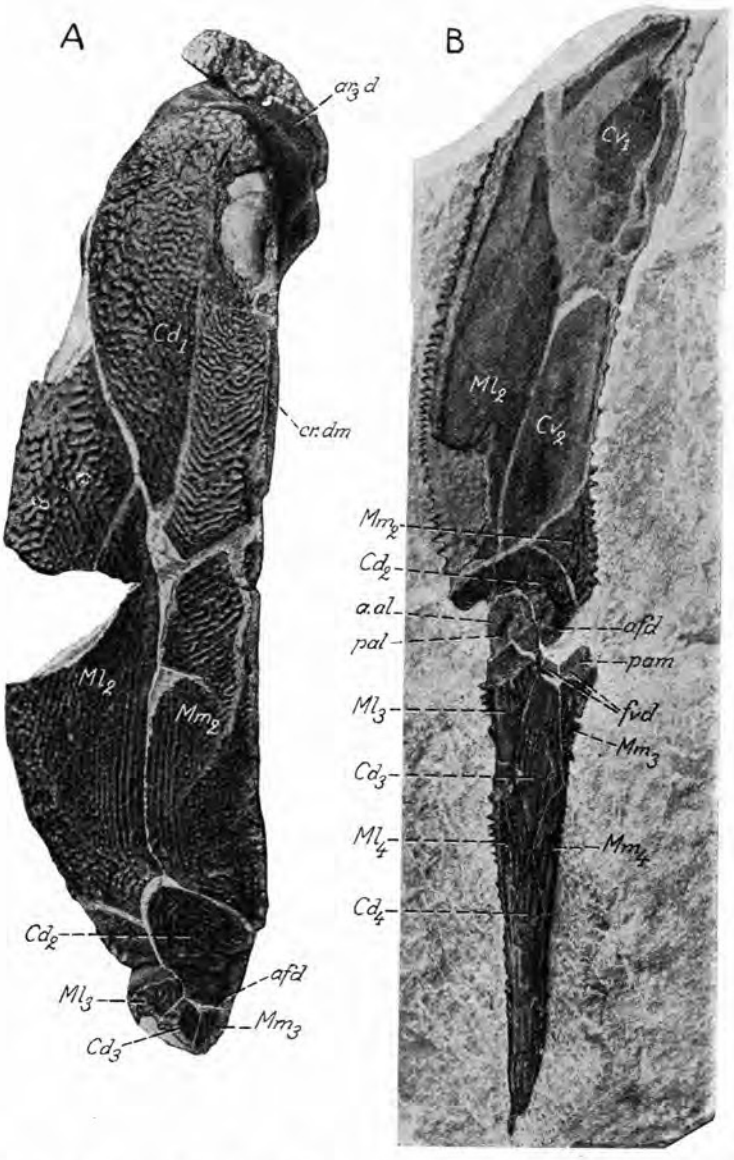
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_4, dorsal central plates 1–4; *Cn*, centro-nuchal plate; Cv_3, Cv_4, ventral central plates 3 and 4 respectively; *Lp*, lateral plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_2–Mm_5, medial marginal plates 2–5; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *T*, terminal plate; dlg_2, posterior oblique abdominal pit-line groove; *pa*, posterior angle of posterior median dorsal plate.

the proximal segment of the pectoral fins and the disappearence of certain of the special external characters of immaturity dealt with above. Finally, it shows also the various anomalous types of the sutural connection between the anterior median dorsal, anterior dorso-lateral and mixilateral plates that are met with in medium-sized and large individuals. – Other restorations of the trunk-armour are given in text-figs. 38, 39 A, B, 40 and 41 A, B.



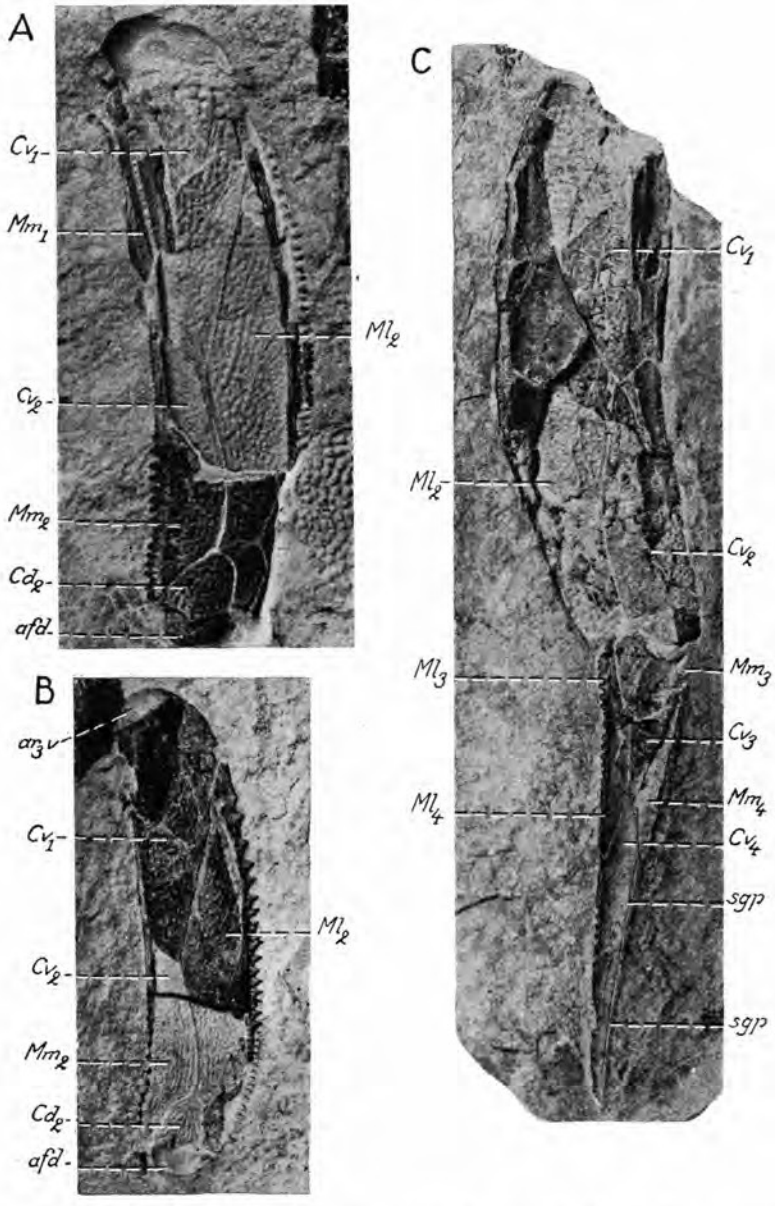
Text-fig. 186. *Bothriolepis canadensis*. *A*, *B*, two large left pectoral fins in ventral aspect. Both the fins somewhat imperfect, and the one in *A* also much compressed and fractured. *A*, R. M. specimen No. P. 2282 (same specimen as in text-fig. 104). *B*, R. M. specimen No. P. 2124 (same specimen as in text-figs. 10, 12, 156, 185, 187A, 189D, 190A, B). About nat. size.

Cd_1, dorsal central plate 1 (proximal part); Cv_1–Cv_4, ventral central plates 1–4; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_1–Mm_5, medial marginal plates 1–5; *T*, terminal plate; *abp*, proximal brachial aperture; *afv*, external articular area of plate Cv_2; ar_3v, external articular area of plate Cv_1; *mt*, postarticular thickening; n_1, lateral corner of proximal brachial aperture; n_2, medial corner of proximal brachial aperture; *pal*, lateral anconeal process; *pam*, medial anconeal process; *vmm*, ventro-medial margin of proximal segment.



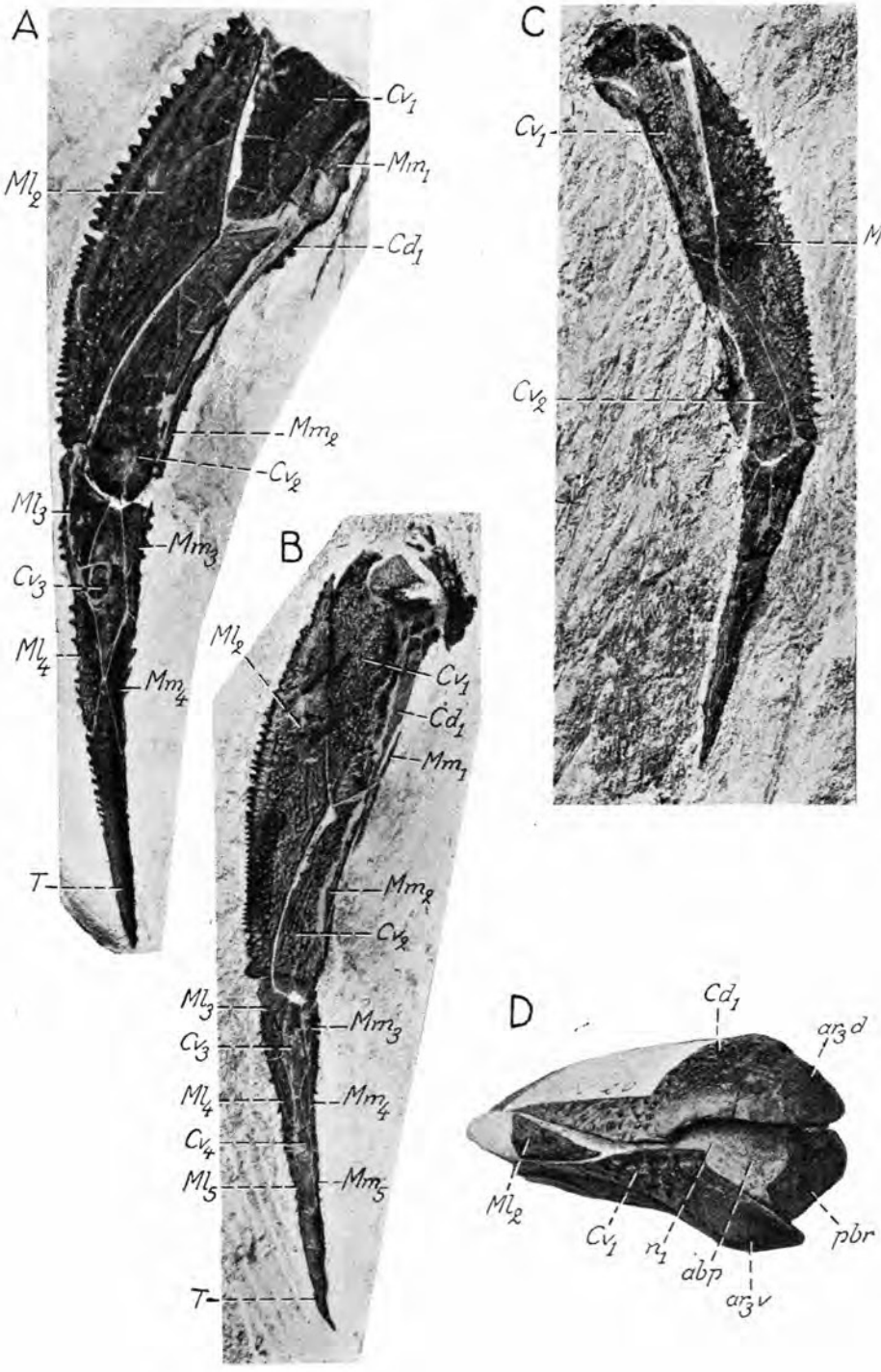
Text-fig. 187. *Bothriolepis canadensis*. *A*, proximal segment of a left pectoral fin with a part of the distal segment attached to it. Dorsal aspect. R. M. specimen No. P. 2124 (same specimen as in text-figs. 10, 12, 156, 185, 186, 189 D, 190 A, B). × $^5/_4$ of the natural size. *B*, left pectoral fin in dorsal aspect. The proximal segment deficient anteriorly and split in such a way as mainly to show the internal (upper) side of its ventral wall. R. M. specimen No. P. 2402. × $^5/_4$ of the natural size.

Cd_1–Cd_4, dorsal central plates 1–4; Cv_1, Cv_2, ventral central plates 1 and 2; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_2–Mm_4, medial marginal plates 2–4; *a. al*, lateral area of „Siebknochen" on the lateral anconeal process; ar_3d, external articular area of plate Cd_1; *afd*, external articular area of plate Cd_2; *cr. dm*, crest on the dorso-medial margin formed by fusions of proximal medial spines; *fvd*, dorsal articular fovea of distal segment; *pal*, lateral anconeal process; *pam*, medial anconeal process.



Text-fig. 188. *Bothriolepis canadensis*. *A*, proximal segment of a right pectoral fin in dorsal aspect. The segment preserved so as mainly to be represented by an impression of the ventral (external) side of its ventral wall. R. M. specimen No. P. 2315 a. × 1.7. *B*, proximal segment of a left pectoral fin in ventral aspect. The distal part of the segment represented by an impression of the dorsal (external) side of its dorsal wall. R. M. specimen No. P. 2315 b. × 1.7. *C*, left pectoral fin preserved mainly as an impression of its lower face. The proximal segment deficient proximally and much crushed. R. M. specimen No. P. 2265. Diminished.

Cd_2, dorsal central plate 2; Cv_1–Cv_4, ventral central plates 1–4; Ml_2–Ml_4, lateral marginal plates 2–4; Mm_1–Mm_4, medial marginal plates 1–4; *afd*, external articular area of the plate Cd_2; ar_3v, external articular area of plate Cv_1; *sgp*, pectoral pit-line groove.


A
Cv_1
Mm_1
Ml_2
Cd_1
Mm_2
Cv_2
Ml_3
Mm_3
Cv_3
Ml_4
Mm_4
T
B
Ml_2
Cv_1
Cd_1
Mm_1
Mm_2
Cv_2
Ml_3
Mm_3
Cv_3
Ml_4
Mm_4
Cv_4
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Cv_1
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pbr

Posterior unarmoured division of trunk.

The posterior unarmoured division of the trunk, that is to say the hindmost dorsal and lateral parts of the abdominal region and the whole caudal region, have already been fully described in the general part of this work. As has already been pointed out (pp. 142–148, 166–168), this division of the trunk (text-figs. 38, 40B, 62) is long and slender. It is known thus far only in medium-sized specimens where it is somewhat more than twice as long as the dorsal wall of the trunk-armour. The squamation is in a highly reduced condition. Vestigial scales persist only laterally and ventrally nearest behind the trunk-armour (*S*, text-figs. 38, 40B, 54, 55, 59) and along the lateral line on the body axis of the caudal fin (*Ls*, text-fig. 62). Otherwise the skin was completely devoid of scales.

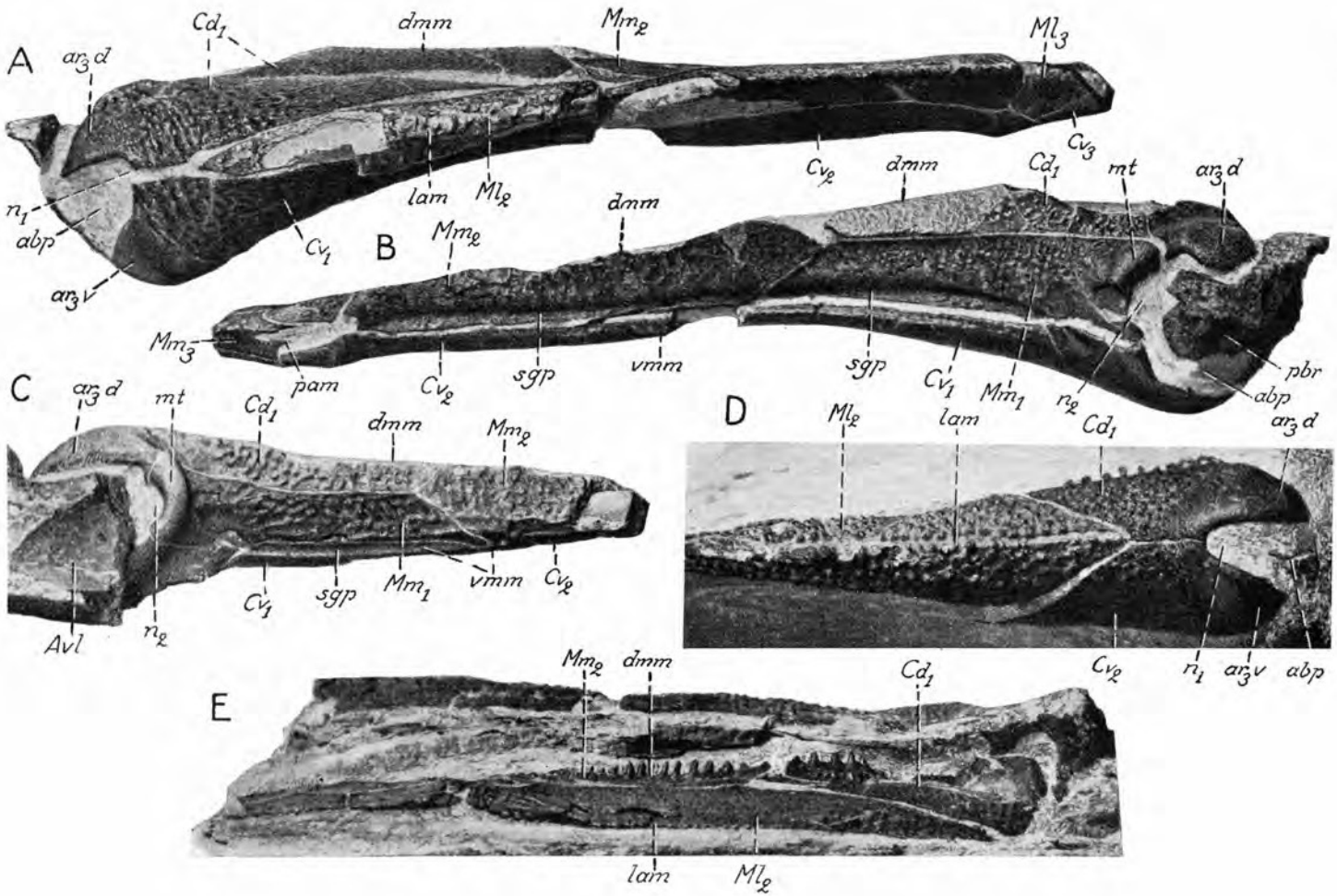
Paired fins.

The pectoral fin. – The pectoral fin (text-figs. 38, 40B, 41B, 88B, 90, 91, 96–98, 114–116, 127–130, 132, 134, 140–143, 149, 155, 157–162, 167–169, 175, 176, 178, 179C, 180A, 181C, 182, 184–191, 192D, E, 194–196, 198) is found more or less completely preserved in a great many specimens representing different stages of growth, and it could be examined, therefore, not only as to its detailed structure, but also as to its variations and as to the changes which it underwent during its growth.

The general shape and proportions of the pectoral fin are shown in the restorations reproduced in text-figs. 38, 40, 41B, 98, 179C, 180A, 181C, 182, 194–196 and 198). The endoskeleton, which may sometimes be lime-incrusted, has been treated above in the general part of this work (pp. 148–150).

When fully adducted so that it lies alongside the body-wall the pectoral fin generally reaches a little beyond the posterior end of the ventral wall of the trunk-armour and thus extends rather far beyond the dorsal wall of the trunk-armour (text-figs. 38, 40B, 41B, 98, 161, 167, 168, 180A, 181C, 182). In certain cases, however, it may be somewhat shorter. In one specimen in which it is particularly short (text-fig. 128) it extends only slightly backwards beyond the transverse plane through the posterior corner (*pa*) of the

Text-fig. 189. *Bothriolepis canadensis*. *A*, deficient right pectoral fin in ventral aspect. A considerable anterior part of the proximal segment missing. R. M. specimen No. 2608. × $^3/_2$. *B*, *C*, a right and a left pectoral fin respectively of one and the same specimen. Ventral aspect. The two fins much compressed and partly also much crushed. R. M. specimen No. 2674 (same specimen as in text-fig. 77 C). × $^3/_2$. *D*, proximal end of a proximal segment of a right pectoral fin in antero-dorso-lateral aspect. R. M. specimen No. P. 2124 (same specimen as in text-figs. 10, 12, 156, 185, 186 B, 187 A, 190 A, B). × $^3/_2$. Cd_1, dorsal central plate 1; Cv_1–Cv_4, ventral central plates 1–4; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_1–Mm_5, medial marginal plates 1–5; *T*, terminal plate; *abp*, proximal brachial aperture; ar_3d, external articular area of Cd_1-plate; ar_3v, external articular area of Cv_1-plate; n_1, lateral corner of proximal brachial aperture; *pbr*, processus brachialis (of anterior ventro-lateral plate).


A
$ar_3 d$
Cd_1
dmm
Mm_2
Ml_3
Cv_3
Cv_2
lam
Ml_2
n_1
abp
Cv_1
$ar_3 v$
B
Mm_2
dmm
Mm_3
pam
Cv_2
sgp
vmm
dmm
Cd_1
mt
$ar_3 d$
sgp
Cv_1
Mm_1
n_2
pbr
abp
C
$ar_3 d$
mt
Cd_1
dmm
Mm_2
Cv_1
sgp
Mm_1
vmm
Cv_2
Avl
n_2
D
Ml_2
lam
Cd_1
$ar_3 d$
Cv_2
n_1
$ar_3 v$
abp
E
Mm_2
dmm
Cd_1
lam
Ml_2

dorsal wall of the trunk-armour; in this specimen the articulation between the proximal and distal segments (in the fully adducted position of the fin) is situated close behind the lateral end of the suture between the dorsal laminae of the anterior dorso-lateral and mixilateral plates, whereas in the majority of other specimens (in the corresponding position of the fin) it lies somewhat in front of the middle of the mixilateral plate and opposite the anterior parts of the posterior ventro-lateral plate.

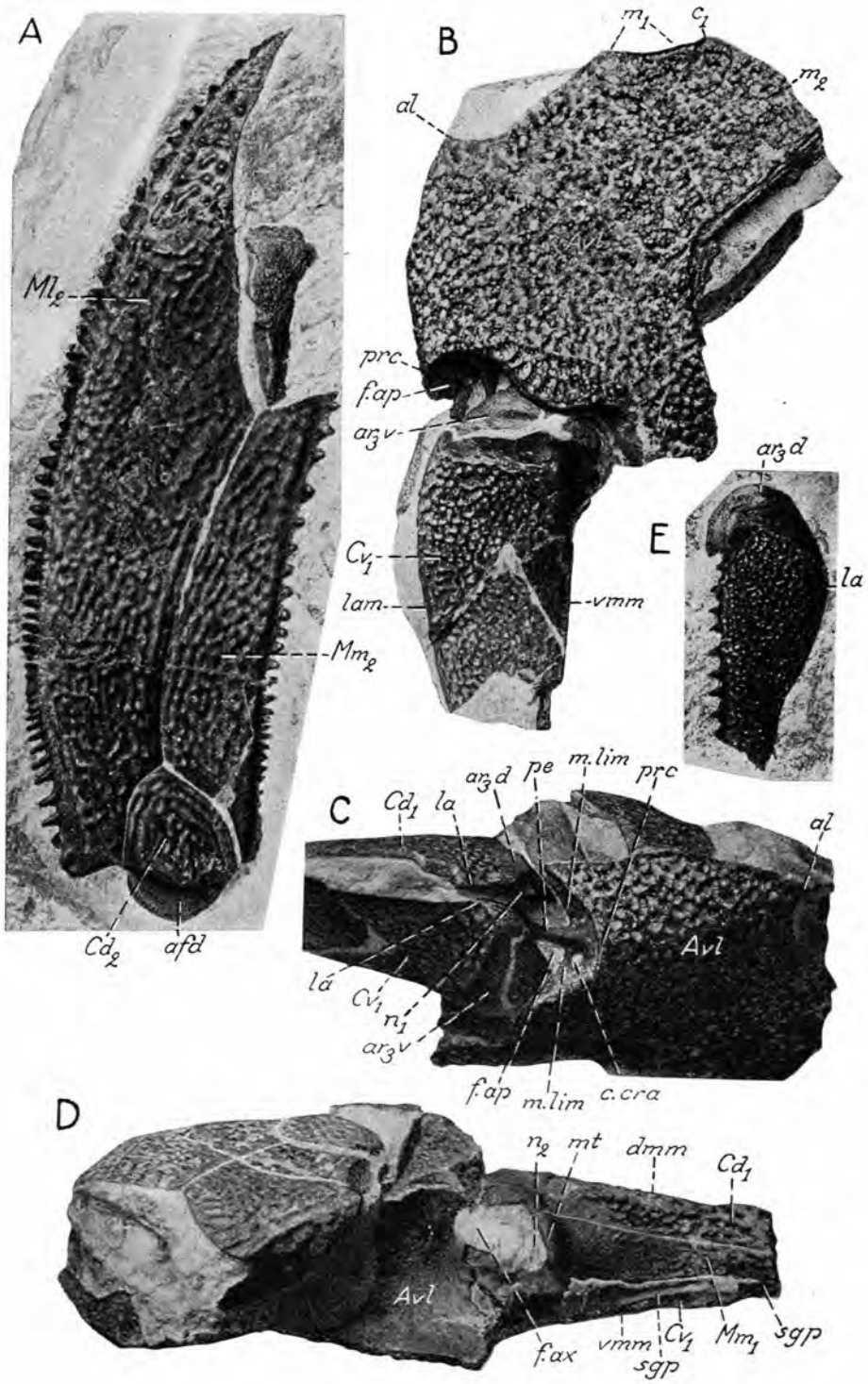
The proximal segment (text-figs. 38, 40B, 41B, 57, 98, 179C, 180A, 181C, 182, 184–191, 192D, E, 194–196, 211) increased considerably in relative breadth during the growth of the individuals and consequently is always much broader in proportion to its length in large than in small individuals (cf. text-figs. 98, 179C, 180A, 181C, 182, 194, 195). The following statements may be given concerning this increase in breadth of the segment. In small specimens the breadth is only 19–22% of the length; in medium-sized specimens the breadth has increased to 22–27% of the length; and in large specimens the breadth amounts to as much as 28–30% of the length[1]). Accordingly the segment is 5,25–4,5 times longer than broad in small specimens, 4,5–3,7 times longer than broad in medium-sized specimens, and 3,6–3,3 times longer than broad in large specimens. As far as may be seen, the segment is also more uniform in breadth throughout its extent in small individuals than what it is in large individuals in which generally it is clearly broader somewhat behind its middle (cf. text-figs. 194–195) than towards its proximal and distal ends.

The distal segment (text-figs. 38, 40B, 41B, 90, 96, 98, 115, 116, 127,

Text-fig. 190. *Bothriolepis canadensis*. *A*, *B*, proximal segment of a left pectoral fin in lateral and medial aspects respectively. A small part of the distal segment is seen in its natural connection with the proximal segment. R. M. specimen No. P. 2124 (same specimen as in text-figs. 10, 12, 156, 185, 186 B, 187 A, 189 D). × 3/2. *C*, proximal parts of the proximal segment of a right pectoral fin. Medial aspect. R. M. specimen No. P. 2117. × 3/2. *D*, proximal part of the proximal segment of a right pectoral fin. Lateral aspect. R. M. specimen No. P. 2775. × 3/2. *E*, a crushed and flattened right pectoral fin in lateral aspect. It is clearly seen here that the spines of the medial row on the longer proximal part of the proximal segment are directed dorsally. R. M. specimen No. 2488 (same specimen as in text-fig. 127). × 3/2.

Avl, anterior ventro-lateral plate (piece of lateral lamina); Cd_1, dorsal central plate 1; Cv_1, Cv_2, ventral central plates 1 and 2 respectively; Ml_2, Ml_3, lateral marginal plates 2 and 3 respectively; Mm_1–Mm_3, medial marginal plates 1–3; *abp*, proximal brachial aperture; ar_3d, external articular area of plate Cd_1; ar_3v, external articular area of plate Cv_1; *dmm*, dorso-medial margin; *lam*, lateral margin; *mt*, postarticular thickening; n_1, lateral corner of proximal brachial aperture, probably for protractor, muscles of pectoral fin or for tendon of this muscle; n_2, medial corner of proximal brachial aperture for nerves and vessels to the interior of the pectoral fin and probably also for the tendon or tendons of the retractor muscles of the pectoral fin; *pam*, medial anconeal process; *pbr*, processus brachialis (of *Avl*-plate); *sgp*, pectoral pit-line groove; *vmm*, ventro-medial margin.

[1]) The length of the proximal segment is exclusive of the external articular area (*a/d*) of the dorsal and ventral central plates 2 (cf. p. 10).


A
Ml2
Cd2
afd
B
m1
c1
m2
al
prc
f.ap
ar3v
Cv1
lam
vmm
Mm2
E
ar3d
la
C
Cd1
la
ar3d
pe
m.lim
prc
al
Avl
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Cv1
n1
ar3v
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m.lim
c.cra
D
n2
mt
dmm
Cd1
Avl
f.ax
vmm
sgp
Cv1
Mm1
sgp

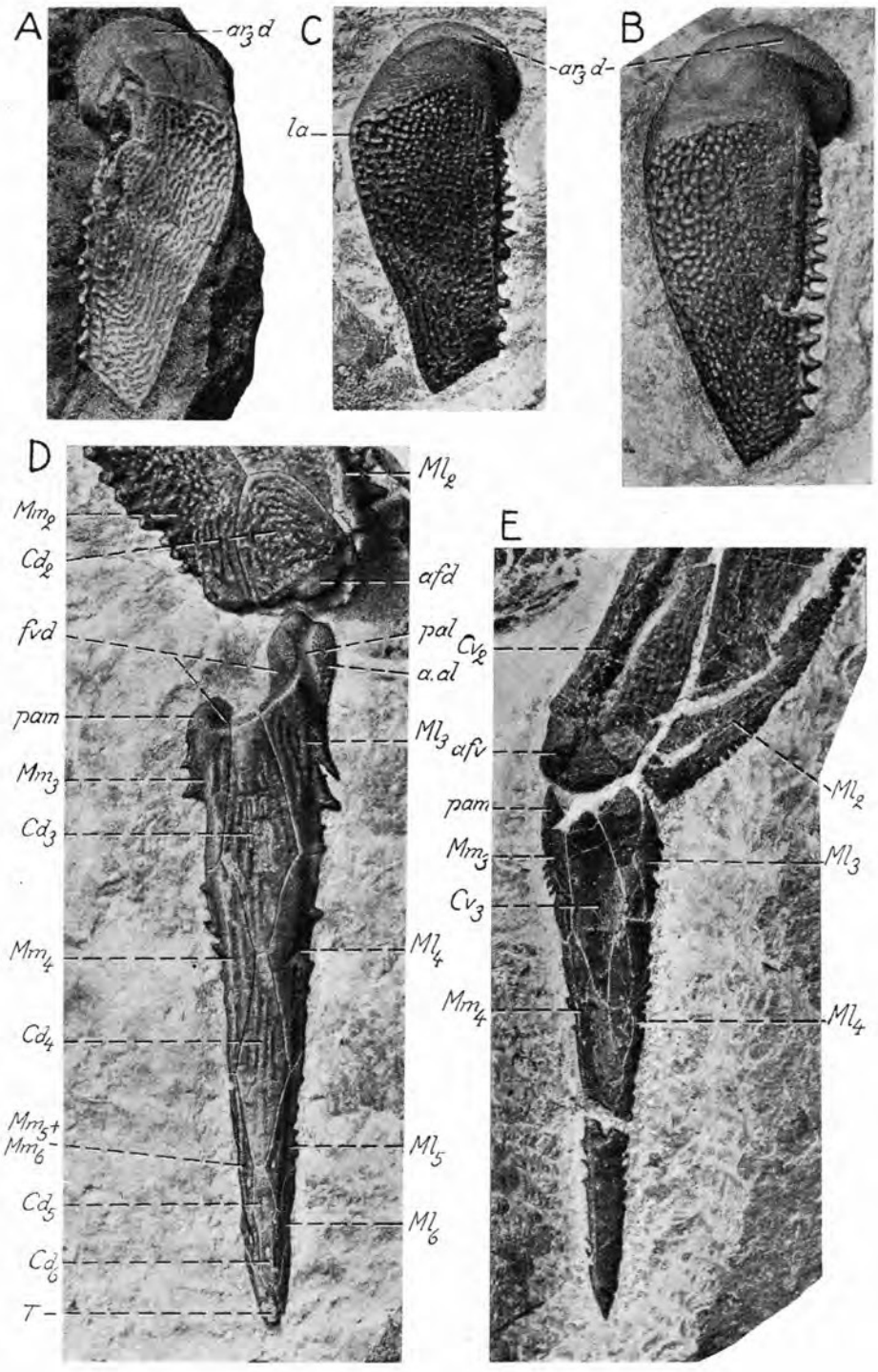
128, 130, 132, 134, 140, 142, 149, 159, 161, 162, 167, 168, 175, 176, 179C, 180A, 181C, 182, 184–187, 188C, 189A–C, 192D, E, 195, 198, 211) is often comparatively robust, but may also be of a more slender type. Its length[1]) is somewhat variably, ranging between 36–47% of the total length of the fin and between 60–80% of the length of the proximal segment.

The pectoral fin-armour is provided with lateral and medial spines. These spines are always stronger in small and small medium-sized specimens (text-figs. 88B, 98, 179C, 180A, 184A, B, 188A, B, 189A–C, 191E, 192A–D, 193, 194A, B, 195A) than in large medium-sized and large specimens (text-figs. 181C, 182, 184C, 185–187, 188C, 190A, B, 192E, 194C, 195B, 196) and thus decreased somewhat in relative size during the growth of the individuals. The spines of the proximal segment are always fewer in number in small and small medium-sized than in large medium-sized and large individuals. Besides, the spines of the proximal segment underwent also several changes during the growth of the pectoral fin: they became normally blunter; the medial spines, in particular, decreased also in breadth (text-fig. 194); all the spines became fused to some extent basally; as regards the spines situated on the dorsal central plate 1 and on an adjacent part of the medial margin plate 2 this fusion exeptionally led as far as to the formation of a real dorso-medial crest (*cr.dm*, text-figs. 187A, 194C) without, or almost without, identations in its margin, and thus practically without any vestiges of the spines by which it was formed.

Text-fig. 191. *Bothriolepis canadensis*. *A*, dorsal wall of a proximal segment of a left pectoral fin in dorsal aspect. Dorsal central plate 1 missing. R. M. specimen No. P. 2261. × 2. *B–D*, proximal part of the proximal segment of a pectoral fin with a part of the right anterior ventro-lateral plate. *B*, in ventral, *C*, in lateral and *D*, in medial aspect. R. M. specimen No. P. 2629. × 3/2. *E*, small right dorsal central plate 1 in dorsal aspect. R. M. specimen No. P. 2138. × 2.

Avl, anterior ventro-lateral plate; Cd_1, Cd_2, dorsal central plates 1 and 2 respectively; Cv_1, ventral central plate 1; Ml_2, lateral marginal plate 2; Mm_1, Mm_2, medial marginal plates 1 and 2 respectively; *afd*, external articular area of Cd_2-plate; *al*, antero-lateral corner of anterior ventro-lateral plate; ar_3d, external articular area of plate Cd_1; ar_3v, external articular area of plate Cv_1; c_1, corner between anterior (m_1) and middle (m_2) divisions of medial margin of ventral lamina of anterior ventro-lateral plate; *c. cra*, opening of a canal; *dmm*, dorso-medial margin of proximal fin-segment; *f. ap*, fossa articularis pectoralis; *f. ax*, foramen axillare (anterior and ventral parts of its boundary); *la*, lateral angle or corner of dorsal and ventral central plate 1; *lam*, lateral margin of proximal fin segment; m_1, anterior division of medial margin of ventral lamina of anterior ventro-lateral plate connected with semilunar plate; m_2, middle division of medial margin of ventral lamina of *Avl*-plate, connected with anterior ventro-lateral plate of opposite side; *m. lim*, dorsal and ventral margo limitans, in all probability developed for the attachment of the articular capsule; *md*, postarticular thickening; n_1, lateral corner of proximal brachial aperture (probably for protractor muscle of pectoral fin); n_2, medial corner of proximal brachial aperture (situated opposite foramen axillare); *pe*, pars pedalis of processus brachialis (discernible in the lateral corner of the proximal brachial aperture); *prc*, prepectoral corner; *sgp*, pectoral pit-line groove; *vmm*, ventro-medial margin of proximal fin-segment.

[1]) The length of the distal segment is measured from the proximal margin of the exposed area of the dorsal or ventral central plate 3 to the distal tip of the segment (cf. p. 10).


A
ar3 d
C
la
ar3 d
B
D
Ml2
Mm2
Cd2
afd
fvd
pal
Cv2
a.al
pam
Ml3 afv
Mm3
Cd3
Mm4
Ml4
Cd4
Mm5+
Mm6
Ml5
Cd5
Ml6
Cd6
T
E
Ml2
pam
Ml3
Mm3
Cv3
Mm4
Ml4

Otherwise the following deserves to be added concerning the spines of the proximal segment. The lateral spines form together a continuous row directed. The most proximal ones of the lateral spines are always short and obtuse, whereas the other more distally situated ones of these spines are longer and more pointed (text-figs. 194, 195). All the lateral spines of the proximal segment may be fairly straight so that they point almost straightly laterally. This is normally the case with the midmost ones of them, whereas the proximal and distal ones often are somewhat curved in proximal and distal directions respectively. These curved proximal and distal spines are most commonly found in small and medium-sized individuals. The medial spines situated on the dorsal central plate 1 and on an adjacent proximal part of the medial marginal plate 2 are directed so that they point almost straightly dorsally (text-figs. 38, 40B, 57A, B, 190D, E, 196), whereas the medial spines situated on the middle and distal parts of the medial marginal plate 2 gradually change their position in such a way that most distally on the proximal segment they point straightly medially. The distalmost ones of the latter spines are often curved more or less in a distal direction.

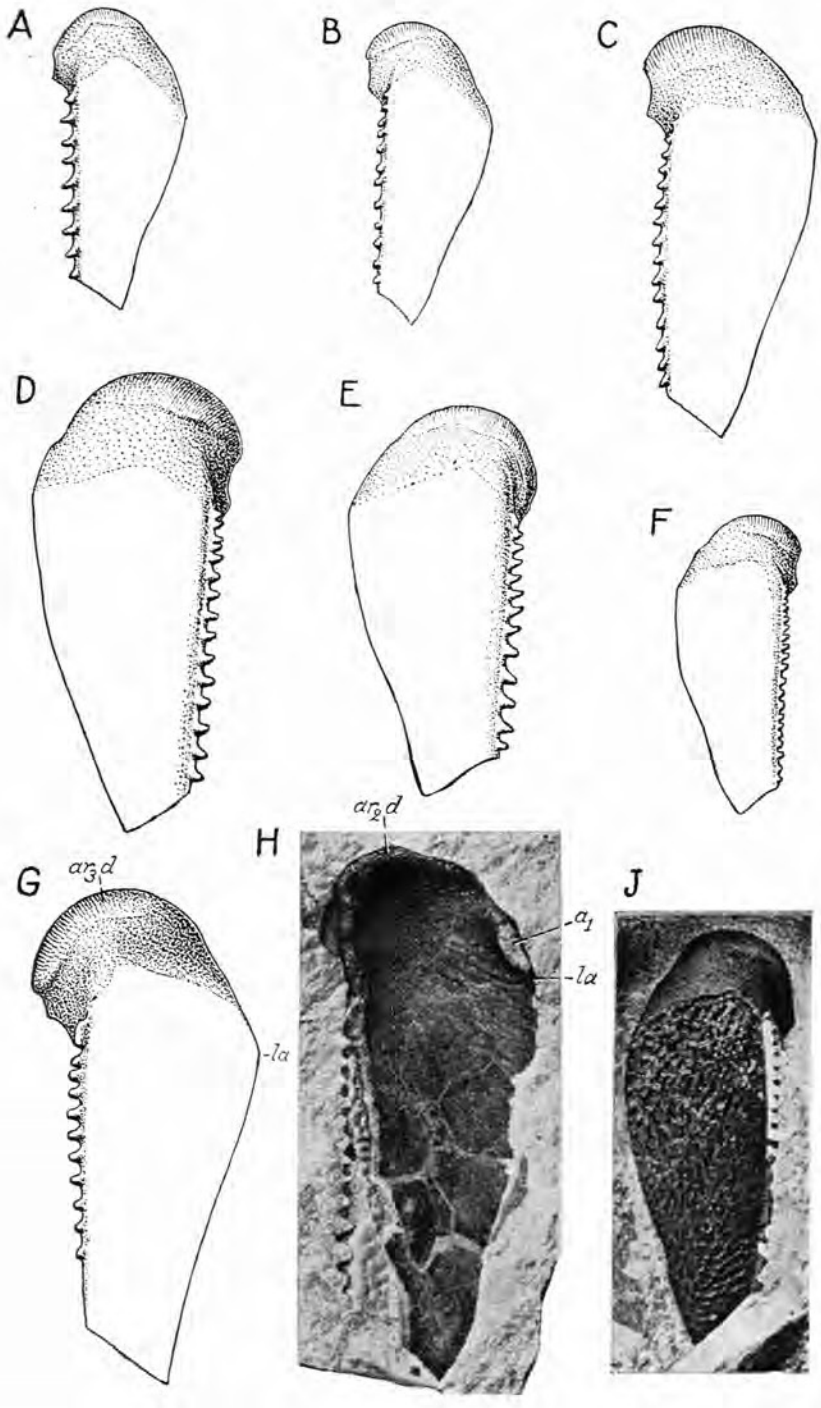
Besides the ordinary lateral and medial spines just dealt with, the proximal segment fortuitously presents also a ventro-medial row of spines. This row (*r. vmm*, text-fig. 197F) is slightly developed, however, and is found only on that part of the ventro-medial margin of the fin which is situated on the ventral central plate 1.

The lateral and medial spines of the distal segment (text-figs. 41B, 98, 186, 187B, 188C, 189A–C, 192D, E, 195, 198) are developed essentially as in other *Bothriolepis*-species. The lateral spines are fewer in number and not so regularly disposed as in *B. nitida* (text-fig. 213) and *B. cellulosa* (text-fig. 228C–E).

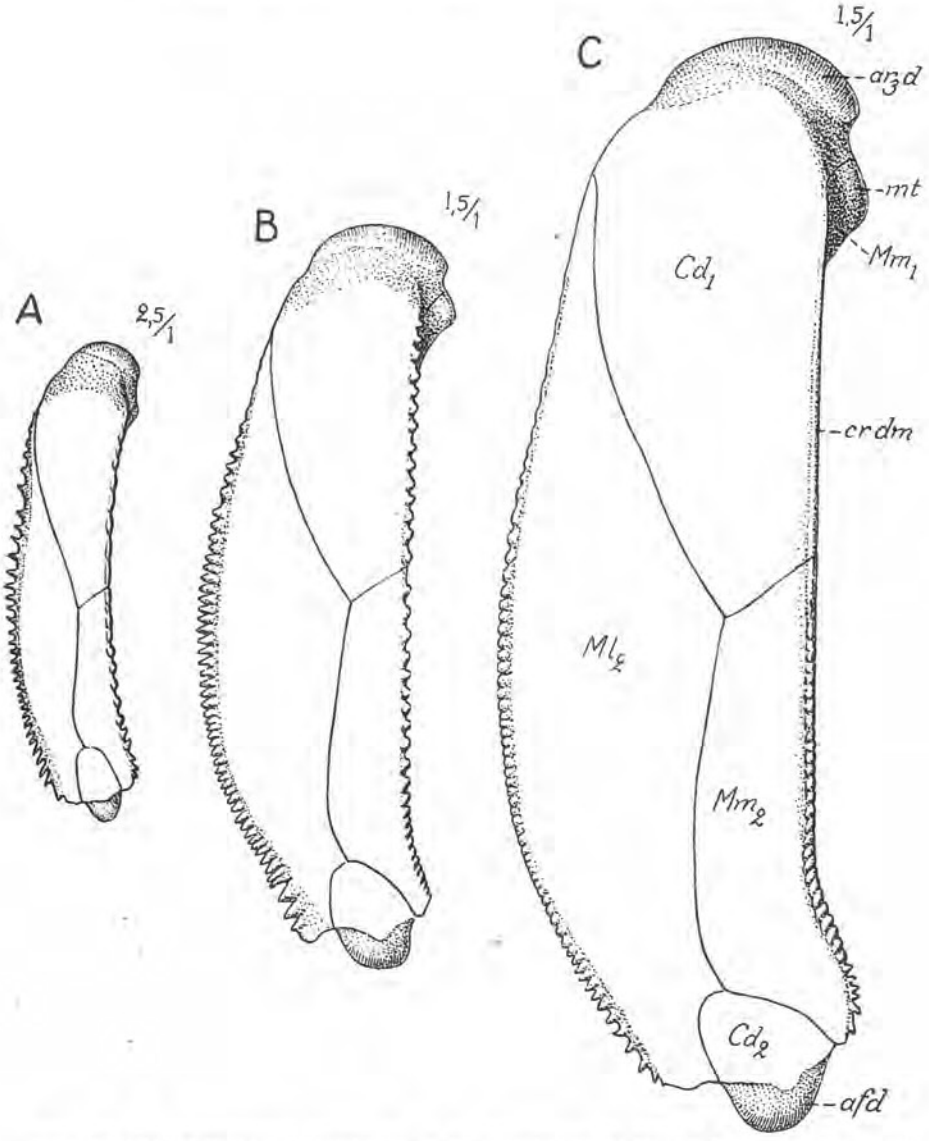
After these general remarks we shall now turn to the four longitudinal series of plates which enter in the formation of the pectoral fin-armour.

The dorsal central series of plates is normally composed of four or five independent elements (Cd_1–Cd_5, text-figs. 40B, 90, 98, 116, 127, 128, 132, 140, 142, 149, 179C, 180A, 181C, 184A–C, 198A, C, D), but in one case this series has been found to consist of as many as six elements (text-figs.

Text-fig. 192. *Bothriolepis canadensis*. *A–C*, three dorsal central plates 1 in dorsal aspect. *A*, right plate. R. M. specimen No. P. 2409. × 2. *B*, *C*, two left plates. R. M. specimens Nos. P. 2261 and 2159 respectively. *B*, × 2; *C*, × 3/2; *D*, distal parts of a right pectoral fin, showing a complete distal segment. Dorsal aspect. R. M. specimen No. P. 2473. × 3. *E*, distal parts of a left pectoral fin in ventral aspect. R. M. specimen No. P. 2840. × 3/2. Cd_2–Cd_6, dorsal central plates 2–6 (Cd_6 fused with Ml_6); Cv_2, Cv_3, ventral central plates 2 and 3 respectively; Ml_2–Ml_6, lateral marginal plates 2–6 (Ml_6 fused with Cd_6); Mm_2–Mm_6, medial marginal plates 2–6 (Mm_5 and Mm_6 fused); *T*, terminal plate; *a. al*, lateral area of „Siebknochen" on lateral anconeal process; *a/d*, external articular area of the plate Cd_2; *afv*, external articular area of the plate Cv_2; ar_3d, external articular area of dorsal central plate 1; *fvd*, articular fovea of dorsal side of distal segment; *la*, lateral angle or corner of dorsal central plate 1; *pal*, lateral anconeal process; *pam*, medial anconeal process.



Text-fig. 193. For explanation see next page.

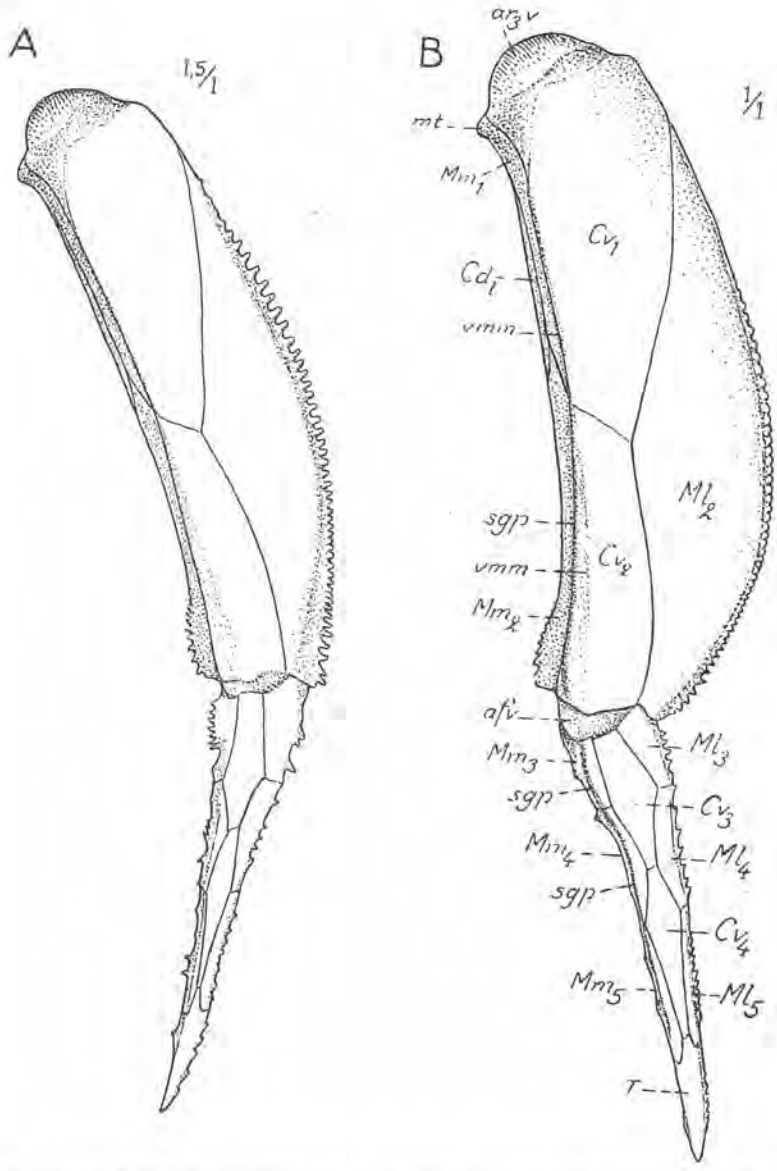


Text-fig. 194. *Bothriolepis canadensis*. *A–C*, restorations of three left proximal segments of pectoral fins. Dorsal aspect. *A*, of a small individual. *B*, of a medium-sized individual. *C*, of a large individual.

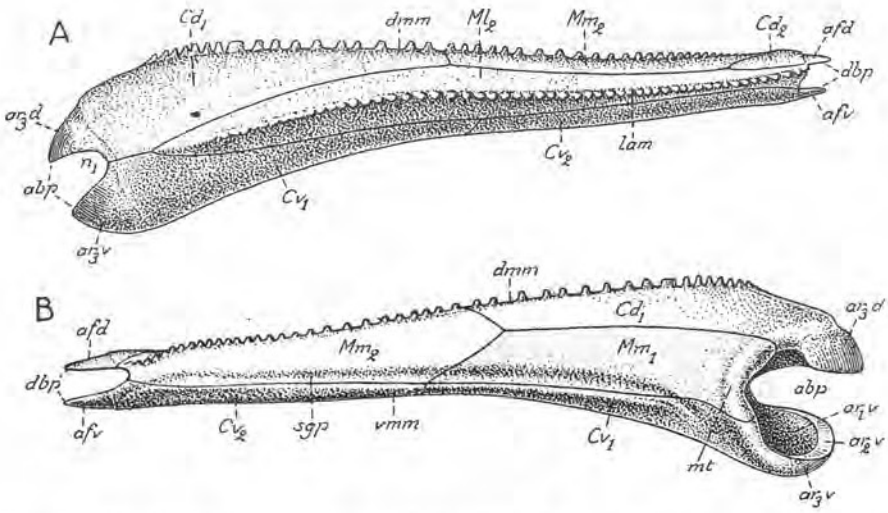
Cd_1, Cd_2, dorsal central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_1, Mm_2, medial marginal plates 1 and 2 respectively; *afd*, external articular area of dorsal central plate 2; ar_3d, external articular area of dorsal central plate 1; *cr. dm*, medial crest formed by fusion of proximal medial spines; *mt*, postarticular thickening.

Text-fig. 193. *Bothriolepis canadensis*. *A–G*, restorations of seven dorsal central plates 1, all of medium-sized individuals. Dorsal aspect. *A–C*, *G*, right plates; *D–F*, left plates. × $^3/_2$. *H–J*, two left dorsal central plates 1. *H*, in ventral aspect. *J*, in dorsal aspect. R. M. specimens Nos. 2139 and 2138 respectively. × 2.

a_1, area on lateral margin connected with ventral central plate 1; ar_2d, marginal articular area of dorsal central plate 1; ar_3d, external articular area of dorsal central plate 1; *la*, lateral angle or corner.



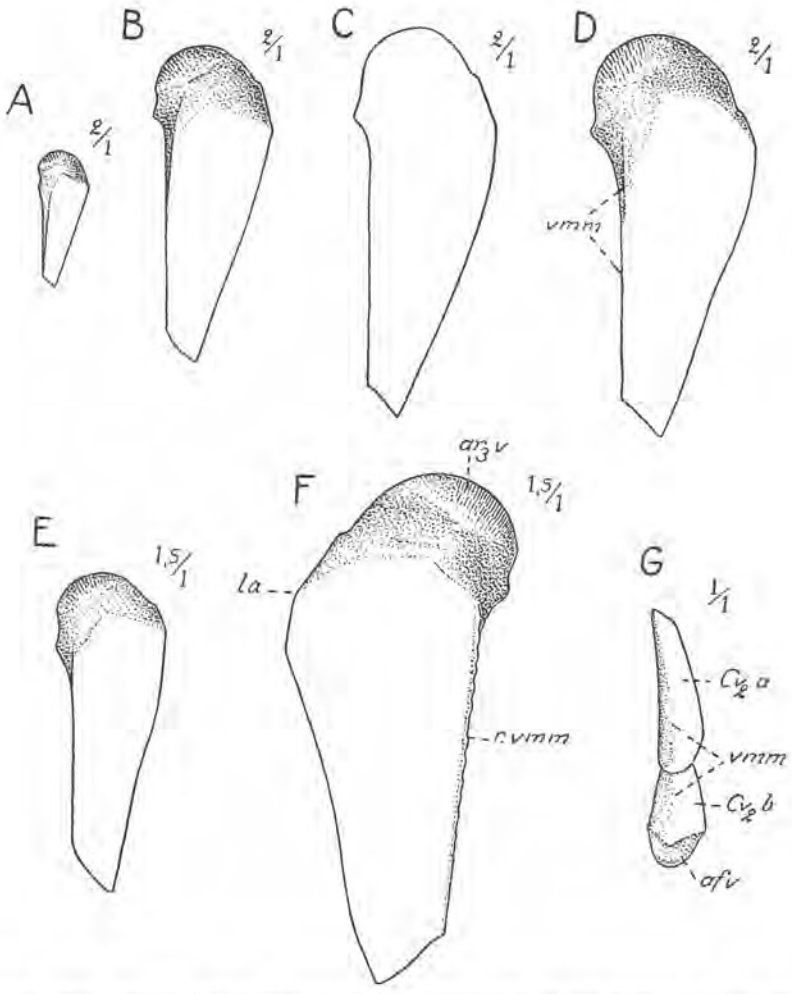
Text-fig. 195. *Bothriolepis canadensis*. *A*, *B*, restorations of two left pectoral fins in ventral aspect. *A*, of a medium-sized individual with the distal segment almost maximally bent medially. *B*, of a large specimen, with the distal segment maximally bent laterally. Cd_1, dorsal central plate 1 (medial lamina); Cv_1–Cv_4, ventral central plates 1–4; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_1–Mm_5, medial marginal plates 1–5; *T*, terminal plate; *afv*, external articular area of plate Cv_2; ar_3v, external articular area of plate Cv_1; *mt*, postarticular thickening; *sgp*, pectoral pit-line groove; *vmm*, ventro-medial margin of proximal segment.



Text-fig. 196. *Bothriolepis canadensis*. Restoration of the proximal segment of a left pectoral fin. *A*, in lateral, and *B*, in medial aspect. Slightly magnified.
Cd_1, Cd_2, dorsal central plates 1 and 2 respectively; Cv_1, Cv_2, ventral central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_1, Mm_2, medial marginal plates 1 and 2 respectively; *abp*, proximal brachial aperture; *afd*, external articular area of plate Cd_2; *afv*, external articular area of plate Cv_2; ar_3d, external articular area of plate Cd_1; ar_1v, ar_2v, ar_3v, internal, marginal and external articular areas respectively of the plate Cv_1; *dbp*, distal brachial aperture; *dmm*, dorso-medial margin; *lam*, lateral margin; *mt*, post-articular thickening; n_1, lateral corner of proximal brachial aperture; *sgp*, pectoral pit-line groove; *vmm*, ventro-medial margin.

192D, 198B). In the last-mentioned case, however, the distalmost element (Cd_6) is not fully independent, but is fused with the lateral marginal plate 6 (Ml_6). In the cases when the series consists only of four plates the terminal plate is provided with a proximal dorsal process between the lateral and medial marginal plates 5, a process which clearly represents a dorsal central element 5. In these cases, therefore, the distalmost – the fifth – element of the series, has simply not become disconnected from the terminal plate. Particularly in large specimens the fourth and fifth elements of the series are often secondarily fused with one another, with the terminal plate, and with other adjacent plates of the distal segment (text-figs. 182, 185, 187B, 198E).

The dorsal central plate 1 (text-figs. 40B, 57, 98, 180A, 181C, 182, 187A, 189D, 190, 191E, 192A–C, 193, 194, 196) is variable as to proportions, but it is fully obvious that normally it increased in relative breadth during its growth. In very small and small medium-sized individuals it is thus 2,9–2,6 times as long as broad, whereas in larger medium-sized and large individuals it is only 2,6–2,3 times as long as broad. The medial spines situated on the plate vary in number from 9–18, but are generally fewer on small plates than on large plates. The unornamented area of the plate just distally to the external articular area (ar_3d) is somewhat variable in size (text-figs. 191E,



Text-fig. 197. *Bothriolepis canadensis*. *A–F*, restorations of six ventral central plates 1, *A–E*, left plates, *F*, a right plate. Except *C*, of which only an outline sketch is given, all the plates shown in ventral aspect. *G*, abnormally developed ventral central plate 2. This plate divided into an anterior and a posterior element.
Cv_2a, Cv_2b, anterior and posterior elements respectively of ventral central plate 2; *afv*, external articular area of plate Cv_2; ar_3v, external articular area of ventral central plate 1; *la*, lateral corner or angle; *r. vmm*, row of vestigial spines on ventro-medial margin of ventral central plate 1; *vmm*, ventro-medial margin of proximal segment (the part of the margin, which is situated on the ventral central plate 2).

192A–C, 193A–G, I, 194), but seems usually to have decreased somewhat in proximo-distal extent during the growth of the plate.

The dorsal central plate 2 (Cd_2, text-figs. 90, 98, 115, 116, 127, 128, 130, 132, 134, 140, 142, 149, 159, 180A, 181C, 182, 184, 185, 187, 188A, B, 191A, 192D, 194, 196, 198B, 211) in small specimens is nearly twice as broad as it is long (text-fig. 194A), but underwent such a change in proportions during

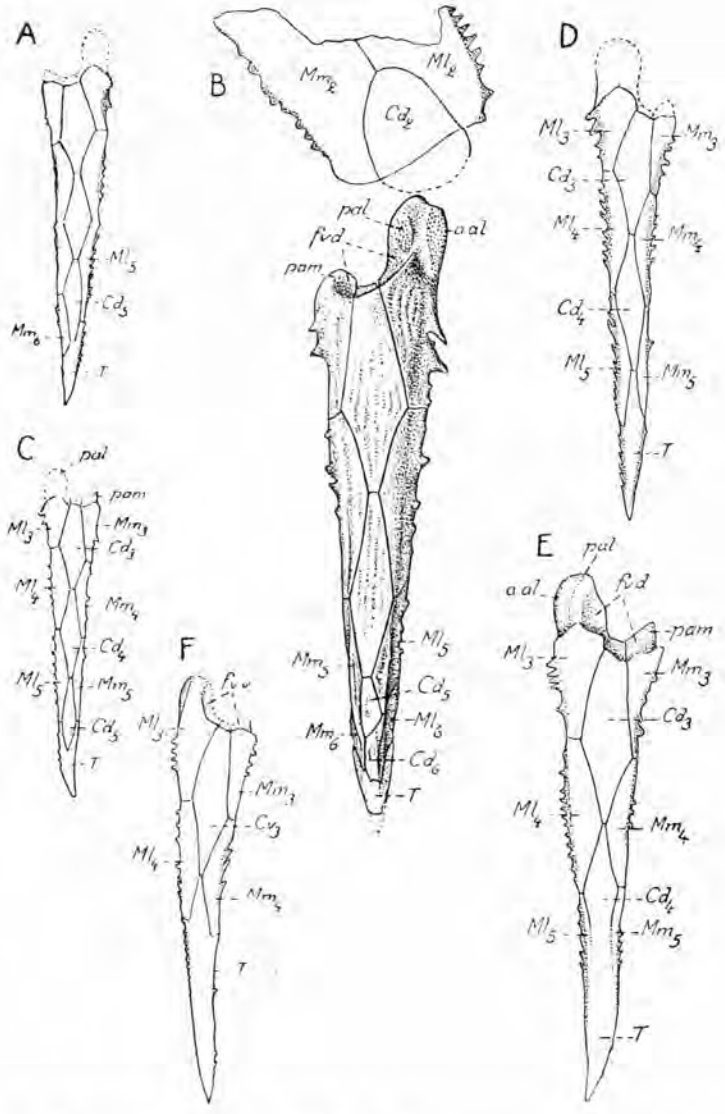
the growth of the pectoral fin that in large specimens it is much shorter and broader (text-fig. 194B, C). More precisely, it is about 1,9 times as long as broad in small individuals, but only about 1,25 time as long as broad in large individuals. The margins of the plate suturing with the lateral and medial marginal plates 2 normally are well rounded off and without marked angular corners.

The dorsal central plates 3–6 (text-figs. 90, 98, 180A, 181C, 182, 185, 187B, 192D, 198A–E) are fairly variable as to their length and breadth, but are as a rule relatively short and broad.

The ventral central series of plates (Cv_1–Cv_5, text-figs. 41B, 57, 161, 162, 167–169, 175, 176, 178, 185, 186, 188B, 189, 190A–D, 191B–D, 192E, 195, 196, 198F) normally consists of four independent elements (text-figs. 41B, 186B, 188C, 189B, 195), but not rarely it may also be represented only by three independent elements (text-figs. 189A, 198F). A potential distal element of the series in question is found in that ventral median process of the terminal plate that projects in a proximal direction towards the distalmost independent element of the series. In those cases when there are four independent elements in the series the said process represents a ventral central plate 5; in those cases, on the other hand, when the series is composed of only three independent elements the process is the equivalent of a ventral central plate 4. The process normally abuts against the distal end of the distalmost independent element of the series, but in certain cases it is separated from that element by the neighbouring marginal plates, which then meet in a more or less long median ventral suture. In large individuals the distalmost plates of the series are usually fused more or less with each other and with the other adjacent plates of the distal segment (text-figs. 186A, 188C).

The ventral central plate 1 (Cv_1, text-figs. 41B, 57, 88B, 161, 162, 167, 168, 176, 178, 186, 188, 189, 190A–D, 191B–D, 195, 196, 197A–F), as normally in the *Bothriolepinae*, is somewhat longer than the dorsal central plate 1. As the last-mentioned plate, it is generally longer in proportion to its breadth in small specimens than in large specimens. In small specimens it is about 3,06–2,8 and in medium-sized and large specimens about 2,85–2,72 times longer than broad. The unornamented area situated just distally to the external articular area (ar_3v) seems as a rule to have decreased in distal extent during the growth of the plate so that in large individuals it is usually shorter than in medium-sized and large individuals (text-figs. 195, 197A–F). The part of the ventro-medial margin that is situated on the plate just under consideration (*vmm*) is generally well-marked. In one case this part of the ventro-medial margin is even spine-bearing (*r.vmm*, text-fig. 197F).

The ventral central plate 2 (Cv_2, text-figs. 41B, 162, 167–169, 176, 178, 186, 187B, 188, 189A–C, 190A–C, 192E, 195) is mostly crushed and poorly preserved, on account of which its variations could not be ascertained. It is



Text-fig. 198. *Bothriolepis canadensis*. *A–E*, five distal segments of pectoral fins in dorsal aspect. *A*, *B*, right distal segments (*B*, with a distal end of the proximal segment). *C–E*, left distal segments. *A*, × 5/2. *B*, × 5/3. *C–E*, × 5/4. *F*, a right distal segment in ventral aspect. × 5/4.

Cd_2–Cd_6, dorsal central plates 2–6; Cv_3, ventral central plate 3; Ml_2–Ml_6, lateral marginal plates 2–6; Mm_2–Mm_6, medial marginal plates 2–6; *T*, terminal plate; *a. al*, lateral area of „Siebknochen" on lateral anconeal process; *afd*, external articular area of plate Cd_2; *fvd*, articular fovea of dorsal side of distal segment; *fvv*, articular fovea of ventral side of distal segment; *pal*, lateral anconeal process; *pam*, medial anconeal process.

probable, however, that it is a little broader in large than in small individuals. The part of the ventro-medial margin (*vmm*) situated on this plate is rounded off posteriorly. In one case the plate is subdivided into two independent elements (Cv_2a, Cv_2b, text-figs. 175, 197 G), anterior and posterior, of which the latter articulated with the distal segment.

The ventral central plates 3 and 4 (Cv_3, Cv_4, text-figs. 41 B, 167, 168, 186, 188 C, 189 A, B, 192 E, 195, 198 F), particularly, however, the latter plate (Cv_4), are longer and narrower than the corresponding dorsal central plates. The two plates may otherwise vary somewhat as to proportions and shape.

The lateral marginal series of plates (Ml_2–Ml_5, text-figs. 41 B, 88 B, 90, 96–98, 115, 116, 127–130, 132, 134, 140–142, 149, 155, 159, 161, 167–169, 176, 178, 180 A, 181 C, 182, 184–189, 190 A, D, E, 191 A, 192 D, E, 194, 195, 196 A, 198, 211) is composed of three or, more often, four fully independent elements. In one case, however, also a fifth element has been found (Ml_6, text-figs. 192 D, 198 B), but this fifth element is fused with the dorsal central plate 6 and probably also with one of the ventral central elements and thus is not fully independent. In large individuals the distalmost elements of this series often are secondarily fused with each other, with, the terminal plate, and with other adjacent elements of the distal segment.

The lateral marginal plate 2 (Ml_2, text-figs. 41 B, 98, 115, 116, 128, 130, 132, 134, 140, 149, 159, 167, 178, 180 A, 181 C, 182, 184–189, 190 A, D, E, 194, 195, 196 A, 211) is a little broader across its ventral lamina than across its dorsal lamina. Besides, it seems normally also to be broader in large than in small individuals.

The lateral marginal plate 3 (Ml_3, text-figs. 41 B, 98, 180 A, 181 C, 182, 184–187, 188 C, 189 A–C, 190 A, 192 D, E, 195, 198) varies a good deal as to its proportions. The lateral anconeal process (*pal*) is mostly broad and always has a well developed lateral area of "Siebknochen" (*a.al*) for the articulation with the internal face of the lateral marginal plate 2 (text-fig. 198). The lateral spines situated on the plate are mostly more or less clearly curved in a distal direction, but may also be fairly straight so that they point almost straight laterally.

The lateral marginal plate 4 is always independent. The lateral marginal plate 5, on the other hand, sometimes is independent, sometimes fused with the terminal plate (Ml_4, Ml_5, text-figs. 41 B, 98, 180 A, 181 C, 182, 184–186, 187 B, 188 C, 189 A, B, 192 E, 195, 198 A, C–F). The lateral marginal plate 6 (Ml_6) has been found fully independent from the terminal plate only in a single specimen. In this specimen, however, it is fused with the dorsal central plate 6 and probably also with the distalmost ventral central element (text-figs. 192 D, 198 B). The lateral spines belonging to the lateral marginal elements 4–6 mostly are curved more or less in a proximal direction.

The medial marginal series (Mm_1–Mm_5, text-figs. 41 B, 57 A, C,

90, 96–98, 115, 116, 127–130, 132, 134, 140–142, 149, 155, 158, 159, 161, 162, 164A, 167, 168, 175, 176, 180A, 181C, 182, 184–188, 189A–C, 190B, C, 191A, D, 192D, E, 194, 195, 196B, 198, 211) may consist only of four elements (text-figs. 189A, 198F), but mostly, however, it is composed of five elements. In two specimens it presents even as many as six elements (text-figs. 149, 192D, 198A, B). The most distal elements of the series in large individuals usually are fused secondarily with each other, with the terminal plate, and with the other adjacent plates of the distal segment. The series is normally developed in relation to the pectoral pit-line groove (*sgp*, text-figs. 57A, C, 188C, 190B, C, 191D, 195B, 196B).

The medial marginal plate 1 (Mm_1, text-figs. 57A, C, 190B, C, 191D, 196B) almost always is very poorly preserved. Nothing could, therefore, be made out concerning its variations. The postarticular thickening (*mt*) is well-marked. The plate varies somewhat as to its connections with the adjacent plates. In certain cases (text-fig. 196B) it is connected with the dorsal central plate 1 (Cd_1), the ventral central plate 1, (Cv_1) and the medial marginal plate 2 (Mm_2), whereas in other cases (text-fig. 190C) it is connected with the three plates just referred to and in addition also with the ventral central plate 2 (Cv_2). Its connection with the last-mentioned plate, however, is very slight.

The medial marginal plate 2 (Mm_2, text-figs. 98, 115, 116, 128, 129, 130, 132, 134, 140, 149, 159, 180A, 181C, 182, 184–187, 188A, B, 189A, B, 190 A–C, 191A, 194, 195, 196B, 198B, 211) generally is longer and narrower in small individuals than in medium-sized and large individuals. Its dorsal lamina thus normally is about four and a half times as long as broad in small individuals, but only about three and a half times as long as broad in large individuals. The medial lamina of the plate in certain cases abuts against the ventral central plate 1 with its ventro-proximal corner (text-fig. 196B), whereas in other cases it is completely separated from the last-mentioned plate by the medial marginal plate 1 and the ventral central plate 2 (text-fig. 190C). As has already been pointed out, the medial spines are directed dorsally on the proximal part of the plate, but medially on distalmost part of the plate.

The medial marginal plate 3 (Mm_3, text-figs. 90, 98, 115, 116, 127, 128, 130, 132, 140, 142, 149, 159, 161, 162, 167, 168, 175, 176, 180A, 181C, 182, 184–187, 188C, 189B, C, 190B, 192D, E, 195, 198) mostly extends a little further distally than the lateral marginal plate 3. As the last-mentioned plate, it varies considerably in proportions. The medial anconeal process (*pam*) is hort and pointed. The medial spines situated on the plate are mostly curved in a distal direction, but may also point rather straight medially. The distal ones of them may even be recurved in a proximal direction.

Of the medial marginal plates 4–6 (Mm_4–Mm_6, text-figs. 90, 98, 116, 128, 130, 132, 140, 142, 149, 167, 168, 180A, 181C, 182, 184–186, 187B, 188C,

189A–C, 192D, E, 195, 198) No. 4 (Mm_4) is always independent. No. 5 (Mm_5) is also often independent, whereas, as already mentioned (pp. 363–364, 371 above), No. 6 (Mm_6) has been found to be independent only in two cases. The medial spines developed on the marginal plates 4–6 are mostly curved in a proximal direction, but may also not rarely be almost straight.

The terminal plate (*T*, text-figs. 58A–C, 90, 98, 115, 128, 142, 149, 161, 167, 168, 182, 184A, C, 185, 186, 187B, 188C, 189A–C, 192D, E, 195, 198) varies considerably as to development and extent. In most cases it is of the ordinary *Bothriolepis*-type as defined by Gross (1941a, pp. 60–63). In these cases on the dorsal side it exhibits a lateral and a medial unpaired process, which are potential homologues of the lateral marginal plate 6 and the medial marginal plates 6 respectively, and on the ventral side a median unpaired process, which is a potential homologue of a ventral central plate 5 (text-figs. 41B, 58A, B, 184C, 189B, 198C). Exceptionally, however, the plate is either confined to a more distal part of the distal segment so that its dorsal lateral and medial processes are potential homologues of the lateral and medial marginal plates 7 respectively (text-figs. 192D, 198B), or else it extends further proximally into the distal segment so that it includes elements of the fifth transverse series (text-figs. 189A, 198F). Not infrequently the plate is of a type similar to that in *Asterolepis ornata* (cf. text-fig. 58D, E) in that it is provided with both a dorsal and a ventral median process and lacks lateral processes (text-figs. 58C, 90, 98, 184A, 189A, 198D, F). When it is of the last-mentioned type its dorsal and ventral median unpaired processes are the potential homologues of the dorsal central plate 5 and the ventral central plate 4 respectively. In these cases it includes ventrally also the lateral and medial marginal plates 5, whereas dorsally it is disconnected from those two marginal plates. Finally, it may rarely also be of a normal *Bothriolepis*-type, except that at least on the dorsal side its lateral medial process is developed as an independent medial marginal plate 6 (text-figs. 149, 198A). In large individuals the plate is normally secondarily fused with several of the central and marginal plates proximally to it so that it extends far proximally into the distal segment, forming an extensive secondary terminal plate (text-figs. 182, 185, 186, 187B, 188C, 192E, 198E). The fusions leading to the formation of this secondary terminal plate mostly are not more intimate, however, than that in many cases the elements entering into it may be traced fairly well when the superficial layer of the bone-tissue is removed by scratching or by etching with acid (text-fig. 186B).

As may be gathered from what has been set forth just above, the terminal plate varies considerably as to its shape, extent and homologies. This plate is thus not nearly as constant in its development as one would perhaps be inclined to believe.

The terminal plate may be practically straight or slightly curved towards the lateral or medial sides (text-fig. 198). The plate generally is spine-

bearing, but may also be devoid of spines. Its lateral spines are always stronger than its medial ones. All the spines of the plate are mostly curved in a proximal direction, but in certain cases they may also be fairly straight.

As has been shown in the account here given of the pectoral fin-armour, the number of independent elements observed in the dorsal central, ventral central, lateral marginal and medial marginal series of the distal segment is at the minimum 2, 1, 3, 3, respectively, and at the maximum 4, 2, 4, 4 respectively.

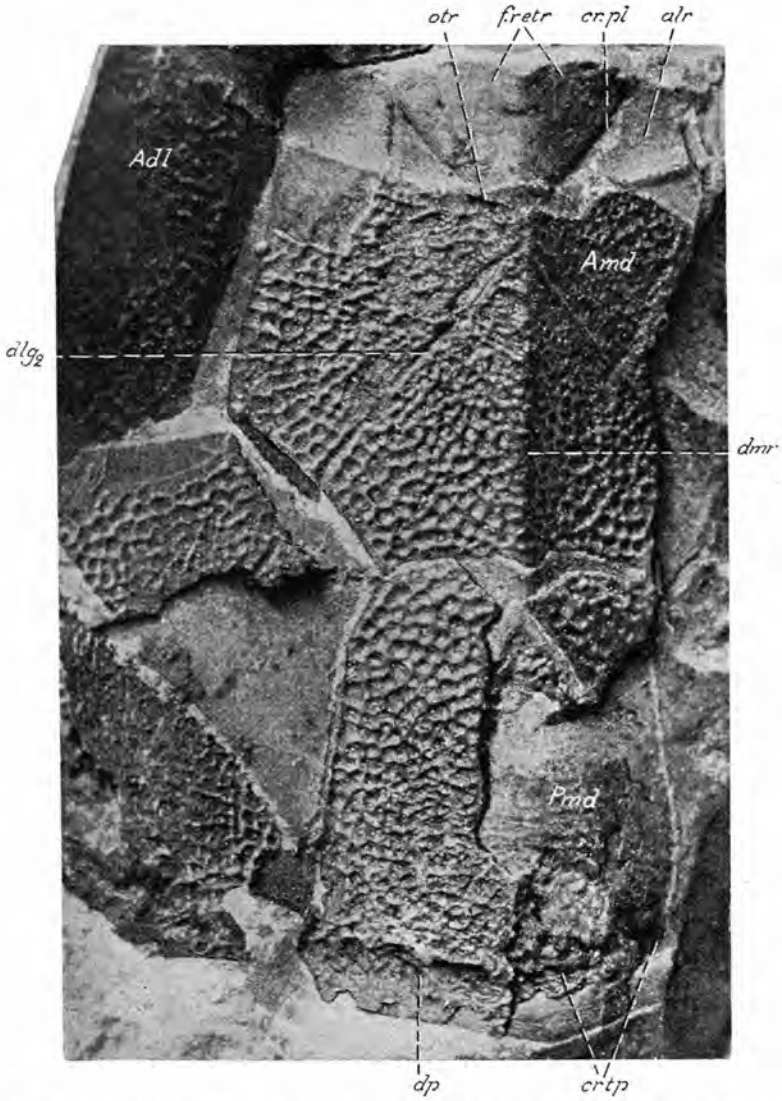
Pelvic fin. – The pelvic fin (*Pv*, text-figs. 38, 40B, 59, 60, 175) has already been described above in the general part of this work (pp. 160–162). It should here be pointed out, however, that in the specimen in which it was described by the present writer it seems to have been a simple laterally projecting fold and not a formation of a more complicated nature (cf. Denison 1941). Its exoskeleton is represented only by scattered 3-radiate dermal structures (*Sc*, text-fig. 56; see p. 146).

Unpaired fins.

The unpaired fins have already been dealt with in the general part of this work (pp. 163–168). The material in the Swedish Museum of Natural History in Stockholm shows well the posterior dorsal fin (D_2) and the caudal fin (text-figs. 38, 40B, 62), but practically nothing of the anterior dorsal fin. As has been pointed out (p. 163), the posterior dorsal fin is probably somewhat variable in shape.

Soft internal structures.

Remains of the intestine are sometimes found in the interior of the trunk-armour. These remains consist of a very delicate carbonaceous film surrounding a shaly mass of rock, sometimes partly rich in organic substance. This Shaly mass in one of the specimens available is concentrated and clearly tends to form a coprolite (R.M. specimen No. P. 2103). The remains of intestines examined by the writer show no traces of the spiral valve described by Denison (1941), but it is nevertheless likely that this valve was present (cf. pp. 168 above). The other formations interpreted by Denison as remains of soft structures are not to be found in the specimens examined by the writer. As has already been emphazised (p. 168 above), the interpretations of these formations given by Denison are certainly on the whole erroneous.



Text-fig. 199. *Bothriolepis canadensis*. Parts of the dorsal wall of the trunk-armour of a very small specimen (total length of trunk-armour 1,85 cm). Dorsal aspect. The characters of the immature type of ornament well shown. R. M. specimen No. P. 2747 (same specimen as in text-fig. 88 A, B). × 6.5

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate (preserved as an impression of its lower side anteriorly and deficient on the right side); *Mxl*, mixilateral plate (partly represented by an impression of its lower side); *Pmd*, posterior median dorsal plate (partly represented by an impression of its lower side); *alr*, postlevator thickening (impression); *cr. pl*, postlevator crest (impression); *crtp*, crista transversalis interna posterior (impression); dlg_2, posterior oblique abdominal pit-line groove; *dmr*, dorsal median ridge; *dp*, groove above median dorsal part of crista transversalis interna posterior; *f. retr*, levator fossa (impression); *otr*, oblique transverse ridge behind anterior abdominal pit-line groove (dlg_1).

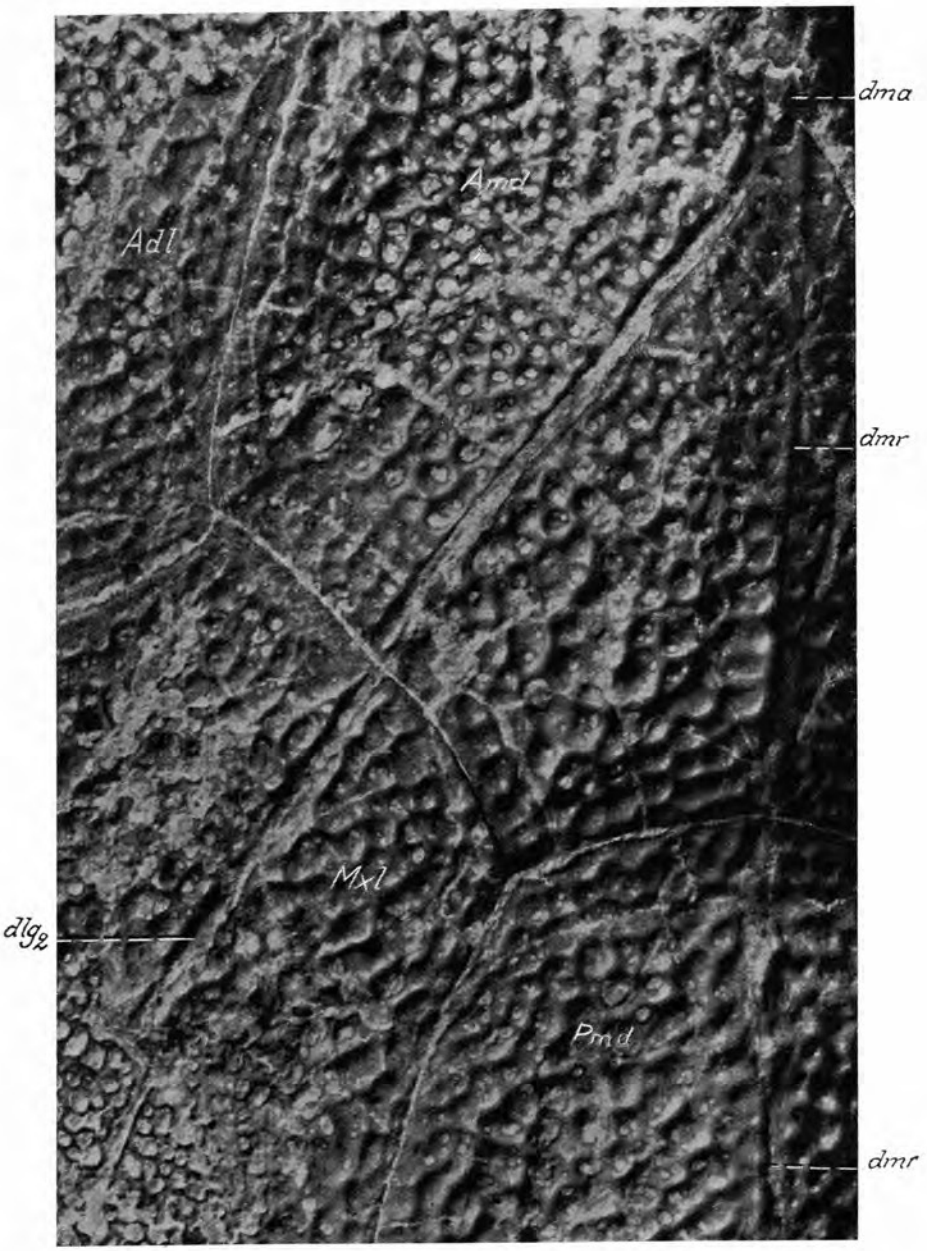
Ornament.

In the smallest specimens examined, in which the dorsal wall of the trunk-armour is only 1,85–3,8 cm long, the ornament invariably consists of somewhat coarse ridges, forming a regular net-work with small meshes of an on the whole somewhat uniform size (text-figs. 88A, B, 90, 91, 95, 199–201, 204, 205, 206, 211). Short isolated ridges and tubercles are absent but the ridges often or generally show more or less clear indications of tubercles at their points of anastomoses, being thickened, elevated and more or less clearly nodose at those points. The meshes of the net-work on the head-shield and trunk-armour are mostly about equally broad as long or do not differ so very much in breadth and length. They may be three-sided to six-sided in outline and may also vary somewhat in diameter. Mostly they are wider than the ridges bounding them but may also be about equally wide as, or narrower than, these ridges. The meshes in the net-work on the pectoral fin mostly are of a type similar to that on the head-shield and trunk-armour, but may sometimes (text-fig. 88B) also be longer in proximo-distal than in transverse directions. A characteristic feature of the ornament in these very small individuals is also the condition that the ridges usually show no or slight indications of a radiating or concentric disposition.

The ornament in somewhat larger individuals in which the dorsal wall of the trunk-armour is from 3,9 cm to about 5,5 cm long is on the whole as that in the smallest individuals with the difference, however, that the ridges on certain of the plates of the head-shield and on the marginal parts of several of the plates of the trunk-armour begin to show a somewhat radiating or concentric disposition or both (text-figs. 80A, 96, 97, 115, 118A, B, 202, 203).

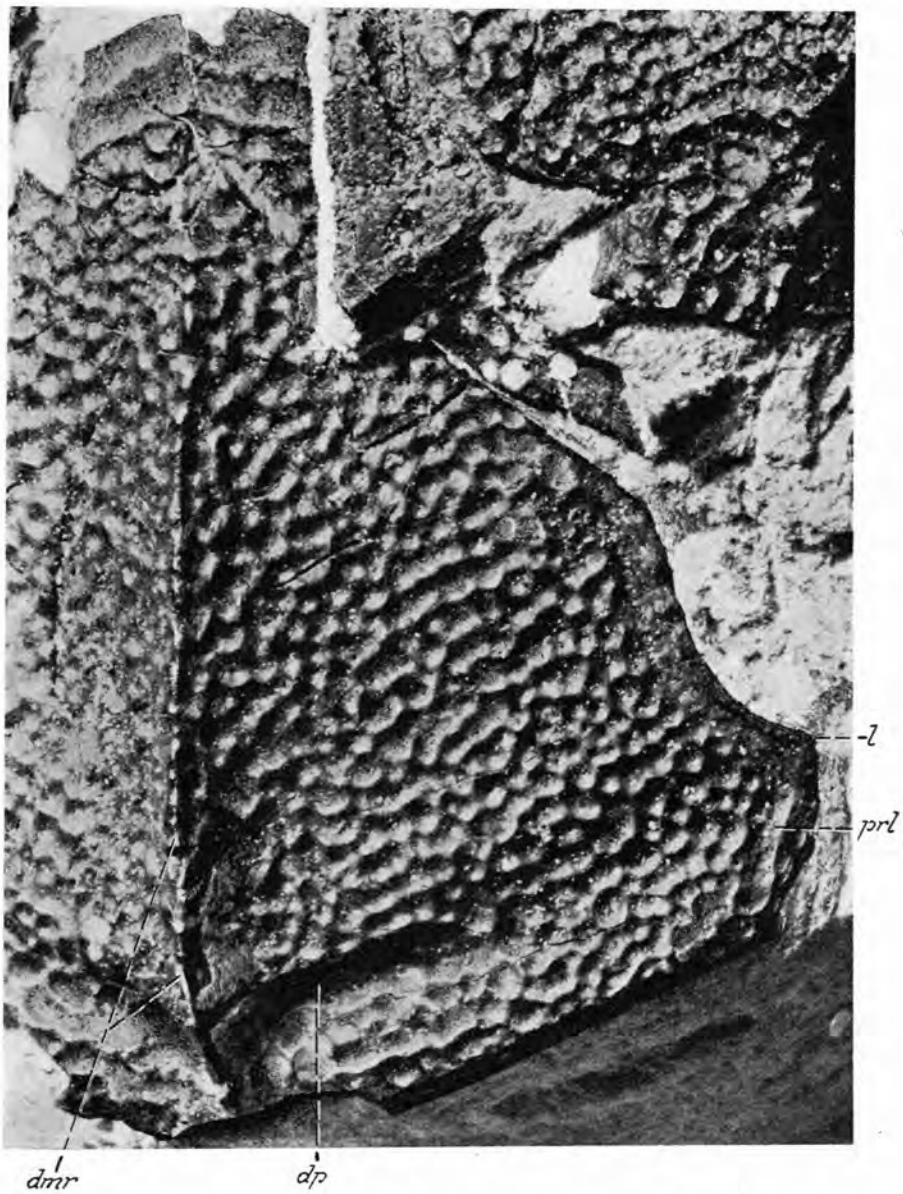
In individuals in which the dorsal wall of the trunk-armour is longer than about 5 or 5,5 cm further changes in the character of the ornament have taken place, in that the ridges, particularly of the marginal parts of the plates, are more or less subdivided into shorter pieces or tubercles and, besides, to some extent are devoid of anastomoses. With the increase in size of the individuals this subdivision and transformation of the ridges proceeded further and spread also on to the central parts of the plates, causing a general more or less complete disintegration of all the ridges. In consequence of this disintegration the ornament in large individuals normally on the whole is decidedly tubercular, above all on the head-shield and on the dorsal parts of the trunk-armour (text-figs. 76–81, 154–159). Otherwise the ornament in large individuals is characterized by the following features. The persisting pieces of ridges are often vermiculating and nodose. The tubercles are frequently stellate at their bases. The ornament of the individual plates usually shows a clear concentric or radiating disposition or both these dispositions at the same time.

As may thus be gathered, we may distinguish in *B. canadensis* two types

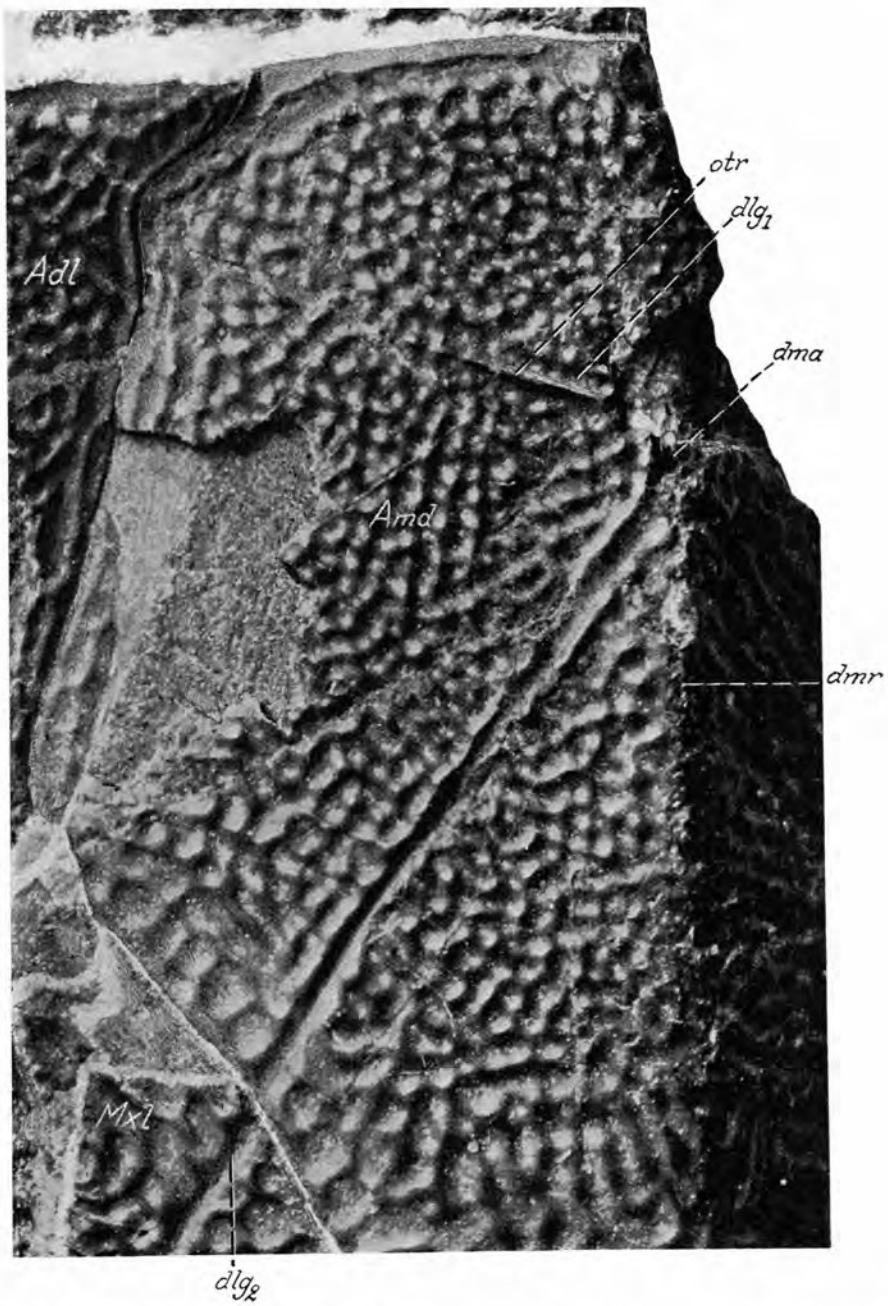


Text-fig. 200. *Bothriolepis canadensis*. Part of the dorsal wall of a trunk-armour of a small specimen (dorsal length of trunk-armour 3,4 cm). Dorsal aspect. The ornament is well shown, but is partly a little abraded. R. M. specimen No. P. 2719 (same specimen as in text-fig. 95). × 8.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge.

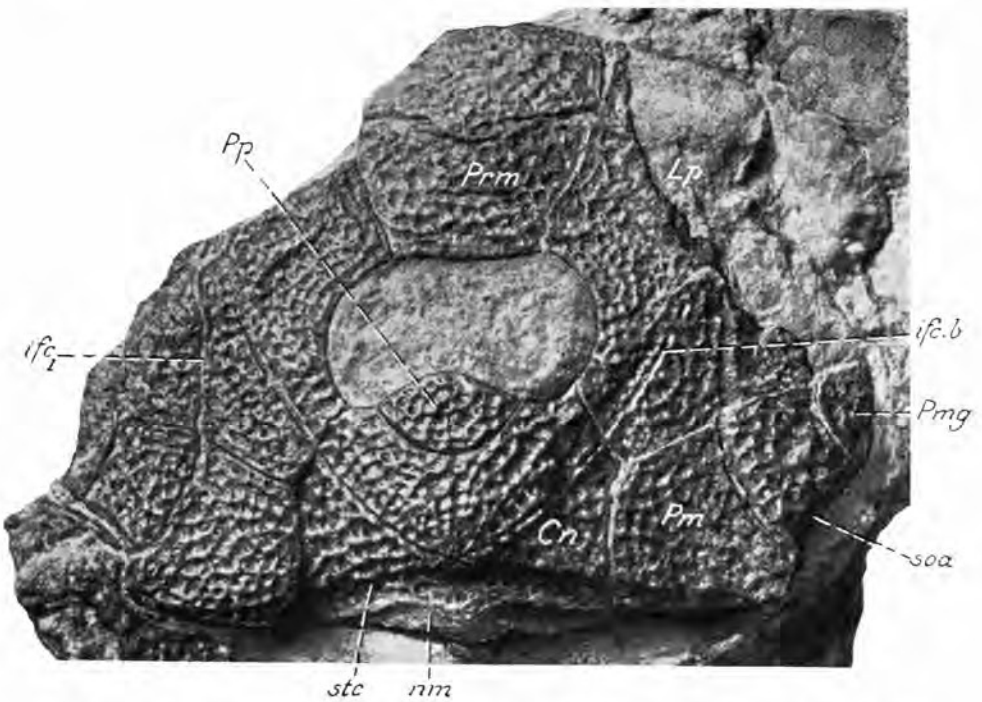


Text-fig. 201. *Bothriolepis canadensis*. Part of a posterior median dorsal plate of a small specimen (dorsal length of trunk-armour 3,6 cm). Dorsal aspect. R. M. specimen No. P. 2326 (same specimen as in text-fig. 91). × 8.
dmr, dorsal median ridge; *dp*, groove above crista transversalis interna posterior; *l*, lateral corner; *prl*, lateral process.



Text-fig. 202. *Bothriolepis canadensis*. Part of an anterior median dorsal plate of a small specimen (length of dorsal wall of trunk-armour 3,9 cm). Dorsal aspect. R. M. specimen No. P. 2448 (same specimen as in text-fig. 96). × 8.

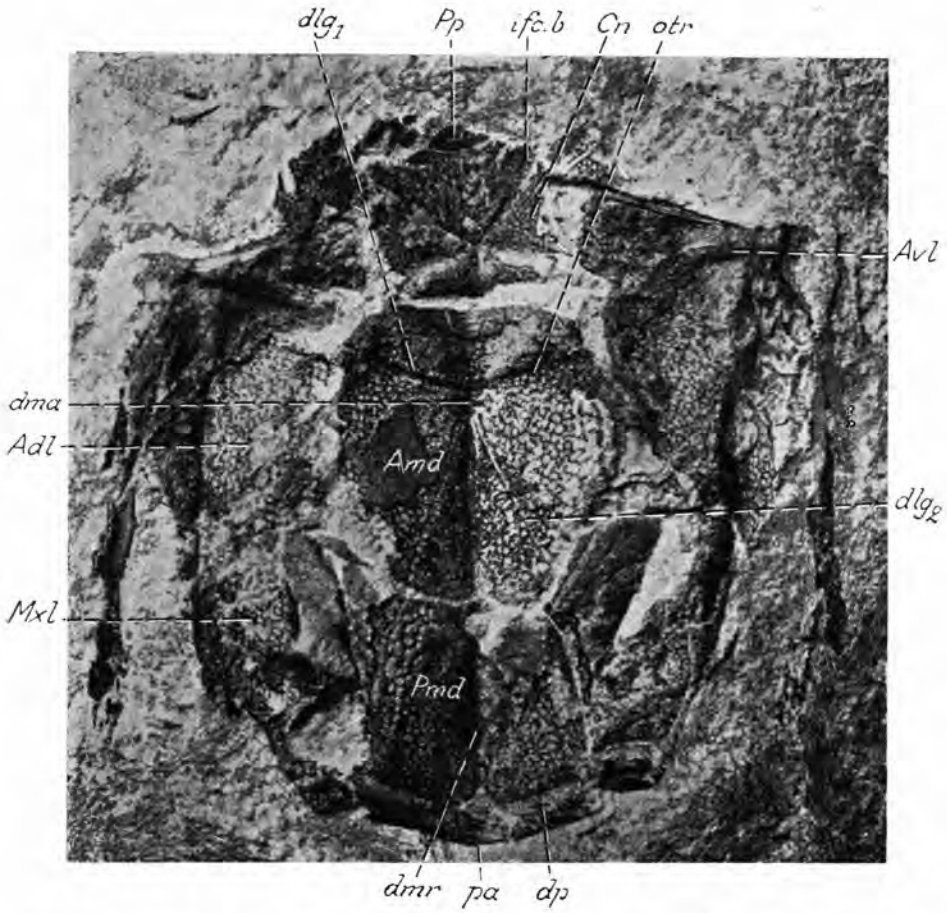
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Mxl*, mixilateral plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle (imperfectly preserved); *dmr*, dorsal median ridge; *otr*, oblique transverse ridge behind groove dlg_1.



Text-fig. 203. *Bothriolepis canadensis*. Head-shield of a specimen in which the dorsal wall of the trunk-armour is 5,2 cm long. This head-shield has retained its immature type of ornament almost unchanged. R. M. specimen No. 2836. × 3.
Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *nm*, obtected nuchal area; *soa*, subobstantic area; *stc*, supratemporal pit-line groove.

of ornament, an immature regularly reticular type and a mature largely or principally tuberculae type. The transformation of the ornament from the immature to the mature type procedded differently fast in different individuals and also ceased at different stages, on account of which considerable variations in the development of the ornament are met with in medium-sized and large individuals. These variations are illustrated by several of the reproductions given above, e.g. text-figs. 76–81, 85, 94, 99, 101, 102, 109, 116–120, 127–135, 140–149, 155–163, 167, 169, 170C, 171, 172D, 175–178, 184–187, 188A, B, 189A–C, 192A–C.

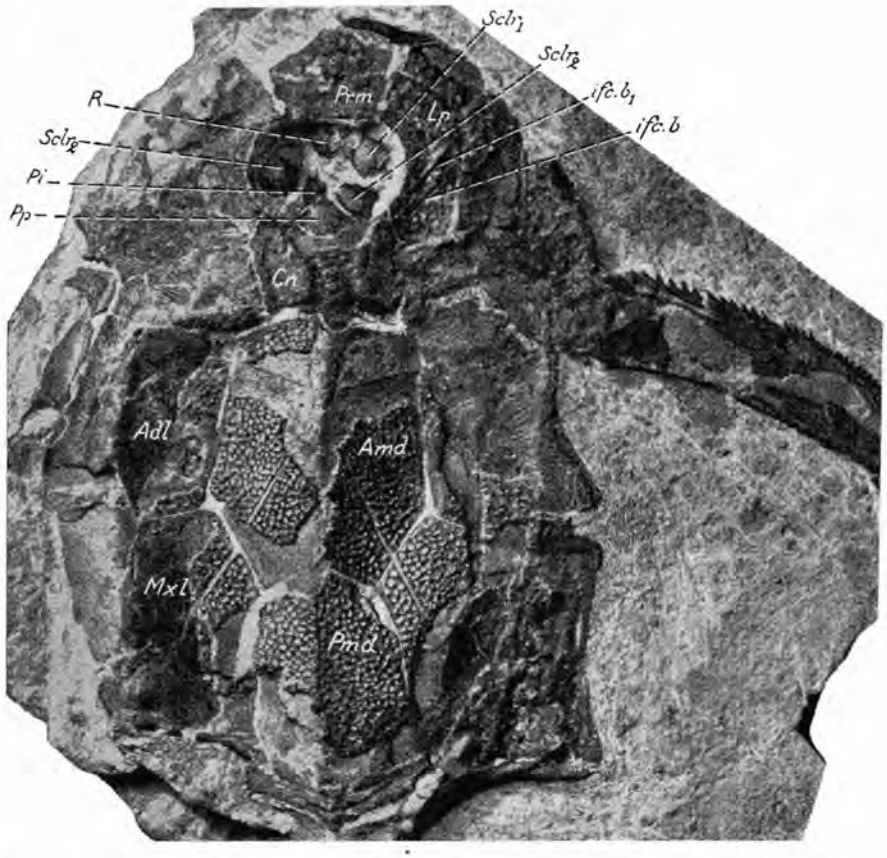
We shall now enter somewhat more in detail upon the development of the ornament in medium-sized and large individuals. In individuals of these two categories of size the ornament generally is most transformed on the head-shield and on the dorsal parts of the trunk-armour. It is there usually more or less irregular and tubercular (text-figs. 10, 25A, 76–81, 101, 109, 116, 117, 119, 120, 127–135, 140–149, 154–159), whereas on the ventral parts of the trunk-armour and on the proximal segment of the pectoral fin it often



Text-fig. 204. *Bothriolepis canadensis*. Small specimen, preserved mainly as impression of the dorsal side of its head-shield and trunk-armour (dorsal length of trunk-armour about 1,85 cm). Impression of the regular reticular ornament well shown. R. M. specimen No. P. 2403. Approximately × 4.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate (fragment); *Cn*, centro-nuchal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; dlg_1, anterior oblique abdominal pit-line groove (impression); dlg_2, posterior oblique abdominal pit-line groove (impression); *dma*, tergal angle; *dmr*, dorsal median ridge (impression); *dp*, groove above the crista transversalis interna posterior (impression); *ifc. b*, posterior oblique cephalic pit-line groove (impression of the ridge behind the groove); *otr*, oblique transverse ridge (behind the anterior oblique abdominal pit-line groove).

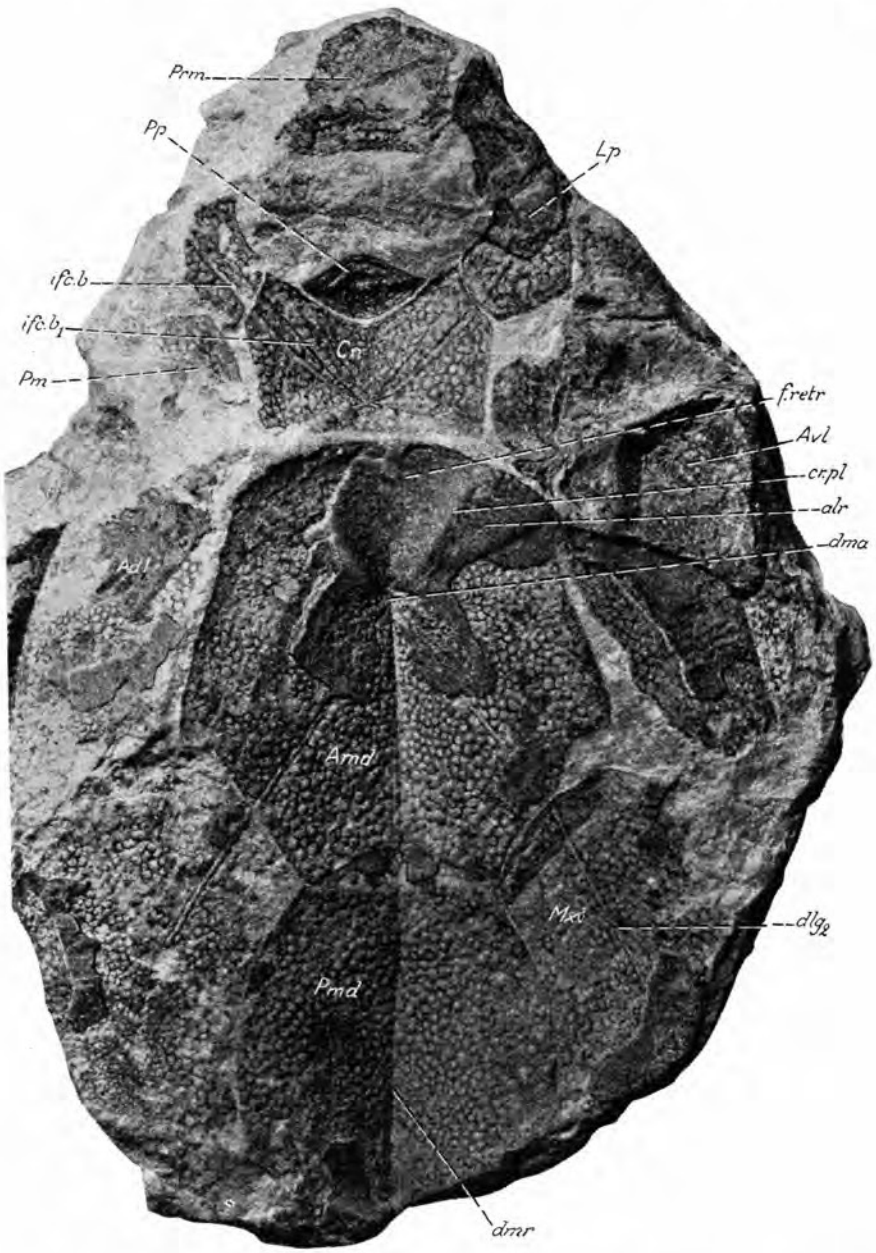
retains more of its immature reticular character (text-figs. 160–163, 164B, 165D, E, 167–169, 170B, C, 171, 172D, 175–178, 184–186, 187A, 189A–C, 190C, D, 191A–D, 192A–C). Often it is also much transformed on the opercular plate (text-figs. 32A, B, 105). On the other hand, it is normally clearly reticular on the anterior and postero-dorsal sclerotic plates, on the prelateral, infraprelateral and mental plates, on the inferognathal, and on the submandi-



Text-fig. 205. *Bothriolepis canadensis*. Small deficient specimen in dorsal aspect. The specimen much dorso-ventrally flattened and the plates of the dorsal wall of its trunk-armour to a large extent represented only by impressions of their lower sides. The immature type of ornament clearly shown in places. R. M. specimen No. P. 2320. Approximately × $^5/_2$.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pi*, pineal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *R*, rostral plate; $Sclr_1$, $Sclr_2$, anterior and postero-dorsal sclerotic plates respectively; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove.

bular plates (text-figs. 21C, 30B, 33, 34, 35A, 36A, 107A, 108, 111). The distal segment of the pectoral fin, as normally in *Bothriolepis*, is provided with an ornament of longitudinal ridges. These ridges, which are low, well rounded off, and slightly undulating, are somewhat well developed on the whole dorsal side of the segment, whereas they are often absent on the distal parts of the ventral side of the segment (text-figs. 127, 132, 149, 159, 161, 162, 167, 184, 186, 187B, 188C, 192D, E, 198B). The pineal plate is but slightly ornamented. Finally, the postero-ventral sclerotic plate and the subhyoideal bone, or bones, seem always to be completely without ornament.



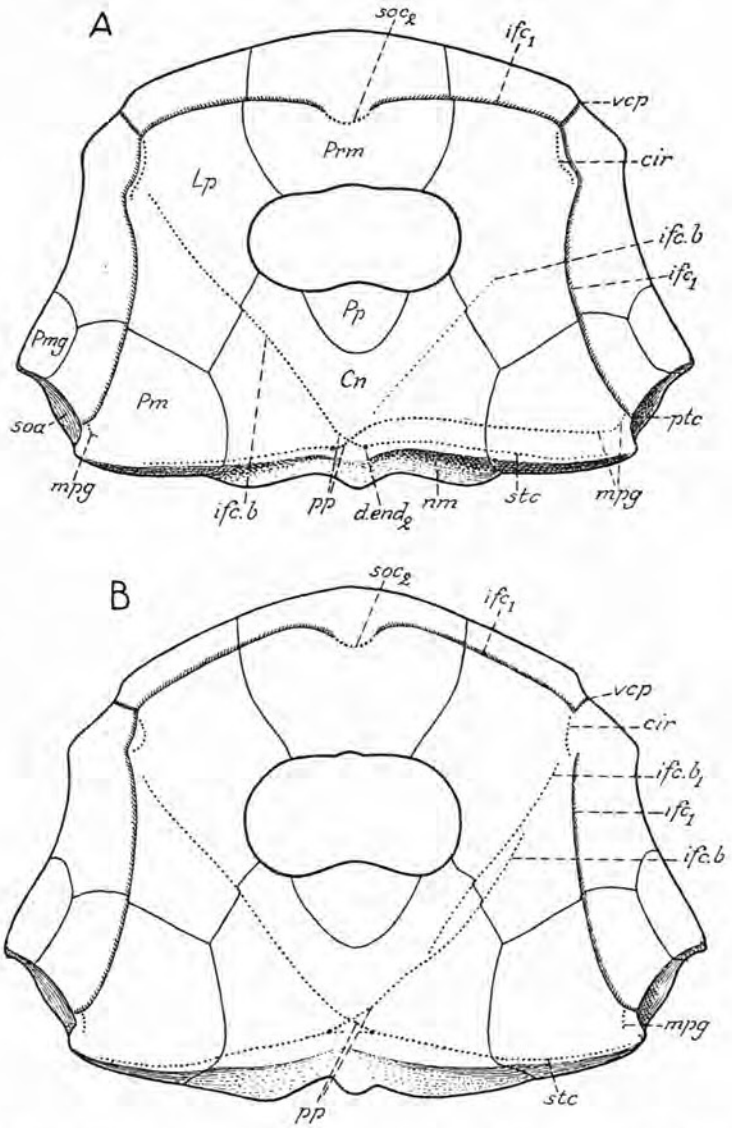
Text-fig. 206. *Bothriolepis canadensis*. Small deficient specimen, preserved mainly as an impression of the dorsal side of the head-shield and trunk-armour (dorsal wall of trunk-armour about 3,5 cm long). R. M. specimen No. P. 2746. Approximately × 3.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate (fragment); *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, post-pineal plate; *Prm*, premedian plate; *alr*, postlevator thickening; *cr. pl*, postlevator crista; dlg_2, posterior oblique abdominal pit-line groove (impression); *dma*, tergal angle (imrpession); *dmr*, dorsal median ridge (impression); *f. retr*, levator fossa; *ifc. b*, posterior oblique cephalic pit-line groove (impression); *ifc.* b_1, anterior oblique cephalic pit-line groove (impression).



Text-fig. 207. *Bothriolepis canadensis*. Posterior parts of the dorsal wall of a trunk-armour in dorsal aspect. R. M. specimen No. P. 2369. × 3/2.
Amd, anterior median dorsal plate; *Mx*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_2a, dlg_2b, posterior oblique abdominal pit-line groove, subdivided into two fairly parallel grooves; *dma*, tergal angle; *dmr*, dorsal median ridge; *pa*, posterior corner or angle.

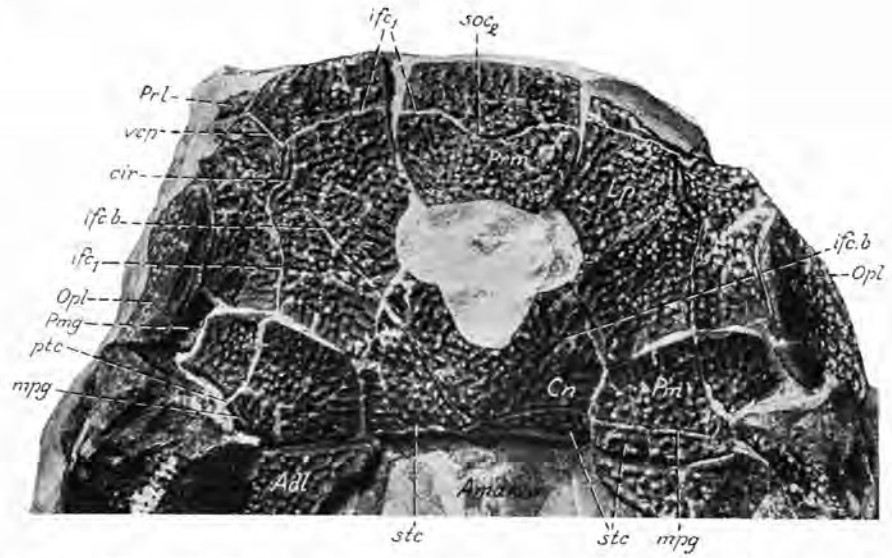
The ornament of the medium-sized and large individuals mostly is comparatively delicate (text-figs. 77B, C, 78–81, 85E–M, O, P, 101, 102, 108, 119, 120, 127–129, 133, 141–146, 148, 151, 154, 156–158, 160–163, 168–171, 172A, D, 175–178, 184–188, 189A–C), but may also not rarely be of a coarser type (text-figs. 85N, 94C, 117, 130–132, 134, 140, 147, 149, 155, 159, 167, 190C, D, 191A).

The medium-sized specimen reproduced in text-fig. 102 shows distinct zones of growth along the margins of most of the plates in the dorsal wall of the trunk-armour. These zones are almost smooth, their ornament consisting only of weak, obscure concentric ridges in an initial stage of development. Similarly ornamented zones of growth in a more advanced stage of development occur in several specimens, e.g. in those shown in text-figs. 108, 160–162, 176 and 207. Zones of growth with a radiating, or both radiating and concentric, disposition of the ornament are frequently met with inter alia also in fairly small specimens (text-figs. 76, 78B, 94C, 95–97, 99B–D, F, 101, 109, 117, 118B, C, D, F, 119A, B, C, E, F, 120, 127, 130–133, 135D–G, 140, 141, 143, 147, 149, 154–157). The conditions in such specimens as those reproduced in text-figs. 102, 109, and 207 seem to show that the growth-



Text-fig. 208. *Bothriolepis canadensis*. *A*, restoration of a head-shield in dorsal aspect. This head-shield shows the middle pit-line groove of the skull-roof completely developed on the right side. Somewhat more than × 3/2. *B*, restoration of another head-shield in dorsal aspect. This head-shields on the right side shows a persisting part of the anterior oblique cephalic pit-line groove. The upper infraorbital sensory canal groove is absent for some distance laterally to the semicircular pit-line groove. × 3/2.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *cir*, semicircular pit-line groove; *d. end*$_2$, external opening of canal for endolymphatic duct; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc. b*$_1$, anterior oblique cephalic pit-line groove; *mpg*, middle pit-line groove of skull-roof (completely developed on right side in fig. *A*); *nm*, obtected nuchal area; *pp*, posterior pit-line groove of skull-roof; *ptc*, cephalic division of main lateral line; *soa*, subobstantic area; *soc*$_2$, anterior median section of the supraorbital sensory canal groove; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.



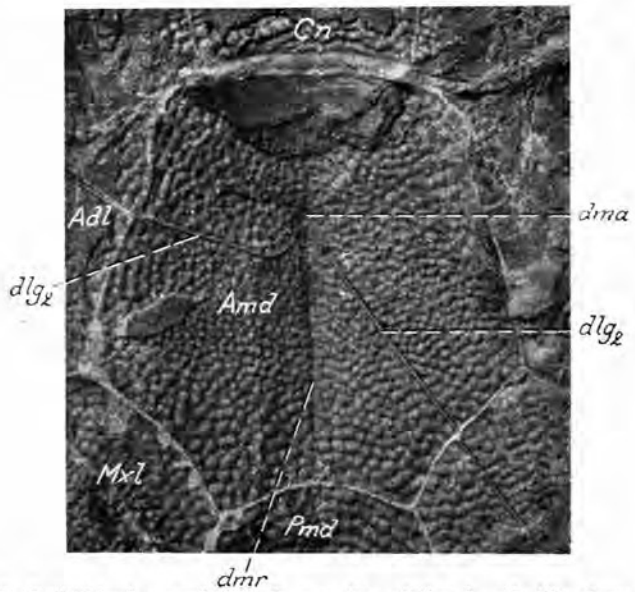
Text-fig. 209. *Bothriolepis canadensis*. Somewhat crushed and flattened head-shield in dorsal aspect. This head-shield has the middle pit-line groove of the right side completely developed. R. M. specimen No. P. 2181. × $^3/_2$ approximately.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate (impression of lower side); *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Prl*, prelateral plate; *Prm*, premedian plate; *cir*, semicircular pit-line groove; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove (shallow and obsure on the right side); *mpg*, middle pit-line groove (completely developed on right side); *ptc*, cephalic division of main lateral line; *soc*$_2$, anterior median division of supraorbital sensory canal groove, the anterior median pit-line; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

zones at first developed in the deeper parts of the corium and that on account of this they became ornamented only later on when they had increased more in thickness in a superficial direction. The concentric and radiating disposition of the ornament on the marginal parts of the bones seems thus to have arisen in consequence of the zonal growth of the bones. Accordingly we have here probably a correlation between the growth of the external dermal bones and the disposition of the ornament fundamentally similar to that in Stegocephalians (Bystrow 1935; Säve-Söderbergh 1937).

In one of the specimens examined the posterior median dorsal plate has been broken through in one place by a wound (*rw*, text-fig. 131). A healing of the wound has taken place and bone tissue has regenerated, but this regenerated bone tissue is throughout situated a little deeper down than the surrounding one because of which the boundaries of the wound are clearly traceable.

Sensory canal system.

As to the general development of the sensory canal system, it is now clear that the pit-line grooves are normally deeper, more pronounced, and



Text-fig. 210. *Bothriolepis canadensis*. Impression of the dorsal side of an anterior part of a dorsal wall of a trunk-armour. The impression shows on the right side (left in the figure) an abnormally passing posterior oblique abdominal pit-line groove. R. M. specimen No. P. 2308. × 2.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge.

more complete in earlier stages of growth than in later stages (text-figs. 84, 88A, B, 90–93, 95–98, 101, 102, 109, 115–124, 127–134, 140–143, 146–149, 154–159, 179–183, 199, 200, 202–206, 211). In addition it is obvious now that at least two of the pit-line grooves, the anterior oblique cephalic pit-line groove and the anterior oblique abdominal pit-line groove, which normally are met with in very small individuals, generally have disappeared completely in medium-sized and large individuals.

The supraorbital sensory canal groove as here defined (cf. pp. 172–173 above) is represented by both its sections. Its posterior paired section (soc_1, text-figs. 21C, 30D, 65, 104, 114) is frequently developed as a more or less marked groove on the postero-dorsal sclerotic plate, more rarely as a very shallow groove along the lateral margin of the pineal plate (Stensiö 1931, p. 142, text-figs. 11A, 74). The anterior median unpaired section of the groove (soc_2, text-figs. 4, 6, 7, 9, 10, 65, 77B, C, 78B, C, 80B, C, 81B, 82–84, 85E–P, 98, 101, 114, 117, 127, 128, 132, 147, 148, 154, 155, 158, 203, 208, 209) varies considerably in length and depth.

The upper infraorbital sensory canal groove (ifc_1, text-figs. 4, 6, 7, 9, 10, 27, 28A, 29, 65, 76–84, 89, 98–103, 106, 109, 114, 203, 208, 209) is as a rule continuous forwards to the anterior median section (soc_2) of the supraorbital sensory canal groove. In certain cases, however, it may be inter-

rupted in its middle part which then sometimes may be replaced by the semicircular pit-line groove (*cir*, text figs. 82B, 83C, 89E, 208B). The lower infraorbital sensory canal groove (ifc_2, text figs. 4, 8, 34, 35A, C, 110, 111, 114) is always present on the mental plate.

The cephalic division of the main lateral line (*ptc*, text figs. 7, 9, 10, 27, 28A, 29, 65, 76–78, 79B, C, 80, 81–84, 98–103, 117, 129, 132, 133, 148, 154, 155, 157, 158, 203, 208, 209) is deep and well developed.

The anterior median section of the supraorbital sensory canal groove, the upper infraorbital sensory canal groove, and the cephalic division (*ptc*) of the main lateral line groove are not constant in their position in relation to the rostral and lateral margins of the head-shield but may pass at a much varying distance from these margins.

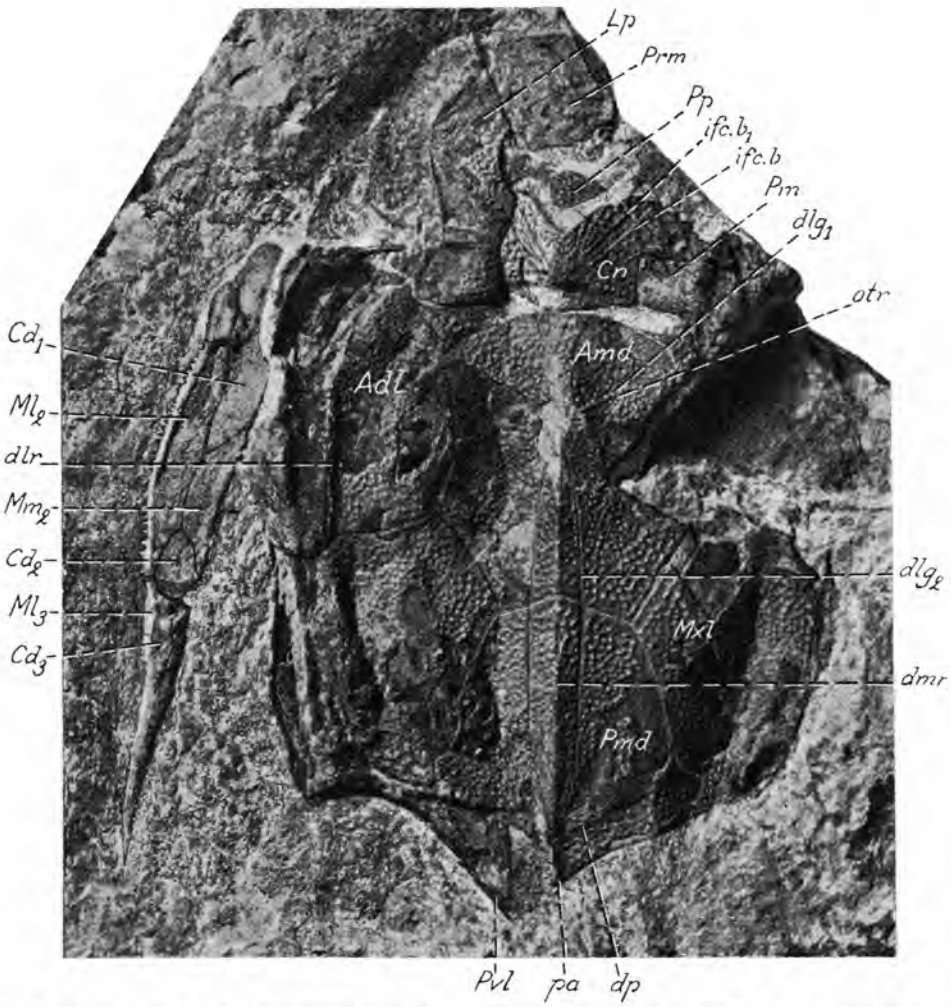
The posterior oblique cephalic pit line groove (*ifc. b*, text-figs. 4, 6, 7, 9, 10, 24A, B, 25A, 26A, 65, 76–84, 88B, 89–93, 94A, C, 95–99, 101, 102, 106, 109, 114, 116, 117, 127–134, 140, 146–148, 154, 155, 157–159, 203, 204, 206, 208, 209, 211) is constantly present, but may exceptionally be very weakly developed (text-figs. 208A, 209). The anterior oblique cephalic pit-line groove (*ifc.* b_1, text-figs. 84A, B, 88B, 90, 91, 92, 93A–E, 95, 96, 98, 204, 206, 211) is normally present in small individuals, but vestiges of it may persist also in medium-sized and large individuals (text-figs. 76B, 78B, 80A, C, 82, 93N).

The semicircular pit-line groove (*cir*, text-figs. 4, 6, 7, 9, 10, 24A, B, 65, 76–84, 89, 97–99, 101, 114, 208, 209) is mostly developed, but may also not rarely be absent on one or on both sides. In some cases it substitutes the foremost part of the upper infraorbital groove (cf. p. 178 above). In one case (text-fig. 80C) it passes over anteriorly directly into the vertical pit-line groove of the cheek.

The last-mentioned pit-line groove (*vcp*, text-figs. 4, 6–10, 24A, B, 31A, 33, 34, 37, 65, 76A, 77A, 78, 79B, C, 80B, C, 81–84, 89, 98, 99, 108, 110, 112C, 114, 208, 209) decreases in depth and width downwards so that it is weakly developed on the infraprelateral plate. In its lower parts it is thus always a typical pit-line groove.

The oral pit-line groove (*orp*, text-figs. 8, 34, 111, 114) seems normally to be narrow and shallow.

The middle pit-line groove of the skull-roof (*mpg*, text-figs. 4, 6, 7, 9, 10, 27, 28A, 29B, D, 65, 76, 82, 99C, D, E, 100C–G, 103B, F, 208, 209) is often present, but may also frequently be absent. In one specimen (text-figs. 208A, 209) it is completely developed, extending from the transition between the upper infraorbital groove (ifc_1) and the cephalic division of the main lateral line groove (*ptc*) as far medially as to the posterior pit-line groove (*pp*) of the skull-roof. In this specimen it has thus an extent exactly similar to that in *Asterolepis, Pterichthyodes, Gerdalepis* and *Remigolepis*. The groove is mostly very shallow and little conspicuous.



Text-fig. 211. *Bothriolepis canadensis*. Deficient small specimen (dorsal wall 3,8 cm long) in dorsal aspect. The armour much compressed and crushed. The specimen is of interest, on account of the abnormal course of the posterior oblique abdominal pit-line groove. R. M. specimen No. P. 2779. × 2.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1–Cd_3, dorsal central plates 1–3; *Cn*, centro-nuchal plate; *Lp*, lateral plate; Ml_2, Ml_3, lateral marginal plates 2 and 3 respectively; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *Pvl*, posterior ventro-lateral plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal groove (abnormal in position); *dlr*, dorso-lateral ridge; *dmr*, dorsal median ridge; *dp*, groove above crista transversalis interna posterior; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *otr*, oblique transverse ridge (behind anterior oblique abdominal pit-line groove); *pa*, posterior corner of posterior median dorsal plate and of dorsal wall of trunk-armour.

The posterior pit-line groove of the skull-roof (*pp*, text-figs. 6, 7, 9, 10, 25A, 26A, 65, 76A, 77B, 78C, 79C, 82–84, 93, 94A, C, 98, 203, 208, 209) is invariably present. Normally it anastomoses with that of the opposite side in the median line.

The supratemporal pit-line groove (*stc*, text-figs. 4, 6, 9, 10, 25A, 26A, 65, 76, 77, 78C, 79B, C, 80C, 81B, C, 82, 83, 84B, C, 91, 93–95, 99, 100C–G, 102, 109, 117, 128, 129, 140, 147, 158, 203, 208, 209) is frequently developed, but is mostly fairly obscure. In certain cases it extends from the median part of the centro-nuchal plate about as far laterally as to the post-obstantic corner, in several cases, however, it is represented only by a medial piece of varying length. Sometimes it is absent on one side.

The main lateral line groove of the trunk (*lcg*, text-figs. 38, 40, 48C, 62, 98, 99E, 101, 103F, 129, 144, 145B, 150D, 153F, G, 158, 182) is deep on the trunk-armour, but shallow on the body axis of the caudal fin, where it passes in a series of small oblong scales. On the trunk-armour it varies somewhat in its position in relation to the dorso-lateral ridge (*dlr*).

The anterior oblique abdominal pit-line groove (dlg_1) is normally present and is fairly completely developed in small specimens (text-figs. 39A, 43A, 88B, 91, 95–98, 118A, 121A, B, 199, 202, 204, 211), but then as a rule rapidly disappeared during the further growth of the specimens. Vestiges of it may, however, persist on the median part of the anterior median dorsal plate, at and near the tergal angle (*dma*). Such vestiges are often met with also in smaller medium-sized specimens, but are rare in larger medium-sized and large specimens (text-figs. 101, 102, 115–117, 118C, D, F, 119B, C, F, 120A, 121C, D, F, G, J, L, 127, 131, 140, 142, 143).

The posterior oblique abdominal pit-line groove (dlg_2, text-figs. 38, 39A, B, 40, 43A, B, 88A, B, 90, 91, 95–98, 101, 102, 109, 115–124, 127–134, 140–143, 146–149, 151B, 153–159, 179–183, 199, 200, 202, 204–206) is almost always present. Among the considerable number of specimens examined by the writer it was in fact absent only in a single one (text-fig. 124A). In medium-sized and large specimens it is always narrower and shallower than in small specimens, in which it is often very pronounded (text-figs. 199, 200, 202, 205, 206). Besides, in medium-sized, and particularly in large specimens, it is sometimes interrupted for some distance in its middle part (text-figs. 124C, 159, 182, 183, 185), whereas in small and comparatively small specimens, on the other hand, it seems always to be continuous throughout its extent (text-figs. 179–181). In two of the specimens examined (text-figs. 123C, 210) the groove of the right side has an abnormal course in that close behind the tergal angle it curves laterally and somewhat forwards and, after crossing the right half of the anterior median dorsal plate, passes on to the dorsal lamina of the anterior dorso-lateral plate. In a third specimen, in which it has also an abnormal course (text-fig. 211), both the right and left grooves run backwards rather close to the dorsal median ridge (*dmr*), end-

ing at the hindmost part of the said ridge, somewhat in front of the posterior corner (*pa*) of the posterior median dorsal plate. According to Robertson (1938, p. 300), it has also this course on the left side in one of the specimens in Patten's collection at Dartmouth College. In *Grossilepis*, as we know (cf. p. 187, and text-fig. 268A–D; cf. also Gross 1941a, pp. 42–43 and text-fig. 30C–H), it has often a somewhat corresponding course in relation to the the dorsal median ridge and also normally passes there more directly backwards than in *Bothriolepis*. Finally, it is worthy of notice in this connection that the pit-line groove here in question in *B. canadensis* may sometimes be double on both sides throughout its length (text-fig. 207).

The subcephalic abdominal pit-line groove (*sg*, text-fig. 160) is known with full certainty only in one specimen. A correspondingly situated ventral pit-line groove is found in Brachythoracid Arthrodires (Gross 1938, pp. 410–412, fig. 2A).

The pectoral pit-line groove (*sgp*) is always well-marked on the proximal segment (text-figs. 57A, C, 190B, C, 191D, 195B, 196B), but is mostly obscure or absent on the distal segment (text-figs. 41B, 186, 188C, 192E, 195B). It begins proximally on the foremost part of the medial face of the proximal segment, more precisely on the anterior part of the medial lamina of the ventral central plate 1 and runs then either distally and slightly upwards on to the lowermost part of the medial marginal plates 1, or else straight backwards on the medial lamina of the ventral central plate 1. In its further course distally it follows either the ventral margin of the medial marginal plate 1 or passes on the medial lamina of the ventral central plate 1, thence continuing distally on the ventral margin of the medial lamina of the medial marginal plate 2 (text-fig. 196B). Finally, most distally on the proximal segment it turns ventrally, crossing a short distal part of the ventral central plate 2 (text-figs. 195B, 196B). On reaching the ventral side of the fin in this way it continues in a distal direction along the medial margin of the distal segment (text-fig. 195B). In the specimen reproduced in text-fig. 188C it is very distinct on the distal segment, where it is traceable as far distally as almost to the tip of the terminal plate. The pit-line groove in question is wide on the proximal segment, but narrows on the distal segment.

Remarks and summary.

Among the *Bothriolepis*-species known in any detail at present *B. canadensis* resembles mostly *B. cellulosa* from the lowermost Upper Devonian of Livonia and is probably fairly closely akin to that species. The condition that *B. canadensis* and *B. cellulosa* thus seem to be relatively closely related to each other is of interest as it forms an additional support for the opinion that the Upper Devonian deposits of Scaumenac Bay are approximately contemporaneous with the *Bothriolepis cellulosa*-marl of Livonia and that like that marl they belong to the lowermost part of the Upper Devonian

(cf. Jarvik 1937, pp. 120–122). It has been shown previously that inter alia *Eusthenopteron foordi* Whiteaves from Scaumenac Bay is closely akin to *E. säve-söderberghi* Jarvik from the *Bothriolepis cellulosa*-marl of Livonia (Gross 1936, p. 69; Jarvik 1937, pp. 70–90).

As is obvious from the description here given, *B. canadensis* shows a wide range of variation in most of its characters. The head-shield and trunk-armour vary about 20% with regard to their breadth:length ratio. The median dorsal ridge of the trunk-armour may be well pronounced, but may also be almost absent. The total length of the pectoral fin is not fully constant. The proximal segment of the pectoral fin is from somewhat more than five times to about three and a third times as long as broad, and the distal segment of the pectoral fin is also of a very different length in different specimens. The spines of the pectoral fin may be very different in size and shape and also vary much in number. The individual plates of the head, trunk and pectoral fin may be very differently developed, both as to their proportions and their other characters. This is above all the case with the premedian, postpineal, anterior median dorsal, and posterior median dorsal plates. The sutural connections of the plates of the trunk-armour have also been found to vary considerably. The number of independent plates in the distal segment of the pectoral fin is subjected to considerable variations. The ornament shows all stages of transition between a regularly fine-meshed reticular type and a more or less pronounced tubercular type. Finally, the sensory canal system also presents several variations in its development. – All these variations are of importance for the definition of the species, but throw much light upon the range of variations in the *Bothriolepis*-species in general.

As proved by the large material here examined the considerable variations in a great many of the characters in *B. canadensis* are due largely to regular changes which took place during the growth. Small specimens thus in most of their characters are very different from very large ones, whereas medium-sized specimens are clearly transitional between small and large specimens.

Small specimens (dorsal length of trunk-armour approximately 1,85–4,5 cm) differ from medium-sized (dorsal length of trunk-armour 4,5–10 cm), and above all from large, specimens (dorsal length of trunk-armour 10–13 cm) in the following principal characters. The dermal bones of the head-shield, trunk-armour and pectoral fins are delicate, at least more so than in medium-sized and large specimens. The orbital fenestra is relatively very large, much larger than in medium-sized specimens, but above all than in large specimens. The dorsal wall of the trunk-armour is clearly narrower than long. More precisely its breadth ranges from 80–90% of its length, whereas in medium-sized and large specimens it is generally larger, from 90–96% of the length. The dorsal median ridge of the trunk-armour is always developed throughout its extent and, besides, normally is also very

well pronounced and sharpedged. In larger specimens it is more weakly developed, more rounded off and, in very large specimens, sometimes more or less reduced, particularly in its middle parts. The postlevator thickening and the median dorsal part of the cirsta transversalis interna posterior are marked by more or less well pronounced grooves or depressions on the outside of the dorsal wall of the trunk-armour. Such depressions or grooves are generally absent in medium-sized and large specimens. The ventral median ridge on the lower side of the dorsal wall of the trunk-armour is developed only nearest in front of and somewhat behind the anterior ventral pit, and the ventral median groove is entirely absent. In medium-sized and large specimens, on the other hand, the median ventral ridge extends backwards as far as to about the middle of the lower face of the posterior median dorsal plate; besides, in medium-sized and large specimens the ventral median ridge often also extends forwards into the levator fossa. The ventral median groove is always present both in medium-sized and large specimens. The postlevator crest in small specimens is more frequently developed than in large specimens. The premedian plate normally is much broader than long. Its breadth generally amounts to 120–150% of the length, whereas in large specimens it is only 90–100% of the length. The postpineal plate is considerably shorter and broader and projects much further forwards into the orbital fenestra than in medium-sized and large specimens. The centro-nuchal plate is somewhat broader than in medium-sized and large specimens and in addition is distinguished from that in these two categories of size by the simpler configuration of its posterior margin. The anterior and posterior median dorsal plates are relatively narrower in proportion to their breadth than in medium-sized and large specimens. This above all applies to the posterior median dorsal plate which often is more than 20% narrower than in large specimens. The proximal segment of the pectoral fin is more than five times as long as broad, whereas in medium-sized and large specimens it is always shorter in proportion to its breadth. In very large specimens it is even only three and a third times as long as broad. The individual plates of the proximal segment of the pectoral fin, but above all the dorsal central plate 2, are longer in proportion to their breadth than in medium-sized and large specimens. The lateral and medial spines of the proximal segment differ from those in medium-sized and large specimens in being fewer in number, larger relatively in proportion to the size of the segment, more pointed, and less fused at their bases. The ornament invariably is a regular fine-meshed network of anastomosing ridges with tubercular thickenings and elevations only at the points of anastomoses of the ridges. In medium-sized and particularly in large specimens, on the other hand, the regular network is more or less subdivided into short pieces and isolated tubercles, on account of which the ornament in such specimens is more or less tubercular instead of clearly and regularly reticular. The ridges show no concentric or radiating disposition, whereas

this is always the case in medium-sized and large specimens. Finally, both the anterior oblique cephalic pit-line groove and the anterior oblique abdominal pit-line groove are as a rule present and well developed. These two structures generally disappeared during the further stages of growth, and hence they are almost always absent in large specimens.

Locality and geological horizons.

The material of *B. canadensis* here described comes from the classic locality Scaumenac Bay in Canada. More precisely, the locality is Meguasha, Scaumenac Bay, N. side of Chaleur Bay, opposite the small town of Dalhousie, New Brunswick, Canada. The geological age of the deposits must now be regarded as Lowermost Upper Devonian.

The majority of the specimens are embedded in flat shaly nodules of limestone. The specimens displaying the unarmoured posterior parts of the body and the caudal fin are embedded in a soft sandstone rich in plant remains. Certain other, mostly detached, plates are in a matrix consisting of a solid green sandstone rich in lime. And finally, certain detached smaller bones and fragments of bones are found in a red conglomerate. The various characters of the rocks in which the specimens available are embedded shows thus clearly that *B. canadensis* occurs in several horizons at Scaumenac Bay. According to observations made by the writer at the find locality in 1922 the soft green sandstone rich in plant remains and the red conglomerate are probably from higher horizons than the flat shaly nodules.

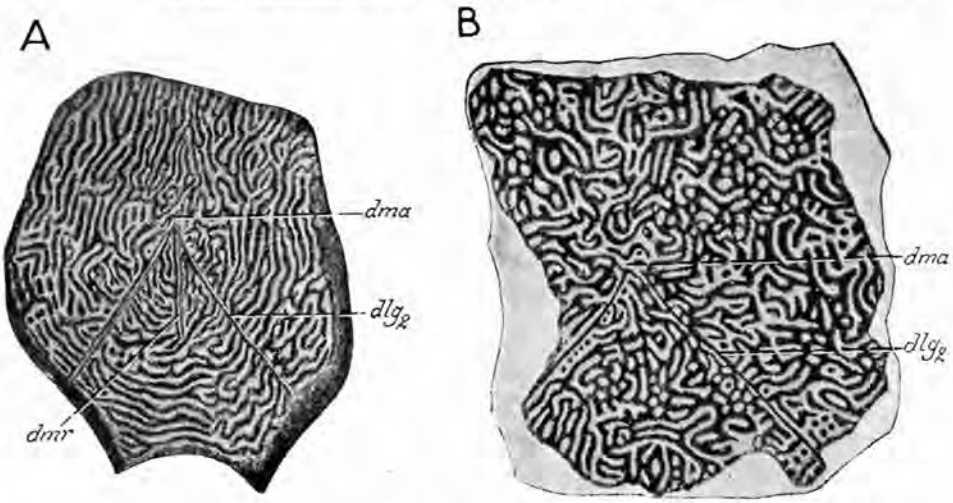
2. **Bothriolepis nitida** (Leidy).

(Text-figs. 212, 213)

For list of synonyms see Gross 1932b, p. 31.

Diagnosis. – The incomplete diagnosis that can be given of this species is as follows. Species probably attaining a moderate or perhaps even somewhat large size. Pineal plate of a semicircular (?) shape. Dorsal wall of trunk-armour conceivably low. Ventral lamina of the anterior ventro-lateral plate probably broad in proportion to its length, possibly not so very much longer than broad. Proximal segment of pectoral fin relatively long in proportion to its breadth, in large individuals perhaps about four and a half or almost five times as long as broad. Distal segment of pectoral fin somewhat robust and with strongly developed, closely set lateral spines. This segment on the dorsal side ornamented with long continuous proximo-distally passing ridges, fairly coarse and practically straight throughout their extent. Ornament as a whole comparatively coarse.

Material. – The material that has been referred to *B. nitida* by the American writers is fairly poor, consisting only of parts of head-shields and of more or less datached remains of the trunk-armour and pectoral fin-



Text-fig. 212. *Bothriolepis nitida*. *A*, *B*, two deficient anterior median dorsal plates in dorsal aspect. From Newberry 1889. Nat. size.
dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge.

armour. Since this material has been superficially and unsatisfactorily described and in addition also badly figured, our knowledge of *B. nitida* is still very slight.

The holotype is a distal segment of a pectoral fin described by Leidy (1856a, b, c) under the name of *Stenacanthus nitidus* (cf. also Woodward 1891b, p. 232; Hay 1902, p. 344; 1929, p. 643; Gross 1932b, p. 31).

Description. – *B. nitida* was said by Eastman (1907, p. 50) to "have equalled or even exceeded the average specimens of *B. canadensis* in size" and seems thus to have attained a somewhat large size.

According to a statement by Eastman (1907, p. 51) the pineal plate is semicircular in shape. The correctness of this statement may, however, be strongly doubted. It is not unlikely that the pineal plate of Eastman's description may be the postpineal plate which, as we know, is somewhat semicircular in shape in the majority of the representatives of the subfamily *Bothriolepinae*. Otherwise nothing of importance in known concerning the development of the headshield and its dermal bones.



Text-fig. 213. *Bothriolepis nitida*. Detached distal segment of a left pectoral fin in dorsal aspect. From Eastman 1907. Nat. size

The three anterior median dorsal plates reproduced by Newberry (text-fig. 212; cf. also Newberry 1889, pl. 18, fig. 2; pl. 20, figs. 4, 5) are so imperfectly preserved that their exact proportions and shape cannot be ascertained However, two of these plates are clearly narrower than long (text-fig.

212A), whereas the third (text-fig. 212B) is somewhat broader. The dorsal median ridge seems mostly to be absent or imperfectly developed on account of which it is conceivable that the dorsal wall of the trunk-armour was comparatively low. The levator fossa is about as in *B. canadensis*. The posterior oblique abdominal pit-line groove (dlg_2) is present and lies as in *B. canadensis*.

Judging from a reproduction given by Newberry (1889, pl. 20, fig. 1), the ventral lamina of the anterior ventro-lateral plate seems not to be more than about a third longer than broad, and thus probably is unusually broad, and broader than at least in *B. canadensis*, *B. cellulosa*, *B. maxima* and *B. groenlandica*.

Judging from the poor figures published by Newberry (1889, pl. 20, figs. 1, 2), the proximal segment of the pectoral fin in somewhat large or large individuals is about four and a half, or almost five, times as long as it is broad. Provided that these reproductions are fairly correct the proximal segment is decidedly longer in proportion to its breadth than in *B. canadensis*, *B. cellulosa* and *B. hydrophila*. The distal segment of the pectoral fin (text-fig. 213) in its general shape is nearest as in *B. canadensis*. However, it differs clearly from the corresponding segment in that species in that it seems to be practically devoid of medial spines and in that its lateral spines are closely set, stronger, and of a much more uniform size.

According to a reproduction by Leidy (1856c, pl. 17, fig. 4) and to a brief statement given by Eastman (1907, p. 50), the ornament in its general characters reminds mostly of that in *B. canadensis*, but judging from the reproductions published by Newberry (cf. text-fig. 212 in the present work), at any event on the anterior median dorsal plate, it is of a special type, different from that both in *B. canadensis* and other *Bothriolepis*-species known at present. Be this as it may, it is obvious, however, that the distal segment of the pectoral fin (text-fig. 213) on its dorsal side is ornamented with long continuous proximo-distally passing ridges which are coarser and straighter at least than in *B. canadensis* (text-figs. 184B, C, 187B, 192D, 198B), *B. cellulosa* (Gross 1941a, pl. 16, 1, 2), *B. maxima* (cf. Gross 1941a, pl. 29, figs. 2, 3) and *B. groenlandica* (pl. 69, fig. 5).

Remarks. – *B. nitida* is still very imperfectly known. It seems to be well distinguished from other species described inter alia in the following characters: the considerable relative breadth of the ventral lamina of the anterior ventro-lateral plate, the strong development of the lateral spines of the distal segment of the pectoral fin, and the development of the ornament on the dorsal side of the distal segment of the pectoral fin.

Localities and geological horizon. – The species occurs in Tioga and Bedford Counties, Pennsylvania, but, according to Eastman, it has been reported also from Delaware County, New York State. It is known so

far only from the Catskill Sandstone, that is to say from the uppermost part of the Upper Devonian (Chemung).

3. **Bothriolepis minor** Newberry.

For list of synonyms see GROSS 1932b, pp. 31–32.

Diagnosis. – This species is still so imperfectly known that no diagnosis can be given of it. For the time being the species is in fact completely undefineable.

Material. – The material of *B. minor* described hitherto consists only of detached remains of the armour, principally anterior median dorsal plates.

The lectotype of the species (chosen by Gross 1932b, p. 31) is a small deficient anterior median dorsal plate figured by Newberry (1889, pl. 20, fig. 7).

Description. – As all the remains recorded as yet are from somewhat small individuals, *B. minor* seems not to have attained quite the same size as *B. canadensis* and *B. nitida* (Eastman 1899, p. 326; 1907, p. 52).

That the material of the species kept in American museums includes remains inter alia also of the head-shield is clear from the descriptions by Cope (1892, p. 224) and Eastman (1907, p. 52), but these remains are still undescribed. The anterior median dorsal plates reproduced by Newberry (1889, pl. 20, figs. 6, 7) are broader than those figured by Eastman (1899, text-fig. 5; 1907, text-fig. 13), which as to shape and proportions seem to be almost as in small medium-sized specimens of *B. canadensis*. Judging from the lectotype, the median dorsal ridge is slightly developed and partly absent. The levator fossa on the whole agrees with the corresponding fossa in *B. canadensis*. The ventral median groove is somewhat well developed on several of the anterior median dorsal plates reproduced. Remains are present also of certain ventral plates of the trunk-armour and of the pectoral fins (Eastman 1899, p. 326), but these remains have not been described or figured.

The ornament is said to consist of "fine closely crowded, vermiculating ridges" (Eastman 1907, p. 52).

The sensory canal grooves of the head-shield have been described to some extent by Cope (1892, p. 224). As far as may be understood from his description, the sensory canal system is as normally in the genus.

Remarks. – As may be gathered from the above, *B. minor* is very unsatisfactorily known. A thorough redescription of all the material of it kept in the American museums is thus highly needed.

According to a statement by Newberry (1889, p. 112), *B. minor* is very suggestive of the Belgian species *B. lohesti* Leriche (cf. pp. 513–515 below; also Leriche 1931, p. 18), but whether this statement is true cannot be decided at present.

Localities and geological horizon. – Chemung group of Bradford County, Pennsylvania, and Catskill of Delaware County, New York State.

4. **Bothriolepis? traquairi** Bryant.

(Text-fig. 214)

For list of synonyms see GROSS 1932b, pp. 30–31.

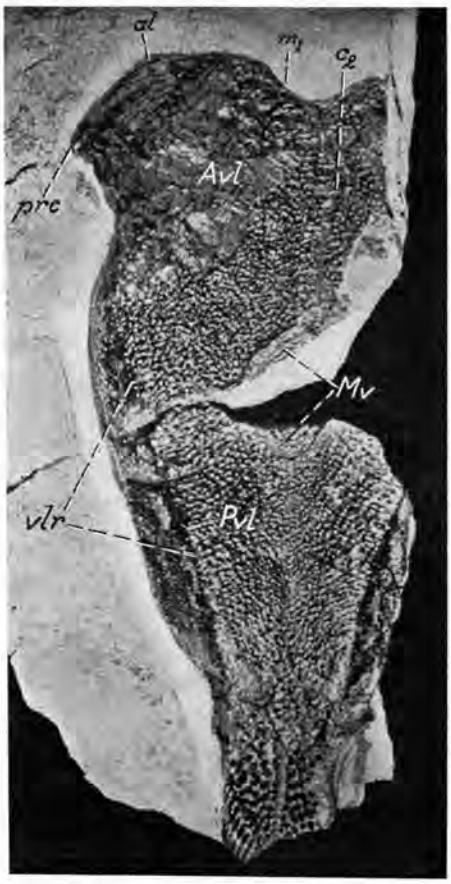
Diagnosis. – Ventral wall of trunk-armour not uniformly broad in its middle division, but decreasing in breadth from close behind the fosaae articulares pectorales backwards as far as to the subanal division. The last-mentioned division long, usually narrow and hardly narrowing backwards, but of a uniform breadth almost to its posterior end. Ventral lamina of posterior ventro-lateral plate very long, about three times as long as broad. Ornament of ventral wall of the trunk-armour fairly delicate and at least partly reticular on the subcephalic and middle divisions, but coarse and clearly tubercular on the subanal division.

Material. – The material of *B? traquairi* known at present is only the holotype (Bryant 1924, pp. 54–55), which consists of ventral parts of the trunk-armour, more precisely, the whole ventral wall and adjacent ventral parts of the lateral walls of the trunk-armour (text-fig. 214; cf. Bryant 1924, pl. 1).

Description. – The holotype is of a size approximately corresponding to that of a somewhat large medium-sized specimen of *B. canadensis*. The dorsal length of the trunk-armour may be estimated at about 7,5–8 cm. The ventral wall of the trunk-armour is about 10,5 cm long and about 6,6 cm broad across the prepectoral corners (*prc*). Taken as a whole the trunk-armour was conceivably narrower in its posterior parts than what is the case in *Bothriolepis* and the *Antiarchi* in general. As normally, the ventral wall (text-fig. 214) is broadest across the prepectoral corners. In contradistinction to what is the case in other *Bothriolepis*-species (text-figs. 41A–C, 161, 162, 292B), *Grossilepis* (text-fig. 41D), *Pterichthyodes* (Traquair 1894–1906, text-figs. 52–55), *Gerdalepis* (Gross 1941b, text-fig. 9), *Asterolepis* (Traquair 1894–1906, text-fig. 38; Nilsson 1941, text-fig. 7), *Remigolepis* (Stensiö 1931, text-fig. 87) and the *Ceraspidae* (Gross 1933b, text-fig. 4E; 1937, text-fig. 10C) it is not, however, of a fairly uniform breadth in its middle division, but decreases in breadth backwards from a transverse plane immediately behind the articular fossae of the pectoral fins. On account of this decreasing in breadth backwards the middle division of the wall is narrow at its transition into the subanal division. In fact the middle division is even so narrow posteriorly that its breadth there amounts only to about a fourth of the maximal breadth of the ventral wall. The subanal division of the ventral wall is long and narrow, and contrary to what is the case in other forms it does not narrow gradually backwards, but retains a uniform breadth practically to its posterior end. In consequence of the peculiar shape of the

ventral wall the ventro-lateral ridge (*vlr*) has a different configuration than in other *Antiarchi*-forms. In ventral aspect (text-fig. 214) this ridge is thus fairly strongly convex most anteriorly, whereas otherwise it forms a long shallow concavity.

The anterior ventro-lateral and posterior ventro-lateral plates are almost equally long and, therefore, in this respect are about as normally in *Bothriolepis*. The ventral lamina of the former plate (*Avl*) as to length and breadth is about as in *B. canadensis*, the length amounting to more than one and a half times the breadth. The ventral lamina of the posterior ventro-lateral plate, on the other hand, is much longer in proportion to its breadth than otherwise in the *Antiarchi*. Roughly taken it is about three times as long as broad. The semilunar plate is missing, but it is obvious that it was small. It was probably unpaired and of the ordinary *Bothriolepis*-type. The median ventral plate as to its relative size is about as normally in *Bothriolepis*. As in *B. canadensis*, the anterior division of this plate, that is to say the division in front of the lateral corners, is a little longer than the posterior division.



Text-fig. 214. *Bothriolepis*? *traquairi*. Ventral parts of the trunk-armour (impression). Holotype in natural size. From Bryant 1924. *Avl*, anterior ventro-lateral plate; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; c_2, corner on the middle division of the medial margin of the right anterior ventro-lateral plate; m_1, division of medial margin of *Avl*-plate attached to semilunar plate; *prc*, prepectoral corner; *vlr*, ventro-lateral ridge.

The ornament is fairly delicate except on the subanal division of the ventral wall, where it is comparatively coarse. On the anteror parts of the ventral wall it seems to be on the whole reticular, whereas further backwards it becomes more tubercular. On the subanal division of the ventral wall it consists chiefly of tubercles.

Remarks. – As may be gattered from the above, *B*? *traquairi* is very different from other *Antiarchi*-forms with regard to the shape of the ventral parts of its trunk-armour. This was fully clear also to Bryant (1924, p. 55), who referred it to *Bothriolepis* provisionally and with doubt.

In the writers opinion it is almost certain that *B? traquairi* will reveal itself as a representative of a new genus. Whether it belongs to the family *Bothriolepidae* as here defined (p. 219) cannot be desided. It is also impossible to say whether it is related some one of the other *Antiarchi*-family here erected (p. 219), or whether it represents a family of its own. At present its relationships are thus quite obscure.

Locality and geological horizon. – Scaumenac Bay, Canada. Together with *B. canadensis* (see p. 394 above) in deposits of lowermost Upper Devonian age.

5. Bothriolepis sp. from Ellesmere Land.

Under the titles of *Bothriolepis* cf. *hydrophila* (Agassiz) and *Bothriolepis* (?) sp. Kiaer in 1915 (pp. 39–43) described a few *Bothriolepis*-remains from Ellesmere Land. These remains, which are very fragmentary, include imperfect plates of the trunk-armour and parts of the pectoral fin-armour. Most of the remains are from small, immature individuals.

A small deficient plate exposed from the inside (Kiaer 1915, pl. 7, figs. 2, 3) was correctly interpreted by Kiaer as an anterior dorso-lateral plate. As far as may be judged, we are in this plate concerned with a left anterior dorso-lateral plate. The plate is of a short and broad type. Its dorsal lamina seems to have been relatively broad in proportion to its length, perhaps somewhat as in *B. hydrophila* (text-fig. 261; cf. also Traquair 1894–1906, text-fig. 62 and pl. 30, figs. 1, 2), and this lamina thus presumably was somewhat broader than the corresponding one in *B. canadensis*, *B. cellulosa*, *B. alvesiensis* and *B. groenlandica* (cf. pp. 311, 419, 474, 561). It is also not impossible that it may have met the lateral lamina at a more obtuse angle than in *B. canadensis* and that the dorsal wall of the trunkarmour thus might have been higher than in the said species. The lateral lamina of the plate seems to have been high in proportion to its length. A fragment of a plate supposed by Kiaer to be of a mixilateral ("posterior dorso-lateral") plate may very well be so, but is too imperfect to be identified with any certainty.

The proximal segment of the pectoral fin in the single small specimen in which it is found preserved (Kiaer 1915, pl. 7, fig. 1) is between four and five times as long as broad and thus presumably is somewhat longer and narrower than in *B. hydrophila*, but somewhat shorter and broader than in small specimens of *B. canadensis*.

The ornament of the smallest plates consists of a delicate regular fine-meshed network, devoid of nodose thickenings and tubercular elements, and thus on these plates is clearly of an immature character (cf. pp. 211–214 above). The ornament of the larger plates, on the other hand, is said by Kiaer (1915, pp. 41, 43) to be coarse and nodose, that is to say at least somewhat tubercular, as is normally the case in medium-sized and large specimens of the *Bothriolepis*-species in general. Accordingly, as far as it is

known thus far the ornament does not present any characters of specific importance.

Remarks. – As may easily be gathered, the *Bothriolepis*-remains from Ellesmere Land are undeterminable as to species. Apart from the comparatively large breadth of the dorsal lamina of the anterior dorso-lateral plate these remains show no characters which indicate a special kinship with *B. hydrophila*. The absence of tubercular elevations and thickenings on the points of anastomoses of the ridges in small specimens shows clearly that the remains cannot belong to *B. canadensis* (cf. pp. 376–386 above and text-figs. 199–202).

The *Bothriolepis*-remains here discussed occur together with a *Psammosteus*, a large Brachythoracid Arthrodire, *Holoptychius*, and certain other Crossopterygians, and were considered by Kiaer (1915, pp. 16–20, 48–54; cf. Säve-Söderbergh 1934, p. 50) to be from the lowermost Upper Devonian. According to recent researches, however, it is also possible that they are from the uppermost Middle Devonian (cf. Gross 1942a, pp. 385–391).

Locality and geological horizon. – Inner parts of Goose-Fjord, Ellesmere Land. Either uppermost Middle Devonian or lowermost Upper Devonian.

Baltic, Russian and Asiatic species.

According to Obrutschew (1930; 1935, p. 19) and Gross (1933a, p. 69; 1934, pp. 420, 422; 1940a, p. 535; 1942a, pp. 385–391) *Bothriolepis* appeared in Russia, together with *Asterolepis radiata* and *Holoptychius*, in the Subsnetogor beds of the uppermost Middle Devonian. *Bothriolepis*-remains have recently been described and recorded from Siberia, Central Asia and China (Obrutschew 1939; 1940; Chi 1940).

The *Bothriolepis*-species from the Baltic States, Russia and Asia that will be dealt with here are as follows: *B. ornata* Eichwald, *B. cellulosa* Pander, *B. panderi* Lahusen, *B. maxima* Gross, *B. turanica* Obrutschew, and *B. sinensis* Chi. The four species described by Gross in 1942 (1942a) are briefly discussed in the Addenda.

B. sibirica Obrutschew from the Minusinsk district and certain other *Bothriolepis*-remains from Siberia (Obrutschew 1940, p. 890) are undescribed, on account of which they cannot be discussed here.

6. **Bothriolepis ornata** Eichwald.

(Text-figs. 26 B, 215–217).

For list of synonyms see Gross 1932b, pp. 23–24; and 1933a, p. 40.

Bothriolepis ornata is the genotype of *Bothriolepis* (Woodward 1891b, p. 225) and was first dealt with by Eichwald (1840, p. 79).

Diagnosis. – Species attainting a somewhat large size. Dorsal wall of trunk-armour maximally about 18 cm long. Anterior median dorsal plate presumably comparatively narrow, its breadth:length ratio at least sometimes in mature individuals amounting to about 79–80 only; anterior margin

of the plate convex. Tergal angle in the foremost part of the middle third of the plate. Posterior median dorsal plate narrow in its anterior parts, and at least sometimes in large individuals also narrow as a whole. Ornament retaining a clear reticular disposition also in large specimens, and otherwise characterized by the absence, or relatively slight development, of tubercular thickenings and elevations at the points of anastomoses of the ridges.

Material. – The material of *B. ornata* that has been described so far is small. It includes only the following clearly identifiable plates, all of which are detched: 1) a single centro-nuchal plate, described and figured by Gross in 1933 (1933a, p. 41, pl. 4, fig. 7); 2) a single anterior median dorsal plate, described and figured by Eichwald in 1860 (1860, pp. 1513–1514, pl. 56, fig. 3); and 3) a single posterior median dorsal plate described and figured by Gross in 1933 (1933a, p. 41, pl. 4, fig. 14). In addition two very deficient plates were described by Agassiz in 1845 (p. 149; pl. 29, figs. 1, 2). However, these two plates are unidentifiable.

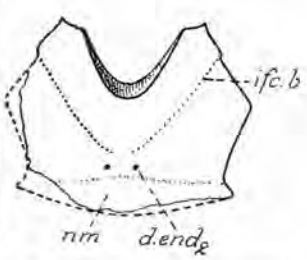
The holotype is the anterior median dorsal plate referred to above that was described and figured by Eichwald (Woodward 1891b, p. 225; Gross 1932b, pp. 23–24).

The subsequent account is based entirely on the descriptions and figures cited just above.

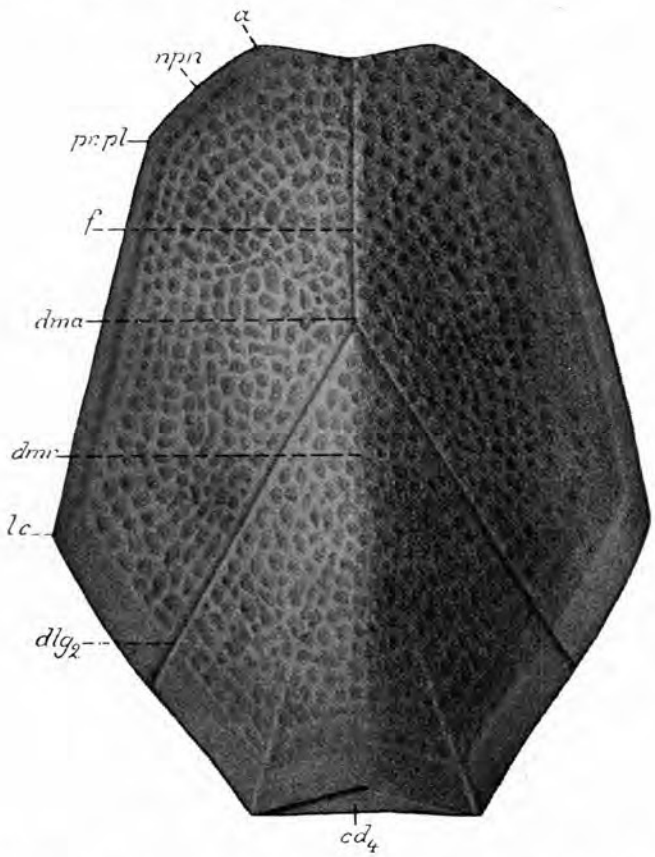
Description. – *B. ornata* attained a larger size than *B. canadensis*. Judging from the remains known to us at present, the maximal dorsal length of the trunk-armour must have amounted at least to about 18 cm.

The centro-nuchal plate (text-fig. 215; cf. Gross 1933a, pl. 4, fig. 7) is imperfect posteriorly, but as far as it is preserved it is nearest as in *B. canadensis* (text-fig. 93) and *B. groenlandica* (text-fig. 278). The configuration of its posterior margin cannot be ascertained.

The anterior median dorsal plate is about 10 cm long and thus is from an individual of somewhat large size. Its breadth : length ratio is about 79–80. The condition that this ratio is so small in a plate of this size probably involves that the anterior median dorsal plate of the species normally was comparatively long and narrow. The reproduction given by Eichwald of the plate, which has been copied here in text-fig. 216, is incorrect as to several details. Lahusen (8180, pp. 133-134) has pointed out that the anterior margin is not concave, but convex, that the anterior and posterior divisions of the lateral margin have been made too straight, and that the groove (*f*) which from the tergal angle extends forwards to the anterior margin is simply a frac-



Text-fig. 215. *Bothriolepis ornata*. Restoration of the centro-nuchal plate reproduced by Gross in 1933 (1933a, pl. 4, fig. 7). Dorsal aspect. Nat. size.
d. end$_2$, external opening of canal for endolymphatic duct; *ifc. b*, posterior oblique cephalic pit-line groove; *nm*, obtected nuchal area.



Text-fig. 216. *Bothriolepis ornata*. Anterior median dorsal plate (holotype) in dorsal aspect. From Eichwald 1860. This figure is somewhat incorrect as to certain of its details. Nat. size.
a, antero-lateral corner; cd_4, area overlapped by posterior median dorsal plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, median dorsal ridge (slightly developed); *f*, fracture-line; *lc*, lateral corner; *npn*, postnuchal notch (probably somewhat concave); *pr. pl*, external postlevator process (probably more pronounced and more rounded off).

ture-line. In addition it may be added here that the paired area overlapped by the mixilateral plate is not shown and that the area (cd_4) overlapped by the posterior median dorsal plate in all probability has been made too narrow, particularly in its lateral parts. Finally, it is also very likely that the postnuchal notch (*npn*) is more marked and that the external postlevator process (*pr.pl*) is longer and more rounded off. The tergal angle (*dma*) is clearly situated in the foremost part of the middle third of the plate. The median dorsal ridge seems to be as much rounded off that it is practically absent.

The posterior median dorsal plate (text-fig. 217) is long and narrow as a whole, and in addition it is strikingly narrow anteriorly. Accord-

ing to measurements given by Gross the breadth: length ratio amounts only to about 75. The dorsal median ridge (*dmr*) is weakly developed. The posterior corner (*pa*) is well pronounced. Both as to its proportions and shape the plate is suggestive of the corresponding plate in *B. groenlandica* (text-fig. 286; pl. 36, figs. 2–6; pl. 37, figs. 1, 2; pls. 38–42; pl. 43, figs. 1, 2), *B. leptocheira* (p. 503 below) and *B. jarviki* (text-fig. 305D).

Although belonging to animals of a fairly large size the three plates here described have an ornament of a clear and regular reticular type. This condition shows that the immature type of ornament did not undergo any greater changes during the growth of the individuals, but in most respects remained as in young individuals. The ridges are not subdivided into shorter pieces or isolated tubercles. Indications of tubercles are pretty rare and, when present, are found only as thickenings and elevations at the points of anastomoses of the ridges. As normally in medium-sized and large specimens of other *Bothriolepis*-species, the ridges present both concentric and radiating dispositions. In all its characters known the ornament is nearest as in *B. maxima* (text-figs. 234, 237, 239, 241, 242, 244–246), *B. gigantea* (text-figs. 252, 253B–D, 254A, 256), *B. leptocheira* (p. 503 below), *B. jarviki* (p. 599 below) and *B. groenlandica* (pp. 582–584 below; cf. also pl. 4, fig. 2; pl. 5, fig. 2; pl. 7, fig. 5; pl. 13, fig. 1; pl. 25, fig. 2; pls. 27–31, 33; pl. 36, fig. 5; pl. 37, fig. 1; pls. 38–41).



Text-fig. 217. *Bothriolepis ornata*. Deficient posterior median dorsal plate in dorsal aspect. From Gross 1933 (1933a, pl. 4, fig. 14). Nat. size.
aa, anterior corner; *aal* antero-lateral corner; *dmr*, dorsal median ridge; *pp*, posterior corner.

Remarks. – As is obvious from the above description, *B. ornata* is very imperfectly known.

The relationships of *B. ornata* with other *Bothriolepis*-species are still fairly obscure. In several of its characters known *B. ornata* agrees well with *B. groenlandica*, and it is likely, therefore, that it will turn out to be closely related to that species. With regard to the shape of the posterior median dorsal plate and the general character of the ornament it resembles also *B. leptocheira* and *B. jarviki*. In the latter respect, however, it is suggestive of *B. maxima* and *B. gigantea* too.

Localities and geological horizon. – *B. ornata* occurs at the rivers Msta, Prischka, Swir and Lowatj in NW Russia and perhaps also at Ketleri near Windau in Latvia (Gross 1933a, p. 70). The deposits from which it comes belong to the upper Upper Devonian (Gross 1942a, p. 408).

7. **Bothriolepis cellulosa** (Pander).

(Text-figs. 2A, 14, 23E–G, 24C, 26C, 28B, 31C, D, 35D, E, 39C, 41C, 45D, E, 50C, 53C, 218–228).

1846. *Pterichthys cellulosa*, Pander in Keyserling, p. 292.
1911. *Bothriolepis retinata*, Hoffman, pp. 293, 297, text-figs. 14, 15 and pl. 24, fig. 4.
1931. *Bothriolepis retinata*, Gross, p. 58.
1931. *Bothriolepis retinata*, Stensiö, p. 11.
1932. *Bothriolepis cellulosa*, Gross (1932b), p. 24 (in part).
1933. *Bothriolepis cellulosa*, Gross (1933a), pp. 36–39, pl. 4, figs. 1, 9, 10, 12, 15; pl. 5, fig. 12 (in part).
1941. *Bothriolepis cellulosa*, Gross (1941a), pp. 4–32, text-figs. 1–8, 9A–C, 10A, 11A–E, 12–24; pls. 1–6; pl. 7, figs. 1–3, 5; pls. 8–13; pl. 14, figs. 2–4; pl. 15; pl. 16, figs. 1–4; pl. 17, fig. 1 (in part)[1]).

B. cellulosa was thoroughly described Gross in 1941 (1941a, pp. 4–32) and is now, therefore, one of the best known *Bothriolepis*-species. The subsequent account is chiefly a summary of that recent description by Gross.

Diagnosis. – Species of moderate size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) presumably amounting maximally to about 18–19 cm. Dorsal wall of trunk-armour maximally about 12–13 cm long. Head-shield with a length : breadth ratio of 130–151 and presumably comparatively flat anteriorly in its preorbital division. Rostral margin of head-shield normally considerably shorter than posterior margin, usually rather slightly convex, and in individuals of all stages of size generally provided with a rostral angle. Lateral margins of head-shield converging more or less forwards and regularly longer than the centro-nuchal plate is broad across its lateral corners. Obstantic margin of either side of head shield comparatively short, ending normally somewhat behind, or at! a transverse plane through the posterior boundary of the orbital fenestra. Median division of preorbital recess with a slightly convex anterior boundary; lateral division of the same recess short. Premedian plate mostly devoid of a clear nasal notch; its ventral lateral notch often well developed and situated at or near the middle of the ventral lateral margin. Pineal plate broader than long or about as broad as long, often somewhat asymmetric; its anterior margin generally somewhat irregular. Postpineal plate with a somewhat convex anterior (orbital) margin. Length : breadth ratio of centro-nuchal plate 64–81. Lateral division of paranuchal-marginal plate comparatively

[1]) The two specimens reproduced by Gross in 1941 (1941a) in pl. 7, fig. 4 and pl. 14, fig. 1 are both of *B. canadensis*. Gross is not, however, responsible for this mistake. These specimens which belong to the Swedish Museum of Natural History in Stockholm were not sent to Gross, who had at his disposal only photographic prints of them. By mistake the prints had been stated by the photographer of the Stockholm Museum to be of *B. cellulosa*.

broad. Postmarginal plate longer than broad and usually stretching only slightly forwards beyond paranuchal-marginal plate. Mental plate about twice as long as high. Trunk-armour imperfectly known as to its shape, but its dorsal wall presumably not particularly high and certainly comparatively broad. Lateral wall fairly high. Tergal angle generally in the foremost part of the middle third of the anterior median dorsal plate. Dorsal median ridge slightly developed and partly absent in large individuals. The median part of the crista transversalis interna posterior situated on the posterior median dorsal plate fairly well developed. Postlevator thickening often comparatively low. Postlevator crest usually present and often very strongly developed in its posterior part, forming there to a certain extent a floor beneath the levator fossa. Ventral tuberosity practically absent. Anterior median dorsal plate fairly variable as to shape and proportions; its breadth:length ratio in medium-sized and large individuals 80–93. Anterior margin more or less convex. Posterior median dorsal plate comparatively broad in its anterior parts, and with a breadth:length ratio of 100–108; its posterior corner somewhat obtuse or rounded off. Dorsal lamina of anterior dorso-lateral plate about twice as long as broad; lateral lamina of this plate about two and a third times as long as high. Dorsal lamina of mixilateral plate from about one and a half to somewhat more than twice as long as broad; lateral lamina of this plate from about two and a half to almost three times as long as high. Lateral lamina of anterior ventro-lateral plate conceivably a little more than three times as long as high. Ventral lamina of anterior ventro-lateral plate from about one and a half times to about twice as long as broad. Posterior ventro-lateral plate often with a somewhat well-pronounced dorsal corner; lateral lamina probably about two and a half times as long as high; ventral lamina from two and a half to about two and three fourths times as long as broad. Median ventral plate comparatively small. Pectoral fin fairly robust. Proximal segment in medium-sized individuals between three and a half and four times as long as broad. Distal segment robust and fairly flat in a dorso-ventral direction. Lateral spines of proximal segment comparatively short. Medial spines of proximal segment fairly strongly developed and independent; the medial spines situated on the dorsal central plate 1 and on the adjacent parts of the medial marginal plate 2 pointing dorsally. Dorsal central plate 1 from not fully three times to about two and a half times as long as broad. Ventral central plate 1 from about three times to about two and three fourths times as long as broad. Ornament in small medium-sized individuals of a fairly regular fine-meshed network of anastomosing ridges, narrow and well-defined and with distinct tubercular thickenings and elevations at their points of union. Ornament in large individuals retaining an on the whole fine-meshed reticular character on the head-shield, but often dissolved into tubercles and noduse tubercular ridges, more or less vermiculating, on the dorsal side of the trunk-armour. Tubercular formations



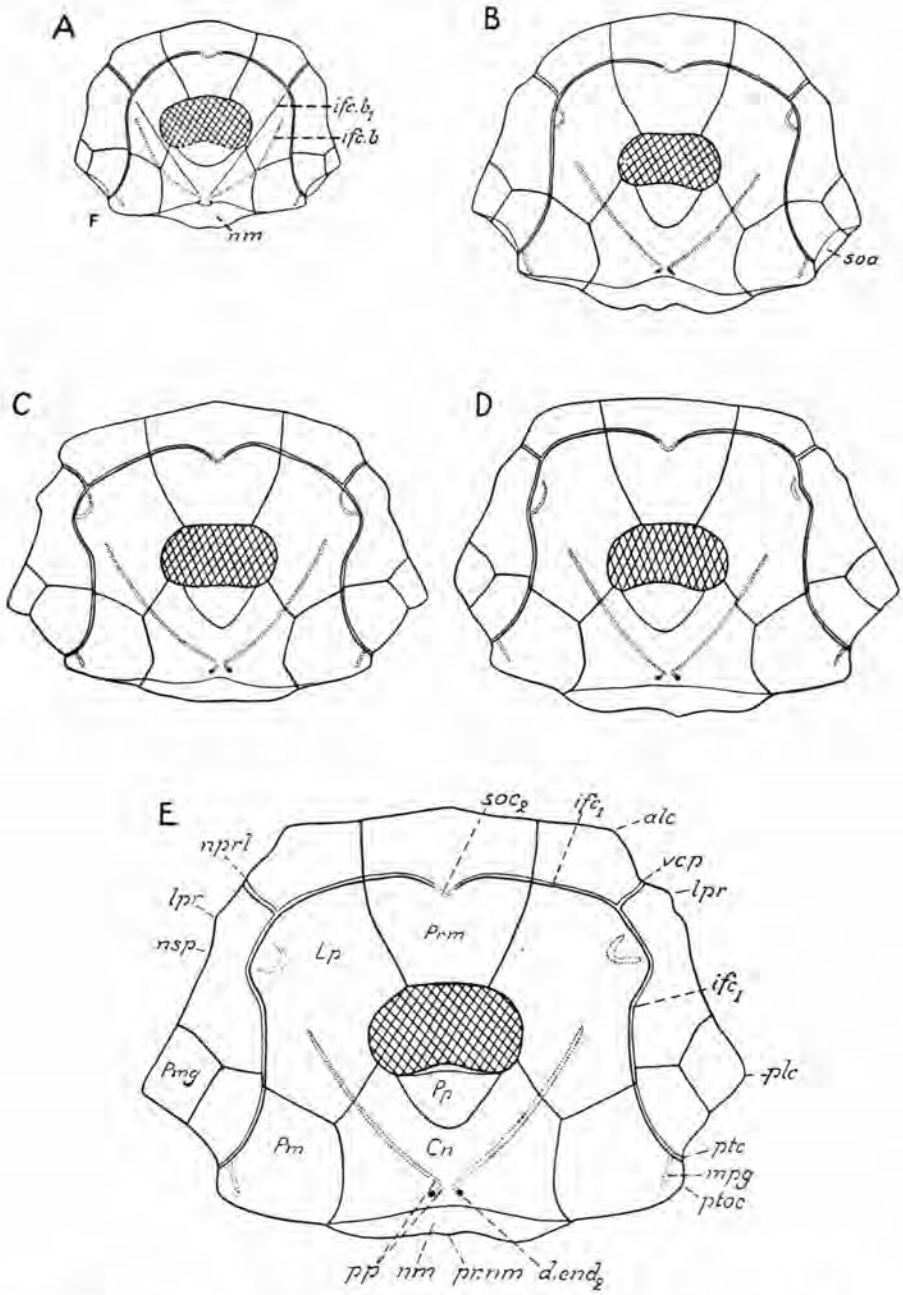
Text-fig. 218. *Bothriolepis cellulosa*. Deficient head-shield in dorsal aspect. A considerable anterior part of the shield represented by an impression of its lower side. R. M. specimen No. P. 1457 (reproduced also by Gross 1941a, pl. 2). Approximately × $^3/_2$.
Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate (impression); *alc*, antero-lateral corner; *a. opl*, area of attachment for extralateral (opercular) plate (impression); *ap*, poriferous area (impression); *cir*, semicircular pit-line groove; *cr. sp*$_1$, *cr. sp*$_2$, prespiracular and postspiracular crests respectively; *ifc*$_1$, upper infraorbital sensory canal goove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *me*, median rostral elevation on lower side of premedian plate (impression); *mpg*, middle pit-line groove of skull-roof; *nl*, ventral lateral notch; *nm*, obtected nuchal area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *pp*, posterior pit-line groove of skull-roof; *prh*, *prh*$_1$, median unpaired and lateral paired divisions of preorbital recess respectively (casts); *pr. po*, antero-lateral corner of otico-occipital depression developed for postorbital process of endocranium (impression); *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *ri*, oblique premedian ridge; *spg*, spiracular groove; *vmp*, ventral medial process of plate *Lp* (impression).

rarely stellate at their bases. Ornament generally more delicate on head-shield than on dorsal parts of trunk-armour.

Material. – The material described by Gross consists only of detached skeletal parts: a few head-shields, a number of bones of the trunk-armour, and parts of pectoral fin-armours. It includes very few remains of small specimens.

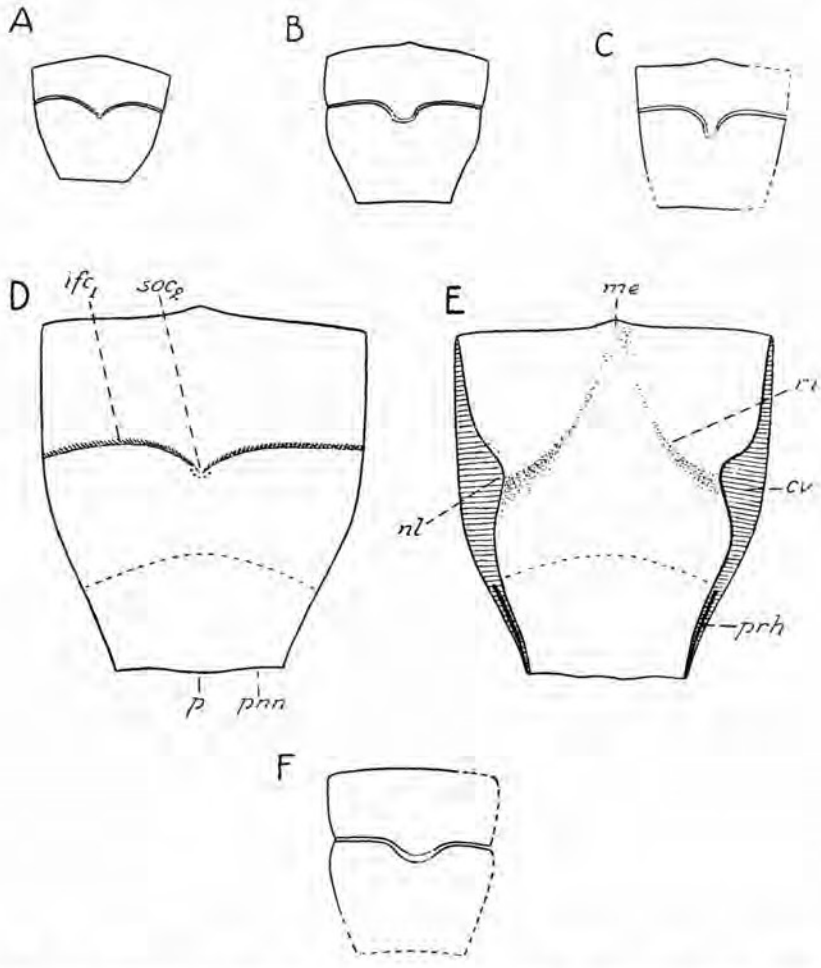
The holotype is a head-shield reproduced by Gross in 1933 (1933a, pl. 4, fig. 15) and 1941 (1941a, pl. 1, fig. 1 and text-fig. 7D).

Description. – As is evident from the measurements given by Gross



Text-fig. 219. *Bothriolepis cellulosa*. *A–E*, restorations of five head-shields in dorsal aspect. *A*, of a small specimen (slightly altered as to the extent of the rostral margin. × 3/2. *B–E*, of medium-sized and large specimens. *B*, *E*, nat. size; *C*, somewhat more than × 8/10; *D*, × 3/4. All figures from Gross 1941a.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner;



Text-fig. 220. *Bothriolepis cellulosa*. *A–F*, restorations of five premedian plates. *A–C*, *F*, from Gross 1941a. Nat. size. *D*, *E*, a plate in dorsal and ventral aspects respectively. Anterior extent of preorbital recess indicated by a broken line. × 2.4.
cv, area overlapping lateral plate; ifc_1, upper infraorbital sensory canal groove; *me*, median elevation, median rostral elevation between anterior ends of ridges *ri*; ventral lateral notch; *p*, nasal process; *pnn*, paranasal notch; *prh*, median unpaired division of preorbital recess; *ri*, premedian ridge; soc_2, anterior median division of supraorbital sensory groove anterior median pit-line groove).

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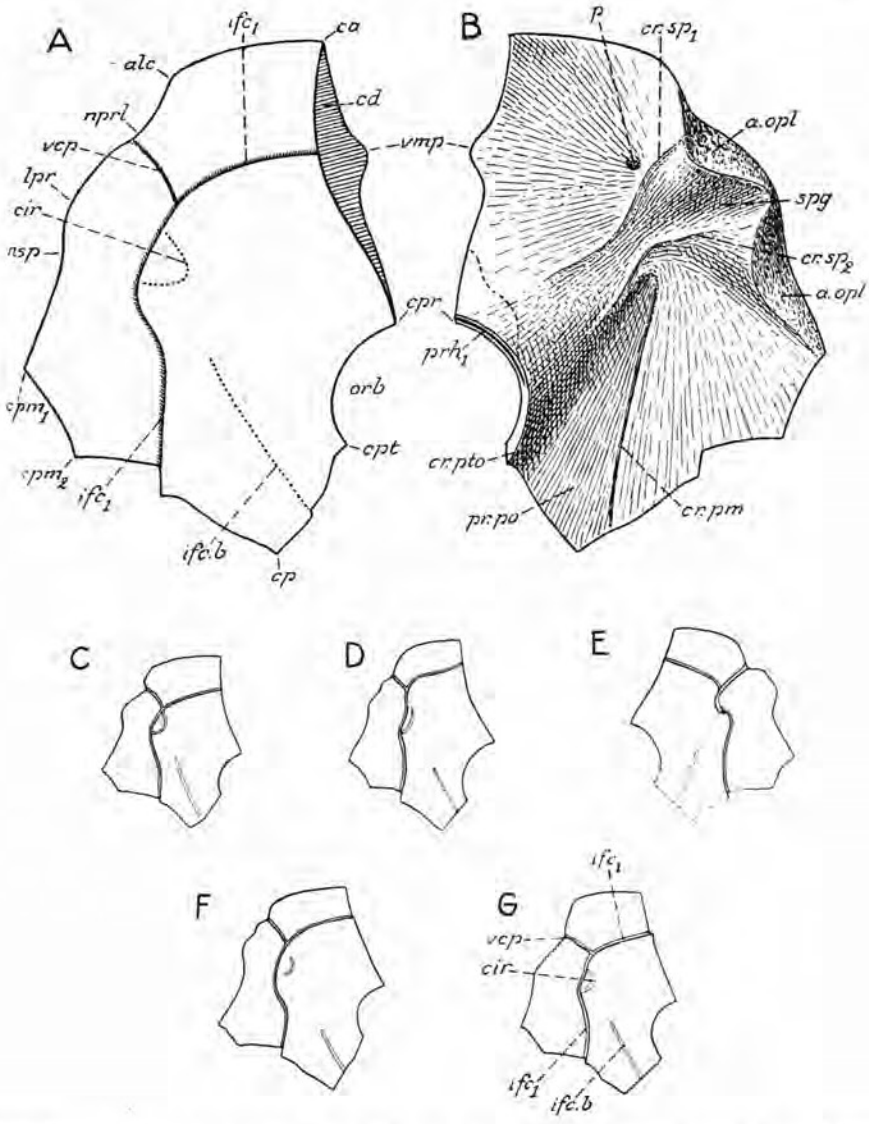
cir, semicircular pit-line groove; *d. end*$_2$, external opening of canal for endolymphatic duct; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *plc*, postero-lateral (preobstantic) corner of head-shield; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process of centro-nuchal plate; *ptc*, cephalic division of main lateral line; *ptoc*, postobstantic corner; soa, subobstantic area; soc_2 anterior median division of supraorbital sensory canal grooves (anterior median pit-line groove); *vcp*, vertical pit-line groove of cheek.

(1933a, p. 39), the maximal dorsal length of the armour (length of head-shield + dorsal length of trunk-armour) may be estimated at about 18–19 cm. The dorsal length of the trunk-armour was maximally about 12–13 cm. *B. cellulosa* seems thus to have attained about the same size as *B. canadensis*.

Head-shield.

The head-shield (text-figs. 14, 218, 219) is much compressed in a dorso-ventral direction so that it is almost flat. As regards the proportion between its breadth and length in this state of preservation it is much as in *B. canadensis*, its breadth:length ratio ranging between 130–151. By the strong flattening it has probably, however, become somewhat broader in relation to its length than what was originally the case. We may suspect, therefore, that in fact it was a little longer and narrower than in *B. canadensis*. It is also conceivable that it was flatter in its preorbital division than in *B. canadensis* (cf. text-figs. 4, 40B, 114). That this may have been so is indicated by the condition that the premedian plate is found in its natural connection with the lateral plates in almost all the head-shields available (Gross 1941a, pls. 1, 2; pl. 4, fig. 1; pl. 6, figs. 1, 2), whereas in *B. canadensis*, on the other hand (text-figs. 76B, 77B, C, 79! 90! 91, 95, 96, 109, 116, 117, 127, 128, 131, 132, 140, 148, 154, 155, 157, 158), it is generally loosened or detached from the lateral plates even in head-shields which are fairly slightly dorso-ventrally compressed. As to the shape of its preorbital division the head-shield would thus have been nearest as in *B. panderi*, *B. maxima*, *B. gigantea* and *B. groenlandica*. Taken as a whole the shield narrows clearly forwards in front of the postero-lateral (preobstantic) corners. The orbital fenestra is narrower both in proportion to its own length and to the size of the head-shield than what is normally the case in *B. canadensis* (cf. text-figs. 76–84), but, as in the last-mentioned species, it is proportionally larger in small than in large head-shields (cf. Gross 1941a, pl. 6, figs. 1, 2). The rostral margin of the shield is always shorter than the posterior margin, generally even considerably shorter, than that margin. In dorsal or ventral view the rostral margin is mostly fairly slightly convex, but in certain specimens, however, it may be about as strongly convex (text-fig. 219B) as in *B. canadensis*. In medium-sized and large individuals the margin generally presents a fairly well-pronounced rostral angle (text-figs. 218–220), and the rostral angle thus as a rule persisted in all stages of growth. The lateral margin differs from the corresponding margin in *B. canadensis* in that it is longer than the centronuchal plate is broad across the lateral corners and in that the supraspiracular process (*lpr*) as a rule is situated further anteriorly, in front of the orbital fenestra, opposite the posterior half of the premedian plate[1]). The

[1]) This constant position of the supraspiracular process in front of the orbital fenestra is possibly due to some extent to the complete flattening of the preorbital division of the head-shield. Through the straightening out of this division the supraspiracular process has probably got a position somewhat further forwards than what it actually had in head-shields with the original depth.



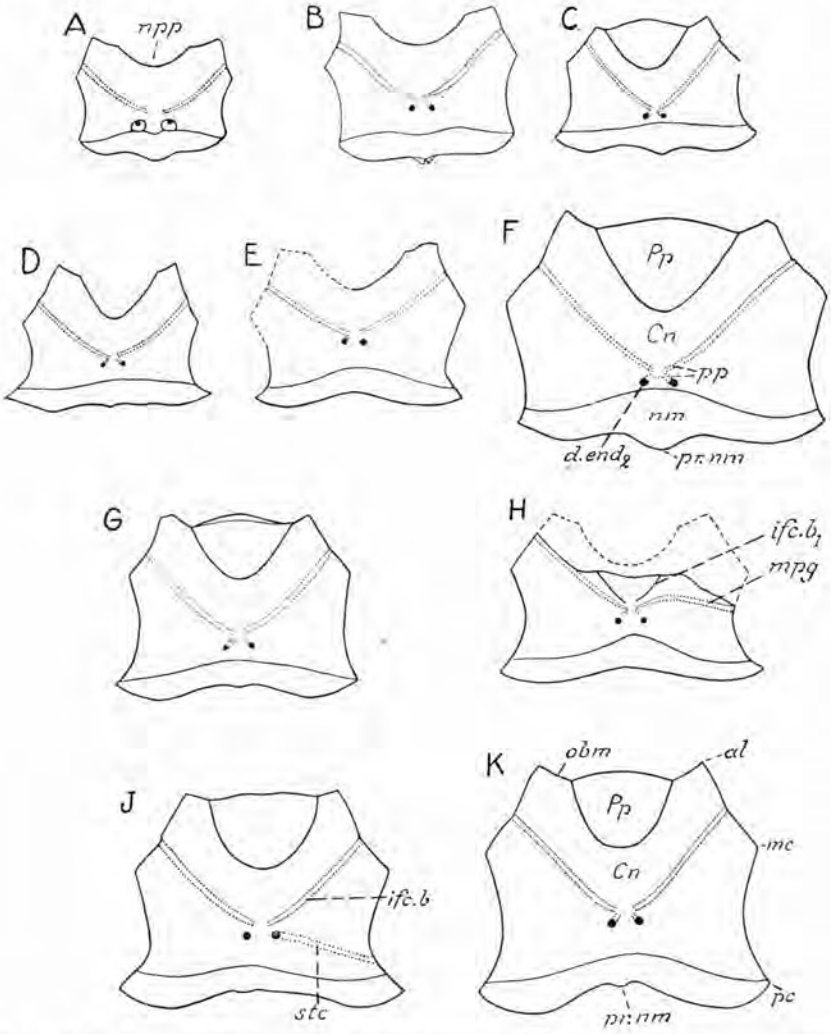
Text-fig. 221. *Bothriolepis cellulosa*. *A*, *B*, restorations of a left lateral plate in dorsal and ventral aspect respectively. Extent of lateral paired division of preorbital recess indicated with a broken line. About × 2. *C–G*, restorations of five lateral plates in dorsal aspect. *C*, *D*, *F*, *G*, left plates; *E*, right plate. *C–G*, from Gross 1941a. Diminished.
alc, antero-lateral corner; *a. opl*, area of attachment for extralateral (opercular) plate; *ca*, antero-medial corner; *cd*, area overlapped by premedian plate; *cir*, semicircular pit-line groove; *cp*, posterior corner; cpm_1, cpm_2, anterior and posterior postmarginal corners respectively; *cpr*, preorbital corner; *cpt*, postorbital corner; *cr. pm*, paramarginal crest; *cr. pto*, postorbital crest; $cr.\ sp_1$, $cr.\ sp_2$, prespiracular and postspiracular crests respectively; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb*, orbital notch; *p*, prespiracular pit; prh_1, lateral paired division of preorbital recess (antero-lateral extent indicated by a broken line); *spg*, spiracular groove; *vcp*, vertical pit-line groove of cheek; *vmp*, ventral medial process.

postero-lateral (preobstantic) corner (*plc*) seems mostly to be situated somewhat further forwards in relation to the orbital fenestra than in *B. canadensis*, more precisely at, or not so very far behind, the transverse plane through the posterior boundary of the orbital fenestra. It differs also somewhat from the corresponding corner in *B. canadensis* in that as a rule it is somewhat rounded off and not produced into a posterior process. The obstantic margin is developed in a manner similar to that in *B. canadensis*, with the difference only that, at least in most cases, it seems to be slightly longer than in that species. Finally, the posterior margin of the shield is characterized by the conditions that its middle part, formed by the centro-nuchal plate, protrudes a little more backwards than in *B. canadensis* (text-figs. 9, 10, 82–84, 208), and that the posterior median process (*pr.nm*, text-figs. 218, 219, 222) generally is slightly developed or absent.

The preorbital recess (*prh*, *prh*$_1$, text-figs. 14, 218, 221B) is of a type similar to that in *B. canadensis*, but the anterior boundary of its median unpaired division is clearly a little more convex. The structures of the lower side of the shield (text-figs. 218, 221B) seem not to differ in any essentials from those in *B. canadensis*. The premedian ridge (*ri*, text-figs. 218, 220E), however, is longer and begins further backwards than in *B. canadensis*.

The premedian plate (*Prm*, text-figs. 14, 218–220) during its growth underwent a change in proportions similar to that in *B. canadensis* and thus is broader in proportion to its length in small individuals than in medium-sized and large individuals. The plate could be measured only in fairly few specimens. In these specimens its breadth:length ratio is between 92–126, but it is not unlikely that the total range of varioation of this ratio is much wider, perhaps about as wide as in *B. canadensis*. The most characteristic features of the plate may be summarized as follows. The rostral angle is mostly present and well marked, but may sometimes be absent. The ventral lateral notch (*nl*, text-figs. 218, 220E) is deep and situated near the middle of the plate. The premedian ridge (*ri*) is long and well developed. Finally, the posterior dorsal margin is mostly slightly concave or straight throughout its extent, but may sometimes also exhibit certain slight indications of a nasal process (*p*, text-figs. 14, 220D; Gross 1941a, pl. 4, figs. 1, 3; pl. 6, fig. 1).

The pineal plate (text-fig. 23E–G; Gross 1941a, text-fig. 6D–H; pl. 5, figs. 1–6) seems normally to be somewhat asymmetric in as much as its lateral margins are of a somewhat different length. The plate sometimes is a little broader than long, sometimes about equally broad as long, and hence with regard to its breadth and length it is somewhat more variable than in *B. canadensis*. The postero-lateral process is shorter than in *B. canadensis* and may sometimes be fairly slightly developed. Characteristic of the plate otherwise is that its anterior and lateral margins are irregularly undulating or irregularly developed in other ways, that its posterior margin is slightly convex, that there are well defined unornamented areas along the



Text-fig. 222. *Bothriolepis cellulosa*. Restorations of ten centro-nuchal plates. Dorsal aspect. In *C*, *F*, *G*, *J*, *K*, also the postpineal plate restored. From Gross 1941a. *A*, *B*, × 2. *C–E*, nat. size. *F*, × 3/2. *G*, *H*, *J*, *K*, nat. size.

Cn, centro-nuchal plate; *Pp*, postpineal plate; *al*, antero-lateral corner; *d. end*$_2$, external opening of canal for endolymphatic duct; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc. b*$_1$, anterior oblique cephalic pit-line groove; *mc*, lateral corner; *mpg*, presumably middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *npp*, postpineal notch; *obm*, orbital facet of anterior margin; *pc*, postero-lateral corner; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process; *stc*, supratemporal pit-line groove.

lateral and posterior margins, and that the pineal pit is situated approximately in the centre of the plate.

The lateral plate (*Lp*, text-figs. 14, 24C, 218, 219, 221; Gross 1941a, text-fig. 3) in all essentials is as in *B. canadensis*. Its breadth across the anterior postmarginal (*cpm*$_1$) and postorbital (*cpl*) corners is from 60% to at

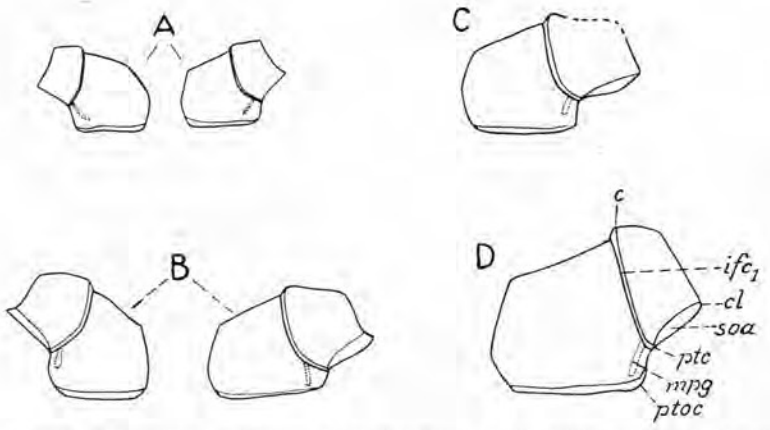
least about 75% of its total length. The ventral medial process (*vmp*) is situated further backwards on the ventral lateral margin than in *B. canadensis* and seems mostly also to be longer than in that species. The lateral and medial divisions of the plate (see fig. 1A) vary rather much in breadth in different individuals.

The postpineal plate (*Pp*, text-figs. 14, 218, 219, 222C, F, G, J, K) was much broader and shorter in small individuals than in medium-sized and large individuals, and during its growth it thus underwent a change as to its proportions similar to that in *B. canadensis*. Its anterior margin is convex, buts its convexity sometimes is fairly slight.

The centro-nuchal plate (*Cn*, text-figs. 14, 26C, 218, 219, 222) is of the ordinary type characteristic of the genus. Its total median length is from 64–81% of its breadth across the lateral corners (*mc*), and as to its length : breadth ratio the plate thus agrees pretty well with the corresponding plate in *B. canadensis*. In contradistinction to what is the case in *B. canadensis* its paramedian length in medium-sized and large individuals normally is a little larger than the total median length. As in *B. panderi*, the plate is mostly broader across the postero-lateral corners (*pc*) than across the lateral corners (*mc*), on account of which the posterior division of its lateral margin, taken as a whole, usually is directed a little anteriorly. The division of the lateral margin just referred to is longer than the anterior division and as a rule deepest concave at, or a little behind, its middle, not near or immediately in front of the postero-lateral corner (*pc*), as is generally the case in *B. canadensis* and several other *Bothriolepis*-species (cf. text-fig. 26). The posterior margin of the plate in small individuals (text-fig. 222A; Gross 1941a, pl. 3, fig. 7; pl. 6, fig. 2) is developed in a manner fundamentally similar to that in small individuals of *B. canadensis* and *B. groenlandica* (text-figs. 93A–E, 278A). In medium-sized and large individuals, on the ohter hand, this margin is often concave as a whole. In the latter case its posterier median process (*pr.nm*) is slightly developed or entirely absent.

The paranuchal-marginal plate (*Pm*, text-figs. 14, 28B, 218, 219, 223) in most of its characters agrees fairly well with the corresponding plate in *B. canadensis*. However, the lateral division of the plate is comparatively broad, clearly broader in proportion to the medial one than in *B. canadensis*. More precisely its breadth in small individuals amounts to about three fourths (about 74%) and in medium-sized and large individuals to between two thirds (67%) and a little less than one half (47%) of the breadth of the medial division. As is seen from text-fig. 223A and B, the breadth of the division just under consideration of the plate may often be fairly different on the right and left sides in one and the same individual.

The postmarginal plate (*Pmg*, text-figs. 14, 28B, 218, 219) is longer than broad and developed much in the same way as in *B. canadensis*. How-



Text-fig. 223. *Bothriolepis cellulosa*. *A*, restorations of the right and left paranuchal-marginal plates of one and the same individual. × $^2/_3$. *B*, restorations of the right and left paranuchal-marginal plates also of one and the same individual. Nat. size. *C*, *D*, two right paranuchal-marginal plates. All the plates in dorsal aspect. All figures from Gross 1941 a. Nat. size.

c, anterior corner; *cl*, lateral corner; ifc_1, upper infraorbital sensory canal groove; *mpg*, middle pit-line groove of skull-roof; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area.

ever, its postero-lateral corner is usually rounded off and not produced backwards into a short process.

The mental plate (text-fig. 35 D, E) is about twice as long as high and is thus clearly higher and shorter than in *B. canadensis* (cf. text-fig. 35 A, C).

The deficient bone-plate interpreted by Gross as a postero-dorsal sclerotic plate (1941 a, pp. 13–14, text-fig. 6; and pl. 6, figs. 3, 4) is difficult to orientate. It is stronger and more extensively ornamented than the corresponding plate in *B. canadensis*.

Trunk-armour.

The trunk-armour is still very imperfectly known with regard to its exact shape and proportions. According to restorations published by Gross (1941a) its shape in dorsal and ventral aspects is somewhat as shown in text-figs. 39 C and 41 C respectively. Whether its dorsal wall was as low and flat as in *B. canadensis* (cf. text-figs. 38, 40) or whether it was a little higher cannot be decided at present. The lateral wall of either side is comparatively high, though not quite as high as in *B. canadensis*.

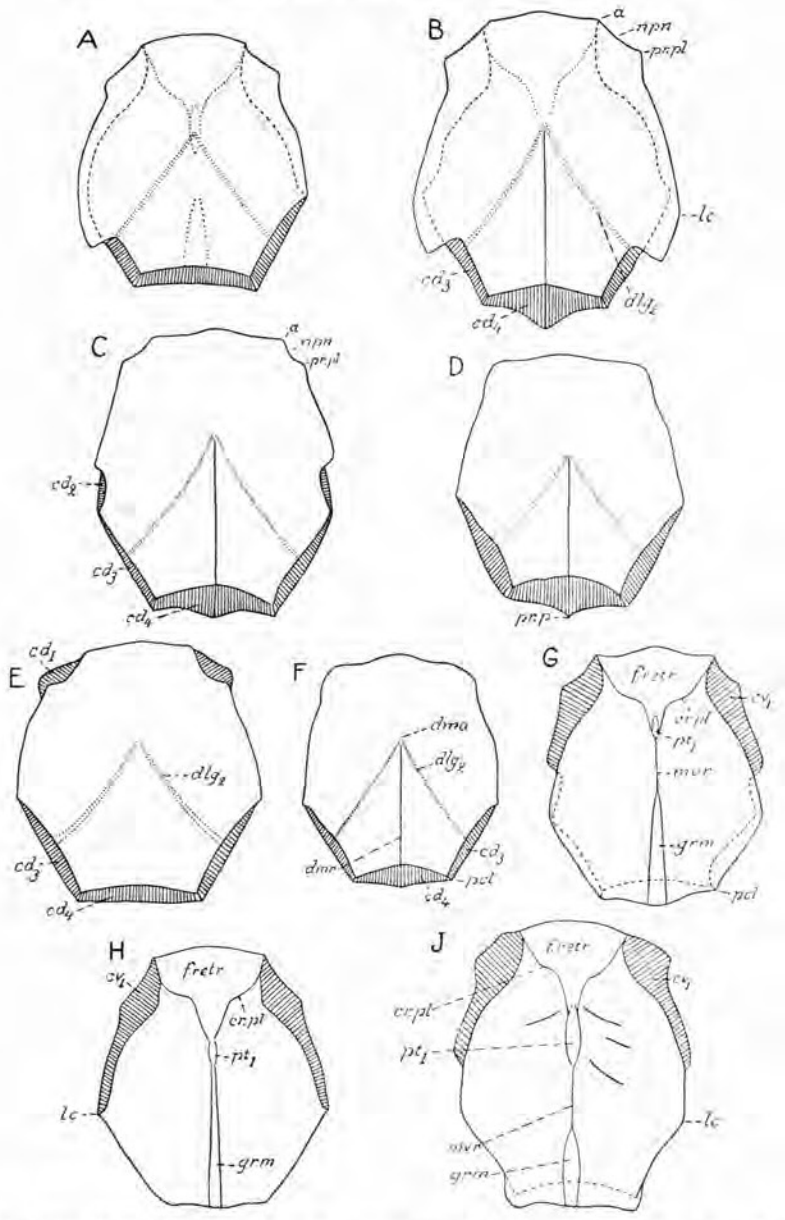
The tergal angle (*dma*, text-figs. 39 C, 41 C, 224 A–F) lies practically always quite in the anterior parts of the middle third of the anterior median dorsal plate, and is thus not only more constant in its position than in *B. canadensis*, but is also situated a little further backwards than in that species. In agreement with the conditions in *B. canadensis* the dorsal median ridge (*dmr*) is

generally more completely developed in small individuals than in large individuals (cf. Gross 1941a, pl. 7, figs. 3, 5; pl. 10, figs. 1, 2, 4–6; pl. 12, fig. 1), in which it is frequently interrupted in its middle part. Otherwise it may be mentioned that this ridge in medium-sized and large individuals seems to be a little more pronounced than in individuals of the corresponding stages of size in *B. canadensis*. The dorso-lateral ridge (*dlr*, text-fig. 226, 227) is generally well-pronounced and fairly sharp-edged.

The following deserves to be pointed out concerning the development of the structures on the lower side of the dorsal wall of the trunk-armour (text-fig. 224G, H, J; cf. Gross 1941a, pl. 7, fig. 1; pl. 8; pl. 9, fig. 1; pl. 10, figs. 3, 6; pl. 17, fig. 1). The median dorsal part of the crista transversalis interna posterior situated on the posterior median dorsal plate seems to be fairly well developed (Gross 1941a, pl. 10, fig. 3). With regard to its proportions and shape the levator fossa (*f. retr*) is approximately as in *B. canadensis*. The postlevator thickening (*alr*) is often low and fairly obscure. The postlevator crest (*cr. pl*), on the other hand, is strongly developed and seems normally to persist also in medium-sized and large individuals. Characteristic of this crest is that it is so high in its posterior half that to some extent it forms a floor of the posterior lateral parts of the levator fossa. The crest is thus considerably stronger developed than what is otherwise mostly the case in the representatives of the genus. The ventral median ridge (*mvr*) and the ventral median groove (*grm*) are present in medium-sized and large individuals, but seem to be fairly weakly developed. The ventral tuberosity of the posterior median dorsal plate, which is well developed in *B. canadensis*, *B. panderi* and several other *Bothriolepis*-species, as a rule is practically absent.

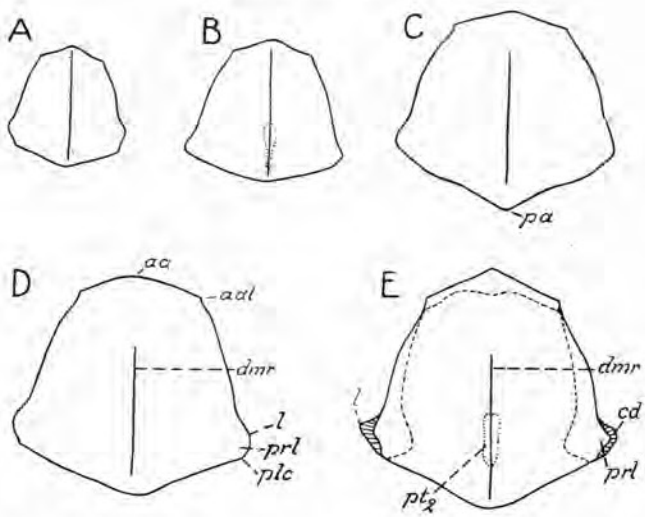
As to the structures on the ventral side of the dorsal wall of its trunk-armour *B. cellulosa* thus to some extent clearly differs from *B. canadensis* and the majority of other *Bothriolepis*-species, such as for instance *B. panderi*, *B. maxima*, *B. gigantea*, *B. alvesiensis* and *B. groenlandica*.

The anterior median dorsal plate (text-figs. 2A, 39C, 224) is known only from medium-sized and large individuals, in which its breadth: length ratio ranges between 80–93. This plate is thus of a somewhat broad type, but seems not to have attained quite as large a relative breadth as in *B. canadensis* and certain other species. As to its outlines it is nearest suggestive of the corresponding plate in *B. canadensis* (text-figs. 118–126) and *B. panderi* (text-figs. 43D, 44B). The anterior margin of the plate as a whole mostly is clearly convex with the most pronounced convexity in its middle part, but may also in certain cases be nearly straight. This margin shows no traces whatever of the median concavity or median notch that is often met with in *B. canadensis*. The lateral margin varies in its configuration in a manner similar that in *B. canadensis* and consequently presents no characters of interest to us in this connection. Finally, the posterior margin is equipped with a broad posterior median process (*pr.p*), which varies much



Text-fig. 224. *Bothriolepis cellulosa*. Restorations of nine anterior median dorsal plates. All figures from Gross 1941a. *A–F*, six plates in dorsal aspect. *A*, × 1/2. *B*, nat. size. *C*, × 1/2. *D–F*, approximately × 2/3. *G–J*, three plates in ventral aspect. *G*, *H*, approximately × 3/4. *J*, approximately × 8/10.

a, antero-lateral corner; cd_1, area overlapped by foremost part of anterior dorso-lateral plate; cd_2, area overlapped by a posterior part of the anterior dorso-lateral plate; cd_3, area overlapped by mixilateral plate; cd_4, area overlapped by posterior median dorsal plate; *cr. pl*, postlevator crista; cv_1, area overlapping anterior dorso-lateral plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *pcl*, postero-lateral corner; *pr. p*, posterior median process; *pr. pl*, external postlevator process; pt_1, anterior ventral pit.



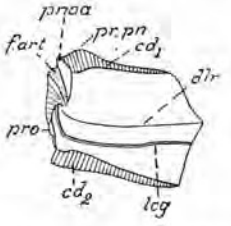
Text-fig. 225. *Bothriolepis cellulosa*. Restorations of five posterior median dorsal plates in dorsal aspect. From Gross 1941a. *A*, of a small individual; *B*, of a somewhat larger individual. *A*, *B*, nat. size. *C–E*, of large individuals. *C–E*, × $^1/_2$.
aa, anterior angle or corner; *aal*, antero-lateral corner; *cd*, area on lateral process overlapped by mixilateral plate; *dmr*, dorsal median ridge; *l*, lateral corner; *pa*, posterior median corner; *plc*, postero-lateral corner; *prl*, lateral process; pt_2, position of posterior ventral pit (indicated with a broken line).

in length and is angular or rounded off. In certain cases this process may even be represented by a short broad median convexity.

As was shown by Gross (1941a, pp. 18–20), the anterior median dorsal plate is often abnormal in its sutural connections with the anterior dorso-lateral and mixilateral plates. Its abnormal sutural connections with the said two plates that were observed by Gross are as follows. 1) The plate has normal sutural connections with the anterior dorso-lateral and mixi-lateral plates with the exception, however, that most anteriorly, at the post-nuchal notch, it both overlaps, and is overlapped by, the anterior dorso-lateral plate (text-figs. 2A, 224E). This abnormal condition has so far been met with only in a single specimen. 2) The plate overlaps the anterior dorso-lateral plate anteriorly for a fairly long distance, whereas further backwards, nearest to its lateral corner (*lc*), it is overlapped by the said plate on one or on both sides (text-fig. 224C, G). This anomaly occurs fairly frequently. 3) The plate not only, as normally, overlaps the anterior dorso-lateral plate, but in addition, on one or on both sides, an anterior part of the mixilateral plate. The hindmost part of it that is overlapped by the mixilateral plate is much shorter, therefore, than normally (text-fig. 224A, B). This anomally seems to be rather frequent. 4) The plate overlaps the anterior dorso-lateral plate only for a rather long distance anteriorly, whereas further backwards, both in front of and behind its lateral corner, it abuts against the posterior part of the anterior dorso-lateral plate, and against the mixi-lateral plate,

exclusively with its very lateral edge (text-fig. 224J). Only most posteriorly, near to its posterior margin, it is slightly overlapped by the mixilateral plate. This anomaly has been noticed only in one specimen.

The posterior median dorsal plate (text-figs. 45D, E, 225; Gross 1941a, pl. 10, figs. 2–6) is of the same general type as in *B. canadensis* and is thus fairly broad and obtuse anteriorly. Its breadth : length ratio is about

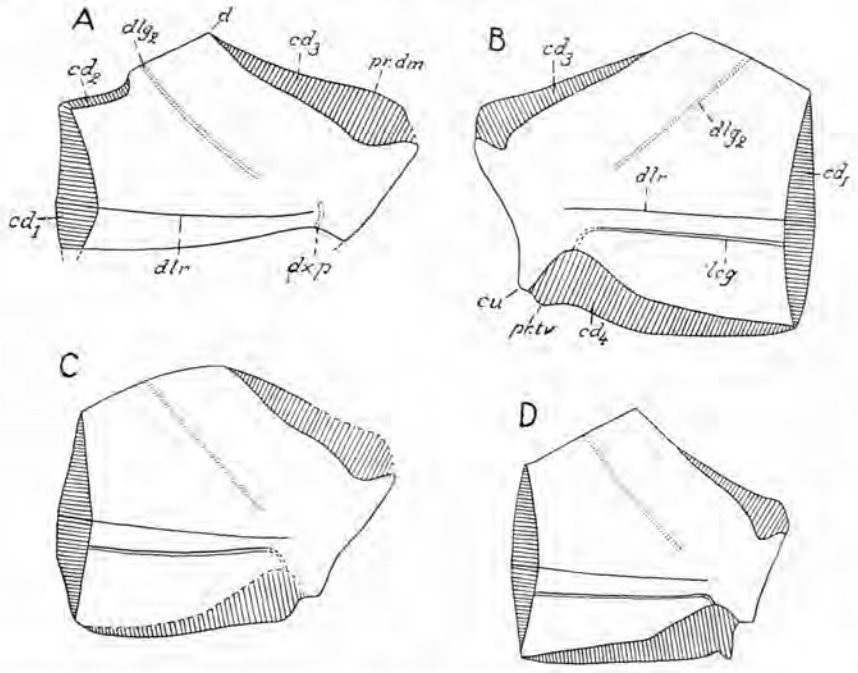


Text-fig. 226. *Bothriolepis cellulosa*. Restoration of a flattened small left anterior dorso-lateral plate. Lateral aspect. From Gross 1941a. Nat. size.
cd_1, area overlapped by anterior dorso-lateral plate; cd_2, area overlapped by anterior ventro-lateral; *dlr*, dorso-lateral ridge; *f. art*, articular fossa (for paranuchal trochlea); *leg*, main lateral line groove; *pnoa*, postnuchal ornamented corner; *pro*, processus obstans; *pr. pn*, internal postlevator process.

100 in small individuals, but about 105–108 in medium-sized and large individuals. The anterior margin forms mostly a more or less clearly marked anterior corner or angle (*aa*), but this angle may sometimes be so much rounded off as to be obscure. The lateral margin and lateral process (*prl*) are as in *B. canadensis*. A mixilateral notch is absent in the few plates at hand. The posterior corner (*pa*) is rounded off and less conspicuous than in *B. canadensis*. The plate overlaps the mixilateral plate, but is also sometimes overlapped by that plate at the lateral process (text-figs. 45E, 225E).

The anterior dorso-lateral plate (*Adl*, text-figs. 39C, 226) among the material examined by Gross is very rare, being represented only by a single specimen (Gross 1941a, pl. 11, fig. 4). Because of the fact that this specimen is much flattened it is impossible to make sure how the angle was between the dorsal and lateral laminae. As a whole the plate is much as the corresponding plate in *B. canadensis*. The dorsal lamina is about twice as long as broad, the lateral lamina about two and a third times as long as high. The latter lamina is thus a little lower relatively than what is normally the case in *B. canadensis*. The internal postlevator process (*pr.pn*) and the postnuchal ornamented corner (*pnoa*) are clearly developed. The ventral margin is almost straight.

The mixilateral plate (*Mxl*, text-figs. 39C, 50C, 227) occurs fairly frequently in the material described by Gross. However, it is much flattened so that the original angle between its two laminae cannot be ascertained. The dorsal lamina is from about one and a half times to somewhat more



Text-fig. 227. *Bothriolepis cellulosa*. Restorations of four flattened mixilateral plates in lateral aspect. From Gross 1941a. *A*, of a deficient left plate with a strikingly narrow dorsal lamina. Nat. size. *B*, of a right plate. Nat. size. *C*, of a left plate. Approximately $\times$ $^8/_{10}$; *D*, of a left plate with a very broad dorsal lamina. $\times$ $^1/_2$.
cd_1, area overlapped by anterior dorso-lateral plate; cd_2, area overlapped by anterior median dorsal plate (developed only in certain specimens); cd_3, area overlapped by posterior median dorsal plate; cd_4, area overlapped by posterior ventro-lateral plate; *cu*, postero-ventral ornamented corner; *d*, dorsal corner; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dxp*, pit-line groove probably representing a part of the pit-line dlg_2; *lcg*, main lateral line groove; *pr.dm*, medial dorsal process; *pr.tv*, postero-ventral process.

than twice as long as broad. The lateral lamina is from about two and a half to almost three times as long as high and is thus a little lower and longer relatively than the corresponding one in *B. canadensis*. The medial dorsal process (*pr. dm*) is more rounded off and less pronounced and the postero-ventral ornamented corner (*cu*) much more obtuse at its ventral end than in *B. canadensis* (cf. text-figs. 50A, B, 153).

The anterior ventro-lateral plate (*Avl*, text-fig. 41C; cf. Gross 1941a, text-fig. 14; pl. 12, fig. 3) as a whole is a little shorter and broader than in *B. canadensis*. The lateral lamina, which presumably decreased fairly slightly in height backwards, seems to have been somewhat more than three times as long as it is high, whereas the ventral lamina is from about one and a half to not fully twice as long as broad.

The posterior ventro-lateral late (*Pvl*, text-fig. 41C, 53C; Gross 1941a, text-fig. 15; pl. 12, fig. 4) has a somewhat well-marked dorsal corner (*dc*). The lateral lamina is about two and a half times as long as high.

The ventral lamina, which is a little narrower than in *B. canadensis*, is from about two and a half to about two and three fourths times as long as broad.

The median ventral plate (*Mv*, text-fig. 41C; Gross 1941a, text-figs. 16, 18; pl. 5, fig. 10) is comparatively small, but, judging from the length of the posterior division of the medial margin of the anterior ventro-lateral plate, it was probably a little larger relatively than in *B. canadensis*. In contradistinction to what is the case in *B. canadensis* it seems normally to be longer behind, than in front of, its lateral corners.

The semilunar plate has not been found preserved, but the development of the medial margin of the anterior dorso-lateral plate shows clearly that it must have been much as in *B. canadensis*, and that, as in that species, it must have been fairly variable in shape.

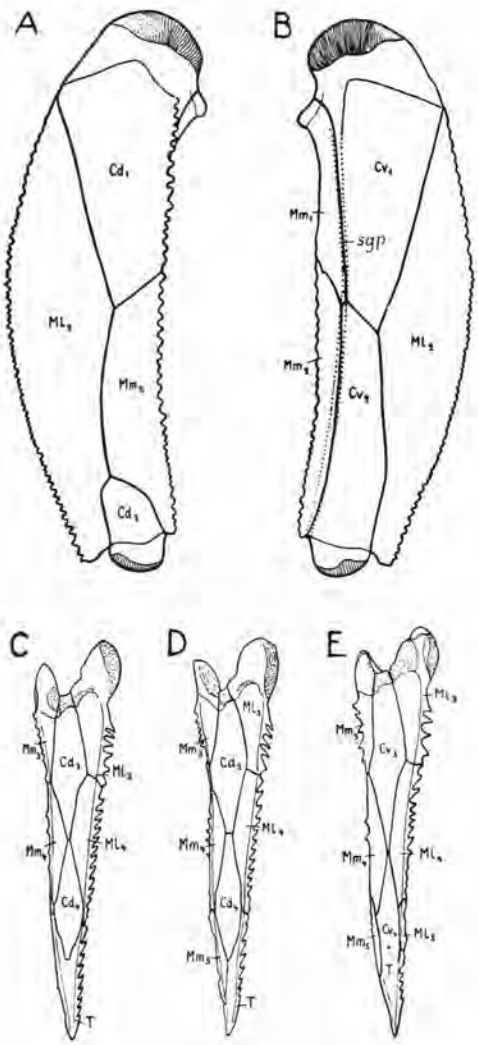
Pectoral fin.

The pectoral fin-armour (text-fig. 228) is not nearly so well known as in *B. canadensis*; this applies above all to its changes during the growth.

The proximal segment (text-fig. 228A, B) is broadest about midway between its proximal and distal ends and thus not, as in *B. canadensis*, behind its middle. In medium-sized individuals it is about three and a half, or betheen three and a half times and four, times as long as broad. As to its proportions in various stages of growth it may, therefore, probably have been somewhat as the corresponding segment in *B. canadensis*. The lateral and medial spines of the segment are also on the whole as in the species just referred to. At least in several cases it is fully evident that the medial spines, situated on the dorsal central plate 1 and on the anterior parts of the median marginal plate 2, point much dorsally, whereas the medial spines belonging to the posterior part of the medial marginal plate 2 are directed medially.

The distal segment (text-fig. 228C, D, E) is of a somewhat robust type suggestive of that in *B. canadensis*. It differs, however, clearly from the corresponding segment in *B. canadensis* by the smaller maximal number of elements in its four longitudinal series of plates and in the condition that its lateral row of spines is more complete, stronger, and more uniformly developed (cf. text-figs. 41B, 195, 198). The maximal number of independent elements observed in the dorsal central, ventral central, lateral marginal, and medial marginal series amounts to 2, 1, 3, 3 respectively.

The dorsal central plate 1 (Cd_1, text-fig. 228A; Gross 1941a, text-fig. 19A–D; pl. 13, fig. 1; pl. 14, figs. 3, 4; pl. 15, fig. 1) is from somewhat more than two and a half times to not fully three times as long as broad. The dorsal central plate 2 (Cd_2, text-fig. 228A; Gross 1941a, text-fig. 22A–C; pl. 13, figs. 1, 6; pl. 14, fig. 2) in a medium-sized individual is 1,74 and in a large individual 1,38 times as long as broad and was, therefore, probably normally somewhat narrower in proportion to its length



Text-fig. 228. *Bothriolepis cellulosa*. *A*, *B*, restoration of a proximal segment of a left pectoral fin in dorsal and ventral aspects respectively. This restoration is based on a pectoral fin that is highly flattened in a dorso-ventral direction, and is, therefore, possibly a little too broad in proportion to its length. *C*, *D*, restorations of two right distal segments of pectoral fins. Dorsal aspect. *E*, restoration of a distal segment of a left pectoral fin. Ventral aspect. From Gross 1941. Nat. size.
Cd_1–Cd_4, dorsal central plates 1–4; Cv_1–Cv_3, ventral central plates 1–3; Cv_4+T, ventral central plate 4 not divided off from terminal plate; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_1–Mm_5, medial marginal plates 1–5; T, terminal plate; *sgp*, pectoral pit-line groove.

than in *B. canadensis*. With regard to its length : breadth ratio this plate seems thus to be nearest as in *B. maxima* and *B. groenlandica*. The ventral central plate 1 (Cv_1, text-fig. 228B, Gross 1941a, text-fig. 19E, F; pl. 15, figs. 2, 3) is from at least about two and two thirds to about three times as

long as broad. The other plates of the various longitudinal series are fundamentally as in *B. canadensis*.

Ornament.

The ornament in small individuals seems to have consisted of a regular fine-meshed network of ridges with tubercular thickenings and elevations at their points of union (Gross 1941a, pl. 6, fig. 2; pl. 10, fig. 5). At least in certain cases in small individuals it is more delicate and more regularly reticular on the head-shield than on the trunk-armour. In medium-sized and large individuals it retains much of its immature reticular type on the head-shield, while at least in many cases it has been much more transformed on the trunk-armour where sometimes it may even be subdivided into isolated pieces of ridges and tubercles almost to the same extent as in *B. canadensis*. In medium-sized and large individuals it has also always a concentric and radiating disposition and, besides, generally is weaker on the head-shield than on the trunk-armour. The tubercular formations are generally not stellate at their bases. Characteristic of the ornament is thus that it is more delicate on the head-shield than on the trunk-armour and that in medium-sized and large individuals its reticular character is much more completely retained on the head-shield than on the trunk-armour.

Sensory canal system.

The sensory canal system (text-figs. 39C, 218–224, 226, 227, 228B) is essentially as in *B. canadensis*. The upper infraorbital groove (*if*c_1) may be absent fore some distance in its middle part and may there be replaced by the semicircular pit-line groove (text-fig. 221E). The semicircular pit-line groove (*cir*) is mostly more curved than in *B. canadensis*. The anterior oblique cephalic pit-line groove (*if*$c.b_1$, Gross 1941a, pl. 6, fig. 2) is clearly developed in small individuals. The middle pit-line groove (*mpg*) of the skull-roof is somewhat more pronounced and more regularly present than in *B. canadensis*. In a single case it extends on one side as far medially as to the medial part of the centro-nuchal plate (text-fig. 222H). In contradistinction to what is the case in *B. canadensis* the supratemporal pit-line groove (*stc*) is rarely present (text-fig. 222J). The anterior oblique abdominal pit-line groove (*dlg*$_1$) has not been observed with certainty so far, a condition which is doubtless due to the fact that all the anterior median dorsal plates available are from medium-sized and large individuals. In one of the mixilateral plates at hand there is a short vertical pit-line groove just antero-dorsally to the postero-ventral ornamented corner (*cu*), a pit-line groove (*dpx*, text-fig. 227A) which,

as maintained by Gross (1941a, p. 21), probably represents a postero-ventral part of the posterior oblique abdominal pit-line groove (dlg_2). The pectoral pit-line groove (*sgp*, text-fig. 228B) is normally present. Judging from the reproductions of the ventral central plate 2 given by Gross (1941a, pl. 13, figs. 3, 4), it is possible that in some cases the pectoral pit-line groove did not pass along the suture between the ventral central plate 2 and the medial marginal plate 2, but further ventro-laterally, along the obscure ventro-medial ridge of the ventral central plate 2. If this be true it would thus have had a position on the distal half of the proximal segment similar to that in *B. groenlandica* (text-fig. 299A).

Remarks. – *B. cellulosa* is a well-defined species. It reminds much of *B. canadensis*, to which in all probability it is closely akin.

Localities and geological horizon. – *B. cellulosa* occurs in the *cellulosa*-marl of the lowermost Upper Devonian of Kokenhusen and Stockmannshof in Latvia. According to Obrutschew (1933) and Gross (1934, p. 420; 1941a, p. 32; 1942a, pp. 392–395) it presumably occurs also in NW Russia, at Neuhausen in Esthonia, at Karlsruhe at the river Ammat in Latvia, and at Rönnen in Latvia. Recently it has been recorded by Obrutschew (1940, p. 890) from Lake Bilyo, Minusinsk region, Siberia.

The close relationship of *B. cellulosa* to *B. canadensis*, the condition that *Eusthenopteron säve-söderberghi* Jarvik (1937, pp. 70–90, 120–121; cf. also Gross 1936, p. 69) is fairly near to *E. foordi* Whiteaves, and several other facts as well, seem now to show that the *cellulosa*-marl of Latvia is of approximately the same age as the Upper Devonian Beds of Scaumenac Bay in Canada (cf. Westoll 1937, pp. 36–40; Gross 1942a, pp. 396–409).

Bothriolepis panderi Lahusen.

(Text-figs. 21D, 23H, 26D, 28C, 43D, 44B, 47B, 229–232).

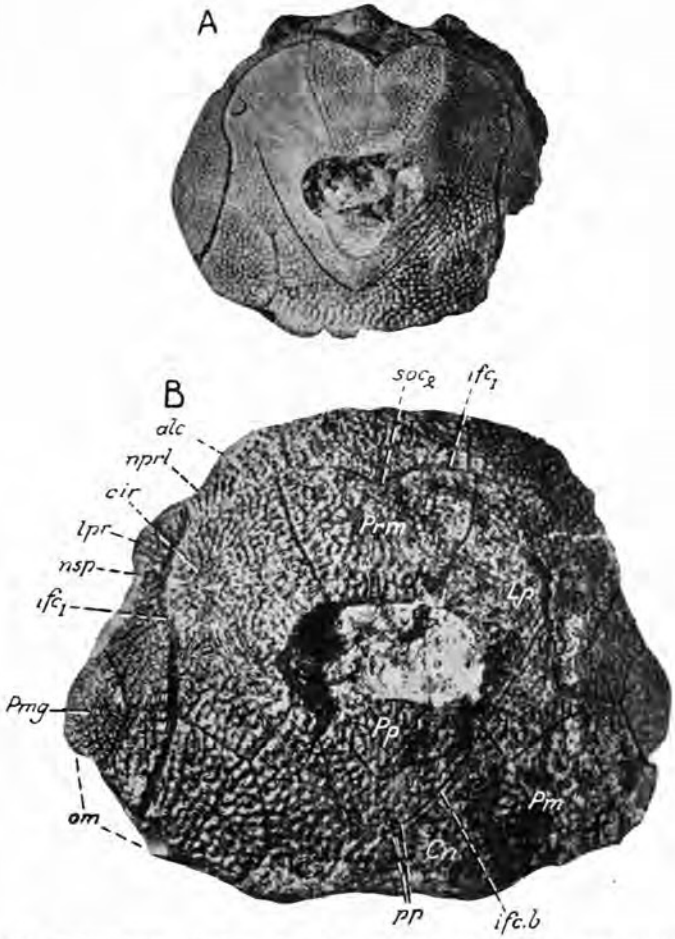
1933. *Bothriolepis panderi*, Gross (1933a), pp. 39–40, 70, text-fig. 21; pl. 4, figs. 6, 8, 16.
1941. *Bothriolepis panderi*, Gross (1941a), pp. 9, 10–12, 19, 20, 22, 32, 36, text-figs. 10B, C, 11F, G, H, 26H, J, K.
For full list of synonyms see Gross 1932b, p. 25 and 1933a, p. 39.

Diagnosis. – Species of a somewhat large size. Total dorsal length of armour (length of head-shield + dorsal lenth of head-armour) maximally at the least 23 cm. Dorsal length of trunk-armour maximally at least about 15–16 cm. Head-shield with a breadth : length ratio ranging between 130–147 and probably not particularly strongly arched in its preorbital division; its rostral margin clearly shorter than its posterior margin, somewhat convex and probably without a rostral angle; its lateral margins converging fairly strongly forwards and about as long as, or longer than, the centronuchal plate is broad across its lateral corners; its obstantic margins comparatively short, ending anteriorly at or somewhat behind a transverse plane through the posterior boundary of the orbital fenestra. Premedian plate pre-

sumably mostly devoid both of a nasal process and a nasal notch. Rostral plate broader than long, more precisely almost twice as broad as long. Pineal plate broad and short and pierced by a pineal foramen; its posterior margin somewhat concave. Anterior margin of postpineal plate slightly convex. Breadth : length ratio of centro-nuchal plate in medium-sized and somewhat large individuals presumably about 76–80. Lateral division of paranuchal-marginal plate often comparatively narrow. Postmarginal plate longer than broad, often reaching fairly far forward beyond the paranuchal-marginal plate. Trunk-armour with a somewhat elevated dorsal wall, meeting the lateral wall of either side of an angle of 110°–120°. Median most elevated part of dorsal wall not particularly strongly elevated. Height of lateral walls unknown. Tergal angle situated in foramost part of the middle third of the anterior median dorsal plate. The median dorsal part of the crista transversalis interna posterior situated on the posterior median dorsal plate at least somewhat clearly developed. Postlevator crest and ventral tuberosity present. Anterior median dorsal plate variable in shape and in medium-sized individuals with a breadth:length ratio of 82–93. Posterior median dorsal plate broad anteriorly, but, increasing only pretty slightly in breadth backwards, it is of a somewhat uniform width throughout its length. This plate presumably as a rule also narrower than long, its breadth:length ratio in large individuals amounting only to about 85–89; posterior corner of the plate fairly pronounced. Dorsal lamina of anterior dorso-lateral plate conceivably somewhat more than twice as long as broad. Proximal segment of pectoral fin comparatively long and slender, in large specimens conceivably between four and five times longer than broad. Medial spines of the dorsal central plate 1 pointing almost straight medially. Ornament on head-shield and on dorsal side of trunk-armour of a somewhat uniform coarseness; in small individuals reticular and with tubercular thickenings and elevations at the points of union of the ridges; in medium-sized and large individuals to a large extent subdivided on the head-shield and on the dorsal side of the trunk-armour into tubercles and short vermiculating ridges with no or comparatively few anastomoses. Ornament of medium-sized and large individuals thus chiefly tubercular on the head-shield and upper parts of the trunk-armour. Tubercles sometimes with stellate bases.

Material. – *B. panderi* seems to be fairly common, but despite that only a scanty material has been described hitherto. Contributions to our knowledge of this species have been given by Lahusen (1880) and Trautschold (1880), and in more recent years by Obrutschew (1927) and Jaekel (1927, pp. 869, 932, text-figs. 21, 60), but above all by Gross (1932b, pp. 24–25; 1933a, pp. 39–40, text-fig. 21 and pl. 4, figs. 6, 8, 16; 1941a, pp. 9, 10–12, 19, 20, 22, 32, 36, text-figs. 10B, C, 11F, G, K, 26H, J, K).

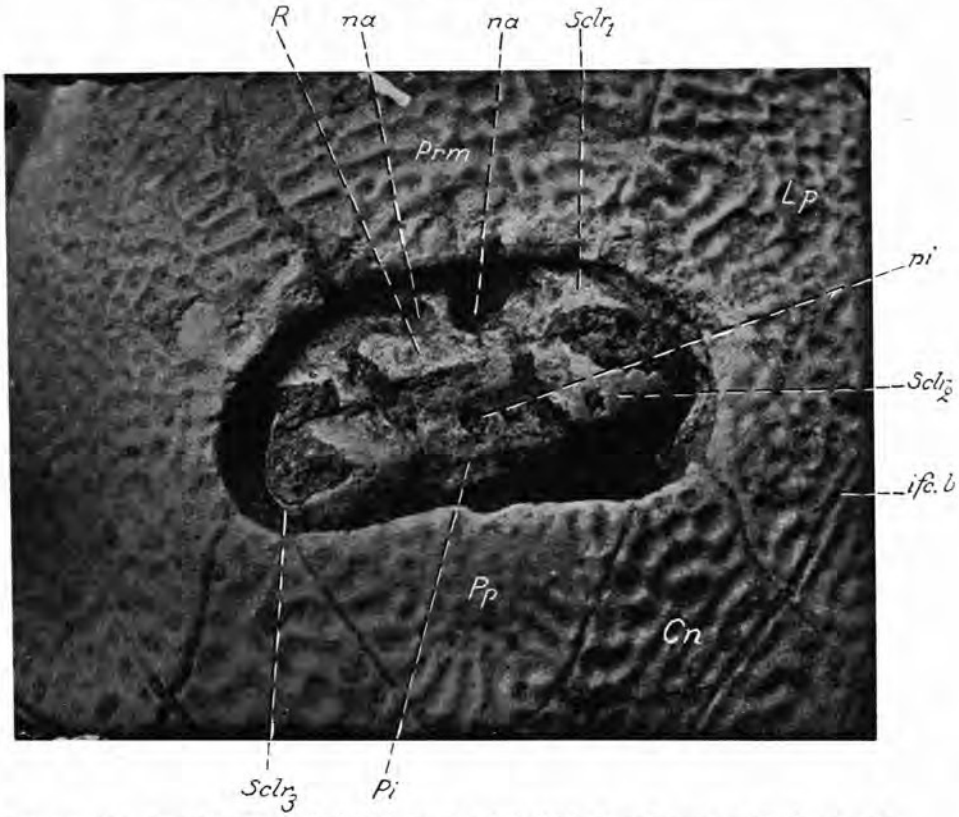
The lectotype of the species (Gross 1932b, p. 24) is the most complete one among the specimens figured by Lahusen (1880, pl. 1, fig. 1).



Text-fig. 229. *Bothriolepis panderi*. *A*, *B*, two head-shields in dorsal aspect. Museum Breslau. From Gross 1933a. Nat. size.
Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *om*, obstantic margin; *pp*, posterior pit-line groove of skull-roof; soc_2, anterior median section of supraorbital sensory canal groove (the anterior median pit-line).

Description. – Judging from the measurements given by Gross (1933a, p. 40), *B. panderi* must be assumed to have attained a somewhat larger size than *B. canadensis*. The maximal dorsal length of its armour (length of head-shield + dorsal length of trunk-armour) must have amounted at least to about 23 cm. The dorsal length of the trunk-armour must maximally have been at least about 15–16 cm.

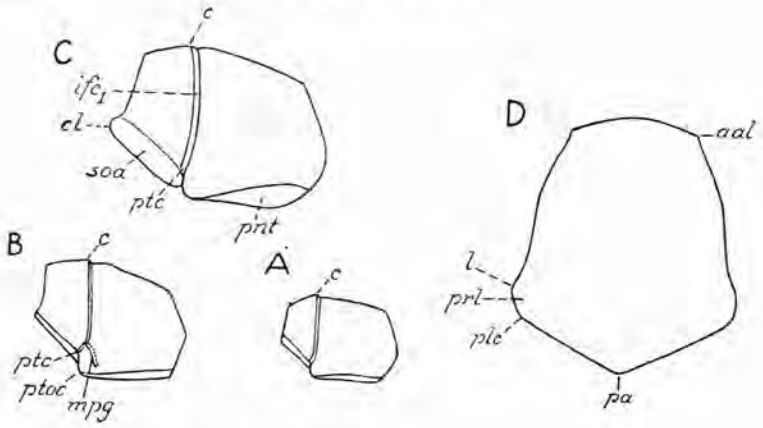
As to its relative breadth and length the head-shield (text-fig. 229) seems to have been about as in *B. canadensis* and *B. cellulosa*, the breadth :



Text-fig. 230. *Bothriolepis panderi*. Part of a head-shield in dorsal aspect with the rostral, pineal and sclerotic plates in a somewhat undisturbed position in the orbital chamber. From Obrutschew 1927. × 3.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pi*, pineal plate; *Pp*, postpineal plate; *R*, rostral plate; $Sclr_1$, anterior sclerotic plate; $Sclr_2$ postero-dorsal sclerotic plate; $Sclr_3$, postero-ventral sclerotic plate; *ifc. b*, posterior oblique cephalic pit-line groove; *na*, nasal notch and aperture; *pi*, pineal foramen.

length ratio in the shields measured by Gross (1933a, p. 40) being 130 and 147 respectively. Judging at least from the few specimens figured so far (text-fig. 229; cf. Lahusen 1880, pl. 2, fig. 2a), the preorbital division was probably comparatively flat, about as flat as in *B. cellulosa, B. maxima, B. gigantea* and *B. groenlandica*. With regard to its general characters otherwise it may be mentioned that the shield seems to narrow fairly much forwards in front of the postero-lateral (preobstantic) corners. It is therefore likely that often or generally it was relatively somewhat narrower than normally in *B. canadensis, B. cellulosa,* and several other species. The rostral margin is considerably shorter than the posterior margin and seems to be fairly slightly convex. At least as far as may be seen from the reproductions, the rostral margin of the head-shield it is devoid of a rostral angle. The lateral margin of the head-shield is almost as long as, or longer than, the distance across the lateral corners of the centro-nuchal plate. The obstantic margin



Text-fig. 231. *Bothriolepis panderi*. *A-C*, restorations of three left paranuchal-margina plates in dorsal aspect. Nat. size. *D*, outlines of a posterior median dorsal plate × 1/2. All restorations from Gross 1941a.
aal, antero-lateral corner of anterior median dorsal plate; *c*, anterior corner of paranuchal-marginal plate; *cl*, lateral corner of paranuchal-marginal plate; *ifc*$_1$, upper infraorbital sensory canal groove; *l*, lateral corner of posterior median dossal plate; *mpg*, middle pit-line groove of skull-roof; *pa*, posterior corner or angle of posterior median dorsal plate; *plc*, postero-lateral corner of posterior median dorsal plate; *pnt*, paranuchal trochlea; *prl*, lateral process of posterior median dorsal plate; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area.

of the head-shield is not particularly long, ending anteriorly at, or somewhat behind, a transverse plane through the posterior boundary of the orbital fenestra. The posterior margin of the head-shield in the material described so far is so deficient that its development cannot be ascertained.

The premedian plate (*Prm*, text-figs. 229, 230; Gross 1933a, pl. 4, fig. 8) seems to be of much the same general type as in *B. canadensis* or *B. cellulosa*. In all the three cases in which it is completely known it narrows suddenly immediately in front of the upper infraorbital sensory canal groove (*ifc*$_1$), so that at this place it presents a well-marked nick. In all these three cases it seems to be devoid of a nasal process and a nasal notch. The rostral plate (*R*, text-figs. 21 D, 230) is much broader and shorter than in *B. canadensis*. Its breadth across the postnasal division is almost twice its length, and its nasal notch is deep and short. The pineal plate (*Pi*, text-figs. 23 H, 230) is symmetric, broader than long, and regular in outline. Contrary to what is the case in most other species it is pierced by a pineal opening (*pi*). Its posterior margin is practically straight. The lateral plate (*Lp*, text-fig. 229) does not seem to present any special characters. The postpineal plate (*Pp*, text-figs. 229, 230) has a slightly convex anterior (orbital) margin. In some cases this plate is of much the same shape as in *B. canadensis* and *B. cellulosa*, in other cases it is narrower and more pointed posteriorly. The centro-nuchal plate (*Cn*, text-figs. 26 D, 229, 230) is deficient posteriorly, and because of this its relative proportions cannot be calculated with full certainty. It is very likely, however, that in medium-sized and somewhat

large individuals its breadth : length ratio was about 76–80. In the two head-shields here reproduced from Gross the plate is clearly broader across the postero-lateral corners than across the lateral ones. The anterior division of its lateral margin is shorter than the posterior division of the same margin (cf. Jaekel 1927, text-figs. 21, 60). As in *B. cellulosa,* the posterior division is as a whole directed a little anteriorly. The deepest concavity of this division is somewhat behind the middle. The paranuchal-marginal plate (*Pm*, text-fig. 28C, 231A–C) in essentials is as in most other species. The lateral division is often, however, comparatively narrow, its breadth amounting only to about one half or less (about 42–53%) of the breadth of the medial division. The postmarginal plate (*Pmg*, text-fig. 229) is lozenge-shaped and longer than broad. It extends much further forwards in front of the paranuchal-marginal plate than what is otherwise mostly the case in the *Bothriolepis*-species; and on account of this the suture between it and the lateral plate has a much more rostro-caudal course than for instance in such species as *B. canadensis, B. cellulosa, B. maxima, B. alvesiensis* and *B. groenlandica.*

The three sclerotic plates ($Sclr_1$, $Sclr_2$, $Sclr_3$, text-fig. 230) in most respects are much as in *B. canadensis* (cf. pp. 83–85 above and text-fig. 30).

As is seen from the reproduction given of it by Lahusen (1880, pl. 1, fig. 1), the trunk-armour is broad and at least in its anterior parts of a normal *Bothriolepis*-shape. According to a statement by Obrutschew (1939, p. 115), the dorsal wall meets the lateral walls at an angle of 110–120°. This must involve, of course, that the dorsal wall was higher than in *B. canadensis* (text-figs. 38, 40), about equally high as in *B. alvesiensis,* but lower than in *B. maxima, B. gigantea,* and *B. groenlandica* (text-figs. 243H, J, 283D, 287B).

The tergal angle (*dma*, text-figs. 43D, 44B) lies on the foremost part of the middle division, or at the transition between the anterior and middle thirds, of the anterior median dorsal plate. The dorsal median ridge is probably rather weakly developed in medium-sized and large individuals (Lahusen 1880, pl. 1, fig. 1; pl. 2, figs. 3, 4).

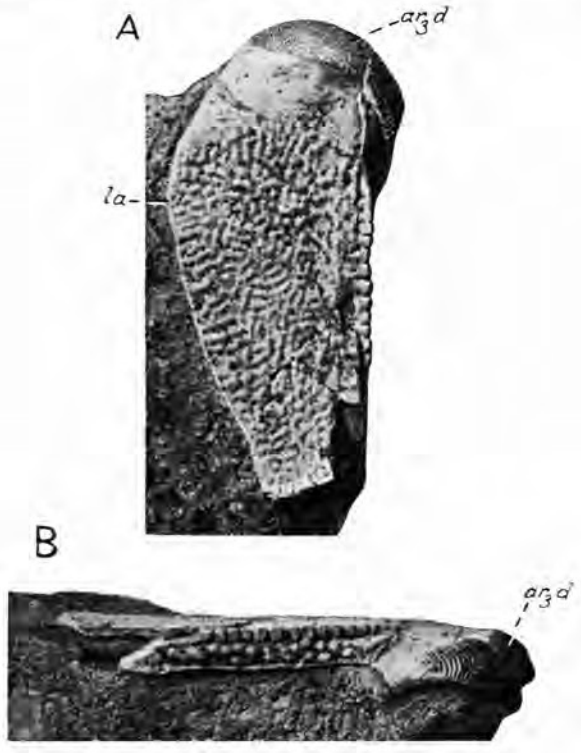
The structures on the ventral side of the dorsal wall of the trunk-armour are still imperfectly known, but seem on the whole, as far as may be seen, to have been about as in *B. canadensis.* In contradistinction to what is the case in *B. cellulosa* the ventral tuberosity (*tb*, text-fig. 47B) is present and well developed.

The anterior median dorsal plate (text-figs. 43D, 44B; cf. Lahusen 1880, pl. 2, fig. 3) is known so far only from three medium-sized individuals, where its breadth : length ratio is 82, 91 and about 93 respectively. As to relative breadth and length this plate seems thus to be approximately as in *B. canadensis.* The anterior margin is more or less convex. The lateral margin shows no characters of any special importance. The posterior median

process (*pr. p*) is broad, short, and much rounded off. The posterior median dorsal plate (text-figs. 47B, 231D) is broad anteriorly, but as it does not widen so very much posteriorly, it is of a somewhat uniform width throughout its extent, and hence in this respect it is somewhat suggestive of the corresponding plate in *Grossilepis tuberculata* (text-fig. 269). The two specimens of the plate nearer known so far (Gross 1941a, text-fig. 11G, H; reproduced here in text-figs. 47B and 231A), which are from large individuals, are narrower than long, their breadth : length ratio amounting only to 85 and 89 respectively. This condition probably involves (cf. pp. 211–214 above) that the plate was narrower than long in all stages of growth, and thus that it was of a narrower type than normally in most other *Bothriolepis*-species. Its anterior margin may be produced into an anterior corner (*aa*), but may also be completely without such a corner. The lateral process (*prl*) is comparatively short and the posterior corner or angle (*pa*) is well pronounced. Judging from the figure of the holotype given by Lahusen (1880, pl. 1, fig. 1), the dorsal lamina of the anterior dorso-lateral plate is probably somewhat more than twice as long as broad. The ventral lamina of the anterior ventro-lateral plate (Trautschold 1880, pl. 2, fig. 1) is about twice as long as broad and in shape reminds nearest of the corresponding plate in *B. cellulosa* (cf. Gross 1941a, text-fig. 14). The processus brachialis (Trautschold 1880, pl. 2, fig. 2) does not seem to differ in any essentials from the one in *B. canadensis* (cf. text-figs. 51A, 164C, 165F, 166E). The semilunar plate and the median ventral plate are unknown, but, judging from the development of the ventral lamina of the anterior ventro-lateral plate (Trautschold 1880, pl. 2, fig. 1), they must have been as in the majority of the *Bothriolepis*-species. The median ventral plate was thus of about the same relative size as in *B. canadensis*.

Of the pectoral fin-armour we know only the proximal segment. According to measurements taken by Gross (1933a, p. 40), this segment in large individuals would be about five and a third times as long as broad, but in a restoration of a large segment given by Gross (1933a, text-fig. 21) it is only about four times as long as broad. The two proximal segments of somewhat large individuals figured by Lahusen (1880, pl. 1, figs. 4, 5) seem to be nearly five times as long as broad. Judging from these conditions, it is likely that the segment in large individuals was about five times as long as broad, and that thus probably it was of type a decidedly longer and slenderer than that in *B. canadensis* and *B. cellulosa*. The proximal ones of the medial spines of the segment are fairly numerous, short and obtuse (text-fig. 232). In contradistinction to what is the case in *B. canadensis, B. cellulosa* and certain other species these spines are not directed dorsally but point almost straightly medially.

The dorsal central plate 1 (text-fig. 232) in large individuals is about two and a half times or somewhat more than two and a half times as



Text-fig. 232. *Bothriolepis panderi*. Deficient left dorsal central plate 1. *A*, in dorsal, and *B*, in medial aspect. R. M. specimen No. P. 3387. River Sjass, Russia. × $^3/_2$.
ar_3d, external articular area; *la*, lateral angle or corner (marking the anterior extent of the lateral marginal plate 2).

long as broad. The medial spines belonging to the plate seem to be more numerous than in *B. canadensis* and *B. cellulosa*. As already pointed out, these spines all point medially, not dorsally, or mainly dorsally, as they do in *B. canadensis* and *B. cellulosa*. As in the last-mentioned species the dorsal central plate 2 (Lahusen 1880, pl. 1, fig. 4) is fairly long; still in large individuals it seems to have been nearly three times longer than broad.

The ornament during the growth of the individuals has obviously undergone modifications corresponding to those in *B. canadensis* (cf. pp. 169–171 above). In certain cases (text-fig. 230) it may retain much of its immature fine-meshed reticular character. In other cases (text-fig. 229), at least on the head-shield and dorsal parts of the trunk-armour (cf. Lahusen 1880, pl. 1, fig. 2), it is to a large extent subdivided into tubercles and short vermiculating ridges. Normally in larger individuals it is, therefore, decidedly tubercular both on the head-shield and on the dorsal parts of the trunk-armour. On the ventral parts of the trunk-armour and on the pectoral fins, on the other hand, it seems generally to have retained its immature characters fairly unchanged. It varies in coarseness in different individuals, but seems

usually to be of almost the same coarseness on the head-shield as on the dorsal parts of the trunk-armour. The tubercles sometimes are clearly stellate at their bases. Finally, it may be mentioned here that in many cases the ornament of the head-shield and dorsal parts of the trunk-armour is decidedly more modified than in *B. canadensis*.

The upper infraorbital sensory canal groove ($if c_1$) may pass close to the rostral and lateral margins of the head-shield (text-fig. 229). The anterior median section (soc_2) of the supraorbital sensory canal grooves is said by Gross (1933a, p. 40) often to be interrupted. According to Gross (1933a, p. 40), the posterior pit-line groove (*pp*) of the skull-roof does not anastomose with that of the opposite side medially.

Remarks. – Although it resembles *B. canadensis* and *B. cellulosa* in certain respects, *B. panderi* is clearly an independent species. As far as our knowledge of it goes, its most distinctive characters are as follows. The shape and porportions of the rostral plate; the shape of the pineal plate and the condition that this plate is perforated by a pineal foramen; the shape and forward extent of the postmarginal plate; the shape of the posterior median dorsal plate and the fact that this plate is narrower than long even in large individuals; the fairly slender shape of the proximal segment of the pectoral fin; and, finally, the often strongly tubercular character of the ornament in medium-sized and large individuals.

Localities and geological horizon. – Sections along the river Sjass in NW Russia; along the river Peddetz, at Braunbergshof and at Jurenski, and at Gemauert-Ponieman, and at other localities in Latvia (Gross 1933a, p. 40). The deposists from which it comes belong to the uppermost part of the Lower Upper Devonian (cf. Jarvik 1937, pp. 120–121; Gross 1942a, p. 405).

9. **Bothriolepis maxima** Gross.

(Textfig. 24D, 26E, 49, 52, 233–246).

Von

Walter Gross, Berlin.

1932. *Bothriolepis maxima*, Gross (1932b), p. 25.
1933. *Bothriolepis maxima*, Gross (1933a), pp. 41–43, 70, Abb. 22, 23; Taf. 3, Fig. 2; Taf. 4, Fig. 3, 4; Taf. 5, Fig. 1, 7, 11, 14.
1934. *Bothriolepis maxima*, Gross, p. 416.
1940. *Bothriolepis maxima*, Gross (1940b), Abb. 14E.
1941. *Bothriolepis maxima*, Gross (1941a), p. 62, Abb. 44A–D; Taf. 29, Fig. 1–4.
1942. *Bothriolepis maxima*, Gross (1942a), p. 418, fig. 8.

Professor Dr. E. Stensiö bat mich, den nachfolgenden Abschnitt über *Bothriolepis maxima* zu verfassen, da mir hier in Berlin ein besonders grosses Material von dieser Art zur Verfügung steht, das auch eine Anzahl aus dem Stockholmer Naturhistorischen Reichsmuseum entliehener Stücke umfasst. Für die Entleihung dieser Stücke und die freundliche Aufforderung zur Ab-

fassung eines Beitrages zu seinem grossen Werk über die Bothriolepiden danke ich Herrn Professor Dr. E. Stensiö auch an dieser Stelle. Sehr wertvoll waren für meine Untersuchungen Skizen von dem wunderbaren Material des Rigaer Geologisches Institutes, die ich 1939 gemacht hatte. Für die liebenswürdige Erlaubnis, dieses Material zu untersuchen, und für die Entleihung mehrerer Stücke möchte ich auch Herrn Dozenten N. Delle, Riga, meinen herzlichen Dank aussprechen.

Definition. – *B. maxima* ist die grösste der bisher bekannten *Bothriolepis*-Arten. Die Dorsallänge des Gesamtpanzers (Schädellänge + dorsale Rumpfpanzerlänge) erreicht nicht selten 50 cm. Das Schädeldach ist breit und kurz; die Breite beträgt 140–150% der Länge. Das vor der Augenöffnung ziemlich flache Schädeldach hat einen Vorderrand, der nicht viel kürzer als der Hinterrand ist, da die Seitenränder ziemlich wenig zur Mitte zugeneigt sind. Der Vorderrand ist schwach vorgebogen, in der Mitte manchmal mit einem rundlichen Vorsprung versehen. Die an den Processus obstans des Rumpfpanzers grenzenden Ränder sind relativ kurz und enden recht weit hinter einer gedachten seitlichen Verlängerung des Hinterrandes der Orbitae. – Die Praemedianplatte hat in der Regel am Hinterrande sowohl einen Nasalvorsprung als auch Nasalbuchten; nitch selten ist sie etwas unsymmetrisch. Die oberen Infraorbitalkanäle (if_{c_1}) berühren einander fast in der Mittellinie, so dass die bogenförmige Grübchenlinie soc_2 so gut wie ganz unterdrückt wird. Die Platte wird von hinten her von einem weit nach vorne reichenden Recessus praeorbitalis ausgehöhlt. Die breite Lateralplatte besitzt ebenfalls einen tiefen, dreieckigen Recessus praeorbitalis. Die Postpinealplatte hat einen fast geraden Vorderrand, sie ist relativ lang und endet hinten zugespitzt. Die Centronuchalplatte ist ziemlich breit und kurz. Ihre Länge erreicht 67–72% der Breite. Die hintere Grübchenlinie *pp* ist bis zum Verschwinden reduziert; die äusseren Mündungen der Ductus endolymphatici sind sehr klein und liegen nahe neben einander. Die Supratemporallinie kann manchmal angedeutet sein. Die Innenseite der Platte wird durch eine ganz auffallend rauche supraoticale Verdickung und zwei breite und tiefe Trichtergruben hinter den inneren Mündungen der Ductus endolymphatici gekennzeichnet. Diese Trichtergruben variieren beträchtlich in der Grösse und im Umriss. – Die Lateralfläche der Paranuchal-Marginalplatte is relativ schmal. Die Postmarginalplatte ist länger als breit. Die Mentalplatte ist nich ganz zweimal so lang wie hoch; die Randzacken ihrer Zahnkomponente sind unausgeprägt.

Der Rumpfpanzer hat eine ziemlich hohe Dorsalwand und relativ niedrige, nicht konkav eingebogene Lateralwände. Die Wölbung der Dorsalwand ist sanft, nach den Seiten hin allmählich steiler werdend. Die Dorsolateralkanten sind vorne wenig ausgeprägt, gerundet, nach hinten zu sind sie deutlich ausgeprägt, aber ohne Leistenbesatz. Die Mediodorsalkante ist kaum angedeutet und trägt keine Leiste. Die Ventrolateralkanten sind ge-

rundet, ohne Skulpturleisten. Die Sinneskanäle sind normal entwickelt. Der von der Anteroventrolateralplatte gebildete Vorderrand des Ventralpanzers besitz keinen spitzen Vorsprung, sondern ist nur sanft vorgebogen. Von Processus brachialis zieht eine breite, furchenartige Mulde in der Lateralwand des subcephalen Teiles nach vorne. Die Anteromediodorsalplatte wird vorne von der Anterodorsolateralplatte überlagert; ihre Breite ist fast so gross wie ihre Länge. Ihre innere mediane Grube ist auffallend lang und reicht weit nach hinten. Die Postlevatorverdickung ist nur schwach entwickelt. Von dem Hinterende der kurzen medianen Ventralleiste breitet sich bis zum Hinterrande der Platte ein deutlich abgesetztes, rauhes, dreieckiges Feld aus, ähnlich der Levatorfossa am Vorderende der Platte. – Die Posteromediodorsalplatte is breit; ihre Breite beträgt an 105–108% der Länge. Ihre ventrale Mediangrube ist kurz und auffallend weit nach vorne geschoben, so dass sie sich meist in der Mitte der Platte befindet. Die Crista transversalis interna posterior ist gering entwickelt. Die Mixilateralplatte hat eine breite Dorsalwand und eine relativ schmale Lateralwand. Beide Wände schliessen einen Winkel von 90° ein. Die Anteroventrolateralplatte hat eine etwas mehr als zweimal so lange wie hohe Lateralwand; die Ventralwand ist $1^1/_2$–2 mal so lang wie breit. Hinter der hohen Crista postbranchialis liegt eine breite, deutlich entwickelte Crista transversalis interna anterior (Hinterast). Die Posteroventrolateralplatte hat eine sehr hohe Dorsalecke der Lateralwand; die Ventralwand ist etwas mehr als zweimal so lang wie breit. Die Medioventralplatte is relativ gross.

Die Brustflosse ist relativ lang und schmal; das Proximalglied ist bei grossen Individuen $4^1/_2$ mal so lang wie breit; das Distalglied ist schmal, sein Querschnitt ist rundlich, und es besitzt meist die Centralplatten 5 und die Marginalplatten 5 in mehr oder weniger ausgebildetem Zustand.

Die Skulptur dürfte bei jungen Individuen einfach netzartig gewesen sein, ohne betonte Tuberkeln. Bei ausgewachsenen Tieren bleibt die Skulptur netzartig; die Wälle sind meist nicht mit Tuberkeln besetzt und oft deutlich konzentrisch angeordnet. Die Skulptur des Schädeldaches ist relativ fein, vor der Supraorbitallinie oft tuberkulär, sonst auch radiär wallartig. Auf dem Rumpfpanzer findet sich eine tuberkuläre Skulptur nur am Vorderende und am Hinterende der Ventralwand. Besonders ausgeprägt ist die Skulptur ferner längs der dorsolateralen und der ventrolateralen Kante. Auf der Brustflosse ist die Skulptur weitgehend verschwunden; skulptiert sind nur die dorsale und die ventrale Centralplatte 1 und die Vorderhälfte der lateralen Marginalplatte 2. Kantentuberkeln sind vorhanden, aber nicht besonders entwickelt; am Distalglied ist ihre Reihe lückenhaft. – Die schräge hintere Grübchenlinie des Kopfes und die schräge Grübchenlinie des dorsalen Rumpfpanzers sind breit und flach.

Folgende Merkmale sind diagnostisch am wichtigsten: 1) Die absolute Grösse der Art. 2) Der Besitz eines tiefen Recessus praeorbitalis in der Prae-

medianplatte und der Lateralplatte. 3) Der Besitz zweier weiter und tiefer Trichtergruben auf der Innenseite der Centronuchalplatte unmittelbar hinter den inneren Mündungen der Ductus endolymphatici. 4) Die weitgehende Reduktion der vorderen medianen Grübchenlinie (soc_2) auf der Praemedianplatte. 5) Die grosse Länge der ventralen Mediangrube der Anteromediodorsalplatte. 6) Die Kürze und die bis zur Mitte des Knochens nach vorne gerückte Lage der hinteren ventralen Mediangrube auf der Posteromediodorsalplatte. 7) Der Besitz einer breiten Furche, die in der Lateralwand des subcephalen Ventralpanzers vom Processus brachialis nach vorne verläuft. 8) Die besondere Skulpturentwicklung.

Holotypus ist der im Geologisch-Paläontologischen Institut und Museum der Universität Berlin aufbewahrte Schädel eines nicht ganz ausgewachsenen Tieres, den Gross 1933 (1933a, Taf. 5, Fig. 14) abgebildet hat. Der mit der Nummer f 124 gekennzeichnete Schädel ist in den c_1-Schichten des unteren Oberdevons am Fluss Immul bei Hohenberg (Bauernhof Lankserde) in Kurland gefunden worden.

Material. – Das zur Untersuchung vorliegende Material ist recht umfangreich. Es gehört dem Geologisch-Paläontologischen Institut und Museum der Universität Berlin (G. I. Berlin), dem Naturhistorischen Reichsmuseum in Stockholm (R. M. Stockholm), dem Paläontologischen Institut der Universität Uppsala (P. I. Uppsala) und dem Geologischen Institut der Universität Riga (G. I. Riga). Das beste Material besitzt das Riagaer Geologische Institut, darunter einen gänzlich intakten Schädel, gänzlich intakte Glieder der Brustflosse und sämtliche grossen Platten des Rumpfpanzers in grösstenteils intaktem Zustande, von denen manche sogar von ein und demselben Individuum zu stammen scheinen. Leider stehen mir gegenwärtig von letzterem Material nur die in natürlicher Grösse angefertigten Skizzen der Rumpfplatten zur Verfügung, ferner einige entliehene Schädelknochen und Distalglieder. Von dem grossen intakten Schädel besitze ich nur die Masse.

Die Knochen von *B. maxima* finden sich meist unverdrückt, sie sind leider oft durch Auflösungserscheinungen in ihrer Spongiosa sehr zerbrechlich geworden. Die Knochen lassen sich nicht selten von beiden Seiten freilegen. – Auffallend ist die Konstanz in der Grösse der Knochen, die weit überwiegend von ganz alten und sehr grossen Individuen stammen. Die Längenmasse von Rumpf- und Schädelknochen schwanken oft nur um $^1/_2$–$1^1/_2$ cm. Knochen jugendlicher Individuen sind fast gar nicht gefunden worden. – Die Knochen sind hellgelb gefärbt und liegen in einem weichen, weisslichgelben Sandstein eingebettet, so dass sie sich gut präparieren lassen, so weit es ihre Zerbrechlichkeit gestattet. Die Bergung des zerbrechlichen Materials in bergfeuchtem Zustande erfordert viel Mühe und Vorsicht. – Susammenhängende Rumpfpanzer sind noch nicht gefunden worden.

Das in Berlin, Stockholm und Uppsala aufbewahrte Material ist von meinem Bruder R. Gross und von mir gesammelt worden; das sehr schöne

Material in Riga haben stud. geol. R. Kampe und Dozent N. Delle entdeckt und geborgen.

Beschreibung.

B. maxima ist die grösste der bisher bekannt gewordenen *Bothriolepis*-Arten. Die Gesamtlänge des Panzers muss längs der dorsalen Mittellinie meist 50 cm erreicht haben, wie die Masse folgender, keines wegs ausnahmsweise grosser Knochen zeigen: Länge des Schädels (G. I. Riga) = 13,5 cm; Länge der Anteromediodorsalplatte (P. 1028, Stockholm) = 22 cm; Länge der Posteromediodorsalplatte (P. 3142, Stockholm) = 17 cm. Das ergibt eine Gesamtlänge (bein angehobenem Schädel) von 52,5 cm. Davon müssen wir 1,5 cm, die auf den von der Anteromediodorsalplatte überlagerten Hinterrand des Centronuchale entfallen, und weitere 1,5 cm der Überlagerung zwischen Antero- und Posteromediodorsalplatte, abziehen, so dass wir zu einer Gesamtlänge des Dorsalpanzers von 49,5 cm gelangen. Da andere Schädel über 14 cm lang wurden, so sind 50–51 cm Gesamtlänge erreicht worden. – Die ventrale Mittellinie des Rumpfpanzers erreichte bei anderen Individuen 42,5–43,5 cm (Anteroventrolaterale: 21,5 cm; Posteroventrolaterale 22,5 cm). Rechnet man hierzu noch etwa 7 cm, die auf den vorragenden Schädel entfallen, so erhält man für diese Individuen eine ventrale Mittellinie des Panzers von 50,8 cm. Bei grösseren Individuen dürfte der Ventralpanzer eine Länge bis zu 54 cm erreicht haben, da auch bei *B. maxima* die ventrale Mittellinie des Panzers die dorsale etwas an Länge übertroffen haben muss. – Der erwähnte 13,5 cm lange Schädel ist 22 cm breit (ohne Extralateralplatten). Das längste Centronuchale (Textfig. 237A u. B) ist 7 cm lang und 8,5 bezw. 10,5 cm breit. – Die Mittelbreite des Dorsalpanzers erreichte 30 cm, die des Ventralpanzers 24 cm (Maximalbreite: 28 cm). Die Mittelhöhe des Rumpfpanzers betrug etwa 15,8 cm. Ein intaktes Proximalglied (Geolog. Institut, Riga) erreicht eine Länge von 23 cm, eine mittlere Breite von 5 cm und eine mittlere Dicke (= Breite der Medialwand) von 3,1 cm. Ein intaktes Distalglied ist 16,5 cm lang. Die Gesamtlänge der Brustflosse muss nach Abzug von 2 cm, die auf das im Proximalglied steckende Gelenk des Distalgliedes entfallen, 37 cm betragen haben. Auch diese Masse stellen keine Ausnahmemasse dar, wie die recht zahlreichen grossen dorsalen und ventralen Centralplatten 1 zeigen.

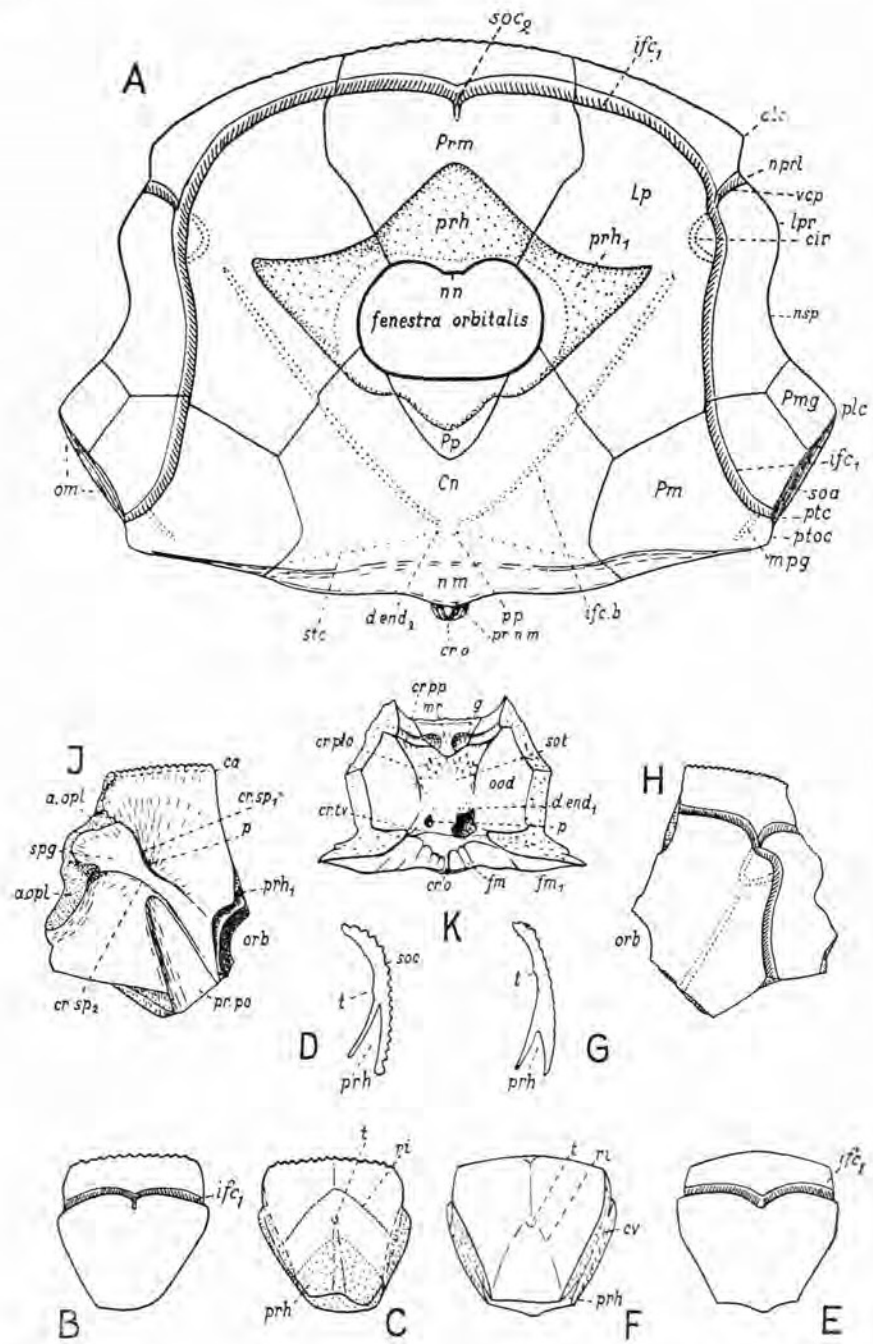
Nilsson (1941) errechnete die Maximallänge des Rumpfpanzers von *Asterolepis scabra*, der dorsal 46 cm und ventral 57 cm erreichen konnte, also noch grösser als bei *B. maxima* wurde. Da der Schädel von *A. scabra* relativ kurz war und steiler abfiel als bei *Bothriolepis*, dürfte die Gesamtlänge des Ventralpanzers + Kopf etwa 58–59 cm betragen haben. Auch die Maximalbreite des Ventralpanzers übertraf mit 33 cm die von *B. maxima* um 5 cm. Nilsson errechnet die Gesamtlänge dieses grössten Individuums von *A. scabra* mit 1,1 m. Legt man für *B. maxima* ein gleiches Verhältnis

der Länge des Panzers zu der des ungepanzerten Hinterleibes wie bei *B. canadensis* (vergl. Textfig. 38) zu Grunde, so dürfte *B. maxima* eine Gesamtlänge von 1,2 m erreicht haben.

Schädeldach.

Das Schädeldach (Textfig. 233A) ist wie bei den anderen Arten der Gattung viel breiter als lang; an zwei intakten Schädeln beträgt die Breite an 150% der Länge. Der Vorderrand ist nach unten gebogen, sonst ist aber der Schädel im praeorbitalen Abschnitt merklich flacher als der von *B. canadensis* (vergl. Textfig. 4, 40B, 114) oder von *B. panderi*. Nur ein Mittelstreifen der Praemedianplatte und der Centronuchalplatte mitsamt der Postpinealplatte ist relativ stärker gewölbt. Im Gegensatz zu *B. canadensis* (Textfig. 82–84), *B. cellulosa* (Textfig. 219), *B. panderi* (Textfig. 229) und anderen Arten verschmälert sich das Schädeldach vor den posterolateralen Ecken nur relativ wenig. Die Orbitalöffnung ist verhältnismässig schmal im Verhältnis zu ihrer eigenen Länge und zur Gesamtgrösse des Schädeldaches. Bei ganz grossen Schädeln wird das Missverhältnis besonders auffallend, da die Orbitalöffnung das allgemeine Wachstum kaum noch mitmacht. In dieser Beziehung erinnert *B. maxima* an *B. cellulosa* (Textfig. 219), *B. gigantea* (Textfig. 253A) und *B. groenlandica* (Textfig. 13, 273, 274). Der Vorderrand des Schädeldaches ist fast so lang oder nur wenig kürzer als der Hinterrand; er ist nur wenig konvex und hat manchmal eine nur von vorne sichtbare rundliche Medianecke (z. B am Holotypus). Der Lateralrand des Schädeldaches ist etwas kürzer als die Breite der Centronuchalplatte. Der supraspiraculare Processus liegt auf der Höhe der Hinterhälfte der Praemedianplatte. Der an den Processus obstans grenzende Rand ist kurz und ziemlich steil nach hinten gerichtet; er endet vorne ziemlich weit hinter dem Hinterrand der Augenöffnung. Die Area subobstantica (*soa*) ist breit. Der Hinterrand des Schädeldaches ist gekennzeichnet durch die geringe Entwicklung des hinteren medianen Fortsatzes (*pr. nm*). Die mediane Crista occipitalis (*cr. o*) ist oft stark entwickelt, in der Mittellinie tief gekerbt oder gespalten (Textfig. 236B) und ragt hinter dem Hinterrand der Platte hervor. Die dorsomediale Occipitalgrube (*fm*) ist bald grösser bald kleiner als die ventrolaterale Grube (fm_1). Beide Gruben sind flach, radial gefurcht und nur undeutlich begrenzt.

Die Sinneslinien weisen auch spezifische Merkmale auf. Stets treten die vordersten Teile der beiden oberen Infraorbitalkanäle (ifc_1) in der Mittellinie so dicht aneinander, dass die supraorbitale Grübchenlinie soc_2 praktisch unterdrückt wird. Die hintere Grübchenlinie des Kopfes (*pp*) ist ebenfalls fast gänzlich verschwunden, nur manchmal schwach angedeutet. Die schräge Grübchenlinie *ifc. b* ist meist flach und unausgeprägt. Spuren eines Supratemporalkanales (*stc*) sind an manchen Stücken angedeutet.



Text-fig. 233. *Bothriolepis maxima*. *A*, Rekonstruktion des Schädeldaches, Dorsalansicht. Der vom Recessus praeorbitalis eingenommene Raum durch Punktierung hervorgehoben. × 1/2. *B–D*, Praemedianplatte, R. M. Stockholm, P. 3145. *B*, Dorsalseite; *C*, Ventralseite; *D*, medianer Längsschnitt; *E–G*, Praemedianplatte, G. I. Riga. *E*, Dorsalseite; *F*, Ventralseite; *G*, medianer Längsschnitt. *I–H*, rechte Lateralplatte; G. I. Riga (vergl.

Die Innenseite des Schädeldaches hat als besonderes Merkmal zwei grosse und tiefe, oft unregelmässig gestaltete, aber stets scharf umgrenzte Gruben (*p*) hinter den Mündungen der Kanäle der Ductus endolymphatici (Textfig. 233K, 235I, 236B, 237B). Ferner ist der vorderste Teil der Centronuchalplatte zwischen der Postpinealplatte und der Crista postorbitalis (*cr. pto*) deutlich gegenüber der übrigen Platte vertieft und abgesetzt und bildet dadurch zusammen mit der Postpinealplatte eine gesonderte Region, die an den Seiten kontinuierlich in den Recessus praeorbitalis der Lateral platten übergeht (Textfig. 233K, 237B). Auffallend rauh skulptiert ist die supraoticale Verdickung (*sol*) des Centronuchale, während die Innenfläche der Praemedianplatte im Gegensatz zu *B. canadensis* (Textfig. 12, *ap*) glatt bleibt. – Das wichtigste Merkmal ist die starke Entwicklung des Recessus praeorbitalis (Textfig. 233A), der an Ausdehnung die Verhältnisse bei *B. groenlandica* (Textfig. 13) noch übertrifft.

Der grösste intakte Schädel (Geol. Institut Riga) ist in der Mittellinie 13,5 cm lang, zwischen den Ecken der Postmarginalplatten 22 cm breit, und seine Wölbungshöhe beträgt 4,3 cm. Die äussere Orbitalöffnung ist 5 cm breit, in der Mittellinie 2,4 cm, seitlich davon 2,9 cm lang. Der Holotypus, ein nicht ganz ausgewachsenes Individuum, hat einen etwa 11,4 cm langes Schädeldach, dessen Breite 16 cm beträgt. Die Orbitalöffnung ist 4 cm breit und 2,1 cm bezw. 2,4 cm lang. Beim Wachstum des Schädeldaches fällt die starke Breitenzunahme auf, während die Längenzunahme zurückbleibt; auch die Orbitalöffnung wird von der Grössenzunahme nur wenig erfasst.

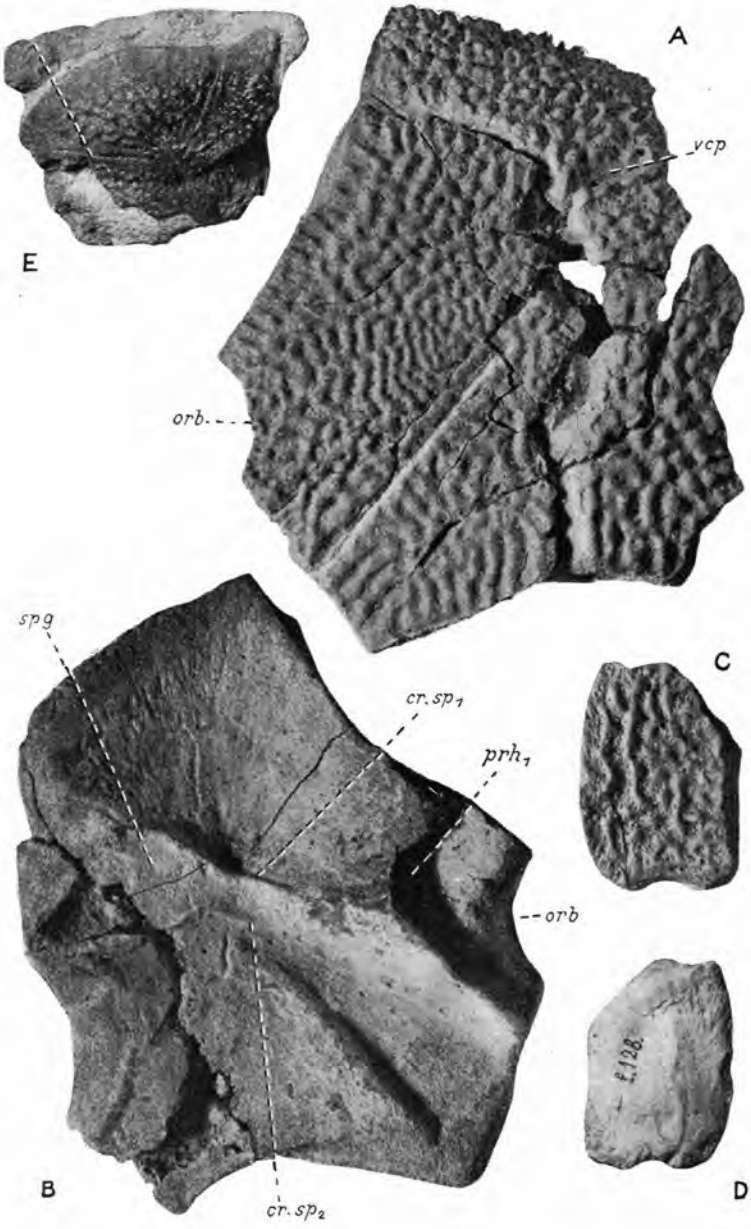
Die Praemedianplatte (*Prm*, Textfig. 233A–G, 235A) ist in den mei-

Text-fig. 234 A, B). *H*, Dorsalseite; *I*, Ventralseite; *K*, Centronucha lplatte und Post pinealplatte, Ventralseite; G. I. Riga (vergl. Text-fig. 237 B). Fig. *B–K*, × 1/3.
Cn, Centronuchalplatte; *Lp*, Lateralplatte; *Pm*, Paranuchal-Marginalplatte; *Pmg*, Postmarginalplatte; *Pp*, postpinealplatte; *Prm*, Praemedianplatte; *alc*, anterolaterale Ecke des Schädeldaches; *a. opl*, Gelenkfläche zur Verbindung mit der Extralateralplatte; *ca*, anteromediale Ecke der Lateralplatte; *cir*, halbkreisförmige Grübchenlinie; *cr. o*, mediane Occipitalcrista; *cr. pp*, postpineale Crista; *cr. pto*, postorbitale Crista; *cr. sp*$_1$, praespiraculäre Crista; *cr. sp*$_2$, postspiraculäre Crista; *cr. tv*, transversale Nuchalcrista; *d. end*$_1$, ventrale und *d. end*$_2$ dorsale Öffnung des Ductus endolymphaticus Kanals in der Centronuchalplatte; *fm*, *fm*$_1$, Insertionsflächen für Teile der Levatormuskel des Kopfes; *g*, Grube in der Postpinealplatte; *ifc*$_1$, obere infraorbitale Sinneslinie; *ifc. b*, hintere shräge Grübchenlinie des Kopfes; *lpr*, Processus supraspiracularis; *mpg*, mittlere Grübchenlinie des Schädeldaches; *mr*, mediane Leiste der Postpinealplatte; *nm*, vom Rumpfpanzer überlagerte Randfläche der Centronuchalplatte; *nn*, Nasalbucht; *nprl*, praelaterale Einbuchtung; *nsp*, supraspiraculäre Einbuchtung; *om*, an den Processus obstans grenzender Schädelrand; *ood*, otico-occipitale Depression; *orb*, Ausschnitt für die Augenhöhle; *p*, trichterförmige Gruben in der Centronuchalplatte, ferner Kanal in der Lateralplatte; *plc*, posterolaterale Ecke des Schädeldaches; *pp*, hintere Grübchenlinie des Kopfes; *prh*, medianer Abschnitt des Recessus praeorbitalis; *prh*$_1$, lateraler Abschnitt des Recessus praeorbitalis; *pr. nm*, hinterer Medianfortsatz der Centronuchalplatte; *pr. po*, anterolateraler Ausläufer der otico-occipitalen Depression der den postorbitalen Processus des Endocraniums aufnimmt; *ptc*, cephale Abteilung der Seitenlinie; *ptoc*, Hinterecke des Schädeldaches; *ri*, niedrige Leisten auf der Ventralseite der Praemedianplatte; *soa*, vom Processus obstans überlagerte Saumfläche; *sol*, supraoticale Verdickung; *spg*, Spiraculafurche; *stc*, supratemporale Grübchenlinie; *t*, medianer Tuberkel auf der Ventralseite der Praemedianplatte; *vcp*, vertikale Grübchenlinie der Wange.

sten Fällen etwas breiter als lang. Im Vergleich zu *B. canadensis* gehört sie einem breiten Typus an, denn selbst bei grossen Individuen von *B. canadensis* ist sie länger als breit. Am breitesten ist sie hinter der Sinneslinie (ifc_1), weiter nach hinten wird sie fast absatzartig schmaler. Ihr Hinterrand weist meistens einen Nasalfortsatz und Nasaleinbuchtungen auf (Textfig. 233A). Die beiden vordersten Teile der oberen Infraorbitallinien, ifc_1, treffen fast immer in der Mittellinie so dicht aufeinander, dass die vordere mediane Grübchenlinie, soc_2, praktisch unterdrückt wird. Die Innenseite der Platte besitzt einen kleinen Mittelhöcher (*t*), von dem zwei schmale und niedrige Leisten (*ri*) schräg nach den Seiten und hinten ziehen. Vom Mittelhöcker nach vorn erstreckt sich ebenfalls eine schwach angedeutete Leiste. Die Hinterhälfte der Platte ist tief dreieckig ausgehöhlt durch den Recessus praeorbitalis (*prh*). Die Dorsalwand des Recessus praeorbitalis ist viel dicker als die Ventralwand (vergl. Textfig. 233D u. G). Die angrenzenden Lateralplatten werden von der Praemedianplatte schräg überlagert.

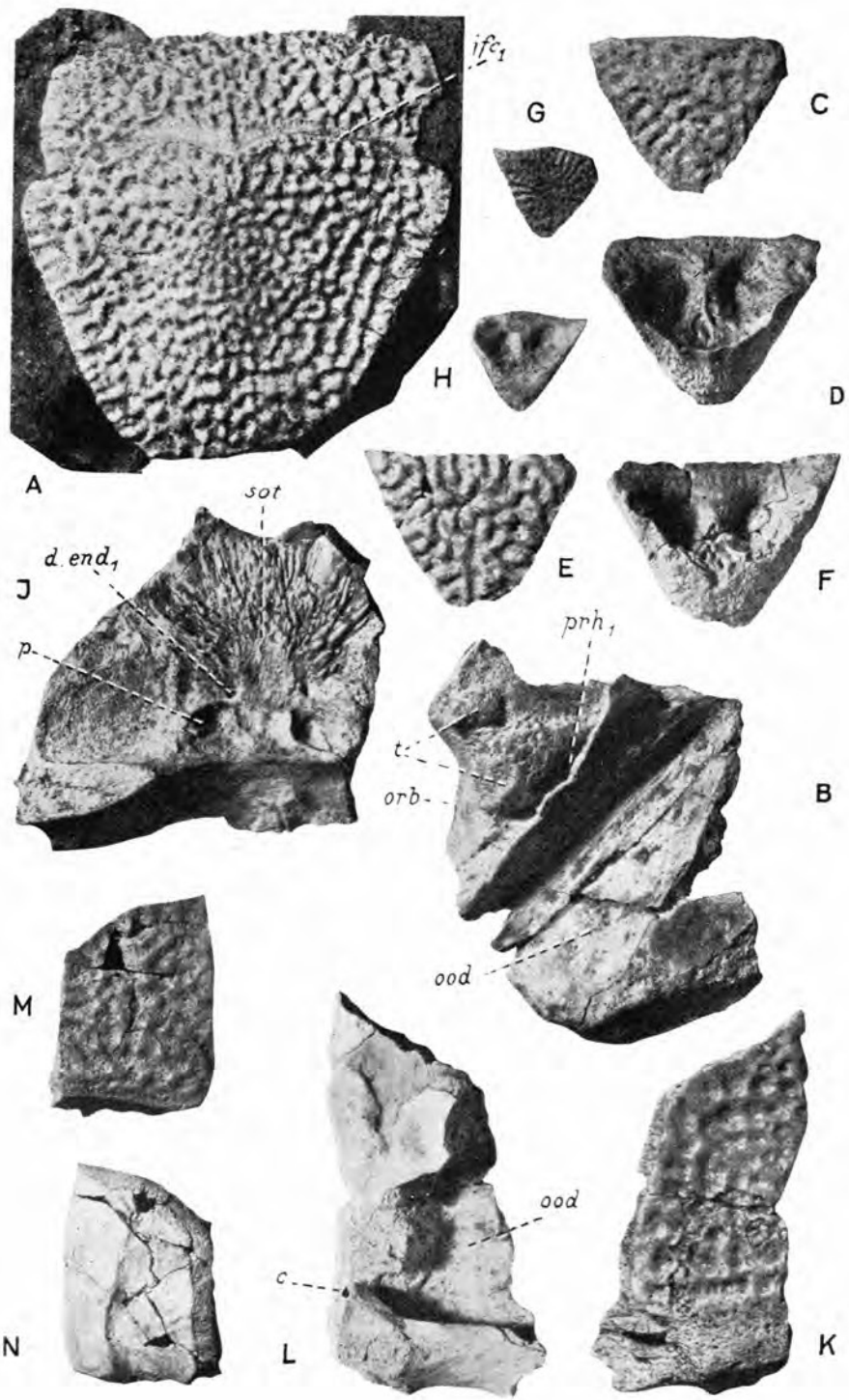
Die Lateralplatte (*Lp*, Textfig. 24D, 233A, H, I; 234A u. B) hat bei den grössten Individuen einen relativ kurzen Orbitalausschnitt (*orb*), der beispielsweise an dem in der Textfigur 234A wiedergegebenen Stück nicht länger ist als an den beträchtlich kleineren Lateralplatten des Holotypus (Gross 1933, Taf. 5, Fig. 14). Recht variabel sind der Verlauf der verticalen Grübchenlinie der Wange (*vcp*) und die Gestalt des Lateralrandes. Die Innenseite zeigt sehr deutlich die von der praespiraculären und der postspiraculären Crista (*cr.* sp_1 u. *cr.* sp_2) begrenzte Spiracularfurche (*spg*). Eine praespiraculäre Grube (Textfig. 233I, *p*) mit einem oder zwei engen, in den Knochen führenden Kanälen ist vorhanden. Ein seitlicher Recessus praeorbitalis (prh_1) schiebt sich tief in den Knochen und endet gleich weit von der Orbita wie die Oticooccipital-Depression. Seine Ventralwand ist dünn (vergl. Textfig. 235B), seine Dorsalwand ist dick. Die Dorsalwand ist neben dem Orbitalrand manchmal wulstartig verdickt (Textfig. 235B, *t*), so dass hier das Lumen des Recessus medial eingeengt wird. Die Ventralwand des Recessus ist etwas kürzer als die Dorsalwand (in der Textfig. 233A durch die Punktschraffur angedeutet), so dass längs der inneren Orbitalöffnung der Recessus von innen zu sehen ist (Textfig. 233I, 234B). Der Recessus geht hinten und medial längs der Crista postorbitalis (*cr. pto*) kontinuierlich in die Vertiefungen über, die von den äussersten Vorderenden der Centronuchalplatte und der Postpinealplatte gebildet werden, und recht scharf begrenzt sind gegenüber der einheitlichen Innenfläche des Centronuchale (Textfig. 233K, 236B u. 237B). – Die otico-occipitale Depression ist ziemlich flach. Die mit der Extralateralplatte artikulierende Fläche des Seitenrandes wird von der Spiracularfurche in zwei fast getrennte Abschnitte geteilt.

Die Postpinealplatte (*Pp*; Textfig. 233A, 235C–H, 236A, B, 237A u. B; ferner Textfig. 26E) ist verhältnismässig lang; die Länge erreicht etwa 76% der Breite. Schon bei jugendlichen Individuen findet sich dieses Ver-



Textfig. 234. *Bothriolepis maxima*. Alle Figuren etwas verkleinert. *A*, rechtes Laterale, Dorsalseite; G. I. Riga. *B*, rechtes Laterale, Ventralseite; G. I. Riga. *C*. u. *D*, Linkes Postmarginale; G. I. Berlin, f. 128. *C*, Dorsalseite; *D*, Ventralseite; *E*, rechte Mentalplatte; G. I. Riga.

cr. sp$_1$, Crista praespiracularis; *cr. sp*$_2$, Crista postspiracularis; *ifc*$_2$, untere infraorbitale Sinneslinie; *orb*, Ausschnitt für die Augenhöhle; *prh*$_1$, lateraler Abschnitt des Recessus praeorbitalis; *spg*, Spiracularfurche; *vcp*, vertikale Grübchenlinie der Wange.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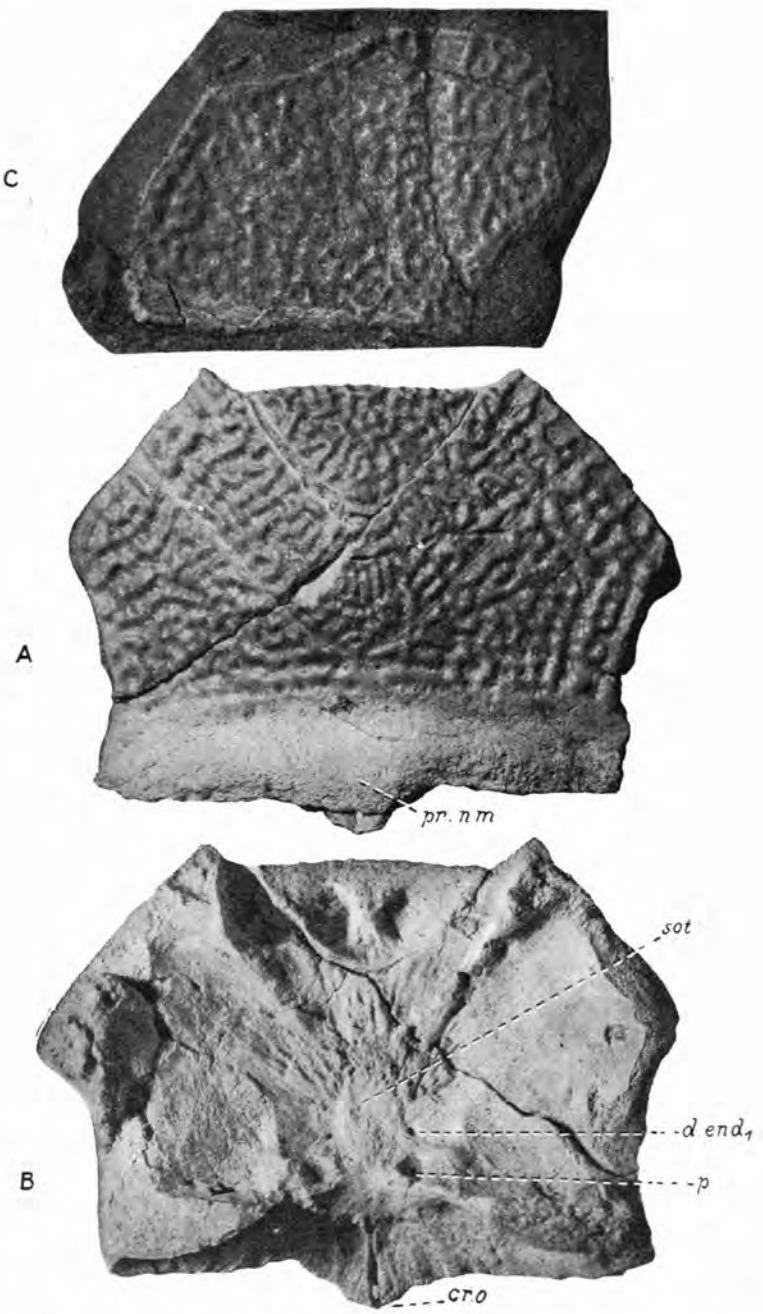
hältnis (Textfig. 235G u. H). Der Vorderrand ist meistens gerade, selten schwach vorgebogen. Das Hinterende ist spitzer als bei den meisten Arten der Gattung.

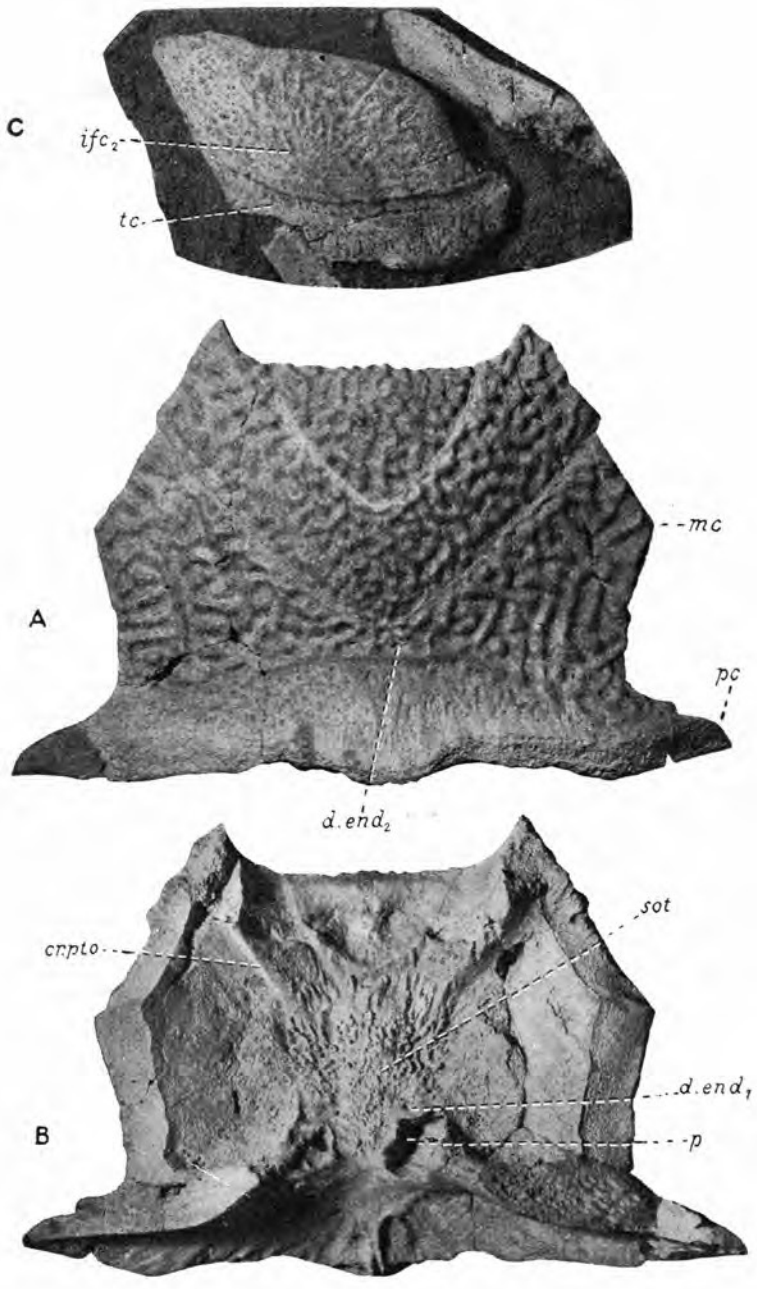
Die Centronuchalplatte (*Cn*; Textfig. 233A, K, 235I, 236A u. B, 237A u. B; ferner Textfig. 26E) ist relativ kurz und breit, die Länge erreicht etwa 67–73% der Breite. Dieses Verhältnis entspricht dem bei jugendlichen Individuen von *B. canadensis*. Ihre grösste Breite erreicht die Platte entweder zwischen den Seitenecken (*mc*; Textfig. 236A) oder zwischen den Posterolateralecken (*pc*; Textfig. 237A). Der Ausschnitt für die Postpinealplatte ist tief und hinten schmal. Der vordere Abschnitt des Seitenrandes ist meist länger als der hintere Abschnitt, dessen tiefste Einbuchtung etwas hinter der Mitte liegt. Der von der Anteromediodorsalplatte überlagerte Hinterrand ist breit und nach vorne gebogen. Manchmal wird er durch eine seichte Furche von der skulptierten Fläche geschieden. Ein Medianfortsatz (*pr. nm*) ist meist entwickelt. Die äusseren Öffnungen der Ductus endolymphatici (*d. end*$_2$) sind sehr eng und liegen nahe bei einander. Die schräge Grübchenlinie des Kopfes (*ifc. b*) ist seicht und wenig ausgeprägt; die hintere Grübchenlinie (*pp*) ist meist nicht zu erkennen; nur selten findet man sie als eben noch sichtbare, sehr kurze Linie (Textfig. 236A). Eine supratemporale Grübchenlinie (*stc*) ist manchmal angedeutet, so an dem von Gross 1933 (1933a) auf Taf. 4, Fig. 3 abgebildeten Centronuchale. Auf der Innenseite der Platte weist die supraoticale Verdickung (*sot*) sehr kräftige, nach vorne gerichtete Skulpturen auf. Die seitlich von der Postpinealplatte und vor der Crista postorbitalis (*cr. pto*) liegenden Spitzen der Centronuchalplatte (Textfig. 233K, 236B u. 237B) sind gegenüber der übrigen Platte deutlich abgesetzt und bilden zusammen mit der Postpinealplatte eine Vertiefung, die seitlich in den Recessus praeorbitalis der Lateralplatte übergeht (Textfig. 233A). Die ventralen Mündungen der Ductus endolymphatici (*d. end*$_1$) liegen weiter auseinander als die dorsalen Mündungen, aber auch sie sind auffallend eng. Hinter ihnen und unmittelbar vor der transversalen Nuchalcrista (*cr. tv*) liegen zwei breite und tiefe Gruben (*p*), anscheinend ein spezifisches Merkmal von *B. maxima* (Textfig. 233K, 235I, 236B, 237B).

Textfig. 235. *Bothriolepis maxima*. Alle Figuren in natürlicher Grösse. *A*, Praemedianplatte, Dorsalseite; R. M. Stockholm, P. 3145. *B*, hintere Hälfte der linken Lateralplatte mit aufgebrochenem Recessus praeorbitalis, Ventralseite; G. I. Berlin, f. 397. *C–D*, Dorsal- und Ventralseite einer Postpinealplatte; G. I. Berlin, f. 398. *E–F*, Dorsal- und Ventralseite einer Postpinealplatte; G. I. Berlin, f 400. *G–H*, Dorsal- und Vent alseite einer jugendlichen Postpinealplatte; G. I. Berlin, f 407. *I*, Bruchstück einer Centronuchalplatte, die die inneren Mündungen der Kanäle der Ductus endolymphatici und die Trichtergruben zeigt; G. I. Berlin, f 125. *K* und *L*, mediale Hälfte einer sehr grossen rechten Paranuchal-Marginalplatte, Dorsal- und Ventralseite; G. I. Berlin, f 402. *M* und *N*, Postmarginalplatte, Dorsal- und Ventralseite; G. I. Riga.

c, kanalartiger Ausläufer der otico-occipitalen Depression; *ifc*$_1$, obere Infraorbitalkanal; *ood*, otico-occipitale Depression; *orb*, Ausschnitt für die Augenhöhle; *p*, Trichtergrube zwischen Ductus endolymphaticus Kanal und transversaler Nuchalcrista; *prh*$_1$, aufgebrochene Höhle des lateralen Recessus praeorbitalis; *sot*, supraoticale Verdickung; *t*, Knochenanschwellungen im lateralen Recessus praeorbitalis.

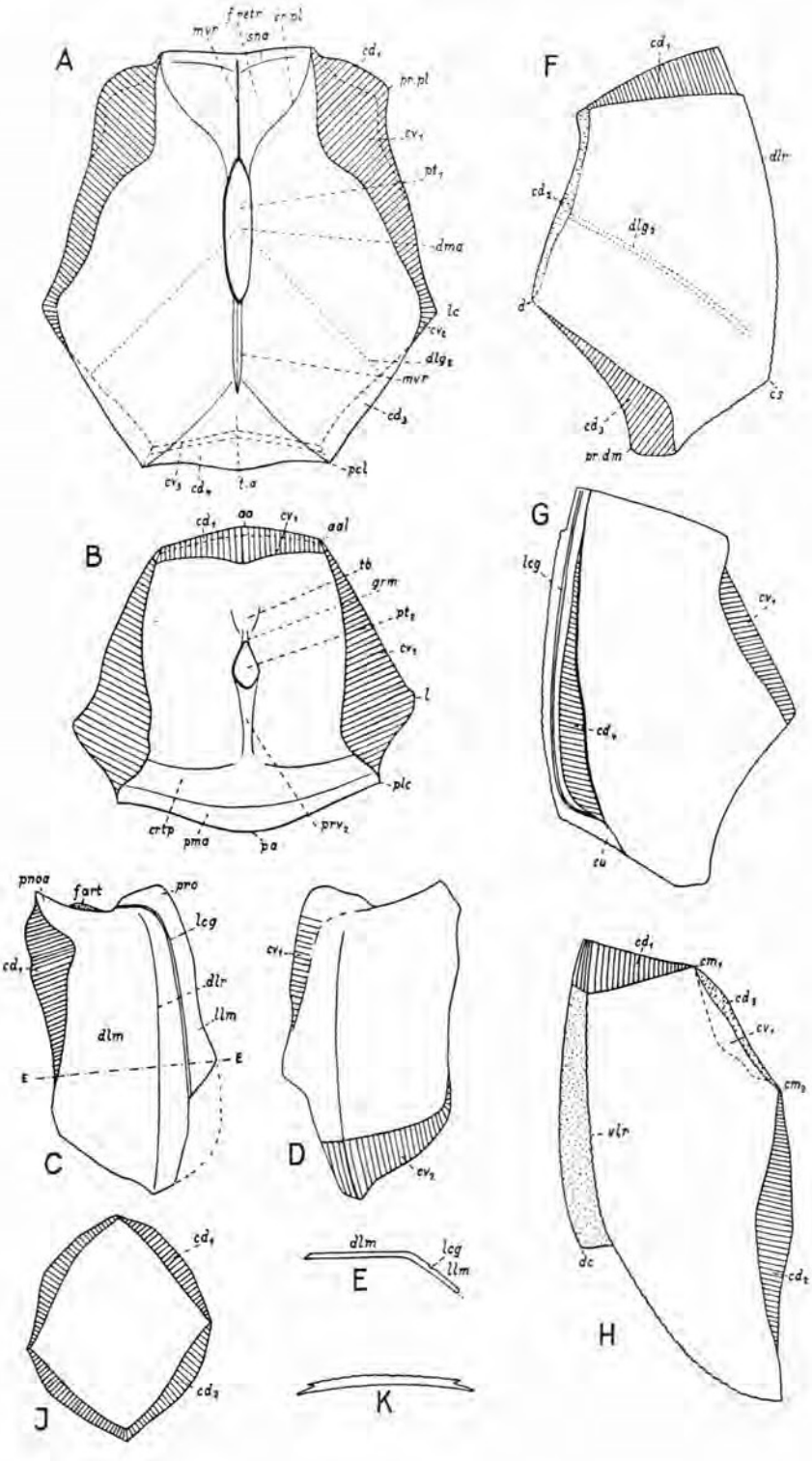


Textfig. 236. *Bothriolepis maxima*. Alle Figuren etwas verkleinert. *A* und *B*, Centronuchalplatte und Postpinealplatte, Dorsal- und Ventralseite; R. M. Stockholm, P. 1032. *C*, Rechte Paranuchal-Marginalplatte; Dorsalseite; R. M. Stockholm, P. 3149. *cr. o*, mediane Occipitalcrista; *d. end*$_1$, innere Mündung des Ductus endolymphaticus Kanals; *p*, Trichtergrube hinter dem Ductus endolymphaticus Kanal; *pr.nm*, hinterer Medianfortsatz der Centronuchalplatte; *sot*, supraoticale Verdickung.



Textfig. 237. *Bothriolepis maxima*. Alle Figuren etwas verkleinert. *A* und *B*, Centronuchalplatte und Postpinealplatte, Dorsal- und Ventralseite; G. I. Riga. *C*, Linke Mentalplatte; R. M. Stockholm, P. 3146.

cr. pto, postorbitale Crista; *d. end*$_1$ und *d. end*$_2$, innere und äussere Mündung des Ductus endolymphaticus Kanals; *ifc*$_2$, untere infraorbitrale Sinneslinie; *mc*, Lateralecke; *p*, Trichtergrube; *pc*, Posterolateralecke; *tc*, Zahnkomponente der Mentalplatte.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Meist sind sie recht ungleich entwickelt; besonders gross ist die linke Grube an dem in der Textfig. 237B wiedergegebenen Stück. Die occipitale Crista (*cr. o*) ist meist gespalten. Die Insertionsgruben für den Levatormuskel des Kopfes (*fm*, fm_1) sind weniger ausgeprägt als bei *B. canadensis* (vergl. Textfig. 11 und Textfig. 233K).

Die Paranuchal-Marginalplatten (*Pm*; Textfig. 233A, 235L u. K, 236C) sind sehr variabel im Umriss, selbst die zu einem Schädeldach gehörenden Platten können stark von einander abweichen. Der laterale Teil der Platte ist schmal und erreicht meist nich einmal die halbe Breite des medianen Teils. Die kurze mittlere Grübchenlinie des Kopfes (*mpg*) ist in den meisten Fällen deutlich zu erkennen. Die Textfig. 235L und K stellen den Medialrand einer besonders grossen Platte dar, bei der die oticooccipitale Depression seitlich in einen Kanal (*c*) ausläuft, dessen weiterer Verlauf leider nicht beobachtet werden kann. Die Paraoccipitalcrista (*cr. pm*) reicht fast bis an den Medialrand.

Die Postmarginalplatte (*Pmg*; Textfig. 233A, 234C u. D, 235M u. N) variiert etwas im Umriss. Ihr Hinterrand weist im Gegensatz zum Lateralrand der anschliessenden Lateralplatte keine Siebknochenfläche auf, war also mit der Extrallateralplatte nicht durch ein Gelenk verbunden.

Die Mentalplatte (Textfig. 234E, 237C; ferner Gross 1933a, Taf. 5, Fig. 11) variiert im Umriss recht beträchtlich. Sie ist sehr dünn, und der auf ihr befindliche untere Infraorbitalkanal ($if c_2$) ist so flach, dass er meist nur undeutlich zu erkennen ist. Die Zahkomponente des Knochens (*tc*) ist deutlich vom übrigen Knochen abgesetzt; ihre Randzacken sind sehr undeutlich ausgeprägt.

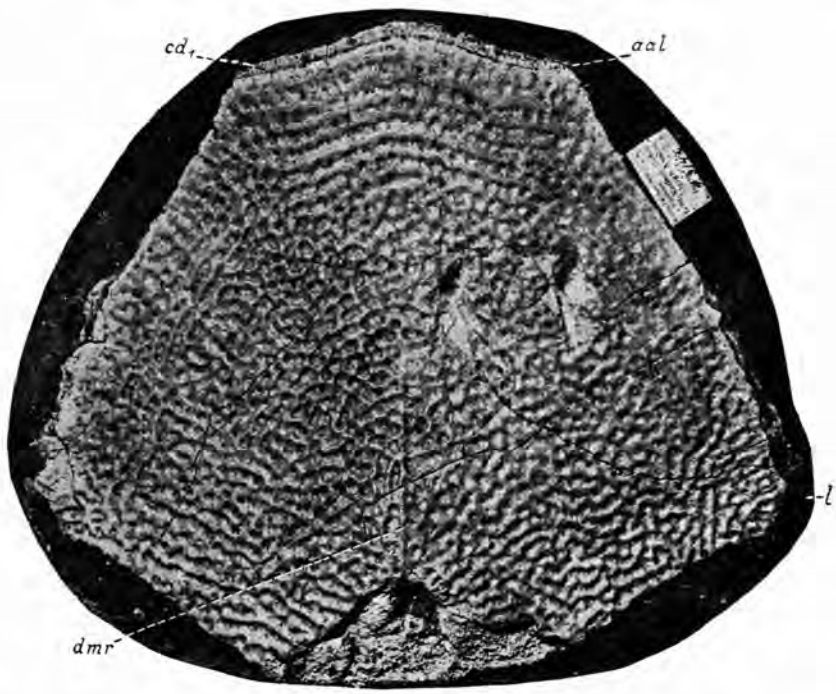
Textfig. 238. *Bothriolepis maxima*. Originale zu den Skizzen im Geol. Institut in Riga. × 1/4. *A*, Anteromediodorsalplatte, Ventralseite mit eingetragenen Merkmalen der Dorsalseite (= unterbrochene Linien). *B*, Posteromediodorsale, Ventralseite. *C* und *D*, Dorsal- und Ventralseite einer nicht ganz vollständigen rechten Anterodorsolateralplatte. *E*, Querschnitt durch letztere Platte längs der Linie *E–E*. *F* und *G*, Dorsal- und Ventralseite der Dorsalwand einer rechten Mixilateralplatte; in Fig. *G* ist die Dorsalseite der Lateralwand, perspektivisch verkürzt, zu sehen *H*, Ventralwand einer rechten Posteroventrolateralplatte, Aussenseite; die Lateralwand (punktiert) z. T. sichtbar. *I*, Medioventralplatte, Aussenseite; *K*, diagonaler Querschnitt durch die Medioventralplatte.
aa, Vorderecke: *aal*, Anterolateralecke; cd_1–cd_4, äussere überlagerte Nahtflächen; cm_1, anteromediale Ecke; cm_2, Mittelecke; *crtp*, Crista transversalis interna posterior; *cr. pl*, Postlevator-Crista; *cs*, Ecke zwischen der Dorsal- und der Lateralwand; *cu*, posteroventraler ornamentierter Fortsatz; cv_1–cv_3, innere überlagernde Nahtflächen; *d*, Dorsalecke; *dc*, Dorsalecke der Lateralwand; dlg_2, hintere schräge Grübchenlinie des Rumpfes; *dlr*, Dorsolateralkante; *dma*, Tergalecke der Dorsalseite; *f. art*, Fossa articularis; *f. retr*, Levatorfossa; *grm*, ventrale Medianfurche; *leg*, Hauptseitenlinie; *l*, *lc*, Lateralecke; *llm*, Lateralwand; *mvr*, ventrale Medianleiste; *pa*, Hinterecke; *pcl*, *plc*, Posterolateralecke; *pma*, hinterer Randsaum; *pnoa*, postnuchaler ornamentierter Fortsatz; *pro*, Processus obstans; prv_2, hinterer ventraler Processus; *pr. dm*, medialer Dorsalfortsatz; *pr. pl*, äusserer Postlevatorfortsatz; pt_1, vordere mediane Ventralgrube; pt_2, hintere mediane Ventralgrube; *sna*, supranuchale Area; *tb*, skulptierte Fläche; *t. a*, dreieckige skulptierte Area; *vlr*, ventrolateralleiste.

Rumpfpanzer.

Vom Rumpfpanzer liegt eine recht grosse Anzahl mehr oder weniger intakter Platten vor, die z. T. auffallend gleiche Grössen aufweisen, obgleich sie von verschiedenen Individuen und von verschiedenen Fundpunkten herstammen. Der Dorsalpanzer war relativ etwas höher als bei *B. canadensis* dagegen waren die Seitenwände des Panzers niedriger als bei jener Art und anscheinend nicht konkav zwischen den lateralen Kanten. Wie die Querschnitte (Textfig. 243H u. I) zeigen, ist der Rumpfpanzer vor der Mitte weniger kantig als hinter ihr. Der Ventralpanzer ist schmaler als der Dorsalpanzer. Die Dorsolateralkanten sind vorne wenig ausgeprägt, hinten dagegen viel mehr, mit Kielleistein sind sie aber nicht besetzt. Die Ventrolateralkante ist gerundet und ebenfalls kiellos. Die mediane Dorsalkante tritt kaum hervor, sie ist meist nur am Hinterende der Posteromediodorsalplatte durch einen niedrigen Skulpturwall angedeutet (Textfig. 239). Im Seitenprofil gesehen, muss der Dorsalpanzer nur sehr wenig gewölbt gewesen sein. – Die Innenseite des Panzers weist besondere Merkmale in der auffallenden Länge der vorderen Mediangrube (pt_1), die weit nach hinten reicht, und in der geringen Grösse und weit nach vorne geschobenen Lage der hinteren Mediangrube (pt_2) auf. In letzterer Eigentümlichkeit stimmt *B. maxima* mit *B. gigantea* überein (vergl. Textfig. 254B, 255). Spezifisch ist auch eine der Levatorfossa äusserlich ähnlich sehende, dreieckige Fläche (Textfig. 238A, *ta*) am Hinterende der Anteromediodorsalplatte. Der subcephale und der subanale Teil des Ventralpanzers sind relativ kurz. – Die hintere schräge Grübchenlinie auf dem Rücken ist flach und unausgeprägt, sie reicht bis nahe an die Dorsolateralkante der Mixilateralplatte.

Die dorsale Mittellinie des Rumpfpanzers wurde bei einigen sehr gut erhaltenen dorsomedianen Platten 37,5 cm lang. Die ventrale Mittellinie grosser, gut zu einander passender Knochen ergibt eine Länge des Ventralpanzers von 42–43 cm; die Mittelbreite des Ventralpanzers konnte 24 cm erreichen, die des Dorsalpanzers an 30 cm. In der Mitte des Rumpfpanzers wurde die Lateralwand 12 cm hoch (= senkrechte Höhe). Diese Masse wurden von der Mehrzahl der gefundenen Individuen erreicht, stellen also keine Ausnahmemasse dar.

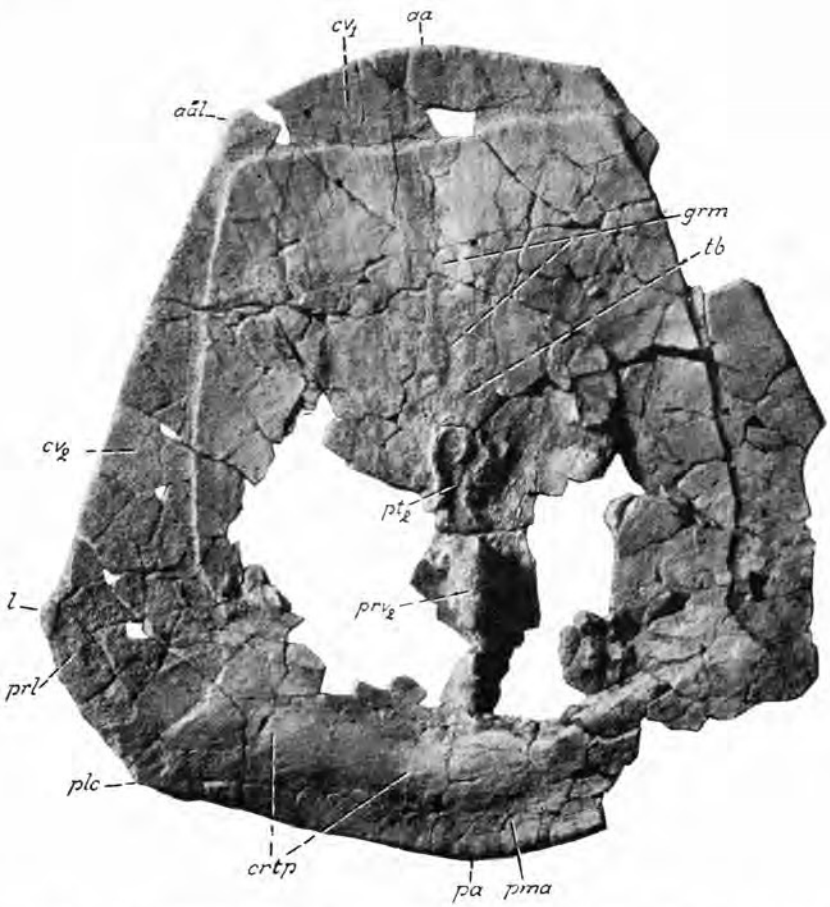
Die Anteromediodorsalplatte (Textfig. 238A) liegt in zwei intakten Stücken vor. Sie ist relativ breit und schwach gewölbt. Eine dorsale Medianleiste ist nicht entwickelt, sie wird nur im hinteren Abschnitt der Platte manchmal durch ein wallartige Verschmelzung der Tuberkel angedeutet. Die Platte überlagert nicht nur die Anterodorsolateralplatte mit ihren Nahtsaum cv_1, sondern wird dorsal auch von jener Platte im Saum cd_1 überlagert, ähnlich wie bei manchen Individuen von *B. cellulosa*. Die innere Saumfläche cv_1 greift manchmal um die Lateralecke (*lc*) etwas nach hinten herum (cv_2). Am hinteren Seitenrande und am Hinterrande wird die Platte nicht nur von den Nachbarplatten überlagert (cd_3 und cd_4), sondern über-



Textfig. 239. *Bothriolepis maxima*. Posteromediodorsalplatte, am Hinterende beschädigt; Dorsalseite. R. M. Stockholm, P. 3142. × 3/4.
aal, Anterolateralecke; cd_1, dorsaler, überlagerter Randsaum; *dmr*, dorsale Mittelkante; *l*, Lateralecke.

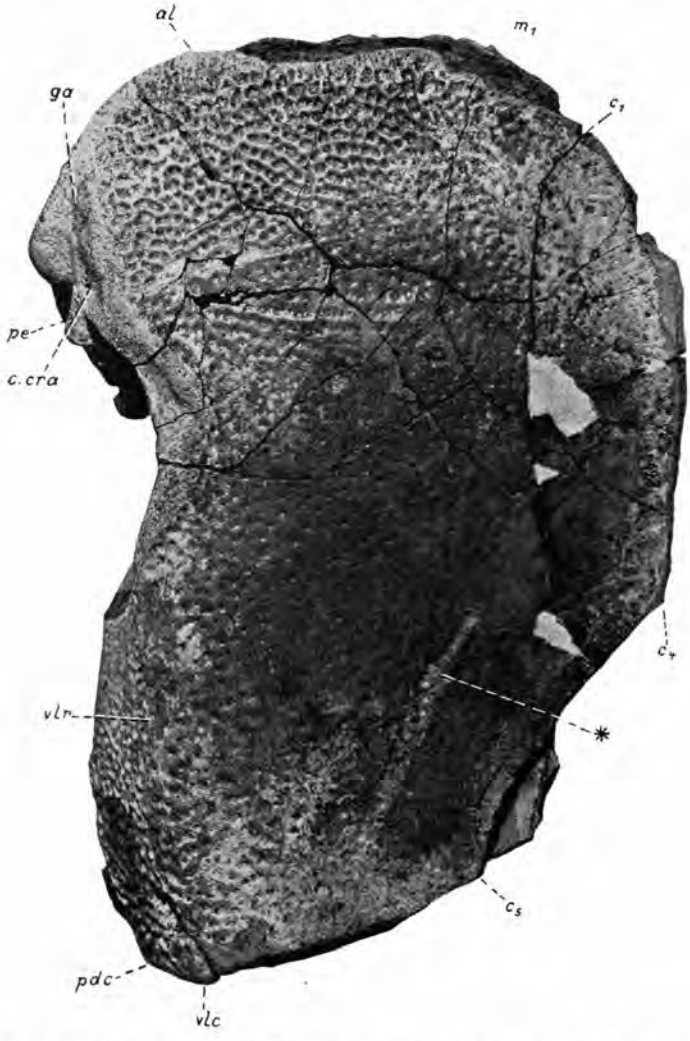
lagert diese Platten ihrerseits mit schmalen Säumen (cv_3). Die supranuchale Area (*sna*), die Levatorfossa (*f. retr*) und die Postlevatorcrista (*cr. pl*) sind deutlich entwickelt. Die vordere mediane Grube (pt_1) ist auffallend lang und reicht fast bis zur Höhe der Lateralecken (*lc*). Die ventrale Medianleiste (*mvr*) dagegen erreicht nicht den Hinterrand. Von ihrer Spitze erstrecken sich bis zu den beiden posterolateralen Ecken (*pcl*) eine etwas vertiefte dreieckige Area (*ta*), deren Bedeutung unklar ist.

Die Posteromediodorsalplatte (Textfig. 238B, 239, 240) hat eine ähnlich breite Gestalt wie bei *B. canadensis* und *B. cellulosa* (vergl. Textfig. 135–139, 225); die Breite übertrifft die Länge um 5–8%. Das Hinterende ist mässig ausgebuchtet. – Die Skulpturen der Mittellinie fliessen in der Hinterhälfte der Platte zu einem niedrigen Wall zusammen (Textfig. 239). Der äusserste Vorderrand (cd_1) schiebt sich in eine Fuge des Hinterrandes der Anteromediodorsalplatte. Die Crista transversalis interna posterior (*crtp*) is gering entwickelt. Die hintere mediane Grube (pt_2) ist auffallend weit nach vorne, oft bis zur Mitte, gerückt, aber bleibt relativ kurz (Textfig. 238B, 240). Der hintere ventrale Processus (prv_2) ist entsprechend lang gestreckt. Die rauhe Fläche (*tb*) vor der medianen Ventralgrube ist klein.



Textfig. 240. *Bothriolepis maxima*. Posteromediodorsalplatte, Ventralseite. Pal. I. Uppsala. × 5/6.
aa, Vorderecke; *aal*, Anterolateralecke; *crtp*, Crista transversalis interna posterior; cv_1, Nachtfläche, die die Anteromediodorsalplatte überlagert; cv_2, Nachtfläche, die die Mixilateralplatte überlagert; *grm*, ventrale Medianfurche; *l*, Lateralecke; *pa*, Hinterecke; *plc*, Posterolateralecke; *pma*, hinterer Randsaum; *prl*, Lateralfortsatz; prv_2, hinterer ventraler Processus; pt_2, hintere mediane Ventralgrube; *tb*, Tuberositas ventralis.

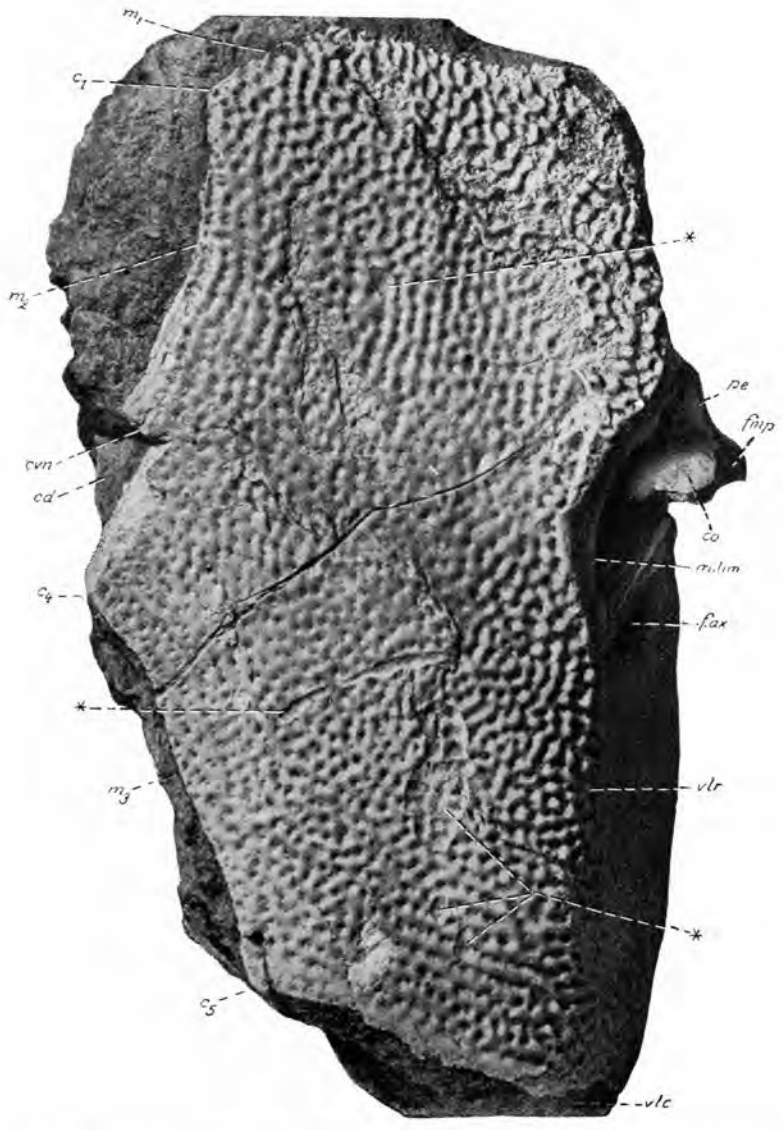
Die Anterodorsolateralplatte (Textfig. 49, 238C, D, E) ist in keinem Stück ganz vollständig erhalten; an dem abgebildete Stück fehlt ein Teil der Lateralwand und der gesamte von der Anteroventrolateralplatte überlagerte Saum. Die Platte ist verhältnismässig schmal und länger als bei *B. canadensis, B. cellulosa* und *B. jarviki* (vergl. Textfig. 38, 40, 48C, 144A, 226 u. 304) und erinnert mehr an *B. gigantea* und *B. groenlandica* (vergl. Textfig. 287B u. 288); die Lateralwand ist ungefähr so schmal wie bei letzteren Arten. Die Dorsolateralkante (Textfig. 238E) tritt in der Skulptur kaum hervor, der Winkel zwischen der Dorsal- und der Lateralwand beträgt längs der Schnittlinie *I–I* (Textfig. 238C) etwa 145°. Die postnuchale Ecke



Textfig. 241. *Bothriolepis maxima*. Rechte Anteroventrolateralplatte, Ventralansicht; der Processus brachialis und die Vorderhälfte der Lateralwand sind abgebrochen. G. I. Berlin, f 129. × $^3/_4$.

al, Anterolateralecke; c_1, Ecke zwischen dem an die Semilunarplatte grenzenden Rand und dem Medianrand; c_4, Ecke zwischen dem Medianrand und dem an die Medioventralplatte grenzenden Rand; c_5, Posteromedialecke; *c. cra*, Mündung eines Kanals; *ga*, Furche in der Lateralwand des subcephalen Teils; m_1, an die Semilunarplatte grenzender Rand; *pdc*, Posterodorsalecke der Lateralwand; *pe*, Pars pedalis des Processus brachialis; *vlc*, hintere Ventrolateralecke; *vlr*, Ventrolateralkante; *, Spuren von parasitären Knochenbeschädigungen.

(*pnoa*) ist stark ausgeprägt. Die Fossa articularis (Textfig. 49) ist dorsal und ventral von einer Kante eingefasst. Die Platte überlagert vorne einen schmalen Streifen der Anteromediodorsalplatte (Textfig. 238A, cd_1); vorne wird sie nicht nur von der Anteroventrolateralplatte überlagert, sondern überlagert auch ihrerseits diese Platte (Textfig. 238D, cv_1). In dieser Be-



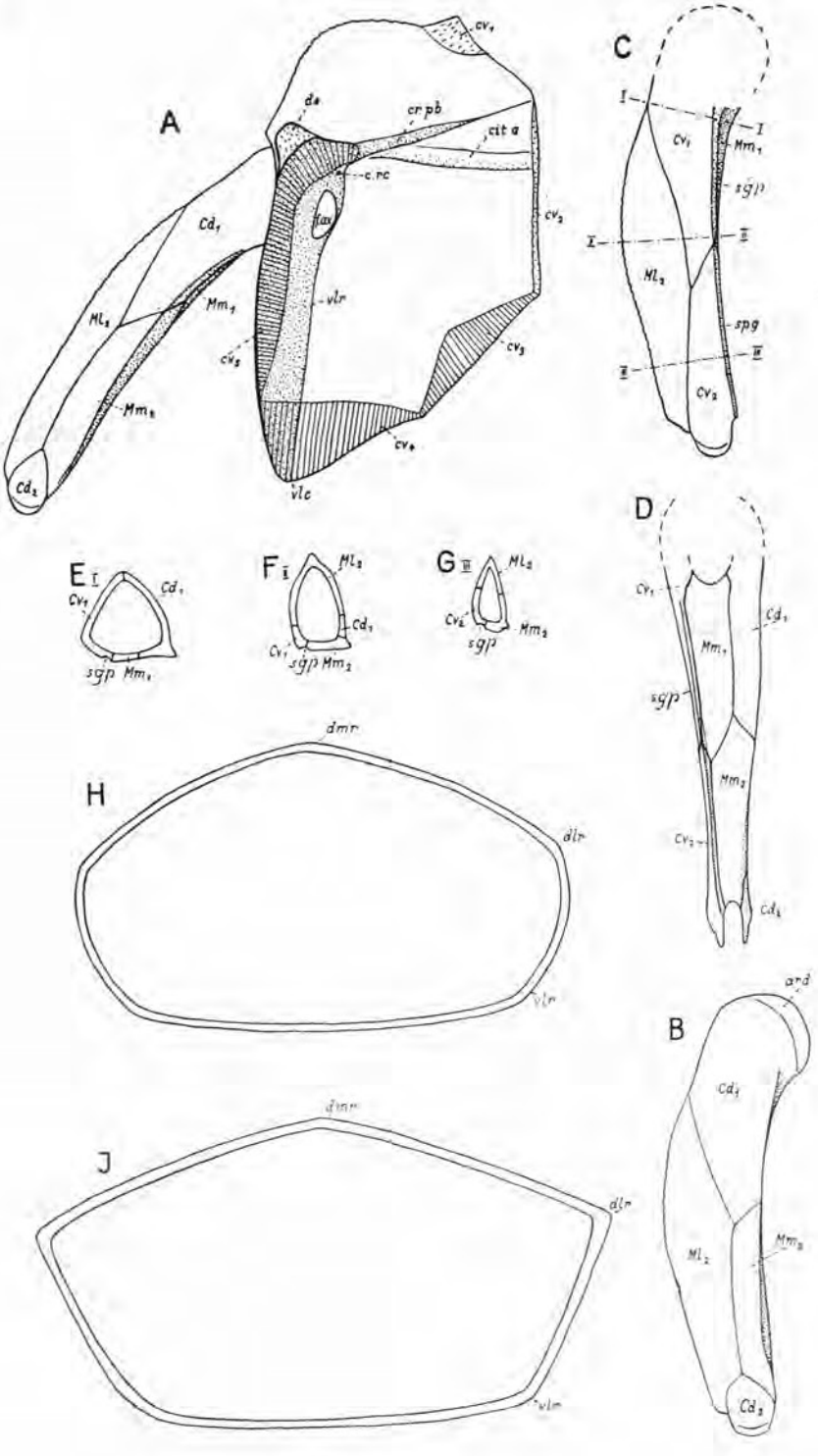
Textfig. 242. *Bothriolepis maxima.* Etwas beschädigte linke Anteroventrolateralplatte, Ventralansicht. R. M. Stockholm, P. 3337. × $^2/_3$.

c_1, Ecke zwischen der vorderen (m_1) und dem hinteren Abschnitt (m_2) des Medialrandes; c_4, Ecke zwischen dem mittleren (m_2) und dem hinteren (m_3) Abschnitt des Medialrandes; c_5, Posteromedialecke der Ventralwand; *cd*, Nachtfläche, die von der rechten Anteroventrolateralplatte überlagert wird; *co*, Pars condyloidea des Processus brachialis; *cvn*, Fläche die einen Teil der rechten Anteroventrolateralplatte überlagert; *f. ax*, Foramen axillare; *f. mp*, Protractor-Area; m_1, m_2, m_3, vorderer, mittlerer und hinterer Abschnitt des Medialrandes der Ventralwand, die sich mit der Semilunarplatte, der rechten Anteronvetrolaetralplatte und der Medioventralplatte verbinden; *m. lim*, Margo limitans (ventrale Hälfte); *pe*, Pars pedalis des Processus brachialis; *vlc*, hintere Ventrolateralecke; *, Narben in der oberen Knochenschicht, die bei Lebzeiten des Tieres vermutlich von Parasiten verursacht worden sind.

ziehung nimmt sie eine Mittelstellung zwischen *B. canadensis* und *B. groenlandica* ein (vergl. Textfig. 288).

Die Mixilateralplatt (Textfig. 238F, G) liegt in einigen fast intakten Stücken vor; der Umriss der Platte ist ähnlich wie bei *B. gigantea* (Textfig. 256) und *B. groenlandica* (Textfig. 287B, 289). Die Dorsalwand ist breit, ihr an die Anteromediodorsalplatte grenzender Rand überlagert diese Platte nicht nur mit dem Saum cv_1 (Textfig. 238G), sondern kann selbst im Saum cd_2 (Textfig. 238F) überlagert werden. Die Lateralwand bildet mit der Dorsalwand einen Winkel von etwa 90°. An der Dorsolateralkante verschmelzen die Tuberkel wallartig, bilden aber keine Kielleiste. Die Lateralwand ist relativ dünn und wird anscheinend nicht nur von der Posteroventrolateralplatte überlagert, sondern überlagert gelegentlich diese Platte mit dünnen Knochenschichten, so dass die Grenze zwischen beiden Platten an intakten Panzerteilen nicht leicht zu ermitteln ist. Die posteroventrale ornamentierte Ecke (*cu*) ist deutlich entwickelt.

Die Anteroventrolateralplatte (Textfig. 241, 242, 243A, ferner Textfig. 52) ist in mehreren gut erhaltenen Stücken gefunden worden. Die Lateralwand ist etwas mehr als zweimal so lang wie breit, sie gehört daher zu einem recht hohen Typus. Der subcephale Teil der Platte ist relativ kurz. Die Ventrolateralkante ist gerundet, ohne Wulst-oder Leistenbildung, aber stets mit ausgesprochener Skulptur versehen. Der Winkel zwischen der Lateral- und der Ventralwand beträgt in der Mitte der Platte etwa 65°. Die Skulptur ist im subcephalen Teil deutlich netzartig, in der Mitte der Platte kan sie fast ganz verstreichen, um nach hinten zu und auf der Lateralwand wieder wall- oder tuberkelartig zu werden. Dem Vorderrand der Platte fehlt der bei vielen *Bothriolepis*-Arten so starkt entwickelte spitze Vorsprung *al*; der an die Semilunarplatte grenzende Rand ist mehr oder weniger deutlich abgesetzt und kann auf der Innenseite (Textfig. 243A, cv_1) eine recht breite Überlagerungsfläche aufweisen. Der an die Medioventralplatte grenzende Rand ist relativ länger als bei *B. canadensis* oder *B. cellulosa* (vergl. Textfig. 41A–C, 51B, C, 166A–D). Die Fossa articularis ist nicht wie bei *B. canadensis* (Textfig. 40, 51A, 166E, F) vorne deutlich begrenzt, sondern läuft in eine breite Furche aus (*ga*; Textfig. 52 u. 241), die auf der Lateralwand des subcephalen Teiles allmählich verstreicht. Die Margo limitans ist scharf ausgeprägt. Die Trichtergrube (*fp*) des Processus brachialis zeigt eine sehr ausgeprägte radiale Riefung ihrer Wände, vermutlich zurbesseren Befestides Ansatzes bestimmter Weichteile oder Knorpel. Die ventral nicht unterbrochene Fläche rings um die Trichtergrube ist furchenartig vertieft und weist ventral und besonders dorsal tiefe Gruben auf. Der Medialrand der Platte kann ausser dem normalen Überlagerungsverhältnis noch eine Fugenbildung aufweisen, wobei die linke Platte mit dem Randsaum cv_2 (Textfig. 243A) den Rand der Gegenplatte (Textfig. 241) überlagert. – Die Innenseite der Platte (Textfig. 243A) zeigt ausser einem als Crista postbranchialis


A
cv1
da
cr pb
cit a
c. rc
Cd1
flax
cv2
Ml1
Mm1
vlr
cv3
Mm2
cv4
Cd2
vlc
C
I
Cv1
Mm1
sgp
II
Ml2
spg
III
Cv2
D
Cv1
Cd1
Mm1
sgp
Mm2
Cv2
Cd2
E I
Cd1
Cv1
sgp
Mm1
F II
Ml2
Cd1
Cv1
sgp
Mm2
G III
Ml2
Cv2
Mm2
sgp
H
dmr
dlr
vlr
B
ard
Cd1
Ml2
Mm2
Cd2
J
dmr
dlr
vlm

(*cr. pb*) wohl entwickelten vorderen Ast der Crista transversalis interna anterior noch einen hinteren Ast (*cit. a*), der viel deutlicher zu erkennen ist als bei *B. cellulosa* oder *B. groenlandica*. Der laterale Ausgangspunkt der Crista transversalis interna anterior ist sockelartig verdickt (*de*), seine Vorsprünge und Nahtflächen sind leider an dem untersuchten Knochen nicht mehr erhalten. An der Crista postbranchialis mündet vor dem Foramen axillare ein Kanal (*c. rc*); vermutlich ist es der Rostrocaudalkanal, der die Crista postbranchialis durchbohrt. Im Vergleich zu *Asterolepis* liegt diese Mündung auffallend hoch, nicht weit von der Nahtfläche cv_5.

Die Posteroventrolateralplatte (Textfig. 238H) liegt in einem intakten Stück vor, dessen Ventralwand fast $2^1/_2$ mal so lang wie breist ist. Die nicht abgebildete Lateralwand hat eine sehr ausgeprägte Dorsalecke. Die Lateralwand bildet mit der Ventralwand einen Winkel von 65°; die Kante ist gerundet. Der an die Medioventralplatte grenzende Rand überlagert nicht nur diese Platte, sondern kann sich auch mit seinem schmalen dorsalen Saum cd_3 in eine Fuge der Medioventralplatte schieben.

Die Semilunarplatte ist bisher nicht gefunden worden; doch ist aus den sie begrenzenden Rändern der Anteroventrolateralplatten auf eine normale Gestalt zu schliessen. Anscheinend wurde sie manchmal von letzterer Platte seitlich überlagert.

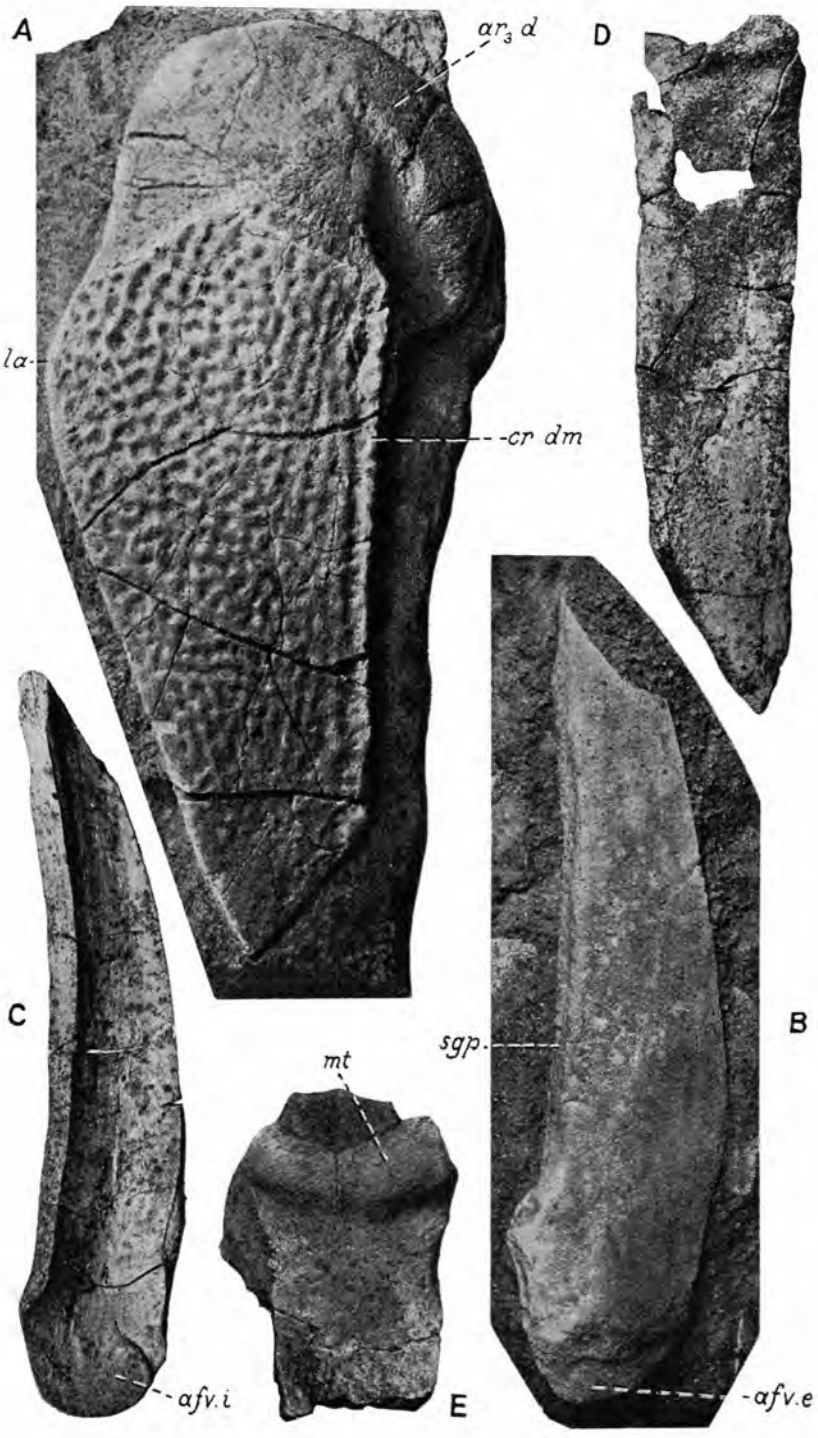
Die Medioventralplatte (Textfig. 238I u. K) hat eine normale Gestalt, ist aber im Vergleich zu den meisten Exemplaren von *B. canadensis* relativ viel grösser. Sie ist schwach gewölbt und kann Nahtfugen über den überlagerten Nahtflächen bilden (Textfig. 238K). Der vordere Abschnitt der Platte ist anscheinend etwas länger als der hintere.

Brustflosse.

Die Brustflosse ist verhältnismässig schlanker als bei *B. canadensis* oder *B. cellulosa*. Das Proximalglied (Textfig. 243B–G) ist fast fünfmal so lang

Textfig. 243. *Bothriolepis maxima*. Originale zu den Skizen im Geolog. Institut in Riga. Alle Figuren × $^1/_4$. *A*, linke Anteroventrolateralplatte, Innenansicht, mit anhängendem Proximalglied der Brustflosse; letzteres in Dorsalansicht. Das Vorderende der Lateralwand beschädigt (*de*). *B*, linkes Proximalglied, Dorsalwand; Medialwand schraffiert. *C*, rechtes Proximalglied, Ventralseite; proximales Gelenk beschädigt. Die Linien *I–I*, *II–II*, *III–III* geben die Lage der Querschnitte wieder, die in den Figuren *E–G* dargestellt sind. *D*, rechtes Proximalglied, Medialwand. *E–G*, Querschnitte durch das rechte Proximalglied der Fig. *C* und *D*. *H*, rekonstruierter Querschnitt durch den Rumpfpanzer kurz vor der Tergalecke. *I*, rekonstruierter Querschnitt durch den Rumpfpanzer hinter der Medioventralplatte.

Cd_1–Cd_2, dorsale Centralplatten 1 u. 2; Cv_1–Cv_2, ventrale Centralplatten 1 und 2; Ml_2, laterale Marginalplatte 2; Mm_1 u. Mm_2, mediale Marginalplatte 1 u. 2; *ard*, Gelenkfläche der dorsalen Centralplatte 1; *c. rc*, vermutlich hintere Mündung des Rostrocaudalkanals; *cit. a*, Crista transversalis interna anterior (hinterer Ast); *cr. pb*, Crista postbranchialis (= vorderer Ast der Crista transversalis interna anterior); cv_1–cv_5, innere überlagernde Nahtsäume, *de*, sockelartige Verdickung der Vorerendes der Lateralwand, beschädigt; *dlr*, Dorsolateralkante; *dmr*, Dorsomediankante; *f. ax*, Foramen axillare; *sgp*, Sinneslinie der Brustflosse; *vlc*, hintere Ventrolateralecke; *vlr*, Ventrolateralkante; *I–I*, *II–II*, *III–III*, Linien, die die Lage der Querschnitte *E–G* angeben.

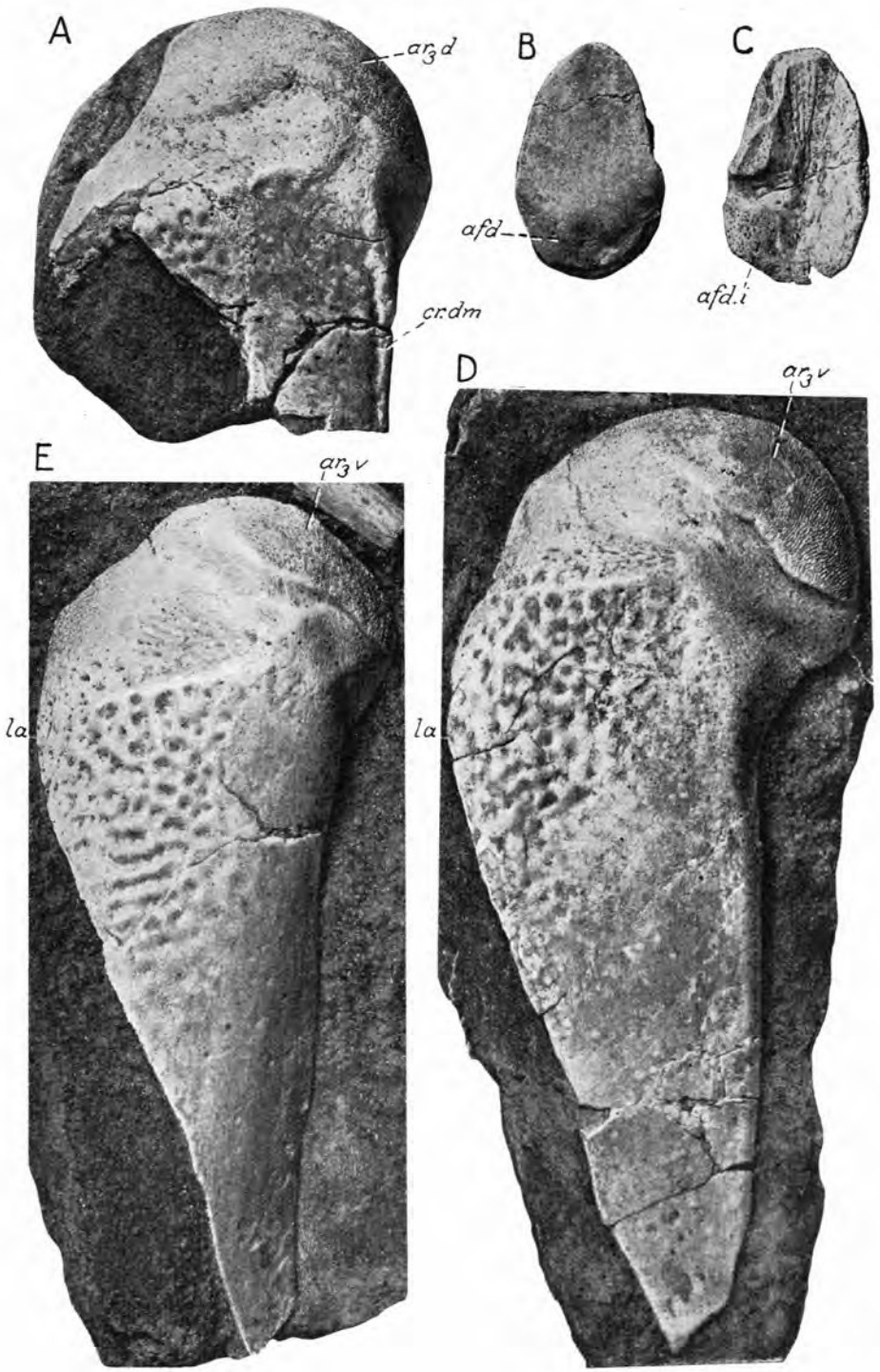

A
$ar_3\ d$
D
$l\alpha$
$cr\ dm$
C
sgp
B
mt
$\alpha fv.i$
E
$\alpha fv.e$

wie breit. Manche Stücke sind recht stark gebogen (Gross 1933a; Textfig 23A). Der Ventromedialrand ist gerundet (Textfig. 243E) und verliert sich distalwärts fast ganz. Deutlich skulptiert sind nur die dorsale – und ventrale Centralplatte 1 und die proximale Hälfte der lateralen Marginalplatte 2 (Textfig. 244A, 245A, E, D, 246). An der Lateralkante verschmelzen die Tuberkeln zu einem leistenartigen Wall, dasselbe findet an der Dorsomedialkante statt. – Das Distalglied (Gross 1941a; Textfig. 44A–D u. Taf. 29, Fig. 1–4) ist ebenfalls schlanker als bei *B. canadensis* und *B. cellulosa* (vergl. Textfig. 198, 228C–E) und im Querschnitt merklich runder als bei diesen Arten. Die Kantenstacheln sind an Zahl und Grösse reduziert und meist proximal gerichtet; am medialen Marginale 5 stehen sie z. T. in alternierender Doppelreihe. Sonstige Skulpturen sind nur als eben noch wahrnehmbare, radial gerichtete Wälle zu sehen.

Grosse Proximalglieder wurden 23 cm lang, während die Distalglieder 16,5 cm erreichen konnten, wovon 2 cm auf den im Proximalglied steckenden Gelenkteil entfallen. Die Brustflossen konnten somit eine Länge von 37,5 cm erreichen. Die Breite des Proximalgliedes betrug in der Mitte 5 cm, die Breite der Medialwand betrug am Distalende des ersten dorsalen Centrale 3,1 cm. Die Distalglieder konnten am proximalen Ende gleich hinter dem Gelenk 2,4 cm breit und 1,4 cm dick werden.

Die Serie der dorsalen Centralplatten (Gross 1941, Textfig. 44C, D) besteht aus vier Elementen; ein fünftes ist manchmal angedeutet, meist aber noch nicht von der Terminalplatte gesondert. Die dorsale Centralplatte 1 (Textfig. 244A, 245A; Gross 1933a, Taf. 5, Fig. 1) ist an 2,5 mal so lang wie breit. Die Tuberkeln der Kante verschmelzen zu einem leistenartigen Wall. Die dorsale Centralplatte 2 (Textfig. 243B, 245B, C) ist oft etwas schlanker als bei *B. canadensis* (vergl. Textfig. 194). – Die Serie der ventralen Centralplatten besteht aus vier Elementen (Gross 1941a, Textfig. 44A u. B). Die ventrale Centralplatte 1 (Textfig. 245D, E) ist ungefähr dreimal so lang wie breit. Im Unterschied zu den meisten *Bothriolepis*-Arten ist ihre Medialwand fast ganz reduziert, namentlich distalwärts. Längs ihrem Medialrand zieht die Sinneslinie (*spg*), sofern sie nicht auf die mediale Marginalplatte 1 übertritt. Die ventrale Centralplatte 2 (Textfig. 244B, C) ist schlank; längs ihrem Medialrand verläuft meist die Sinneslinie. Die ventrale Centralplatte 4 (im Distalglied) ist manchmal von der Terminalplatte durch die einander berührenden medialen Mar-

Textfig. 244. *Bothriolepis maxima*. Alle Figuren in natürlicher Grösse. *A*, linke dorsale Centralplatte 1; Dorsalansicht. R. M. Stockholm, P. 3338 (vergl. Textfig. 228 A). *B*, linke ventrale Centralplatte 2, mit Sinneslinie; G. I. Riga. *D*, rechte mediale Marginalplatte 1, Aussenseite; links am Gelenkrand beschädigt. G. I. Riga. *E*, Vorderende einer rechten medialen Marginalplatte 1. G. I. Berlin, f 403.
afv. e, äussere Gelenkfläche der ventralen Centralplatte 2; *afv. i*, innere Gelenkfläche der ventralen Centralplatte 2; ar_3d, äussere Gelenkgläche der dorsalen Centralplatte 1; *cr. dm*, mediale Leiste, durch Verschmelzung von Tuberkeln entstanden; *mt*, mediale ringartige Verdickung hinter dem Gelenk; *sgp*, Sinneslinie der Brustflosse.


A
ar3 d
cr.dm
B
afd
C
afd.i
D
ar3 v
la
E
ar3 v
la

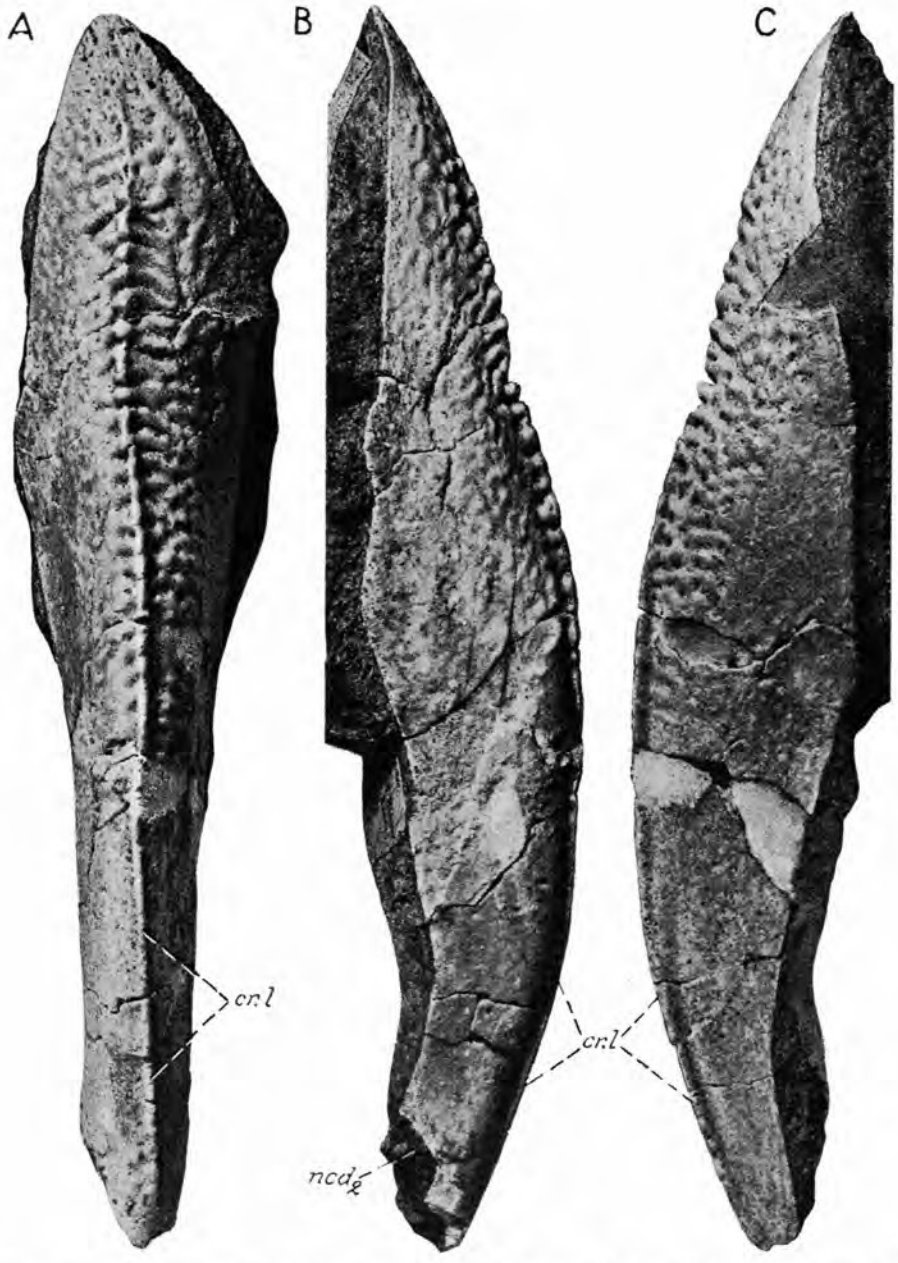
ginalplatten 5 getrennt. – Die laterale Marginalplatte 2 (Textfig. 246) hat grobe Kantentuberkeln, die sich distalwärts zu einer niedrigen Leiste verbinden. Die übrigen Platten der lateralen Marginal-Serie sind bei Gross (1941a, Textfig. 44A–D) abgebildet. Die lateralen Marginalia 5 sind oft noch mit der Terminalplatte verbunden. – Die mediale Marginalplatte 1 (Textfig. 244D u. E) ist langgestreckt und distalwärts nur schwach verjüngt. Die übrigen Platten der Serie sind in der Textfig. 243 B u. D und ferner bei Gross 1941a, Textfig. 244A–D abgebildet. Auch die mediale Marginalplatte 5 kann noch mit der Terminalplatte verbunden bleiben, dementsprechend variiert die Terminalplatte in der Gestalt ähnlich wie bei *B. canadensis*.

Skulptur.

Die Skulptur der Platten besteht bei den wenigen Resten, die zu jungen Individuen dieser Art gehört haben mögen (Textfig. 235G) aus einem Netzwerk niedriger Wälle. Von den fast ausschliesslich gefundenen grosses Individuen ist die Skulptur gut bekannt. Sie behält ihren wenig entwickelten Netzcharakter; auf der Brustflosse ist sie weitgehend geschwunden. Auf der Mitte der Ventralwand der Anteroventrolateralplatte wird sie oft ganz flach und undeutlich, so dass nur noch kleine Grübchen sie andeuten (Textfig. 241). Die Skulpturwälle sind meist glatt, ohne Tuberkeln auf den Kreuzungsstellen der Maschen. Deutlich tuberkuliert sind eigentlich nur der Vorderrand des Schädels (Textfig. 234A, 235A), die Lateralfächen des subcephalen Teiles des Rumpfpanzers und der Hinterrand des subanalen Teiles der Posteroventrolateralplatte. Diese Tuberkeln sind meist als Knotenpunkte der Skulpturmaschen entwickelt. Die Wülste und Wälle der Platten sind meist in radialer oder konzentrischer Richtung angeordnet; die radiale Richtung kann besonders längs den Rändern der Schädelknochen hervortreten (Gross 1933a, Taf. 5, Fig. 14) während sich die konzentrischen Anordnung auf den Platten des Rumpfes findet, besonders ausgeprägt auf der Posteromediodorsalplatte (Textfig. 239). Die Skulpturen des Schädels sind feiner als die des Rumpfpanzers, die besonders grob längs der Dorsolateralkante, der Ventrolateralkante und ferner im vordersten und hintersten Abschnitt des Ventralpanzers sind. Die Brustflossen sind nur an den vordersten und seitlichen Teilen des Proximalgliedes skulptiert.

Viele Platten weisen streifenartige oder auch flächenhafte vertiefte Nar-

Textfig. 245. *Bothriolepis maxima*. Alle Figuren in natürlicher Grösse. *A*, Proximalhälfte einer linken dorsalen Centralplatte 1, Dorsalansicht; R. M. Stockholm, P. 3336. *B*, rechte dorsale Centralplatte 2, Dorsalansicht; R. M. Stockholm, P. 3359. *C*, rechte dorsale Centralplatte 2, Innenansicht; G. I. Berlin, f 405. *D* u. *E*, zwei rechte ventrale Centralplatten 1, Ventralansicht. R. M. Stockholm, P. 3329 u. P. 3331.
a/d und *a/d. i*, äussere und innere Gelenkflächen der dorsalen Centralplatte 2; ar_3d, äussere Gelenkfläche des dorsalen Centralplatte 1; ar_3v, äussere Gelenkfläche der ventralen Centralplatte 1; *cr. dm*, mediale Leiste verschmolzener Kantentuberkeln; *la*, laterale Ecke, an der die laterale Marginalplatte 2 endet.



Textfig. 246. *Bothriolepis maxima*. Fast vollständige rechte laterale Marginalplatte 2, in Seitenansicht (*A*), Dorsalansicht (*B*) und Ventralansicht (*C*); R. M. Stockholm, P. 3340. Natürliche Grösse.

cr. l, laterale Leiste verschmolzener Tuberkeln; ncd_2, Ausschnitt für die dorsale Centralplatte 2.

ben auf, die fast ganz skulpturlos sind (vergl. Textfig. 241 u. 242; ferner Gross 1941a, Taf. 29, Fig. 2). Manchmal sind die Ränder der Narben etwas höher als die benachbarten skulptierten Flächen und deuten damit an, dass sie noch während des Wachstumes der Knochen entstanden sind. Daraus kann man folgen, dass diese Narben durch Hautverletzungen entstanden sind, die vielleicht von Parasiten hervorgerufen wirden.

Bemerkungen.

B. maxima ist eine gut definierte Spezies. Von allen besser bekannten *Bothriolepis*-Arten steht ihr anscheinend *B. gigantea* Traquair am nächsten. Auch bei *B. gigantea* kann der Dorsalpanzer eine auffallende Grösse, nämlich 32–38 cm erreichen. Beide Arten ähneln sich in vielen Merkmalen, deren wichtigsten folgende sind: die allgemeine Gestalt des Kopfschildes; die Wölbung des dorsalen Rumpfpanzers; die relativ geringe Höhe der Lateralwände des Rumpfpanzers; die geringe Entwicklung der medianen Teilde der Crista transversalis interna posterior; die geringe Entwicklung der Postlevatorverdickung; die schlanke Gestalt des Proximalgliedes der Brustflosse; das Fortbestehen einer feinmaschigen Netzskulptur auch bei mittelgrossen und grossen Individuen; die Skulpturlosigkeit der Brustflosse, abgesehen von der Vorderhälfte des Proximalgliedes.

Vorkommen.

Locus typicus ist das Mündungsgebiet der Flüsse Immul und Ammul bei Hohenberg in Kurland; stratum typicum sind die Old Red Sandsteine der *c*-Schichten des Oberdevons. Der Holotypus wurde in einem Aufschluss beim Bauernhof Lankserde an der Immul gefunden. Sehr schöne Reste fanden stud. geol. R. Kampe und Dozent N. Delle im Sandstein der Teufelshöhle an der Abau unweit Hohenberg. Die Aufschlüsse an der Ammul unterhalb der Mühlenstauung haben weniger gute Reste geliefert wie die beiden vorher genannten Aufschlüsse. Möglicherweise reicht *B. maxima* noch in die untersten Schichten der nächshöheren Stufe des lettländischen Oberdevons, in die *e/f*-Stufe, die ebenfalls an der Ammul und Immul aufgeschlossen ist. Von anderen Fundpunkten sind noch keine völlig sicher zu dieser Art gehörigen Reste gefunden worden, wenn auch ihr Vorkommen wahrscheinlich ist. Zur sicheren Bestätigung gehören eben gut erhaltene, grosse Reste.

In Nordwestrussland kommt *B. maxima* im Oberen Old Red des Lowatj-Flusses zwischen den Buregi-Schichten und den Smota-Lowatj-Schichten vor, wie mir D. Obrutschew freundlichst mitteilte. Dortselbst sind grosse, schön erhaltene Reste gefunden worden, unter anderem auch zusammenhängende Dorsal- und Ventralpanzer. *B. maxima* findet sich in diesen Schichten zusammen mit: *Aspidophorus heckeri, Psammosteus falcatus, Holopty-*

chius, Eusthenopteron (wenjukowi?) und *Panderichthys (= Polyplocodus)*. Diese Schichten können sehr wohl den c-Schichten von Hohenberg entsprechen, da die als Liegendes der *B. maxima* führenden Sandsteine vermuteten Dolomite bezw. Kalke zu den Buregi-Schichten gestellt werden. Die Buregi-Schichten entsprechen nach älteren Auffassungen den *d*-Schichten Lettlands, nach jüngerer Auffassung aber den b_4-Schichten (cf. Gross 1942a, pp. 398–409).

10. **Bothriolepis turanica** Obrutschew.

1939. *Bothriolepis turanica*, Obrutschew, pp. 115–116, text-fig. 1.

Diagnosis. – Small species. Trunk-armour with a very high dorsal wall, meeting the lateral wall of either side at angle of about 145°. Mixilateral plate high and short; its dorsal lamina about one and two thirds times as long as broad; its lateral lamina about two and a third times as long as high. Ornament very delicate, on the whole reticular, but with clear tubercular thickenings and elevations at the points of anastomoses of the ridges.

Material. – The material of the species known at present consists only of the holotype, a single right mixilateral plate, described and figured by Obrutschew in 1939 (pp. 115–116 and text-fig. 1).

Description. – The description published by Obrutschew of the holotype is from all points of view exhaustive and fully up to date. A good photographic print kindly sent me by professor Obrutschew enables me, however, to add a few remarks concerning the interesting plate in question. As far as may be seen from that print, the posterior dorso-medial corner of the dorsal lamina of the plate is missing. The area overlapped by the posterior median dorsal plate was, therefore, in all probability not particularly short. And as this seems to be so, the posterior median dorsal plate was conceivably not fully as short as maintained by Obrutschew. The ornament is strikingly delicate and characteristic of it is otherwise that on the whole it forms a fine-meshed network. Tubercular thickenings and elevations are developed at the points of anastomoses of the ridges.

Remarks. – Judging from what is known of it at present, *B. turanica* probably had a trunk-armour with a very high dorsal wall. In this respect, as well as with regard to the high short shape of the mixilateral plate, it seems to be nearest comparable to such species as *B. obesa*, *B. cristata* and *B. gippslandiensis* (cf. pp. 492–499, 511–512, 516–521 below; cf. also text-fig. 264). It is still quite impossible to decide whether it is actually akin to anyone of these three species.

Locality and geological horizon. – Zaktan-say, tributary of Kok-zu river. 1,5 km downstream of Brich-Mulla. 80 km NE of Tashkent, W. Tian-Shan. Upper Devonian, Frasnian (Obrutschew 1939, p. 115).

11. **Bothriolepis sinica** Chi.

1940. *Bothriolepis sinica*, Chi, pp. 57–72, text-fig. 3; pl. 1.

Diagnosis. – The species here under consideration is still very imperfectly known. No diagnosis can, therefore, be given of it at present. What is known concerning the species may be briefly summarized as follows. Probably a fairly small species. Anterior median dorsal plate strikingly narrow in proportion to its length. Ornament delicate, to a large extent reticular, but in part probably also somewhat tubercular.

Material. – *B. sinica* was erected and described by Chi in 1940 (p. 57–72) on a material comprising three anterior median dorsal plates and a few other imperfectly preserved plates of the trunk-armour.

No holotype being chosen by Chi the anterior median dorsal plate reproduced by him in pl. 1, fig. 1 is herewith suggested as a lectotype.

Description. – All the remains dealt with by Chi are from individuals of a fairly small size. More precisely they are from individuals in which the dorsal wall of the trunk-armour may be supposed to have been about 7–8 cm long.

The anterior median dorsal plate (cf. Chi 1940, text-fig. 3; pl. 1, figs. 1–3), which is represented only by impressions of its lower side, is of the ordinary *Bothriolepis*-type. According to statements given by Chi, its breadth : length ratio would be about 69–70 only, but, as is clearly seen from one of the reproductions given by him (pl. 1, fig. 3), this ratio of the most deficient one of the plates at hand must have been somewhat larger, probably amounting at least to about 80. The tergal angle was situated in the foremost part of the middle third of the plate and thus as to position was as in the majority of the other *Bothriolepis*-species. The anterior margin of the plate is clearly convex. On account of the narrow shape of the plate the levator fossa is fairly long and narrow. The postlevator crest is well developed. The condition that the ventral median ridge and the ventral median groove are completely, or fairly completely, developed proves that we are concerned with plates of medium-sized or large individuals.

The other plates of the trunk-armour reproduced by Chi seem to include inter alia an anterior dorso-lateral plate and a mixilateral plate, both of which are so deficient that they show no details of any interest.

The ornament is fairly delicate. Judging from the reproductions and descriptions by Chi it would be mainly reticular, but with clear indications of tubercular formations.

Remarks. – The remains described under the species-name of *B. sinensis* present no real species-characters and in fact are thus undeterminable. As there is much reason to suspect, however, that they represent an independent species the species-name of *B. siensis* has here been retained.

As to the shape and proportions of its anterior median dorsal plate *B. si-*

nensis resembles to some extent *B. leptocheira* from Scotland (cf. pp. 500–504 and text-fig. 260), but above all *B. jarviki* from East Greenland (cf. pp. 592–593; and text-fig. 305A–C).

Localities and geological horizon. – N. side of Nanmuchung, N of the village Tiomachien, Central Hunan, China. Uppermost Middle Devonian or Upper Devonian.

12. **Bothriolepis sp. from Novaya Zemlya.**

Certain fragmentary remains were described by Kiaer in 1926 (pp. 5–7; pl. 1, figs. 3–7) from Novaya Zemlya under the little of *Bothriolepis* sp. These remains consist only of detached plates or fragments of plates. They include inter alia two deficient centro-nuchal plates, fragments of plates of the trunk-armour, and fragmentary plates belonging to pectoral fins. Two skeletal pieces interpreted by Kiaer as fin-spines of Elasmobranchs (Kiaer 1926, p. 9, pl. 2, figs. 10, 11) are probably fragments of distal segments of pectoral fins of *Bothriolepis*.

The remains in question are from individuals of fairly small or moderate size. Most of them are a little distorted.

The two centro-nuchal plates (Kiaer 1926, pl. 1, figs. 3, 4) are of a somewhat different size. The smallest plate seems to be somewhat broader and shorter than the other plate. Their breadth : length ratio cannot be made out. The postpineal notch seems to be somewhat angular posteriorly. The anterior division of the lateral margin is clearly shorter than the posterior division of the same margin. The latter division is fairly strongly concave with the deepest concavity far backwards. The postero-lateral corner, at least sometimes, is strongly developed, whereas the posterior median process is weakly developed or absent. A fragment which presumably is a right posterior part of an anterior median dorsal plate (Kiaer, loc. cit. pl. 1, fig. 5) shows a double posterior oblique abdominal pit-line groove, the posterior one of which has such a posterior course that it probably passed on to the posterior median dorsal plate. The other remains present no characters of any interest.

The ornament consists of a regular fine-meshed network of anastomosing ridges with few or slight indications of tubercular formations. The ridges of the centro-nuchal plate are fairly sharp-edged and to some extent radiatingly disposed. The ornament of the centro-nuchal plate is suggestive of that in *B. cellulosa*, except that the tubercular formations are less pronounced. The ornament of the possible anterior median dorsal plate differs clearly from that in *B. cellulosa* in that it shows no indications of tubercular formations.

Remarks. – The remains here in question remind to a certain extent of *B. cellulosa*, but are too poor to be determined as to species.

Locality and geological horizon. – Archangel Bay, Novaya Zemlya. Uppermost Middle Devonian or Lower Upper Devonian.

British species.

No real revision of the British *Bothriolepis*-material could be made during the present conditions. I have therefore confined myself to give only certain remarks on the British *Bothriolepis*-species. These remarks are based on the descriptions previously published, on a series of plaster casts of Scottish material kindly presented to the Stockholm Museum by Dr. A. C. Stephen of Edinburgh, and on some notes made by the writer in 1938 during a visit to some English and Scottish Museums.

As in Russia (cf. p. 401 above), *Bothriolepis* appeared also in Scotland together with *Asterolepis* even as early as in the uppermost part of the Middle Devonian. More precisely, *Bothriolepis* has been found in Scotland in *Asterolepis maxima*-bearing beds at Whitemere, between Alves and Nairn (Evans 1929, p. 150, foot-note 3). The *Bothriolepis*-remains occurring in these middle Devonian beds are said by Evans to be of *B. major*, but it is very unlikely that this is true. In all probability these *Bothriolepis*-remains belong to some other species, most probably a new species.

The British species to be dealt with here are as follows: *Bothriolepis major* (Agassiz), *B. alvesiensis* n. sp., *B. gigantea* Traquair, *B. obesa* Traquair, *B. leptocheira* Traquair, *B. hydrophila* (Agassiz), *B. macrocephala* Egerton, and *B. cristata* Traquair. It is highly conceivable, however, that still other *Bothriolepis*-species occur in the British Old Red deposits.

13. **Bothriolepis major** (Agassiz).

1844. *Pterichthys major*, Agassiz, pp. 5, 19, 133; pl. 31, figs. 1, 2, 3a, b.
1860. *Asterolepis major*, Eichwald, p. 1511 (in part),
1880. *Bothriolepis major*, Lahusen, p. 136 (in part),
1888. *Bothriolepis major*, Traquair (1888a), p. 510 (in part),
1888. *Bothriolepis major*, Traquair (1888b), p. 501 (in part),
1891. *Bothriolepis major*, Woodward (1891b), p. 226 (in part),
1892. *Bothriolepis major*, Traquair, pp. 285–286 (in part),
1895. *Bothriolepis major*, Traquair, pp. 265–266 (in part),
1894–1906. *Bothriolepis major*, Traquair, pp. 114–119 (in part),
1931. *Bothriolepis major*, Gross, p. 59 (in part),
1931. *Bothriolepis major*, Stensiö, p. 105 (in part),
1932. *Bothriolepis major*, Gross (1932b), pp. 25–26 (in part).

B. major (Agassiz) was erected by Agassiz in 1844 (pp. 5, 19, 133; pl. 31, figs. 1, 2, 3a, b) for three fragments from the Elgin district. Two of these fragments consist of proximal pieces of pectoral fins in connection with parts of anterior ventro-lateral plates, whereas the third fragments is a proximal piece of a dorsal central plate 1. After that time almost all *Bothrio-*

lepis-materal found in the Elgin district and at Scaat Craig has been placed to *B. major*. It is now clear, however, that the large material thus referred to *B. major* includes remains of at least two, and possibly even of three or four, different species. In these circumstances and since without a thorough reexamination of the entire Elgin material it is impossible to make sure which ones of the various remains actually belong to *B. major*, I have found it necessary at present to confine this species only to the material described by Agassiz. The other Elgin material is here provisionally divided upon two species *B. alvesiensis* n. sp. and *B. gigantea* Traquair, both of which are dealt with below.

Diagnosis. – In the sense here taken *B. major* at present is an undefineable species.

Material. – As pointed out just above *B. major* as here provisionally defined includes only the three specimens originally ascribed to it by Agassiz.

The lectotype is the specimen reproduced by Agassiz in 1884 in pl. 31, fig. 1 (cf. Woodward 1891b, p. 226; Gross 1932b, p. 25). Strictly taken, however, only the lectotype is at present referrible to the species.

The subsequent notes on the species are based entirely on the reproductions given by Agassiz (1844, pl. 31, figs. 1, 2, 3a, b).

Description. – The three specimens available to Agassiz are presumably from three individuals of a somewhat uniform size. As far as may be judged, they belonged to individuals not quite as large as the largest ones known of *B. canadensis*, that is to say individuals in which the dorsal wall of the trunk-armour may be assumed to have been about 10–12 cm long. Only an antero-lateral piece of the anterior ventro-lateral plate is preserved, a piece which does not seem to show any characters of specific importance. The proximal segment of the pectoral fin is represented only by a little more than its proximal half. Judging from the figures given by Agassiz, this segment would have been about four times, or between four and five times, as long as broad. Its medial face was provided with an ornament of coarse tubercles.

Remarks. – The description and figures given by Agassiz do not enable the writer to make sure whether *B. major* as here defined presents any characters of taxonomic importance. In the strict sence here taken *B. major* is, therefore, a completely undefinable species. Whether it is identical with one or the other of the two species described below (pp. 467–492) from Elgin can be ascertained only by a thorough revision of the whole material of *Bothriolepis* from the Elgin district.

Locality and geological horizon. – The material here referred to *B. major* is said by Agassiz to be from the Banks of Findhorn River, Elgin, Scotland. It is from the upper Old Red Sandstone, but as it occurs relatively far W. of Alves it is possible that it may be from a rather low horizon in that sandstone series. This opinion is supported by certain statements (Evans

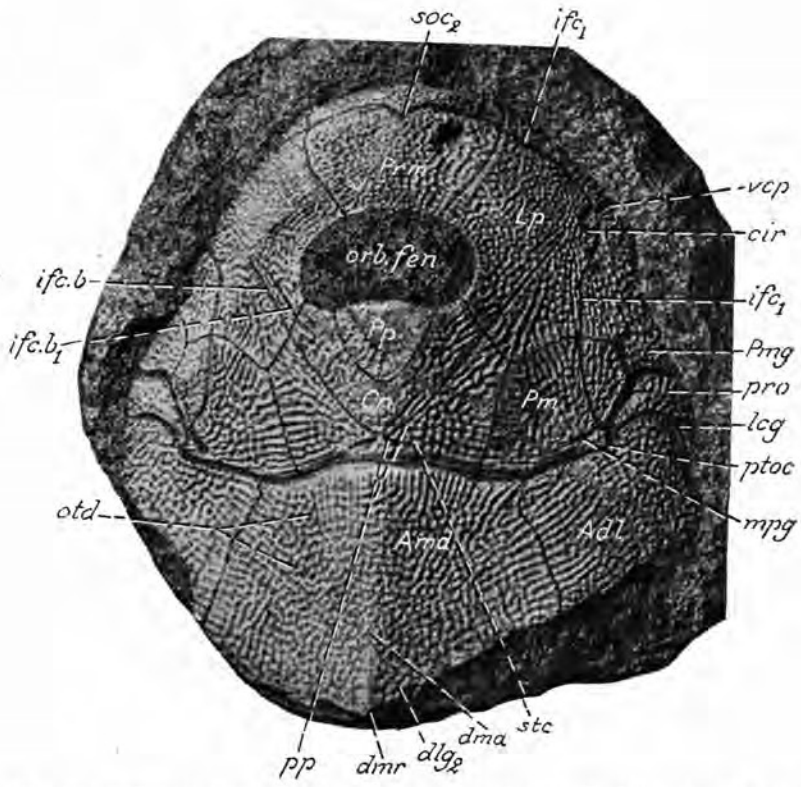
1929, p. 150, with foot-notes 2 and 3) that layers transitional between the Nairn Sandstone and the Alves or Scaat Craig Beds have been encountered at Whitemere, near Brodie Station between Alves and Nairn. These transitional layers are of special interest for they contain both *Asterolepis maxima* and *Bothriolepis*-remains, which are said to be of *B. major*, but which at a closer examination will presumably turn out to represent another species (cf. p. 465).

14. **Bothriolepis alvesiensis** n. sp.

(Text-figs. 26F, 247–251).

1891. *Bothriolepis major*, Woodward (1891b), p. 227, pl. 6, fig. 5 (in part).
1894–1906. *Bothriolepis major*, Traquair, pp. 114–119, pl. 23, fig. 5; pl. 26, fig. 1 (in part).
1931. *Bothriolepis major*, Gross, p. 59 (in part).
1931. *Bothriolepis major*, Stensiö, p. 105 (in part).
1932. *Bothriolepis major*, Gross (1932b), pp. 25–26 (in part).

Diagnosis. – Species attaining a moderate or somewhat large size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) amounting to about 18–19 cm or perhaps even more. Total dorsal length of trunk-armour at least about 13 cm. Head-shield with a breadth : length ratio of at least 140 and strongly downward-curved anteriorly both in rostro-caudal and transverse directions. Rostral margin of head-shield slightly shorter than, or about as long as, posterior margin and fairly strongly convex. Lateral margins of head-shield converging fairly strongly forwards and conceivably about equally long as, or a little shorter than, the distance between the lateral corners of the centro-nuchal plate. Obstantic margins of head-shield short, ending far behind a transverse plane through the posterior boundary of the orbital fenestra and in addition comparatively strongly concave anteriorly. Premedian plate strikingly broad, and, at least sometimes, with indications of a nasal process. Postpineal plate with a convex anterior margin. Length:breadth ratio of centro-nuchal plate in large individuals about 80–84. Lateral division of paranuchal-marginal plate long and narrow. Postmarginal plate strikingly broad, about as broad as long, and extending only slightly forwards beyond the paranuchal-marginal plate. Trunk-armour not particularly high. Dorsal wall comparatively long and narrow, its breadth : length ratio in mature individuals amounting to about 80 only. This wall somewhat elevated and meeting the lateral wall of either side at an angle of about 110°. Lateral walls presumably at least somewhat high. Tergal angle situated in the foremost part of the middle third of the anterior median dorsal plate. Dorsal median ridge slightly developed and partly absent in medium-sized and large individuals. Anterior median dorsal plate comparatively broad, its breadth : length ratio ranging at the least between 80–97; its anterior margin convex, normally fairly broad, and often broader than the part of the centro-nuchal plate underneath and nearest in



Text-fig. 247. *Bothriolepis alvesiensis* n. sp. Specimen No. 2. Plaster cast of a somewhat deficient head-shield in its natural connection with an anterior part of the dorsal wall of the trunk-armour. This plaster cast presented to the Swedish Museum of Nat. Hisl. by Dr. A. C. Stephens of Edinburgh. Nat. size.

Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *cir*, semicircular pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *mpg*, middle pit-line groove of skull-roof; *orb. fen*, orbital fenestra; *otd*, oblique transverse depression above postlevator thickening; *pp*, posterior pit-line groove of skull-roof; *pro*, processus obstans; *ptoc*, postobstantic corner of head-shield; soc_2, anterior median section of the supraorbital sensory canal grooves (the anterior median pit-line); *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

front of it. Posterior median dorsal plate broad in its anterior parts; as a whole, however, presumably generally of a rather narrow type, and at least in several cases narrower than long even in large individuals. Dorsal lamina of anterior dorso-lateral plate about two and a third times as long as broad. Ornament of an approximately uniform coarseness both on head-shield and trunk-armour, and in medium-sized and large individuals more or less subdivided into pieces of ridges and tubercles.

Material. – The following material is here referred to *B. alvesiensis*:

1) a deficient head-shield, figured by Woodward in 1891 (1891b) in pl. 6, fig. 5; 2) a head-shield with an anterior part of the trunk-armour, of which a plaster cast was figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 5 (text-fig. 247 in the present work); 3) a somewhat deficient impression of the dorsal side of a head-shield and a trunk-armour, figured by Traquair in 1904 (1894–1906) in pl. 26, fig. 1 (text-fig. 248 in the present work); and finally, 4), 5) two detached anterior median dorsal plates of which plaster casts are reproduced below in text-fig. 250 in the present work. Besides the remains mentioned, also 6) a detached, rather large mixilateral plate has provisionally and with much hesitation been described under the species here in question (text-fig. 251).

As a holotype of the species is suggested the specimen No. 3 referred to above (text-fig. 248 below).

Description. – In the holotype the total dorsal length of the armour (length of head-shield + dorsal length of trunk-armour) amounts to about 18–19 cm, of which the dorsal length of the trunk-armour constitutes almost 13 cm. Specimen Nos. 1, 2, 4 and 5 are all from smaller individuals than the holotype. Judging from the material known at present, the species in question would thus be of about the same size as *B. canadensis*. It is possible, however, that it attained a larger maximal size than that species. The mixilateral plate described with doubt under this species at any event is from a considerably larger individual than anyone of the specimens Nos. 1–5.

Head-shield.

The head-shield is somewhat well known (text-figs. 247–249; cf. Woodward 1891b, pl. 6, fig. 5). Its breadth : length ratio may be estimated at 140 or thereabouts. As is fully evident from a plaster cast of specimen No. 2 available to the writer (text-fig. 247), the preorbital division is strongly curved downwards both in rostro-caudal and transverse directions, and this division in this respect is, therefore, much as in *B. canadensis* (cf. text-figs. 4, 38, 40B, 114). Taken as a whole the shield narrows fairly much forwards in front of the postero-lateral (preobstantic) corners (*plc*) and thus in this character differs from the ones in *B. maxima* (cf. text-fig. 233A) and *B. gigantea* (text-figs. 252, 253A). The orbital fenestra is comparatively broad both in proportion to its own length and to the breadth of the shield. The rostral margin agrees with the corresponding margin in *B. maxima* (cf. text-fig. 233A), *B. gigantea* (cf. text-fig. 253A) and *B. groenlandica* (cf. text-figs. 13, 273, 274) in that it is only slightly shorter than, or about equally long as, the posterior margin, whereas on the other hand it differs from that of the said three species in the condition that in dorsal or ventral aspect it is much more convex. In the latter respect it is thus as in most other *Bothriolepis*-species. Whether it was provided with a rostral angle cannot be made out.

The lateral margin of either side seems to be a little shorter than, or about equally long as, the distance between the lateral corners of the centro-nuchal plate. The supraspiracular process (*lpr*, text-fig. 249) was probably situated opposite the foremost part of the orbital fenestra, at any event not much further forwards. The postero-lateral (preobstantic) corner (*plc*) is produced backwards into a distinct short process. The obstantic margin extends less far forwards than in most other *Bothriolepis*-species, ending anteriorly pretty far behind a transverse plane through the posterior boundary of the orbital fenestra. Otherwise it is also characteristic of this margin that as a whole it is directed much posteriorly. The antero-medial boundary of the subobstantic area, that is to say the boundary of the subobstantic area towards the exposed ornamented parts of the shield, is decidedly much more concave than in other *Bothriolepis*-species known in detail at present. The posterior margin is shown only in specimen No. 1 (Woodward 1891, pl. 6, fig. 5), where it is equipped with a somewhat strong posterior median process (*pr.nm*) and on the whole is developed as in medium-sized and large individuals of *B. canadensis* (cf. text-figs. 82, 83, 84C, 93F–O).

The premedian plate (*Prm*, text-figs. 247–249) is somewhat well preserved in two specimens (Nos. 1 and 2) in which its breadth:length ratio amounts to as much as 140 and 134 respectively. At least in these two cases the plate is thus considerably broader than in medium-sized and large individuals of *B. canadensis* and most other species (cf. pp. 239, 412, 440, 485). In these two cases the plate is also clearly broadest across its foremost part. The posterior dorsal margin of the plate may show indications of a small nasal process. The lateral plate (*Lp*, text-figs. 247–249) presents no particularly characteristic features. The rostral and pineal plates are both unknown. The postpineal plate (*Pp*, text-figs. 247–249) is of the normal *Bothriolepis*-type and has a somewhat convex anterior (orbital) margin. The centro-nuchal plate (*Cn*, text-figs. 26F, 247–249) is comparatively long and narrow, its length:breadth ratio in at least two of the specimens amounting to 80–84 or thereabouts. This plate narrows decidedly more backwards than what is the case in most other *Bothriolepis*-species. On account of this narrowing backwards, and for the reason that its postero-lateral corners are short and slightly or not produced into lateral processes (cf. Woodward 1891b, pl. 6, fig. 5), the plate is much narrower across its postero-lateral corners than across its lateral corners. The anterior division of the lateral margin is considerably shorter than the posterior division of the same margin. The posterior division may be nearly straight or somewhat concave with the deepest concavity at its middle or somewhat further backwards. Taken as a whole this division is directed somewhat backwards. The posterior margin of the plate is produced, at least in certain cases, into a posterior median process (Woodward 1891b, pl. 6, fig. 5). The paranuchal-marginal plate (*Pm*, text-figs. 247–249) is comparatively long in



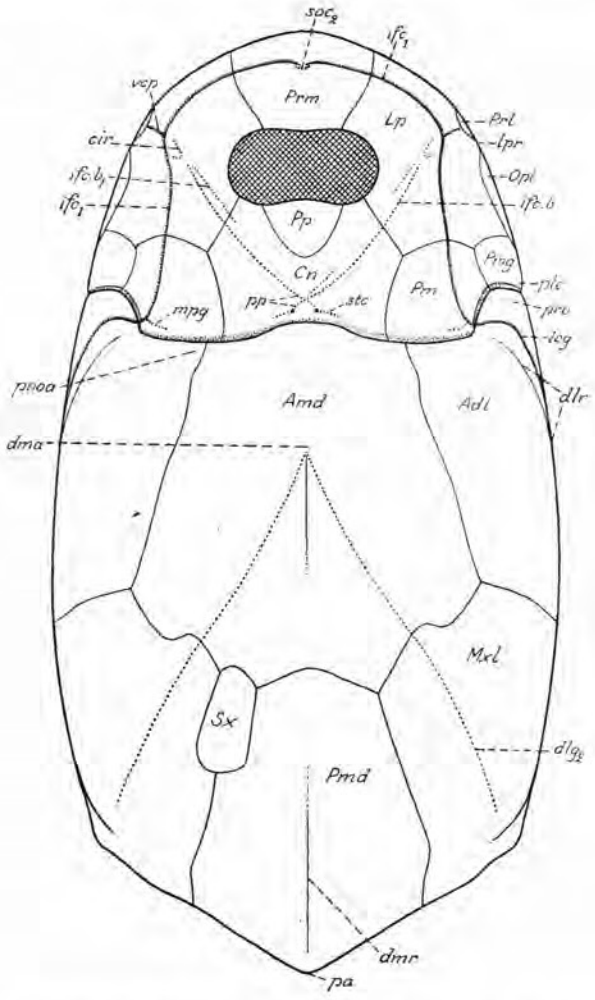
Text-fig. 248. *Bothriolepis alvesiensis*. Specimen No. 3. Deficient impression of the dorsal side of a head-shield and trunk-armour. From Traquair 1894–1906. Slightly diminishedl *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nucha, plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*. premedian plate; *Sx*, supramixilateral plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *orb. fen*, orbital fenestra; *pa*, posterior corner or angle of posterior median dorsal plate; *plc*, postero-lateral (preobstantic) corner of head-shield; *pnoa*, postnuchal ornamented corner; *pro*, processus obstans.

proportion to its breadth, but is, nevertheless broader than long. In the specimens Nos. 2 and 3, in which it is completely preserved, the lateral division of the plate is strikingly long and in addition also narrow, its breadth amounting to between one half and one third only of the breadth of the medial division. The latter division is also fairly narrow, slightly broader than long, or about as broad as long. Finally, the postmarginal plate (*Pmg*, text-figs. 247–249) is strikingly broad, in specimen No. 2 even nearly as broad as long. It is thus broader than in *B. canadensis*, *B. cellulosa* and *B. maxima*, but is not as broad, however, as in *B. groenlandica* (text-figs. 13, 273, 274, 279A–C, F). Characteristic of it is in addition that its postero-lateral corner is produced backwards into a distinct process. As in *B. canadensis* and *B. cellulosa*, the plate does not extend particularly far forwards beyond the anterior margin of the lateral division of the paranuchal-marginal plate.

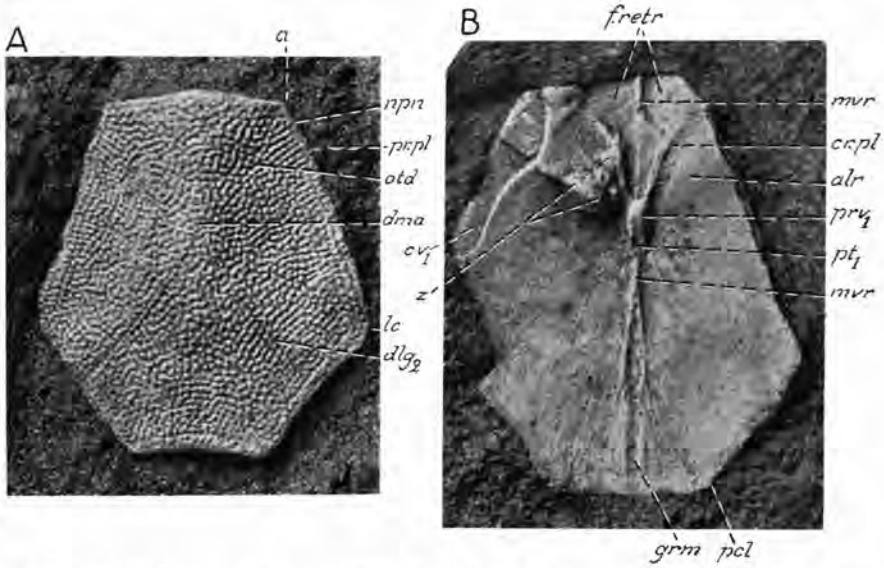
Trunk-armour.

The trunk-armour (text-figs. 247–249) is imperfectly preserved, being represented only by parts of its dorsal wall. This wall is low and flat, but not quite as low and flat as in *B. canadensis* for on either side of the dorsal median ridge it slopes so much laterally that it meets the lateral walls at an angle of almost 110°. In the holotype the dorsal wall has a breadth : length ratio of about 80 only. The lateral walls were presumably relatively high. The tergal angle (*dma*, text-figs. 247–249, 250A) is situated in the anterior part of the middle third of the anterior median dorsal plate. The oblique transverse depression (*otd*) above the postlevator thickening is rather well shown in specimens 2 and 4 (text-figs. 247, 250A) and may be suspected, therefore, frequently, or normally, to persist even in medium-sized and large individuals. The dorsal median ridge (*dmr*) is approximately as in *B. canadensis*. In certain specimens (text-fig. 250A) it may be absent on the anterior median dorsal plate. The postlevator thickening (*alr*) is well developed, and the postlevator crest (*cr. pl*) is present, at any rate in certain individuals (text-fig. 250B).

The anterior median dorsal plate (*Amd*, text-figs. 247–250) is about as broad in proportion to its length as in small and medium-sized individuals of *B. canadensis*, its breadth : length ratio ranging between 80–97. At any event in two of the specimens (Nos. 2 and 3) the foremost part of the plate is considerably broader than the underlying posterior part of the centro-nuchal plate. The anterior margin is convex. The anterior division of the lateral margin presents the following characteristic features: the post-nuchal notch (*npn*) is shallow; the external postlevator process (*pr.pl*) is relatively slightly developed; and the hindmost part of the division behind the external postlevator process is somewhat undulating. At least in certain cases the posterior margin of the plate has only a short much rounded off



Text-fig. 249. *Bothriolepis alvesiensis* n. sp. Restoration of the head-shield and trunk-armour in dorsal aspect. The restoration based on the specimens Nos. 2 and 3 (cf. text-figs. 247, 248) mainly, however, on the former specimen. About $^2/_3$ of the nat. size. *Adl*, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Mxl*, mixilateral plate; *Opl*, extralateral (opercular) plate; *Pm*, paranuchal-marginal plate; *Pmd*, posterior median dorsal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prl*, prelateral plate; *Prm*, premedian plate; *Sx*, supra-mixilateral plate; *cir*, semicircular pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; $ifc.\ b_1$, anterior oblique cephalic pit-line groove; *lcg*, main lateral line groove; *lpr*, supra-spiracular process; *mpg*, middle pit-line groove of skull-roof; *orb. fen*, orbital fenestra; *pa*, posterior corner or angle of posterior median dorsal plate; *pp*, posterior pit-line groove of skull-roof; *pnoa*, postnuchal ornamented corner; *pro*, processus obstans; soc_2, anterior median section of supraorbital sensory canal groove, the anterior median pit-line; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

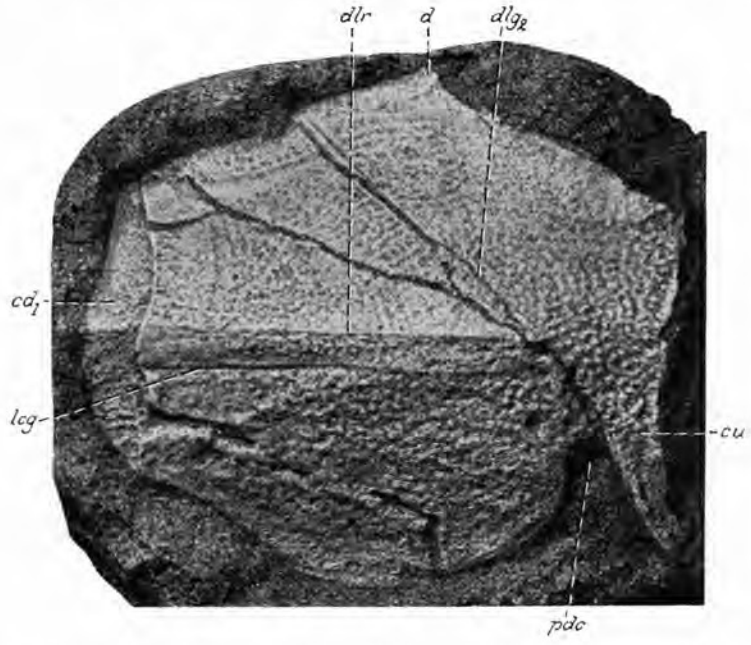


Text-fig. 250. *Bothriolepis alvesiensis* n. sp. *A*, a fairly complete anterior median dorsal plate of a medium-sized individual. Dorsal aspect. *B*, a deficient anterior median dorsal plate. Ventral aspect. Both the figures reproductions of plaster casts presented to the Swedish Museum of Natural History by Dr. A. C. Stephen of Edinburgh. Slightly diminished.

a, antero-lateral corner; *alr*, postlevator thickening; *cr. pl*, postlevator crista; cv_1, area overlapping anterior dorso-lateral plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *otd*, oblique transverse depression above postlevator thickening (*alr*); *pcl*, postero-lateral corner; *pr. pl*, external postlevator process; prv_1, anterior ventral process; pt_1, anterior ventral pit; *z*, abnormal thickening.

posterior median process (text-fig. 250B). The posterior median dorsal plate (*Pmd*, text-figs. 248, 249) is preserved only in the holotype where it is as follows. It is much narrower than long, its breadth:length ratio amounting only to about 78; it is broad anteriorly, but increases only slightly in breadth backwards and is, therefore, as a whole of a narrow type; on its left side it presents a large mixilateral notch, which is occupied by a special independent plate, the supramixilateral plate (*Sx*) descriped below; the posterior corner (*pa*) is well marked; as a whole the plate reminds mostly of the corresponding plate in *B. panderi* (cf. text-figs. 46B, 231D). The anterior dorso-lateral plate (*Adl*, text-figs. 247–249) is still imperfectly known. Its dorsal lamina is about two and a third times as long as broad. The dorsal lamina of the mixilateral plate (*Mxl*, text-figs. 248, 249) in the holotype is not fully twice as long as broad. The holotype presents also a small supernumerary plate, the supramixilateral plate, already referred to, which on the left side is wedged in between the anterior median dorsal plate, the posterior median dorsal plate and the mixilateral plate (*Sx*, text-figs. 248, 249; cf. pp. 141–142).

The mixilateral plate referred to the species provisionally and with much



Text-fig. 251. *Bothriolepis alvesiensis*? n. sp. Somewhat deficient left mixilateral plate referred to the species only provisionally and with much doubt. Dorso-lateral aspect. From a plaster cast presented to the Swedish Museum of Nat. Hist. by Dr. A. C. Stephen of Edinburgh. × 4/5.

cd_1, area overlapped by anterior dorso-lateral plate; *cu*, postero-ventral ornamented corner; *d*, dorsal corner; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *lcg*, main lateral line groove; *pdc*, emargination in ornamented area of lateral lamina for dorsal corner of posterior ventro-lateral plate.

hesitation (spec. No. 6; text-fig. 251) is of a considerably larger individual than the specimens Nos. 1–5 dealt with above. Its dorsal and lateral laminae meet at a much more obtuse angle than what is the case in the specimens Nos. 2 and 3, more precisely at an angle of about 125°. The dorsal lamina is not fully twice as long as broad, while the lateral lamina seems to be two and a third times as long as high or thereabouts. The postero-ventral ornamented corner (*cu*) is long and narrow and the emargination in the ornamented area for the dorsal corner of the posterior ventro-lateral plate is very deep. The main lateral line groove (*lcg*) passes strikingly close below the dorso-lateral ridge (*dlr*).

The fact that the dorsal and lateral laminae of the single detached mixilateral plate just described meet at a more obtuse angle than normally in *B. alvesiensis* may, perhaps be due to a secondary deformation of the plate in the rock. If this turns out not to be true, however, the plate cannot belong to *B. alvesiensis*, but must be of some other species. Its high lateral lamina shows clearly that it is not referrible to *B. gigantea* (cf. p. 488 below, and text-fig. 256).

Ornament.

The specimens Nos. 1–5, which, as we have seen, are from medium-sized or large individuals are ornamented as follows (text-figs. 247–250). Their ornament is comparatively delicate and approximately of the same coarsners on the whole dorsal side of the armour. The immature regularly reticular disposition of the ornament has to a large extent disappeared. In several places the ridges are much subdivided into shorter pieces and tubercles with no or comparatively few anastomoses. The subdivision of the ridges has often proceeded further on the dorsal parts of the trunk-armour than on the head-shield, and the ornament of the anterior and posterior median dorsal plates, and of the adjacent parts of the anterior dorso-lateral and mixilateral plates, is, therefore, often of a more decided tubercular type than that of the head-shield. However, the ornament of the head-shield is also not rarely in a highly advanced stage of transformation so that it too is of a tubercular type (Woodward 1891 b, pl. 6, fig. 5). The ridges and pieces of ridges are narrow and low, but very well-defined. They present distinct tubercular thickenings and elevations particularly at their points of union, but also at other points. As normally in individuals of the corresponding stages of growth of other species, the ornament is both concentrically and radiatingly disposed.

The ornament of the mixilateral plate referred with doubt to the species (text-fig. 251) consist almost entirely of rounded tubercles, several of which are fairly pointed.

Remarks. – *B. alvesiensis* has hitherto been confused with *B. gigantea*. As we have seen (pp. 465–467), it has been included together with *B. gigantea* into *B. major*, which thus has long remained a heterogenous species.

As far as our present knowledge of it goes, *B. alvesiensis* differs from *B. gigantea* (cf. pp. 477–492, in particular pp. 491) in the following features which cannot possibly be suspected to be characters of immaturity: 1) a somewhat longer and narrower shape of the head-shield; 2) a much stronger downward curvature of the preorbital division of the head-shield both rostrally and laterally; 3) the much stronger convexity of the rostral margin of the head-shield; 4) the relatively greater length of the centro-nuchal plate; 5) the condition that the centro-nuchal plate narrows fairly much backwards and that presumably in most cases it is considerably narrower across its postero-lateral than across its lateral corners; 6) a longer and narrower shape of the paranuchal-marginal plate; 7) a considerably smaller height of the dorsal wall of the trunk-armour; 8) a greater relative length of the anterior margin of the anterior median dorsal plate; 9) the condition that the anterior end of the anterior median dorsal plate is often or, perhaps normally, considerably broader than the posterior part of the centro-nuchal plate underneath and immediately in front of it; 10) the presumably shorter and higher lateral laminae of the anterior dorso-lateral and mixi-

lateral plates; and finally, 11) in medium-sized and large individuals the usually advanced subdivision of the ornament into pieces of ridges and tubercles and the comparatively frequent absence of anastomoses between the ridges and their derivates.

The characters nos. 1–11 just enumerated show that *B. alvesiensis* cannot be so very closely akin to *B. gigantea*. It seems also to differ from all other *Bothriolepis*-species known in any detail. The question whether it is identical with *B. major* must be left unanswered for the time being.

The mixilateral plate described with doubt under *B. alvesiensis* differs from the typical mixilateral plate of this species in its greater height and in the much more obtuse angle between its dorsal and lateral laminae. As pointed out, it cannot at present be decided whether these differences are original or whether they are secondary and due to deformations after the embedding in the rock. If the former one of these two alternatives turns out to be true the plate cannot belong either to *B. alvesiensis* or to *B. gigantea*, but must represent a third species.

Localities and geological horizon. – All the specimens here dealt with are from the Elgin district, Scotland. The two specimens Nos. 1 and 2 are both from Alves, whereas specimen No. 3 is from Rosebrae Quarry near Elgin. The specimens Nos. 4, 5 and specimen No. 6 (the mixilateral plate referred with doubt to this species) are also from near Elgin, but no further information concerning their exact find-localities could be obtained during the present political conditions. – All the specimens here treated come from the Upper Old Red Sandstone.

15. **Bothriolepis gigantea** Traquair.

(Text-figs. 24E, 44C, 252–257).

1845. *Bothriolepis ornata*, Agassiz, p. 149; pl. 29, figs. 3–5 (in part).
1888. *Bothriolepis major*, Traquair (1888a), p. 510 (in part).
1888. *Bothriolepis gigantea*, Traquair (1888a), p. 510.
1888. *Bothriolepis major*, Traquair (1888b), p. 501 (in part).
1888. *Bothriolepis gigantea*, Traquair (1888b), pp. 501, 504; pl. 18, fig. 3.
1891. *Bothriolepis major*, Woodward (1891b), pp. 226–227 (not pl. 6, fig. 5 and presumably none of the specimens from Scaat Craig).
1892. *Bothriolepis major*, Traquair, pp. 285–286 (in part).
1895. *Bothriolepis major*, Traquair, pp. 265–266 (in part).
1894–1906. *Bothriolepis major*, Traquair, pp. 114–119; pl. 23, figs. 1, 2, 3?, 4, 6?, 7 (not fig. 5); pl. 24; pl. 25, figs. 1, 2, 4?, 5, 6?; pl. 26, figs. 2, 3 (in part).
1931. *Bothriolepis major*, Gross, p. 59 (in part).
1931. *Bothriolepis major*, Stensiö, p. 105 (in part).
1932. *Bothriolepis major*, Gross (1932b), pp. 25–26 (in part).

B. gigantea was erected by Traquair in 1888 (1888a, p. 510; 1888b, p. 501, pl. 18, fig. 3) for certain large, somewhat coarsely ornamented *Bothriolepis*-remains earlier referred to *B. ornata* Agassiz (Agassiz 1845, pl. 29, figs. 3–5). Four years later, however, it was withdrawn by Traquair himself (1892, pp. 285–286), who then united it with *B. major* (Agassiz),

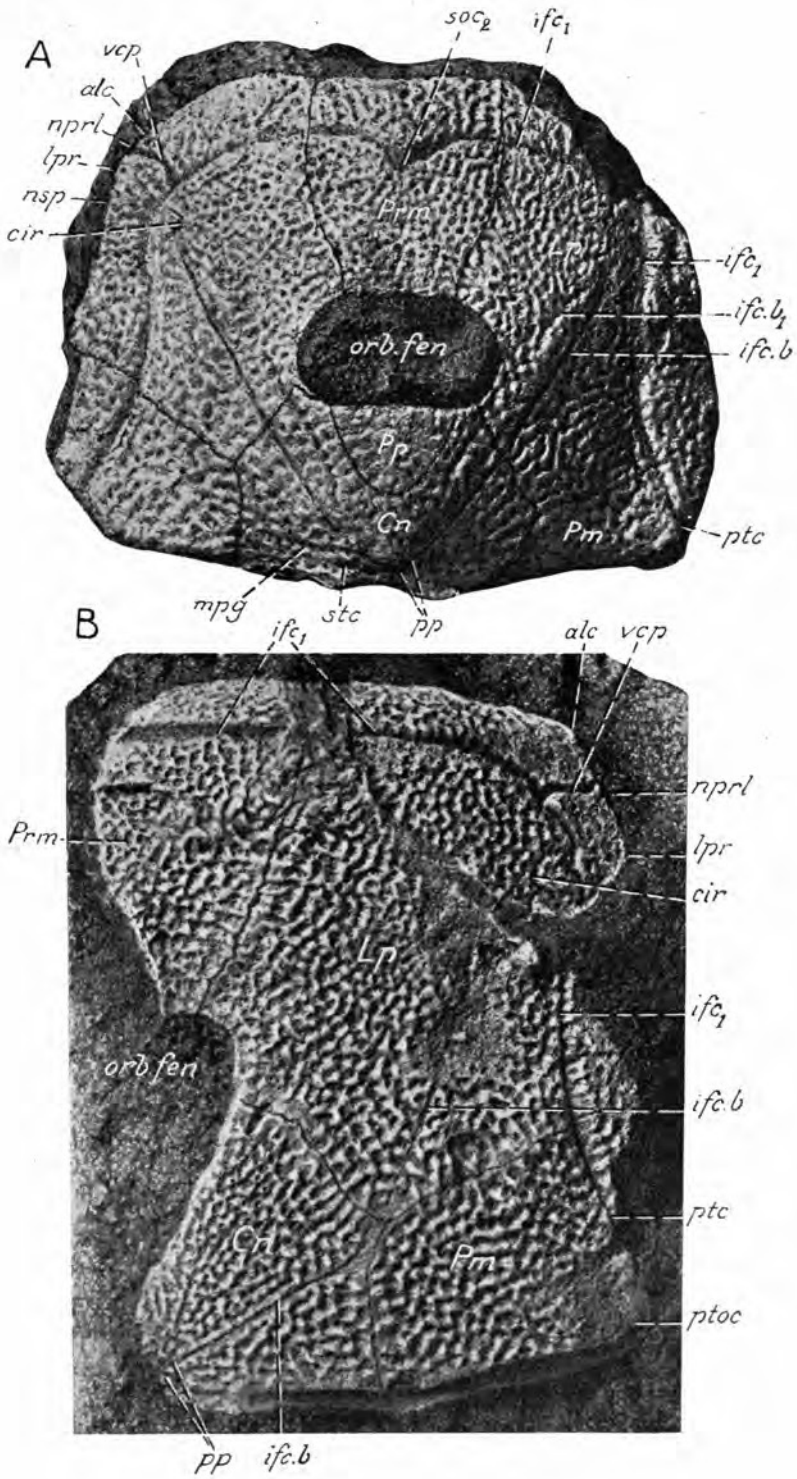
maintaining that he was unable to discover any characters distinguishing it with certainty from the latter species. This union of *B. gigantea* Traquair with *B. major* (Agassiz) was accepted by all subsequent writers. A critical examination of plaster casts of Elgin material presented to the Stockholm Museum by Dr. A. C. Stephens of Edinburgh gives as a result, however, that the Elgin material includes a number of remains which cannot belong to *B. alvesiensis* and which for reasons given above (pp. 465–467) cannot either, at least for the time being, be referred to *B. major*. For these remains I have here provisionally reintroduced the species name of *B. gigantea* Traquair.

Diagnosis. – Species attaining a considerable size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) exceeding 30 cm, and sometimes probably amounting to about 40 cm. Head-shield broad in proportion to its length, its breadth : length ratio often about 150–160. Its preorbital division comparatively flat both in rostro-caudal and transverse directions. Margins of head-shield developed as follows: rostral margin nearly as long as posterior margin and only slightly convex; lateral margins converging somewhat forwards and slightly shorter than the distance between the lateral corners of the centro-nuchal plate; obstantic margin of either side presumably rather short. Premedian plate in medium-sized and large individuals probably about as broad as long, or even somewhat narrower than long. This plate with a short nasal process and a shallow nasal notch. Postpineal plate with a somewhat convex anterior (orbital) margin. Centro-nuchal plate still in medium-sized and large individuals comparatively short and broad, its length : breadth ratio amounting only to about 65–75. The plate of a fairly uniform width in its posterior part, or at any event narrowing only slightly backwards. Lateral division of paranuchal-marginal plate narrow. Trunk-armour with a high dorsal wall and low lateral walls. Dorsal wall somewhat flattened or rounded in its median most elevated part, otherwise sloping fairly steeply laterally and meeting the lateral wall of either side at an angle of about 120–130°. Tergal angle in anterior part of middle third of anterior median dorsal plate. Median dorsal ridge in large individuals sometimes highly reduced and to a large extent completely absent. The median dorsal part of the crista transversalis interna posterior situated on the posterior median dorsal plate fairly low and weakly developed. Postlevator thickening also fairly low. Posterior ventral pit situated fairly far forwards. Ventral tuberosity present, but weakly developed. Anterior median dorsal plate broad, its breadth:length ratio in large individuals about 95–100; its anterior margin fairly short, about as long as, or slightly longer than, the posterior margin and at least sometimes a little concave. Posterior median dorsal plate broad anteriorly and in medium-sized and large individuals slightly broader than long; its posterior

median corner slightly developed. Lateral lamina of anterior dorso-lateral plate long and low. Lateral lamina of mixilateral plate about four times as long as high. Pectoral fin slender. Proximal segment long in proportion to its breadt, in fairly large individuals still somewhat more than four times as long as broad. Spines of pectoral fin conceivably in a reduced condition. Ventral central plate about three times as long as broad. Ornament in medium-sized and large individuals retaining much of its immature fine-meshed reticular character; ridges to some extent without anastomoses on head-shield and dorsal parts of trunk-armour, but with clear tubercular thickenings and elevations at their points of anastomoses. These tubercular formations strongly developed in certain cases on head-shield and on anterior parts of the ventral wall of trunk-armour, and in these cases often also more or less stellate at their bases.

Material. – The following material is here provisionally referred to *B. gigantea:* 1) a somewhat complete head-shield, figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 1 (text-fig. 252A in the present work); 2) a deficient right half of a large head-shiedl, not previously described (text-figs. 252B in the present work); 3) a deficient right lateral plate, figured by Agassiz in 1845 in pl. 29, fig. 1 (text-fig. 253D); 4) an antero-lateral part of a left lateral plate, figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 4 (text-fig. 253C); 5) a large centro-nuchal plate, figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 2; 6) a deficient large premedian plate, not previously described (text-fig. 253B); 7); 8) two anterior median dorsal plates, figured by Traquair in 1904 (1894–1906) in pl. 24, figs. 1, 2 (text-fig. 254A, B); 9) an anterior median dorsal plate in ventral aspect, not previously described (text-fig. 255); 10), 11) plates of the trunk-armour, figured by Agassiz in 1845 in pl. 29, figs. 4, 5; 12), 13) two posterior median dorsal plates, figured by Traquair in 1904 (1894–1906) in pl. 25, figs. 1, 2; 14) a left anterior dorso-lateral plate, figured by Traquair in 1904 (1894–1906) in pl. 24, figs. 3, 4; 15) a deficient left mixilateral plate, not previously described (text-fig. 256); 16) an antero-lateral part of a ventral lamina of a right anterior ventro-lateral plate, reproduced by Traquair in 1904 (1894–1906) in pl. 23, fig. 7; 17) a considerable part of the ventral lamina of a left anterior ventro-lateral plate with a left pectoral fin attached, figured by Traquair in 1904 (1894–1906) in pl. 25, fig. 5 (text-fig. 257); 18) a median ventral plate, figured by Traquair in 1904 (1894–1906) in pl. 24, fig. 5; and 19), 20) two ventral central plates 1, figured by Traquair in 1904 (1894–1906) in pl. 26, figs. 2 and 3.

The following specimens are included with doubt in *B. gigantea*: 21) a detached premedian plate, figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 3; 22), 23) a right anterior ventro-lateral plate and a left posterior ventro-lateral plate, figured by Traquair in 1904 (1894–1906) in pl. 25, figs.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4 and 6 respectively; 24) a centro-nuchal plate, not previously described (text-fig. 253E); and finally, 25) a small anterior median dorsal plate, figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 6.

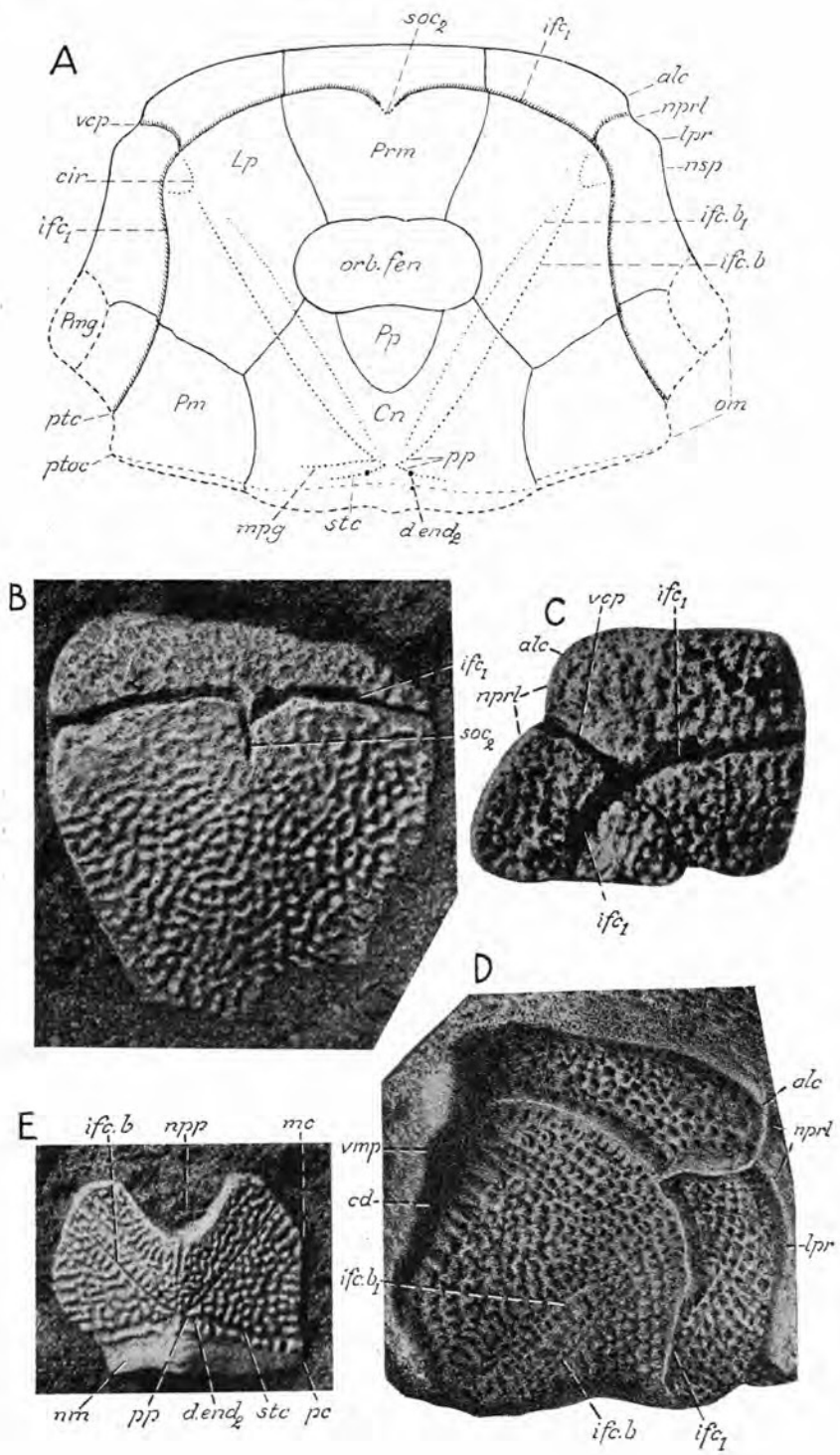
As a lectotype of the species is chosen the head-shield figured by Traquair in 1904 (1894–1906) in pl. 23, fig. 1 (specimen No. 1).

Description. – *B. gigantea* is one of the largest *Bothriolepis*-species known at present. However, it did not attain the same maximal size as *B. maxima* (cf. p. 436 above). The dorsal length of its armour (length of head-shield + dorsal length of trunk-armour) often exceeded 30 cm and may probably sometimes have amounted to as much as about 40 cm. A fairly large head-shield (specimen No. 2) is about 10 cm long; a smaller head-shield (the lectotype, specimen No. 1) has a length of about 7 cm. The largest detached premedian plate known (specimen No. 6) is about 6 cm long and must be from a head-shield the length of which may be estimated at about 12–13 cm. The largest anterior median dorsal plates (specimens Nos. 7, 8) are 15,7 and 16,8 cm long respectively. And finally, the largest mixilateral plate available (specimen no. 15) was in all probability about 17 cm long.

Head-shield.

The head-shield (text-figs. 252, 253A) is deficiently preserved, but it is obvious that it was strikingly broad in proportion to its length, broader than in most other *Bothriolepis*-species. Its breadth : length ratio may be estimated at about 150–160. The head-shield chosen as a lectotype (text-fig. 252A), which is only slightly dorso-ventrally compressed, is strikingly little curved downwards in front of the orbital fenestra, above all in a rostro-caudal direction. This condition probably involves that the head-shield normally was comparatively flat in its preorbital division, flatter than in *B. canadensis* (cf. text-figs. 4, 38, 40B, 114) and *B. alvesiensis* (cf. p. 469 above). The correctness of this opinion is supported by the fact that both in the lectotype and in another head-shield which is completely flat (text-fig. 252B) the premedian plate retains its natural sutural connection with the lateral plates of both sides, whereas in flattened head-shields of *B. ca-*

Text-fig. 252. *Bothriolepis gigantea*. *A*, deficient head-shield of a medium-sized individual. Dorsal aspect. Plaster cast of lectotype (specimen No. 1). From Traquair 1904 (1894–1906). Nat. size. *B*, deficient right half of a flattened head-shield. Dorsal aspect. Plaster cast presented to the Stockholm Museum by Dr. A. C. Stephen of Edinburgh. Nat. size. *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pp*, post-pineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semi-circular pit-line groove; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc. b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull roof; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb. fen*, orbital fenestra; *pp*, posterior pit-line groove of skull-roof; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soc*$_2$, anterior median section of supraorbital sensory canal grooves, the anterior median pit-line groove; *stc*, supratemporal pit-line groove. *vcp*, vertical pit-line groove of cheek.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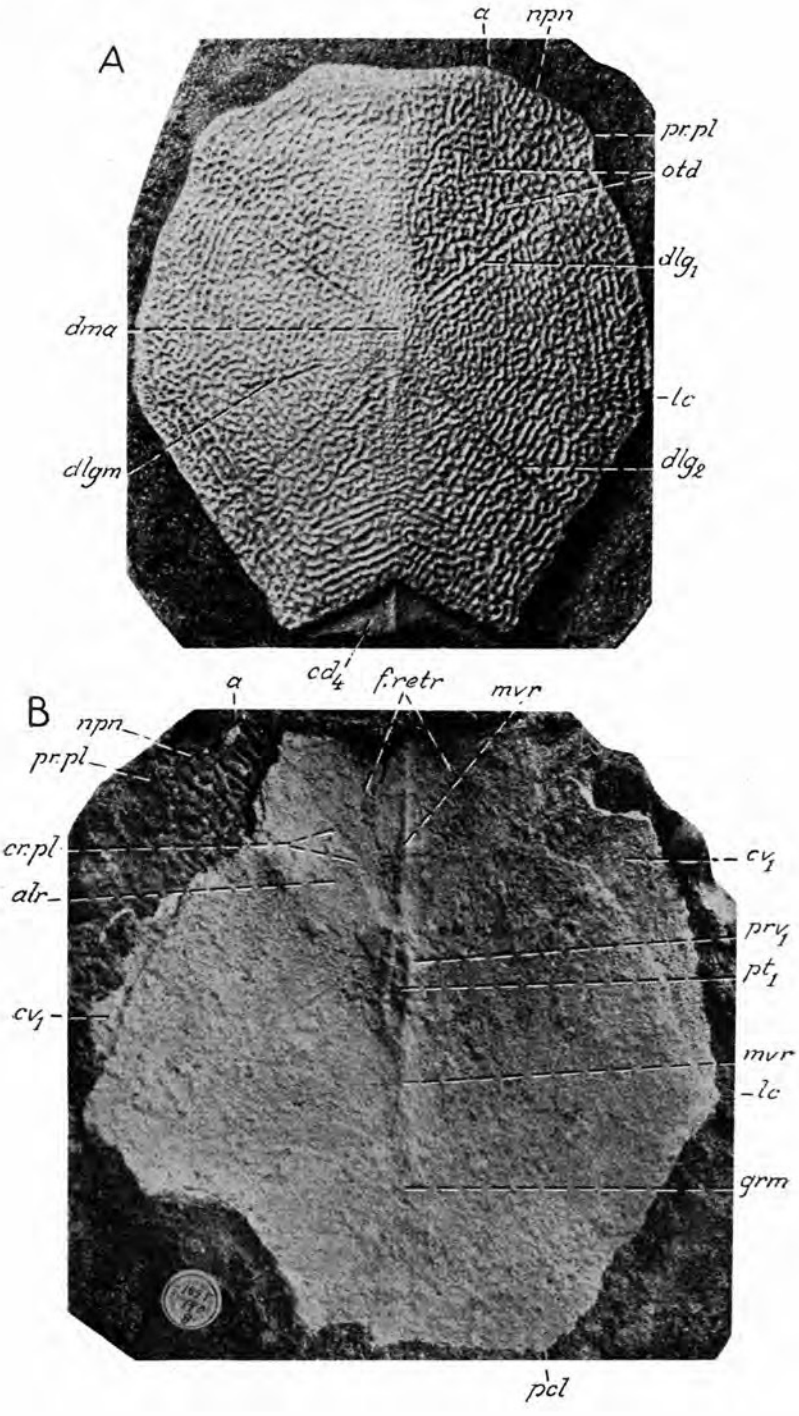
nadensis it has generally become more or less detached from the lateral plates (cf. text-figs. 10, 12, 76, 77B, C, 88, 90, 91, 95–97, 101, 109, 116, 117, 127, 128, 131, 132, 134, 140, 147, 148, 154, 155, 157–159). As to the comparatively slight downward arching of its preorbital division the head-shield seems thus to have been about as in *B. cellulosa*, *B. panderi*, *B. maxima* and *B. groenlandica*. The shield narrows forwards in front of the postero-lateral (preobstantic) corners, though probably not as much as in most other species. The orbital fenestra is relatively narrow in proportion to the breadth of the shield. The rostral margin is about equally long as, or a little shorter than, the posterior margin and in addition is very slightly convex. The antero-lateral corner (*alc*, text-figs. 252A, 253A, C, D), is usually very distinctly developed. The lateral margin of either side is slightly shorter than the distance between the lateral corners of the centro-nuchal plate. The supraspiracular process (*lpr*, text-figs. 252B, 253A, C, D) is situated opposite the posterior part, or posterior half, of the premedian plate, and lies thus further anteriorly than in *B. alvesiensis*. The obstantic margin of either side (*om*, text-fig. 253A) is imperfectly preserved, but cannot possibly have been particularly long, and was probably a little longer and more laterally directed than the corresponding margin in *B. alvesiensis*. As far as may be judged, it ended anteriorly somewhat far behind a transverse plane through the posterior boundary of the orbital fenestra. Finally, the posterior margin is imperfectly known, but judging from specimens Nos. 5 (Traquair 1894–1906, pl. 23, fig. 2) and 24 (text-fig. 253E in the present work) its median part would be somewhat concave with a slightly developed median process.

The premedian plate (*Prm*, text-figs. 252, 253A, B) is imperfectly known, being completely preserved only in the lectotype (specimen No. 1). In that specimen, and in specimen No. 6 (text-fig. 253B), it is about equally

Text-fig. 253. *Bothriolepis gigantea*. *A*, attempted restoration of the head-shield in dorsal aspect. The restoration based on the lectotype. *B*, deficient large premedian plate in dorsal aspect. Plaster cast presented to the Stockholm Museum by Dr. A. C. Stephen of Edinburgh. *C*, antero-lateral part of a left lateral plate. Dorsal aspect. From Traquair 1904 (1894–1906). *D*, part of a right lateral plate in dorsal aspect. From Agassiz 1845. *E*, centro-nuchal plate referred to the species with doubt. Dorsal aspect. Plaster cast presented to the Stockholm Museum by Dr. A. C. Stephen. All figures somewhat diminished.

Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of lateral plate and of head-shield as a whole; *cir*, semicircular pit-line groove; *cd*, area overlapped by premedian plate; *d. end*$_2$, external opening of canal for endolymphatic duct; *ifc*, upper infraorbital sensory canal groove; *ifc.b*, posterior oblique cephalic pit-line groove; *ifc. b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mc*, lateral corner of centro-nuchal plate; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *npp*, postpineal notch; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb. fen*, orbital fenestra; *om*, obstantic margin; *pc*, postero-lateral corner of centro-nuchal plate; *pp*, posterior pit-line groove of skull-roof; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soc*$_2$, anterior median section of supraorbital sensory canal grooves, the anterior median pit-line groove; *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek; *vmp*, ventral medial process of lateral plate.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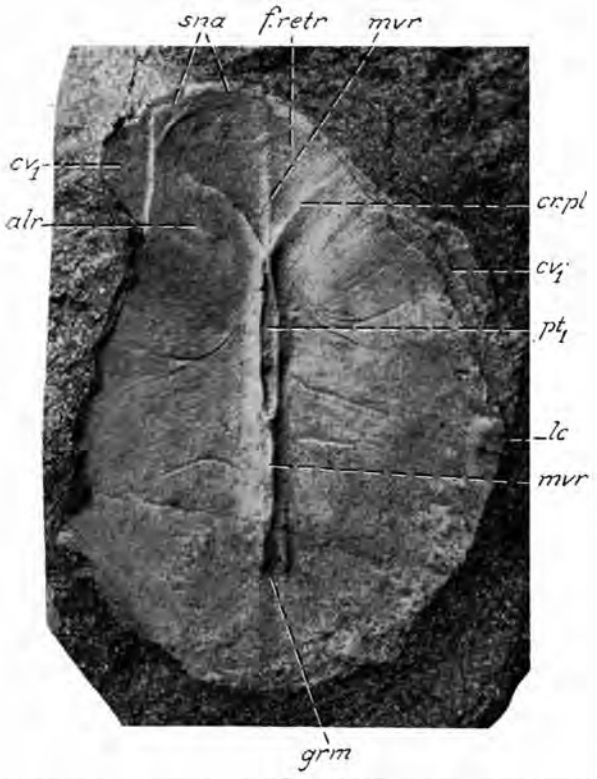
broad as long, whereas in specimen No. 2 (text-fig. 252B) it seems to have been a little broader than long. Although it may thus vary considerably as to its breadth and length it is likely, however, that in medium-sized and large individuals it was mostly about as broad as long or slightly broader than long. The posterior dorsal margin of the plate was conceivably provided with a short nasal process and a shallow nasal notch. The lateral plate (*Lp*, text-figs. 24E, 252, 253A, C, D) is broad and in its general shape resembles mostly the corresponding plate in *B. maxima* and *B. groenlandica* (cf. text-figs. 24D, F, 233A, 234A, 277). The rostral and pineal plates have not been found preserved. The postpineal plate (*Pp*, text-figs. 252A, 253A) is of the normal type and as normally has also a somewhat convex anterior (orbital) margin. In the configuration of its anterior margin it thus differs clearly from the corresponding plate in *B. maxima* and *B. groenlandica* (cf. text-figs. 233A, 235C–F, 273! 274). The centro-nuchal plate (*Cn*, text-figs. 252, 253A, E) is of a shorter and broader type than in *B. alvesiensis*. Its length : breadth ratio ranges between 65–75 and is thus approximately as in *B. maxima*. Otherwise this plate presents the following characteristic features: it narrows only slightly, or not all, backwards, but is about equally broad across its lateral and postero-lateral corners; the latter corners are slightly produced; the anterior division of the lateral margin in medium-sized and large individuals is about equally long as, or longer than, the posterior division of the same margin; and, finally, the last-mentioned division of the lateral margin is normally slightly concave and taken as a whole directed practically straight laterally. The posterior margin of the plate in small individuals (text-fig. 253E) is fundamentally as in small individuals of *B. canadensis* (cf. text-fig. 93A–E), *B. cellulosa* (cf. text-fig. 222A) and *B. groenlandica* (cf. text-fig. 278), but the median angle is smaller. On the other hand, in medium-sized and large individuals this margin presents only a slightly developed median process and in its general configuration is much as in individuals of the corresponding stages of growth of *B. cellulosa* (cf. text-fig. 222B–K) and *B. maxima* (cf. text-figs. 236A, B, 234A). The paranuchal-marginal plate (*Pm*, text-figs. 252, 256A) is broader and shorter than in *F. alvesiensis* and in its general shape resembles mostly the corresponding plate in *B. canadensis* and *B. cellulosa*. The lateral division of

Text-fig. 254. *Bothriolepis gigantea*. *A*, large anterior median dorsal plate in dorsal aspect. *B*, large anterior median dorsal plate in ventral aspect. Both figures from Traquair 1904 (1894–1906). × $^1/_2$.

a, antero-lateral corner; *alr*, postlevator thickening; *cr. pl*, postlevator crista; cd_4, area overlapped by posterior median dorsal plate; cv_1, area overlapping anterior dorso-lateral plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dlgm*, middle abdominal pit-line groove; *dma*, tergal angle; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *otd*, oblique transverse depression above postlevator thickening (*alr*); *pcl*, postero-lateral corner; *pr. pl*, external postlevator process; prv_1, anterior ventral process; pt_1, anterior ventral pit.



Text-fig. 255. *Bothriolepis gigantea*. Deficient large anterior median dorsal plate in ventral aspect. Plaster cast presented to the Stockholm Museum by Dr. A. C. Stephen of Edinburgh. × 1/2.
alr, postlevator thickening; *cr. pl*, postlevator crista; cv_1, area overlapping the anterior dorso-lateral plate; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; pt_1, anterior ventral pit; *sna*, supranuchal area.

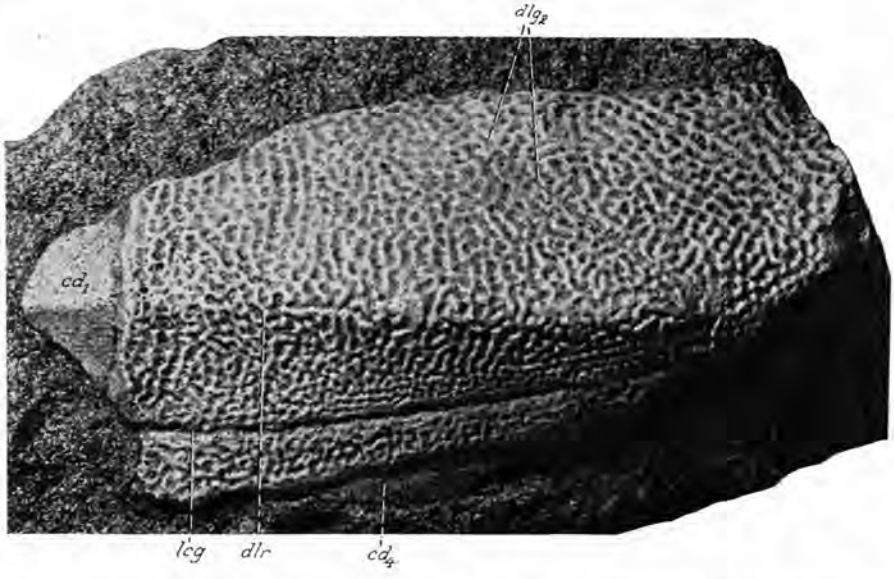
the plate in medium-sized and large individuals is narrow, its breadth amounting only to one half, or less than one half, of the breadth of the medial division. The postmarginal plate (text-fig. 253A) is unknown, but, judging from the curvature of the posterior part of the lateral margin of the lateral plate, it seems to have been of a narrow type.

Trunk-armour.

In general shape the trunk-armour was somewhat as in *B. maxima* and *B. groenlandica* (cf. text-figs. 243H, J, 283B, 287B). The dorsal wall was thus high and the lateral walls relatively low. The dorsal wall meets the lateral wall of either side at an angle of about 120–130°. On account of the relatively flat shape of the anterior and posterior median dorsal plates it must, quite as in *B. maxima* and *B. groenlandica* (cf. text-fig. 283B), have been flatter in its median mot elevated part than further laterally, where it sloped fairly steeply towards the dorso-lateral ridge of eitehr side. In contra-

distinction to what is the case in *B. obesa* and *B. cristata* it was thus not of a decided roof-like type. The tergal angle (*dma*, text-fig. 254A) lies in the anterior part of the middle third of the anterior median dorsal plate. The oblique transverse depression (*otd*) may persist to some slight extent even in large individuals (text-fig. 254A). As in most other species, the dorsal median ridge is much reduced in large individuals. The dorso-lateral ridge (*dlr*, text-fig. 256) is not particularly strongly marked, and, at least sometimes, the ventro-lateral ridge is rounded off and fairly obscure. The crista transversalis interna posterior is low and slightly pronounced dorsally in its dorsal median part situated on the posterior median dorsal plate (Traquair 1904, pl. 25, fig. 2), being there nearest as in *B. maxima* (text-figs. 238B, 240). The postlevator thickening (*alr*, text-figs. 44C, 254B, 255) is also low, but decidedly more pronounced than in *B. maxima* (p. 449 above, and text-fig. 237A). The postlevator crest seems often to persist, but is not rarely low and little conspicuous (*cr.pl*, text-figs. 44C, 254B, 255). As normally in the genus, the ventral median ridge (*mvr*) and groove (*grm*) are well developed in medium-sized and large individuals. The anterior and posterior ventral processes (prv_1, prv_2) are present and so are also the anterior and posterior ventral pits (pt_1, pt_2). The posterior ventral process is longer than normally and, as in *B. maxima* (cf. text-fig. 240), the posterior ventral pit (pt_2) is situated further forwards, therefore, than in most other species of the genus (cf. text-fig. 47). The ventral tuberosity (*tb*) is much more weakly developed than in *B. canadensis* and *B. groenlandica*. Finally, it deserves to be mentioned that the supranuchal area (*sna*, text-fig. 255) is regularly present in large individuals.

The anterior median dorsal plate (text-figs. 44C, 254, 255) in large individuals has a breadth : length ratio of 95–100. Its anterior margin is unusually short, being either about equally long as, or slightly longer than, the posterior margin, a condition which indicates that it must have been of about the same breadth as the underlying part of the centro-nuchal plate. At any rate in large individuals it is clearly concave (text-figs. 44C, 254). The postnuchal notch (*npn*) is long and distinctly marked, and the external postlevator process (*pr. pl*) is well developed. The posterior margin of the plate in large individuals was probably almost, or entirely, devoid of a posterior median process. The area (cv_1) of the plate overlapping the anterior dorso-lateral plate is strikingly broad as far backwards as to the posterior margin of the postlevator thickening (*alr*). In several of its characters the anterior median dorsal plate is nearest suggestive of that in *B. maxima* (cf. text-fig. 238A). The posterior median dorsal plate is broad anteriorly and broadens also much backwards. At least in medium-sized and large individuals it is normally somewhat broader than long, with a breadth : length ratio of about 101–106. Its posterior corner is fairly well rounded off and slightly pronounced. The anterior dorso-lateral plate (Traquair



Text-fig. 256. *Bothriolepis gigantea*. Deficient left mixilateral plate in lateral aspect. Plaster cast presented to the Stockholm Museum by Dr. A. C. Stephen of Edinburgh. × 7/10.
cd_1, area overlapped by anterior dorso-lateral plate; cd_4, area overlapped by posterior ventro-lateral plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *lcg*, main lateral line groove.

1906, pl. 24, figs. 3, 4) is of a long and low shape similar to that in *B. maxima* (cf. text-fig. 238C) and *B. groenlandica* (cf. text-fig. 288). The lateral lamina is low in proportion to its length, but anything nearer concerning the proportions between its length and height cannot be made out on the basis of the material at present available to the writer. The mixilateral plate (text-fig. 256) is imperiectly preserved, but it is obvious that in its general shape it must have been somewhat as in *B. maxima* and *B. groenlandica* (cf. text-figs. 238F, G, 289). Its lateral lamina is about four times as long as high. The other plates of the trunk-armour referred to the species do not seem to show any characters of particular taxonomic importance. They will, therefore, not be dealt with here, but the reader is referred to the reproductions of them given by Traquair in 1904 (1894–1906, pl. 23, fig. 3; pl. 26, fig. 5; pl. 25, fig. 5). It deserves to be pointed out, however, that the median ventral plate probably was relatively large.

Pectoral fin.

The pectoral fin is of a slender shape. It is still imperfectly known, however, being represented only by an impression of the ventral side of a single deficient proximal segment (text-fig. 257), which is from a pretty large individual. This segment is about four and a half times as long as broad, and as to its length: bredth ratio it is thus approximately as the corresponding

segment in *B. maxima* and *B. groenlandica* (cf. text-figs. 243B–D, 293, 294). In contradistinction to what is the case in *B. maxima*, however, its ventromedial margin is well developed forming a distinct boundary between the medial and ventral faces of the segment. The medial spines of the segment are not preserved. No distinct lateral spines are to be seen, a condition which may probably indicate that the lateral spines were higly reduced and had become fused into a low lateral crest. There is thus reason to suspect that the lateral spines of the proximal segment were reducal and transformed to an extent similar to that in *B. maxima* (cf. pp. 457, and text-figs. 243B–D, 246).

The ventral central plate 1 (Cv_1, text-fig. 257) is about three times as long as broad. In contrast to what is the case in *B. maxima* the medial lamina is well developed throughout the total extent of the plate. The ventral central plate 2 (Cv_2, text-fig. 257) and the lateral marginal plate 2 (Ml_2) are both of a long narrow shape, about as in *B. maxima* and *B. groenlandica*.



Text-fig. 257. *Bothriolepis gigantea*. Somewhat deficient proximal segment of a left pectoral fin of a large individual. Ventral aspect. Plaster cast presented to the Stockholm Museum by Dr. A. C. Stephens of Edinburgh. A plaster cast of the same specimen also figured by Traquair in 1904 (1894–1906) in pl. 25, fig. 5. × 5/6.
Avl, anterior ventro-lateral plate; Cv_1, Cv_2, ventral central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2.

Ornament.

The ornament (text-figs. 252, 253B–D, 254A, 256, 257) in medium-sized and large individuals is in the whole fine-meshed reticular and thus retains much of the original immature character. It is clearly seen, however, that on the head-shield and particularly on the dorsal parts of the trunk-armour the ridges fail to anastomore in places. Tubercular thickenings and elevations are found at the points of union of the ridges and sometimes in medium-sized and large individuals are strongly developed particularly on the head-shield (text-figs. 252B, 253B, C) and on the anterior parts of the ventral wall of the trunk-armour (Traquair 1894–1906, pl. 23, fig. 7). As nor-

mally in the genus, the ornament in medium-sized and large individuals shows a concentric and radiating disposition. The extent of the ornament on the dorsal side of the proximal fin segment is unknown; the medial face of the segment is conceivably without ornament; finally, the ventral face of the segment is sometimes ornamented on its antero-lateral part only (text-fig. 257), whereas in other cases it may be ornamented to a much greater extent (Traquair 1894–1906, pl. 26, fig. 2).

Sensory canal sytem.

The sensory canal system presents certain characters of interest. The anterior oblique cephalic pit-line groove (*ifc.* b_1) persists in the lectotype (text-figs. 252A, 253A). The lectotype shows also vestiges of both the middle pit-line groove of the skull-roof and of the supratemporal pit-line groove. On one large anterior median dorsal plate we find not only well developed anterior and posterior oblique abdominal pit-line grooves (dlg_1, dlg_2, text-fig. 254A), but in addition, between them, a third paired middle abdominal pit-line groove (*dlgm*, text-fig. 254A).

Remarks on the specimens referred with doubt to *B. gigantea.*

After the above description some remarks should also be given on the specimens placed with doubt under *B gigantea*, thus the specimens Nos. 21–25 referred to above.

The specimen No. 21, which is a detached premedian plate (Traquair 1894–1906, pl. 23, fig. 3), is of a considerably smaller individual than the plate shown in text-fig. 253B. The condition that in spite of that it is considerably narrower than long renders it doubtfull whether it actually belongs to *B. gigantea.*

The specimen No. 24 (text-fig. 253E), a detached comparatively small centro-nuchal plate, agrees in shape fairly well with the corresponding plate in *B. gigantea.* It differs, however, considerably from that plate by its ornament, which is made up entirely of tubercles and short ridges with very few anastomoses. Its ornament is, therefore, clearly in a considerably more advanced stage of subdivision than what is normally the case in *B. gigantea.*

The small anterior median dorsal plate here referred to as specimen No. 25 (Traquair 1894–1906, pl. 23, fig. 6) might, if we were to judge only from its shape, be considered to be of a somewhat young individual of *B. gigantea,* but the fairly advanced stage of transformation in which its ornament is found renders it doubtfull whether this actually is so.

The comparatively small, right anterior ventro-lateral plate in this description denoted as specimen No. 22 (Traquair 1894–1906, pl. 25, fig. 4) may very well belong to *B. gigantea.* The ornament of the ventral lamina, however, is clearly coarser than what seems usually to be the case on the ventral wall of the trunk-armour in this species.

Finally, the left posterior ventro-lateral plate referred to as specimen No. 23 (Traquair 1894–1906, pl. 25, fig. 6) and the centro-nuchal in specimen No. 24, have an ornament in a considerably further advanced stage of subdivision than what seems normally to be the case in *B. gigantea*, their ornament at least largely consisting of short ridges and tubercles practically without anastomoses.

Remarks. – *B. gigantea* has hitherto been confounded with *B. alvesiensis* and *B. major*, the latter of which, as we have seen, at present is an undefinable species.

B. gigantea differs from *B. alvesiensis* (cf. pp. 476–477) in the following features which cannot possibly be considered as characters of maturity: 1) a shorter and broader shape of the head-shield; 2) a flatter shape of the preorbital division of the head-shield; 3) a much slighter convexity of the rostral margin of the head-shield; 4) a relatively small length and great breadth of the centro-nuchal plate; 5) the fact that the centro-nuchal plate decreases only slightly in breadth backwards behind its lateral corners; 6) a broader and shorter shape of the paranuchal-marginal plate; 7) a considerably greater height of the dorsal wall of the trunk-armour; 8) a smaller relative length of the anterior margin of the anterior median dorsal plate; 9) the condition that the anterior end of the anterior median dorsal plate seems normally to be about equally broad as the posterior part of the centro-nuchal plate underneath and immediately in front of it; 10) the fact that the lateral laminae of the anterior dorso-lateral and mixilateral plates are low and long; and finally 11) the persistance in medium-sized and large individuals of an on the whole reticular type of ornament.

The differences in all these characters show that *B. gigantea* and *B. alvesiensis* cannot be closely akin to one another.

In several of its characters *B. gigantea* resembles clearly *B. maxima*, to which it seems to be closely related. To some extent it is also suggestive of *B. groenlandica* to which, however, it seems to be much less akin than to *B. maxima*.

The specimens referred with doubt to *B. gigantea* may perhaps belong to it, but it is also not impossible that all, or some, of them may be either of *B. alvesiensis* or of some other species.

On account of its high and short lateral lamina the left mixilateral plate figured by Traquair in 1904 (1894–1906) in pl. 25, fig. 3 cannot possibly belong to *B. gigantea*. This plate must, therefore, be either of *B. alvesiensis* or of some other species.

Traquair referred to *B. major* also several *Bothriolepis*-remains from Scaat Craig, inter alia a proximal piece of a proximal segment of a pectoral fin reproduced by him in 1904 (1894–1906) in text-fig. 60. However, it is likely that these remains do not belong to *B. gigantea*, but to some other large *Bothriolepis*-species. It is possible that they may be referrible to the

same species as the large centro-nuchal plate reproduced in text-fig. 258 (cf. pp. 499, 513 below).

Localities and geological horizon. – All the specimens here referred to *B. gigantea* are from the Elgin district. According to statements given by Traquair (in the explanation of the plates in his monograph) they come from the following localities: Newton Quarry and Rocky Park at Alves and Whitemere near Forres. The deposits in which they occur belong to the Upper Old Red Sandstone.

16. **Bothriolepis obesa** Traquair.

(Text-fig. 259).

For list of synonyms see Gross 1932b, p. 26.

B. obesa was erected by Traquair in 1888 (1888a, p. 510) for specimens from Rule Water near Jedburgh, Roxburghshire, Scotland. In 1906 he published a full description of this species, placing to it also a number of specimens from Harelaw, near Chirnside, Berwickshire, Scotland (Traquair 1894–1906, pp. 120–122). Though, as we shall see, there is strong reason to suspect that the Jedburgh and Harelaw material belong to different species, *B. obesa* will nevertheless at present be retained with its previous conception.

Diagnosis. – The diagnosis which is here given of *B. obesa* is based on the Jedburgh material only and is, therefore, very incomplete. It is as follows. Species of fairly large size. Dorsal wall of trunk-armour presumably attaining a maximal length of about 17–19 cm. Trunk-armour short and high, with high dorsal and lateral walls. Dorsal wall meeting the lateral wall of either side at an angle of 120–130°. Tergal angle situated strikingly far backwards, not far in front of the middle of the anterior median dorsal plate. Dorsal median ridge presumably well marked even in large individuals. Postlevator thickening weakly developed and low. Postlevator crests of both sides uniting posteriorly with each other in front of anterior ventral process so as to separate this process from the levator fossa. Anterior ventral process strikingly broad, almost circular in horizontal section. Ventral median ridge absent for a considerable distance behind the anterior ventral process. Anterior median dorsal plate in large individuals about as broad as long, very high, roof-like, and sloping steeply laterally on either side of the dorsal median ridge. Anterior dorso-lateral and mixilateral plates high and short. Dorsal lamina of mixilateral plate presumably about one and a half times, or between one and a half times and twice, as long as broad; lateral lamina of this plate conceivably about two and a half times as long as high. Lateral laminae of anterior and posterior ventro-lateral plates high in proportion to their length. Lateral lamina of the last-mentioned plate produced into a

high dorsal corner. Median ventral plate presumably small and much reduced. Ornament practically unknown.

Material. – The material referrible to *B. obesa* with full certainty comprises only the specimens from Jedburgh described and figured by Traquair in 1906 (1894–1906, pl. 27, figs. 1, 2 and pl. 28, figs. 1–5).

The material from Harelaw described and figured by Traquair in 1906 (1894–1906, pl. 27, figs. 3–6) is here referred to *B. obesa* provisionally and with much hesitation.

As a lectotype of *B. obesa* is herewith chosen the deficient anterior median dorsal plate figured by Traquair in 1906 (1894–1906) in pl. 27, fig. 2, that is also reproduced in text-fig. 259A in the present work. In 1932 Gross (1932b, p. 26) suggested as a lectotype of the species the deficient anterior median dorsal plate shown by Traquair in 1906 in pl. 27, fig. 3. Since the latter plate is not from the type-locality, but from Harelaw, and since in addition it may be suspected to turn out not to belong to *B. obesa*, it cannot, however, be retained as the lectotype of this species.

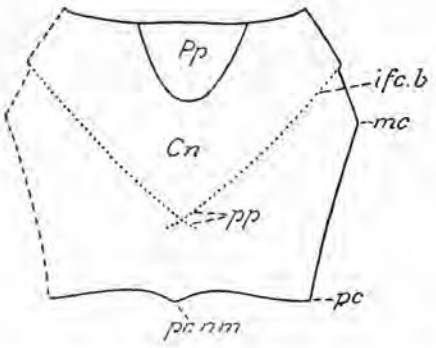
Description. – In the brief description here given of *B. obesa* the Jedburgh and Harelaw material will be dealt with separately.

The Jedburgh material.

This material includes only a number of detached plates of the trunk-armour.

The anterior median dorsal plate here chosen as a lectotype (text-fig. 259A) is about 11 cm long. The dorsal length of the trunk-armour from which this plate comes must thus be estimated at about 17–19 cm. As all the other plates known from Jedburgh are of a somewhat corresponding order of size it is obvious that *B. obesa* attained a fairly large size.

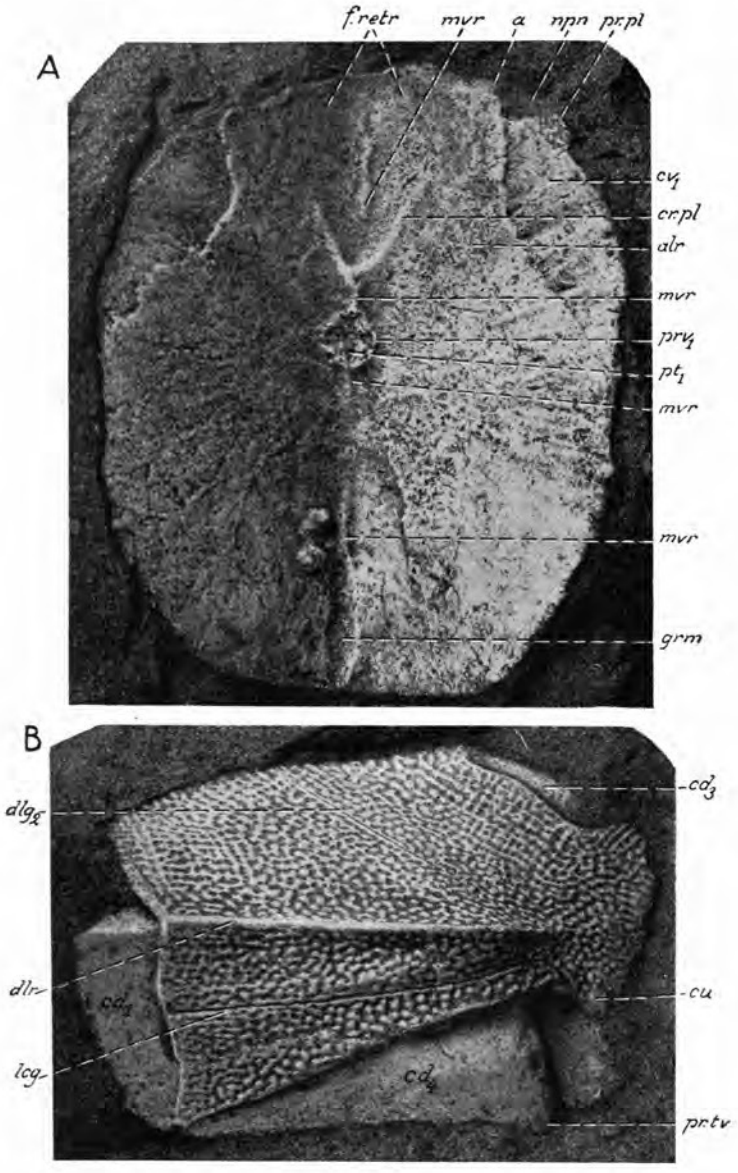
The trunk-armour seems to have been high and short. Not only its dorsal wall, but also its lateral walls were high. The dorsal wall must have met the lateral wall of either side at angle of 120–130°. In contradistinction to what is the case in such species as *B. maxima*, *B. gigantea* and *B. groenlandica* (cf. text-figs. 243H, J, 283B) the dorsal wall was not rounded off or somewhat flattened in its median most elevated part, but roof-like, its right and left halves forming a pronounced angle with one another at the median dorsal ridge. As the trunk-armour is represented only by detached plates no more exact statements as to its proportions can be given. The tergal angle is not shown itself, but it is clearly seen that it must have been situated further backwards than what is mostly the case in *Bothriolepis*. More precisely, it must have lain slightly in front of the middle of the anterior median dorsal plate. The dorsal median ridge must have been well-marked not only in small individuals, but also in large individuals. The postlevator thickening (*alr*, text-fig. 259A) is low and fairly obscure. The postlevator crest



Text-fig. 258. *Bothriolepis* sp. Restored outlines of a centro-nuchal plate with the postpineal plate attached. Rough sketch made after specimen No. P. 8278 in the British Museum. The specimen is from Scaat Craig. Nat. size.
Cn, centro-nuchal plate; *Pp*, postpineal plate; *ifc. b*, posterior oblique cephalic pit-line groove; *mc*, lateral corner of centro-nuchal plate; *pc*, postero-lateral corner of centro-nuchal plate; *pr. nm*, posterior median process; *pp*, posterior pit-line groove of the skull-roof.

(*cr. pl*, text-fig. 259A) persists and is comparatively well developed in its posterior parts. Very characteristic of it is that it meets and unites with the corresponding crest of the opposite side some distance in front of the anterior ventral process (prv_1), in consequence of which the levator fossa (*f.retr*) does not extend as far backwards as to the said process. The levator fossa is, therefore, shorter than what might be expected from the remote position of the tergal angle. The ventral median ridge (*mvr*, text-fig. 259A) is developed in a manner somewhat different from the normal one in the genus, being interrupted at two places so that it is represented by three pieces, an anterior, in the levator fossa, a middle, nearest in front of, and just behind, the anterior ventral process, and a posterior, developed on the posterior third of the anterior median dorsal plate and on the adjacent parts of the posterior median dorsal plate. The ventral median groove (*grm*, text-fig. 259A) begins far backwards on the anterior median dorsal plate and is thus short. Finally, the anterior ventral process is robust and as broad as nearly to be circular in outline when looked at from below.

The anterior median dorsal plate (text-fig. 259A; cf. also Traquair 1894–1906, pl. 27, figs. 1, 2) is of a peculiar shape and differs clearly from the corresponding plate in all other *Bothriolepis*-species known in any detail at present. It is much higher than the corresponding plate in such specimens as *B. maxima*, *B. gigantea* and *B. groenlandica*, in which, as we now know, the trunk-armour has also a high dorsal wall. Besides, in contrast to what is the case in those three species it is not flattened or rounded off in its median most elevated parts, but its right and left halves meet at a pronounced angle at the dorsal median ridge in a manner similar to that in *B. cristata*. The tergal angle, as has been pointed out, lies unusually far back-



Text-fig. 259. *A. Bothriolepis obesa*. Deficient anterior median dorsal plate in ventral a pect (lectotype, from Jedburgh). Photograph of a plaster cast presented to the Stockholm Museum by Dr. A. C. Stephens of Edinburgh. *B*, deficient mixilateral plate from Harelaw placed to *B. obesa* with hesitation. Photograph of a plaster cast presented to the Stockholm Museum by Dr. A. C. Stephens of Edinburgh. Both figures. × 4/5.
a, antero-lateral corner of anterior median dorsal plate; *alr*, postlevator thickening; cd_1, area overlapped by anterior dorso-lateral plate; cd_3, area overlapped by posterior median dorsal plate; cd_4, area overlapped by posterior ventro-lateral plate; *cr. pl*, postlevator crest; *cu*, postero-ventral ornamented corner; cv_1, area overlapping anterior dorso-lateral plate; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *f. retr*, levator fossa; *grm*, ventral median groove; *lcg*, main lateral line groove; *mvr*, ventral median ridge; *npn*, approximate position of postnuchal notch; *pr.pl*, external postlevator process; *pr.tv*, postero-ventral process of mixilateral plate; prv_1, anterior ventral process; pt_1, anterior ventral pit.

wards. And finally, as has also been mentioned, the structures on the lower side of the plate present also certain remarkable features not met with in other *Bothriolepis*-species. The plate is of a broad type, but is imperfect laterally, on account of which its breadth:length ratio could not be ascertained. The anterior margin is about equally long as the posterior margin and clearly convex. As normally in *Bothriolepis*, the lateral margin is provided with a postnuchal notch (*npn*) and an external postlevator process (*pr.pl*) both of which, however, are imperfectly preserved. The sutural connections of the plate with the anterior dorso-lateral and mixilateral plate seem to have been the normal ones characteristic of the genus *Bothriolepis*. The posterior median dorsal plate is unknown, but it must be assumed that it was of a high shape. The anterior dorso-lateral plate has also not been found preserved, but, as is clear from the development of the mixilateral plate, it must be assumed to have been short and high with an at least somewhat high lateral lamina. The mixilateral plate (Traquair 1894–1906, pl. 28, fig. 5) is of a short and high type. Its dorsal lamina seems to be about one and a half times or between one and a half times and twice as long as broad, whereas its lateral lamina presumably is about two and a half times as long as high. As in *B. groenlandica* (cf. text-fig. 289), the last-mentioned lamina is highest in its posterior part. The lateral lamina of the anterior ventro-lateral plate (Traquair 1894–1906, pl. 28, figs. 1, 2) is short and high; more precisely, it seems only to be slightly more than twice as long as high, and is thus probably higher even than in *B. canadensis*. The posterior ventro-lateral plate (Traquair 1894–1906, pl. 28, figs. 3, 4) is also characterized by the condition that its lateral lamina is high and short. In addition this lamina increases much in height backwards towards the dorsal corner, which is produced into a high dorsal process. The semilunar plate is not preserved. Everything seems to indicate, however, that it was about as normally in the genus. Finally, the median ventral plate is also not preserved; judging from the development of the medial margin of the ventral lamina of the anterior and posterior ventro-lateral plates, it was very small, much smaller than in anyone of the other *Bothriolepis*-species in which it is known in detail.

The ornament is in such an abraded condition that nothing can be said of its special features.

The Harelaw material.

This material consists of a piece of a large centro-nuchal plate with a postpineal plate attached to it, a fragmentary large anterior median dorsal plate, a somewhat deficient left mixilateral plate and a small fragment of a proximal segment of a pectoral fin.

The centro-nuchal plate is about 5,5 cm long, and is thus of about the same length as in medium-sized specimens of *B. maxima* (cf. p. 436 above). Under the supposition that the proportions of the different parts of the armour were somewhat as normally in the genus we should be concerned here with a centro-nuchal plate of an individual in which the dorsal length of the trunk-armour would have been about 35 cm. The other remains are all from somewhat smaller, but nevertheless fairly large individuals. As may thus be gathered from these statements, the Harelaw specimens are from a species which attained almost the same size as *B. gigantea*.

The large centro-nuchal plate already referred to (Traquair 1894–1906, pl. 27, fig. 6) is represented only by a right part, which suffices to show, however, that the plate in large individuals was long in proportion to its breadth, that its ornament extends far backwards behind the posterior pit-lines of the skull-roof and the supratemporal pit-line groove, and that its obtected nuchal area is narrow with presumably only a very slightly developed posterior median process. The postpineal plate (Traquair 1894–1906, pl. 27, fig. 6), which is found attached to the large centro-nuchal plate just described, is small and strikingly short for an individual of such a large size. In fact it is so short that its length is considerably less than a third of the total median length of the centro-nuchal plate. It is thus much shorter and smaller than normally in the genus. Finally, it deserves to be mentioned that it is characterized also by a strongly convex anterior margin, which with its median parts projects nearly as far forwards into the orbital fenestra as in small individuals of *B. canadensis* (cf. text-fig. 84A, B). A postpineal plate of a type somewhat similar to that here dealt with from Harelaw is known only in a *Bothriolepis*-specimen from Scaat Craig (text-fig. 258) to be described below (p. 513). This postpineal plate from Scaat Craig is also attached to a large relatively narrow centro-nuchal plate, probably reminding in shape of the one described just above from Harelaw.

The trunk-armour was presumably of a high shape similar to that in the Jedburgh-material. Both its dorsal and lateral walls are high, and the dorsal wall meets the lateral wall of either side at an angle of about 120–130°. The tergal angle is situated rather near the middle of the length of the anterior median dorsal plate (Traquair 1894–1906, pl. 27, fig. 3). The dorsal median ridge is well-marked even in large individuals, and characteristic of it is otherwise that in its foremost part, just behind the tergal angle, it rises into a low obtuse process. The oblique transverse depression (*otd*) above the postlevator thickening persist even in somewhat large individuals. The dorsolateral ridge (*dlr*, text-fig. 259B) is very strongly developed, forming a pronounced crest. The development of the structures on the lower side of the dorsal wall of the trunk-armour is unknown.

The anterior median dorsal plate (Traquair 1894–1906, pl. 27, fig. 3) seems to be of a high shape similar to that in the Jedburgh material,

its right and left halves meeting at a marked angle at the dorsal median ridge. It is also obvious that the plate in large individuals was about as broad as long. The margins of the plate are so deficiently preserved that nothing of importance can be made out concerning their configuration. The mixlateral plate (text-fig. 259B) is not compressed or otherwise affected by pressure and has therefore retained its original relief and proportions. It is clearly of a broad and high type, but is decidedly lower and longer, however, than the corresponding plate in the Jedburgh-material. More precisely, it was about one and a half times longer than broad, whereas the Jedburgh-plate is about equally long as broad. The dorsal and lateral laminae meet at an angle of 120–130°. The dorsal lamina seems to have been nearly two and a half times as long as broad, and is, therefore, clearly considerably longer than in the Jedburgh-material, where it is only about one and three fourths times as long as broad. The lateral lamina is a little more than two and a half times as long as high and is thus not much longer than in the Jedburgh-material. The postero-ventral ornamented corner (*cu*) is strikingly short. As may thus be gathered, the plate here under consideration differs in its proportions from the one in the Jedburgh material. The fact that taken as a whole it is longer and lower than the Jedburgh plate is certainly due to the condition that, as has been pointed out, it retains its original shape and relief, whereas the Jedburgh plate seems to be much flattened so that the angle between its two laminae is considerably larger than 130°. On the other hand, the differences between the two plates as to the proportions of their laminae cannot be explained in that way, but must involve that the laminae are actually different as to their length:breadth and length:height ratios respectively. No other plates of the trunk-armour than those just discussed are known from Harelaw. From the shape of the overlapped area (cd_4, text-fig. 259B) along the ventral margin of the mixilateral plate it is seen, however, that the lateral lamina of the posterior ventro-lateral plate did not increase as much in height backwards as in the Jedburgh material (cf. Traquair 1894–1906, pl. 28, fig. 4) and that in addition the dorsal corner of this lamina was much lower and less pronounced than in the Jedburgh material. – Accordingly both the mixilateral and posterior ventro-lateral plates are clearly somewhat different in the Harelaw and Jedburgh materials.

The piece of a proximal segment of a pectoral fin found associated with the Harelaw material (Traquair 1894–1906, pl. 27, fig. 5) is too defective to enable any conclusions as to possible distinctive features of the pectoral fins.

The ornament is well shown in several of the Harelaw specimens. On the centro-nuchal and postpineal plates and on the anterior median dorsal plate it is subdivided into tubercles and pieces of ridges which are vermiculating, whereas on the mixilateral plate (text-fig. 259B) it retains to a large extent

its immature reticular characters. On the last-mentioned plate it shows, however, clear tubercular swellings at the points of anastomoses of the ridges. The mostly narrow and weakly developed ridges are obviously in an advanced stage of reduction. As is thus evident, the ornament in medium-sized and large individuals tended to become transformed into short pieces of ridges and tubercles with no, or only few, anastomoses. In individuals of these two stages of growth the ridges and tubercles, as normally in the genus, are concentrically and radiatingly disposed. Very characteristic of the ridges and tubercles is that they are well defined and flat. On some of the plates they are even as flat as to appear almost as if somewhat abraded.

Remarks. – Already Traquair (1894–1906, p. 122) was aware of certain differences between the Jedburgh and Harelaw materials and he wrote, therefore about the comprehension of *B. obesa* as follows: "In looking back on the rather fragmentary material which I have brought together under the term *Bothriolepis obesa*, it is difficult to clear one's mind altogether of a doubt as to whether more than one species may not be here included. In other words, might not possibly the Harelaw specimens (Pl. XXVII, figs. 3–6) be different in that respect from the others which are from the neighbourhood of Jedburgh? It is, however, difficult to formulate unmistakable evidence of such a view, so I consider it better to keep the specimens together under one name until further material is forthcoming".

Traquair's suspicion that *B. obesa* as defined by him in 1906 possibly might include two different species has gained a further support by the analysis of the Jedburgh and Harelaw materials here undertaken. It is likely, therefore, that these materials represent two different deep-bodied species, resembling one another in certain general characters of the trunk-armour. If in the future the Jedburgh and Harelaw materials actually turn out to belong to two different species the species-name of *B. obesa* should be retained for the former material, whereas a new species name has to be introduced for the Harelaw material.

B. obesa and the possible new species here included in it are both characterized by the condition that their trunk-armour was short and high. In this respect they were probably somewhat as *B. turanica* (cf. Obrutschew 1929, text-fig. 1), which, judging from the shape of the mixilateral plate, seems also to have had a short and high trunk-armour. The centro-nuchal and postpineal plates in the Harelaw material are clearly suggestive of the corresponding plates of an undeterminable species from Scaat Craig (cf. text-fig. 258, and p. 513).

Localities and geological horizon. – As is already clear from the statements given above, the typical material of *B. obesa* is from Rule Water, Jedburgh, Roxburghshire, Scotland, whereas the other material comes from Harelaw, near Chirnside, in Berwickshire, Scotland. All the material is from the Upper Old Red Sandstone.

17. **Bothriolepis leptocheira** Traquair.

(Text-fig. 260).

For list of synonyms see Gross 1932b, pp. 26–27.

B. leptocheira was erected by Traquair in 1892 (p. 286) for *Bothriolepis*-remains from Heads of Ayr, Scotland. In the more complete description of this species given in 1906 (1894–1906, pp. 122–124) Traquair placed to it also a few remains from Siccar Point, Berwickshire.

Diagnosis. – Species of moderate size. Dorsal wall of trunk-armour conceivably attaining a length of 12–14 cm or thereabouts. Shape of head-shield unknown. Premedian plate broad, broader than long even in mature individuals; its posterior dorsal margin without nasal process and nasal notch. Shape of trunk-armour imperfectly known. The median most elevated part of its dorsal wall, however, fairly flat. Tergal angle situated about at the transition between the anterior and middle thirds of the anterior median dorsal plate. Crista transversalis interna posterior comparatively low and obscure in its median dorsal part situated on the posterior median dorsal plate. Ventral tuberosity slightly developed. Anterior median dorsal plate comparatively narrow, its breadth:length ratio in mature individuals only about 76; anterior margin convex; antero-lateral corner practically absent and anterior margin, therefore, passing over without definite boundary into the lateral margin of either side; posterior parts of anterior divisions of lateral margins in front of lateral corners directed almost straight laterally and thus almost parallel. Posterior median dorsal plate of a narrow type, narrower than long still in mature individuals, but presumably not particularly narrow in its anterior parts; its posterior corner somewhat rounded off. Ventral lamina of anterior ventro-lateral plate one and a half times, or between one and a half times and twice, as long as broad. Median ventral plate not particularly large. Pectoral fin slender; proximal segment in mature individuals more than five times, probably about five and a third times, as long as broad; distal segment also long and narrow. Ornament in mature individuals on the whole reticular, but its ridges subdivided into shorter pieces and tubercles on the anterior parts of the head-shield. Tubercular swellings and elevations often developed at the points of union of the ridges.

Material. – The material of *B. leptocheira* dealt with below includes only the specimens from Heads of Ayr available to Traquair in 1906 (1894–1906, pp. 122–124), which are as follows: 1) a single detached premedian plate, figured by Traquair (pl. 29, fig. 1); 2) an almost complete anterior median dorsal plate in ventral aspect, mentioned, but not figured by Traquair (text-fig. 260 in the present work); 3) a deficient posterior median dorsal plate and a left dorsal central plate 1, preserved on the same slab, figured by Traquair (pl. 29, fig. 4); 4) a right anterior ventro-lateral plate in ventral aspect with a deficient proximal segment of the pectoral fin, figured by Traquair (pl. 29, fig. 3); and 5), 6) fragments of a proximal and a distal

pectoral fin segment, figured by Traquair (pl. 29, figs. 2, 5). All these specimens seem to be of mature, or at least fairly mature, individuals.

The material from Siccar Point was said by Traquair (1894–1896, p. 124) to comprise an "anterior dorso-lateral plate and some other fragments", but no description and no figures were given of it. As I had no time for an examination of it during my visit to Edinburgh in 1938 I am unable to say anything about this material here. Whether it actually is of *B. leptocheira* must, therefore, be left undecided.

The lectotype of the species is the anterior ventro-lateral plate with a proximal segment already referred to above (specimen No. 4 from Heads of Ayr; Gross 1932b, p. 26).

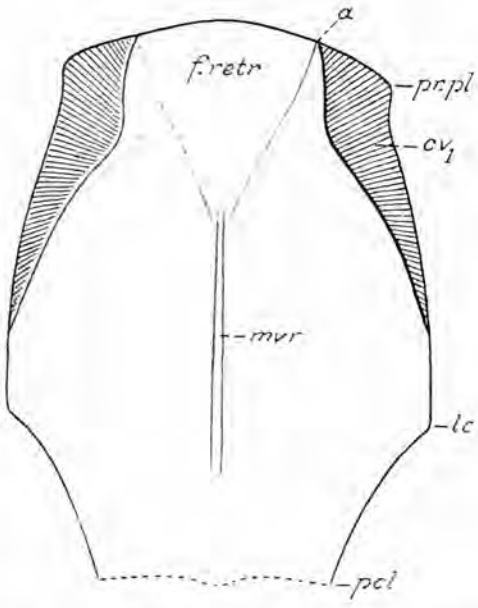
The subsequent account is based in the main on the descriptions and figures published by Traquair in 1906 on the material from Heads of Ayr, but certain observations made by the writer on that material will also be given.

Description. – *B. leptocheira* seems to have attained a size somewhat similar to that of *B. canadensis* or *B. cellulosa*. The maximal length of the dorsal wall of its trunk-armour may be estimated at about 12–14 cm or thereabouts. The single premedian plate from Heads of Ayr is 2,5 cm long and 3 cm broad. The anterior median dorsal plate from the same locality is about 7,5 cm long and 5,6 cm broad.

The general shape and proportions of the head-shield cannot be ascertained on the basis of the material available.

The premedian plate known (specimen No. 1; Traquair 1894–1896, pl. 29, fig. 1) is broad in proportion to its length, its breadth : length ratio amounting to about 120. The plate is broadest near its rostral end, thence decreasing as much in breadth backwards as to be strikingly narrow posteriorly. The dorsal posterior margin, which is concave and devoid of a nasal process and nasal notch, is so short that it corresponds to between one third and one half only of the length of the rostral margin. Finally, it may also be mentioned here that the sensory canal grooves cross the plate comparatively close to the rostral margin.

The shape of the trunk-armour is still on the whole unknown. Above all it is impossible to say anything concerning the height of the dorsal and lateral walls. As to the dorsal wall it is obvious, however, that its right and left halves did not meet at a pronounced median angle as they do in *B. obesa*, but that the medianmost elevated parts of this wall must have been somewhat flattened or rounded off in a manner corresponding to that in the majority of the *Bothriolepis*-species. The tergal angle lies about at the transition between the anterior and middle thirds of the anterior median dorsal plate. The dorsal median ridge in mature individuals is weakly developed and partly even absent. The dorsal median part of the crista transversalis interna posterior that lies on the posterior median dorsal plate is compara-



Text-fig. 260. *Bothriolepis leptocheira.* Rough outline sketch of an anterior median dorsal plate in the Royal Scottish Museum. This plate mentioned, but not figured by Traquair. Ventral aspect. Nat. size.
a, antero-lateral corner; cv_1, area overlapping anterior dorso-lateral plate; *f. retr*, levator fossa; *lc*, lateral corner; *mvr*, ventral median ridge; *pcl*, postero-lateral corner; *pr. pl*, external postlevator process.

tively low and obscure. The postlevator crest was presumably present. Finally, the ventral tuberosity is slightly developed or almost absent.

The anterior median dorsal plate (specimen No. 2) is somewhat as shown in the sketch reproduced in text-fig. 260. Despite the circumstance that it is from a somewhat mature, or perhaps even fully mature, individual it is comparatively narrow, its breadth: length ratio amounting only to about 76. The plate is not high and roof-like as in *B. obesa*, but of the ordinary low type as found in the majority of the *Bothriolepis*-species. The anterior margin is convex and strikingly short, probably shorter than the posterior margin. On account of the fact that the antero-lateral corner (*a*) is very slightly developed or practically absent, the anterior margin passes over without any definite boundary into the lateral margin of either side. The latter margin is characterized by the following features: the postnuchal notch is obscure or absent; the hind part of the anterior division of the margin is directed almost straight laterally and is very nearly parallel, therefore, with the posterior part of the corresponding division of the opposite side; the posterior division of the margin is strongly concave. The posterior margin of the plate seems to have been comparatively broad, at any event somewhat broader than the anterior margin. In contradistinction to what is normally

the case in the genus the area (cv_1) overlapping the anterior dorsolateral plate ends posteriorly already fairly far in front of the lateral corner (*lc*). As to general shape the plate reminds somewhat of the corresponding plate in *B. jarviki* (text-fig. 305A–C). The posterior median dorsal plate (specimen No. 3) is deficient anteriorly and on its right side (Traquair 1894–1906, pl. 29, fig. 4). It is obvious, however, that it is of a narrow type, its breadth being smaller than its length. At least as far as may be judged, it was not particularly narrow in its anterior parts. Its posterior corner is rounded off and slightly pronounced. The anterior ventro-lateral plate (specimen No. 4), chosen as a lectotype (Traquair 1894–1906, pl. 29, fig. 3), displays only its ventral lamina, which is about one and a half times, or between one and a half times and twice, as long as broad. The development of the posterior division of this lamina shows that the median ventral plate must have been of normal size, about as in *B. canadensis* or *B. cellulosa*.

The pectoral fin is slender. The proximal segment (specimen No. 4; Traquair 1894–1906, pl. 29, fig. 3), is clearly somewhat more than five times, conceivably about five and a third times, as long as broad. The distal segment (Traquair 1894–1906, pl. 29, fig. 5) was presumably also of a slender shape. The medial spines situated on the dorsal central plate 1 (Traquair 1894–1906, pl. 29, fig. 4) are very numerous and short and seem to point somewhat dorso-medially. The dorsal central plate 1 (specimen Nos. 3, 4; Traquair 1894–1906, pl. 29, figs. 3, 4) in mature individuals is considerably more than three times as long as broad and is thus unusually long and narrow. As the corresponding plate in *B. groenlandica* (cf. text-fig. 296), it bears a large number of medial spines. The dorsal central plate 2 (specimen No. 4; Traquair 1894–1906, pl. 29, fig. 3) is comparatively long and narrow, about as in *B. cellulosa* (cf. text-fig. 228A) and *B. maxima* (cf. text-figs. 243B, 245B, C). The plates of the distal segment seem also to be comparatively long and narrow.

The ornament is well preserved on several of the plates. On the premedian plate (specimen No. 1) it consists of tubercles and ridges with very few anastomoses, whereas on the posterior median dorsal, anterior ventrolateral, and dorsal central plates it is mainly or entirely reticular with tubercular swellings and elevations at the points of anastomoses of the ridges. As far as may be judged, the ornament in mature individuals thus retained a regularly, fine-meshed reticular disposition, the anterior parts of the headshield excepted, where at least to some extent the ridges were subdivided into shorter pieces and tubercles.

Remarks. – *B. leptocheira* is well distinguished as a species above all by the shape of its anterior median dorsal plate. Whether in addition to the material from Heads of Ayr it includes also the material from Siccar Point

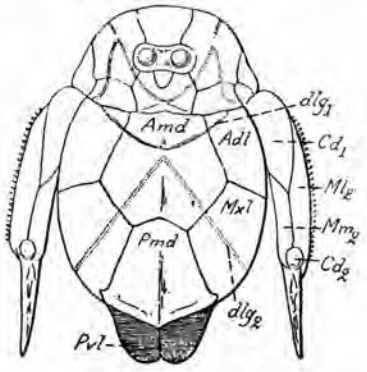
ascribed to it by Traquair is a question which must be left unanswered for the time being (cf. p. 501 above).

Localities and geological horizon. – As has already been mentioned, *B. leptocheira* occurs at Heads of Ayr, Ayrshire, Scotland, and possibly also at Siccar Point, Berwickshire, Scotland. The deposits at both these localities are said to belong to the Upper Old Red Sandstone.

18. **Bothriolepis hydrophila** (Agassiz).

(Text-figs. 261, 262).
For list of synonyms see Gross 1932b, pp. 27–28.

Diagnosis. – Species of small size or possibly young individuals of a species of large size. Total dorsal length of armour (length of head-shield + length of trunk-armour) maximally 13 cm or thereabouts. Dorsal length of trunk-armour maximally about 9 cm. Head-shield relatively broad in proportion to its length and strongly curved downward anteriorly both in transverse and rostro-caudal directions; its nostral margin shorter than its posterior margin and comparatively strongly convex in dorsal and ventral aspects; the lateral margins converging forwards and conceivably longer than the distance between the lateral corners of the centro-nuchal plate; obstantic margin of either side certainly not particularly long. Premedian plate broader than long. Pineal plate narrow, but with a large paired postero-lateral process. Dorsal wall of trunk-armour at least somewhat elevated and usually broad, its breadth : length ratio ranging between 90–98 or thereabouts. Tergal angle about at the transition between the anterior and middle thirds of the anterior median dorsal plate. Anterior median dorsal plate broad, as a rule nearly or approximately as broad as long. Anterior margin of the plate convex or fairly straight, and sometimes probably with a median concavity; this margin otherwise often, or as a rule, broad, brodar than the underlying part of the centro-nuchal plate. Posterior median dorsal plate rather variable as to proportions, but presumably as a rule narrower than long, or about as broad as long. Dorsal lamina of anterior dorso-lateral plate between one and a half times and twice as long as broad. Ventral lamina of anterior ventro-lateral plate about twice, or a little more than twice, as long as broad. Dorsal median ridge very well developed and sharp edged throughout its extent. Oblique transverse depression above postlevator thickening and anterior oblique abdominal pit-line groove normally present and well developed. Pectoral fin relatively robust. Proximal segment about four times, or perhaps slightly more than four times, as long as broad. Distal segment also somewhat robust. Lateral spines of proximal segment relatively few and strong. Ornament throughout of a regular fine-meshed net-work of anastomosing ridges, probably as a rule with weak tubercular thickenings and elevations of their points of anastomosis.



Text-fig. 261. *Bothriolepis hydrophila.* Restoration of the armour in dorsal aspect. From Traquair 1888 (1888b, pl. 18, fig 4; and 1894–1906, text-fig. 62) This restoration is inaccurate in several respects. Nat. size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; Cd_1, Cd_2, dorsal central plate 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove.

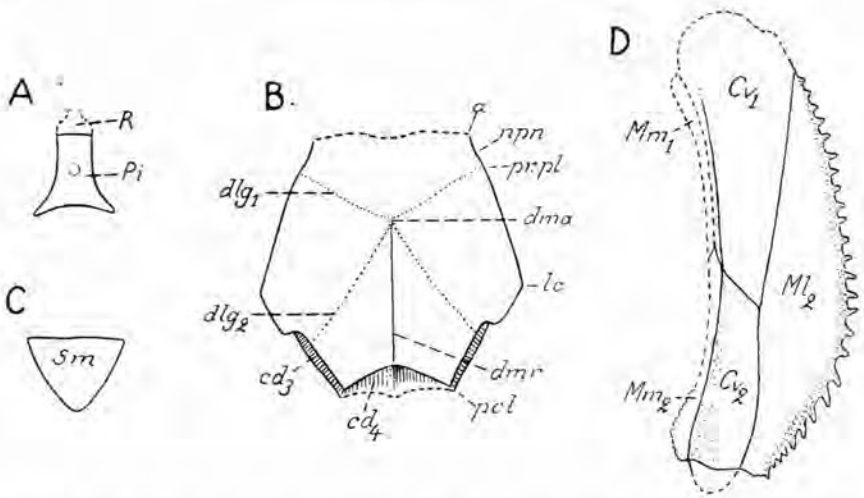
Material. – The material of *B. hydrophila* here discussed includes only the specimens from Dura Den, Scotland. The single anterior median dorsal plate from Clashbennie, Perthshire, referred by Traquair (1894–1906, p. 126, pl. 30, fig. 3) with doubt to *B. hydrophila* seems to belong to another species (cf. pp. 510, 513 below).

The lectotype of *B. hydrophila* is one of the imperfect individuals preserved in the Museum of Practical Geology in London (Woodward 1891b, p. 230; Gross 1932b, p. 27).

Description. – The material known for the time being is only of small or fairly small individuals. No exact measurements can be given, but judging from some notes made by the writer on specimens belonging to the Royal Scottish Museum in Edinburgh the total dorsal length of the armour (length of head-shield + length of trunk-armour) would maximally be about 13 cm, which involves that the dorsal wall of the trunk-armour would have attained a maximal length of about 9 cm. The majority of the individuals, however, are considerably smaller.

Head-shield.

The head-shield (text-fig. 261; cf. Traquair 1894–1906, pl. 30, figs. 1, 2) seems to have been about as broad as in *B. canadensis.* Its preorbital divisions is clearly much downward-curved both in rostro-caudal and transverse directions. The orbital fenestra, at least in several cases, is fairly large. The rostral margin of the shield is not completely shown in the two specimens figured by Traquair, but it is obvious, however, that it was shorter than



Text-fig. 262. *Bothriolepis hydrophila*. *A*, sketch showing the approximate outlines of the pineal plate and the postnasal division of the rostral plate. Magnified. *B*, an anterior median dorsal plate in dorsal aspect. Nat. size. *C*, semilunar plate. Nat. size. *D*, sketch showing the approximate shape of a proximal segment of a left pectoral fin in ventral aspect. Nat. size.

Cv_1, Cv_2, ventral central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_1, Mm_2, medial marginal plates 1 and 2 respectively; *Pi*, pineal plate; *R*, rostral plate (postnasal division); *Sm*, semilunar plate; *a*, antero-lateral corner of anterior median dorsal plate; cd_3, area overlapped by mixilateral plate; cd_4, area overlapped by posterior median dorsal plate; dlg_1, anterior oblique abdominal pit-line groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *lc*, lateral corner of anterior median dorsal plate; *npn*, postnuchal notch; *pcl*, postero-lateral corner of anterior median dorsal plate; *pr. pl*, external postlevator process.

the posterior margin of the shield; characteristic of it is otherwise that it is strongly convex both in dorsal and ventral aspects. The lateral margins converge forwards and seem to be longer than the distance between the lateral corners of the centro-nuchal plate. The obstantic margin of either side must have been relatively short. Finally, the posterior margin is long, but otherwise nothing is known concerning its development.

The premedian plate (text-fig. 261; Traquair 1894–1906, pl. 30, fig. 2) at least in several cases is broader than long. The rostral plate (*R*, text-fig. 262A) is partly preserved, but its exact shape could not be made out. The pineal plate (*Pi*, text-fig. 262A; Traquair 1894–1906, pl. 30, fig. 2) is longer and narrower than in other species in which it is known at present (cf. text-fig. 23), but on account of the condition that its postero-lateral processes are much produced it is a little broader than long. According to the restoration given by Traquair (text-fig. 261), the postpineal plate is unusually long and narrow, and of a shape somewhat similar to that in *B. obesa*, and an undeterminable *Bothriolepis*-species from Scaat Craig (text-fig. 258). Judging from the very specimens figured by Traquair

(1894–1906, pl. 30, figs. 1, 2), it is to be suspected, however, that this plate was broader and of a more normal shape. The specimen figured by Traquair in 1906 (1894–1906) in pl. 30, fig. 2, seems even to indicate that it might have been of a broad immatura type, nearest comparable to that in small specimens of *B. canadensis* (cf. text-fig. 93A–E). As will be understood from the subsequent account, it is of a certain interest how the postpineal plate is shaped, for this will help in throwing light upon the question whether in the specimens of *B. hydrophila* known at present we are concerned with a small species with several persisting immature characters or with immature individuals of a species of large size. In the restoration published by Traquair the centro-nuchal plate is long and narrow and the paranuchal-marginal plate short and broad (text-fig. 261), but at least in the specimens figured by Traquair in 1906 (1894–1906, pl. 30, figs. 1, 2) this seems not to be so; in these specimens it seems rather as though the centro-nuchal plate was broad and short and the paranuchal-marginal plate about as long relatively as in *B. canadensis* (cf. text-figs. 82–84).

The sclerotic ring is often preserved, and it is clearly seen that at least the postero-dorsal sclerotic plate is much as in *B. canadensis* (p. 84, and text-figs. 21C, 30A, D, E, G, I).

Trunk-armour.

The trunk-armour (text-fig. 261) is dorso-ventrally compressed and little only can, therefore, be made out concerning its shape. Its dorsal wall cannot possibly have been as low and flat as in *B. canadensis* (cf. text-figs. 38, 40), but must have been higher, at least as high as in *B. alvesiensis* (cf. p. 472 above). Characteristic of this wall is otherwise that despite the comparatively small size of the individuals it is nearly as broad as long, its breadth:length ratio amounting to 90–98 or thereabouts. It is thus approximately as broad as in large individuals of *B. canadensis* (cf. p. 231 above). The tergal angle (*dma*, text-fig. 262B) is situated about at the transition between the anterior and middle thirds of the anterior median dorsal plate. The dorsal median ridge (*dmr*, text-fig. 262B; Traquair 1894–1906, pl. 30, figs. 1, 2) is strongly developed, edge-like, and continuous from the tergal angle backwards to the hindmost part of the posterior median dorsal plate. As to its development this ridge is, therefore, much as in small individuals of *B. canadensis* (cf. pp. 274–276 above, and text-figs. 88, 91, 199–202, 204–206) and *B. groenlandica* (cf. pp. 538, 581–584 below, and text-figs. 280A, C, D, 302). The anterior oblique abdominal pit-line groove (dlg_1, text-fig. 262B) and the oblique transverse depression (*otd*) above the postlevator thickening (*alr*) are normally present and are often conspiracuous (cf. Traquair 1894–1906, pl. 30, figs. 1, 2). On account of their completeness and distinct development

these two formations were noticed already by Traquair (1888b; 1894–1906, p. 125), and the anterior oblique abdominal pitline is even shown in his restoration of the armour copied in the present work (text-fig. 261). As we have seen (cf. pp. 211–214, 276–281), the two formations in question in *Bothriolepis* generally persist only in early stages of growth and are thus normally characteristic of young individuals.

The anterior median dorsal plate (*Amd*, text-figs. 261, 262B) is of a broad type. Despite the relatively small size of the individuals it is nearly or practically as broad as long. Its anterior margin seems to be fairly straight or slightly convex, but at least in certain individuals it shows a more or less distinct median concavity. This margin is also often, or perhaps even as a rule, broader than the part of the centro-nuchal plate underneath and nearest in front of it. In the few cases in which it is known the lateral margin of the plate is distinguished by the conditions that its postnuchal notch (*npn*) and external postlevator process (*pr. pl*) are slightly developed. In this respect, as well as in the great breadth of its anterior margin in proportion to the centro-nuchal plate, the plate reminds considerably of the corresponding one in *B. alvesiensis* (cf. pp. 472–474, and text-figs. 247–249). In certain cases it is seen (text-fig. 262B) that the plate was not only overlapped by the mixilateral plate, but that it also overlapped that plate for a certain distance nearest behind its lateral corner (*lc*). The posterior median dorsal plate (*Pmd*, text-fig. 261) varies conceivably a great deal as to its proportions, but, as far as may be judged, it is narrower than long, or about equally broad as long. Its posterior corner or angle seems to be well pronounced. Otherwise nothing certain can be said concerning its shape and development. The anterior dorso-lateral and mixilateral plates (*Adl, Mxl*, text-fig. 261; cf. also Traquair 1894–1906, pl. 30, figs. 1, 2) are also imperfectly known. The dorsal lamina of the former of these two plates is between one and a half times and twice as long as broad and is thus somewhat broader than what seems mostly to be the case in the other *Bothriolepis*-species. The dorsal lamina of the mixilateral plate is not fully twice as long as broad, and is thus also relatively broad. The ventral lamina of the anterior ventro-lateral plate (Woodward 1891, pl. 6, fig. 9) is about twice, or somewhat more than twice, as long as broad and is in most of its characters about as in *B. canadensis* (cf. text-fig. 166). The ventral lamina of the posterior ventro-lateral plate seems to have been about as normally in the genus. A sketch of the semilunar plate is shown in text-fig. 262C. The median ventral plate is unknown, but judging from the reproduction given by Woodward of the ventral lamina of an anterior ventro-lateral plate (Woodward 1891b, pl. 6, fig. 9) it is possible that it was very large, larger even than in *B. maxima* (cf. text-fig. 52), and about as large relatively as in *Grossilepis* (cf. text-fig. 41D).

Pectoral fin.

The pectoral fin (cf. Traquair 1894–1906, pl. 30, figs. 1, 2) is of a fairly robust type. The proximal segment (text-fig. 262D) which has been made too slender in the restoration given by Traquair (text-fig. 261 in the present work) is about four times, or a little more than four times, as long as broad. The distal segment is also fairly broad; its length amounts to one half or thereabouts of the length of the proximal segment. Lateral spines are present both on the proximal and distal segments and not on the proximal segment only as in the restoration given by Traquair. The lateral spines of the proximal segment are strongly developed, much pointed and relatively few in number (text-fig. 262D) and are, therefore, on the whole as in young individuals of other species (pp. 153–154, 361, text-figs. 194, 195, 293, 294). The development of the medial spines cannot be ascertained from the figures given by previous writers.

Ornament.

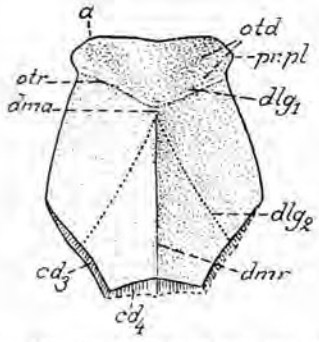
The ornament (Traquair 1894–1906, pl. 30, figs. 1, 2; Woodward 1891b, pl. 6, fig. 9) consists of a regular fine-meshed network of ridges and is on the whole very uniformly developed on the head-shield and trunk-armour. Hardly no concentric or radiating disposition of the ridges seems to occur. Tubercular swellings and elevations are probably present at the points of union of the ridges. As is thus obvious, the ornament is of a pronounced immature character (cf. pp. 169–171, cf. also text-figs. 199–206, 302).

Sensory canal system.

According to Traquair (1894–1906, p. 125), there are no sensory canal grooves on the preorbital division of the head-shield, but whether this really is so cannot be decided without acess to material of the species. As pointed out above (pp. 507–508), the anterior oblique abdominal pit-line groove (dlg_1, text-figs. 261, 262B) is normally well developed.

Remarks. – The specimens known at present of *B. hydrophila* are remarkable in that they present a mixture of immature and mature characters. As the immature characters on the whole are preponderant, it is likely that all the material described is of young individuals belonging to a species which attained a considerable size. Further researches, above all on certain details in the head-shield (the shape of the postpineal plate), and on the development of the structures of the lower side of the dorsal wall of the trunk-armour, will presumably show conclusively whether this actually is true.

In the development of its anterior median dorsal plate and perhaps also in some other features *B. hydrophila* is suggestive of *B. alvesiensis* (cf. pp.



Text-fig. 263. *Bothriolepis* sp. Outline sketch of the detached anterior median dorsal plate from Clashbennie referred by Traquair with doubt to *B. hydrophila*. Dorsal aspect. Rough restoration made by the writer after the actual specimen in the Royal Scottish Museum in Edinburgh. About nat. size.

467–477 above). However, it is well distinguished from that species inter alia by the larger breadth of the dorsal wall of its trunk-armour.

The single anterior median dorsal plate from Clashbennie included by Traquair (cf. p. 505 above, and p. 513 below) with doubt in *B. hydrophila* is somewhat as shown in the sketch reproduced in text-fig. 263. It is clearly of a young individual. The dorsal median ridge (*dmr*), the anterior oblique abdominal pit-line groove (dlg_1) and the oblique transverse depression or groove above the postlevator ridge are all well developed. The plate is considerably narrower in proportion to its length than in the specimens of the corresponging size of *B. hydrophila* and in all probability, therefore, it is of a species in which the anterior median dorsal plate normally was narrower than in *B. hydrophila*. It differs also from the corresponding plate in *B. hydrophila* in certain other respects, as for instance its more pronounced external postlevator process (*pr. pl*) and the different configuration of the anterior division of its lateral margin behind the said process. As far as may be seen, the plate cannot belong to *B. hydrophila*. It cannot be decided whether it is referrible to someone of the species now known from Scotland or whether it represents a new species.

Locality and geological horizon. – *B. hydrophila* is known so far only from Dura Den, in Fifeshire, Scotland. The deposits in which it occurs belong to the Upper Old Red Sandstone.

19. **Bothriolepis macrocephala** Egerton.

For list of synonyms see Gross 1932b, p. 28.

Diagnosis. – Very small species or perhaps young individuals of a species of a somewhat moderate size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) about 2 cm only. Head-

shield long, its length almost equalling its breadth and amounting to considerably more than one third of the total dorsal length of the armour. Ventral lamina of anterior ventro-lateral plate probably from about one and a half times to not fully twice as long as broad. Ventral lamina of posterior ventro-lateral plate probably somewhat more than twice as long as broad. Median ventral plate relatively small. Pectoral fin somewhat robust. Proximal segment long, in a fully adducted position extending as far backwards as to about opposite the posterior margin of the lateral wall of the trunk-armour. This segment conceivably about six times as long as broad. Distal segment relatively short, about half as long as the proximal segment. Lateral spines numerous and strongly developed. Ornament presumably consisting of a regular fine-meshed network of anastomosing ridges.

Remarks. – In certain of its characters *B. macrocephala* is somewhat suggestive of *B. hydrophila,* but it is distinguished from that species in the greater relative length of its head-shield and greater relative length of the proximal segment of its pectoral fin. It is not quite impossible that all the specimens known at present are of very young individuals.

Localities and geological horizon. – Farlow, in Shropshire, England, Upper Old Red Sandstone.

20. **Bothriolepis cristata** Traquair.

For list of synonyms see Gross 1932b, p. 28.

Diagnosis. – Species of fairly small size, dorsal wall of trunk-armour attaining a length of about 6–7 cm only. Trunk-armour long with a high dorsal wall and comparatively high lateral walls. Dorsal wall fairly narrow in proportion to its length, its breadth : length ratio amounting to about 75 only. This wall sloping fairly steeply towards the sides and meeting the lateral wall of either side at an obtuse angle (probably about 130°). Tergal angle presumably situated somewhat far forwards in the hindmost part of the anterior third of the anterior median dorsal plate. Dorsal median ridge raised into a dorsal median crest, extending backwards as far as at least on to the middle of the posterior median dorsal plate. This crest highest above the posterior parts of the anterior median dorsal plate, thence decreasing in height both forwards, towards the tergal angle, and backwards, towards the posterior part of the posterior median dorsal plate, and comparatively low in its posterior parts. Anterior median dorsal plate narrower than long. Posterior median dorsal plate presumably comparatively broad. Anterior dorso-lateral and mixilateral plates comparatively high with somewhat high lateral laminae. Lateral laminae of anterior and posterior ventro-lateral plates also fairly high. Ventral lamina of anterior ventro-lateral plate between one and a half times and twice, or about twice, as long as broad. Ven-

tral lamina of posterior ventro-lateral plate from about two and a half to two and two thirds times as long as broad. Proximal segment of pectoral fin much arched in such a manner that its lateral edge is pretty strongly convex and its medial wall correspondingly concave. Ornament at least to a large extent reticular.

Remarks. – Although excellent for their time the descriptions of *B. cristata* published by Traquair (1895, pp. 266–268, pl. 9; 1894–1906, pp. 130–131, pl. 31) contain only few statements as to the features which are certainly shown by the specimens available and which are of importance both for the determination and for the comparison with other *Bothriolepis*-species. Thus Traquair's descriptions give no information concerning the following features: the proportions and shape of the various plates of the trunk-armour, the proportions of the two segments of the pectoral fin, the shape and proportions of the various plates of the fin-armour, and the detailed development of the ornament. Most of these features cannot be made out from the figures given by Traquair, and nothing certain can, therefore, be said of them here.

As far as our knowledge of it goes, *B. cristata* is somewhat suggestive of *B. obesa*, and it is not impossible, therefore, that it will turn out to be related to that species, which, as we have seen (cf. pp. 492–499 above), is very unsatisfactorily known. It is developed much in the same direction as is the crested Australian species *B. gippslandiensis*, from which it is clearly distinguished, however, above all by its longer and lower trunk-armour, a different shape of its dorsal crest, and a different development of its anterior median dorsal plate. Finally, it is possible that it resembles also *B. turanica* from Tian-Shan (cf. p. 462 above).

Locality and geological horizon. – Rosebrae Quarry, near Elgin, Scotland. Upper Old Red Sandstone.

21. Bothriolepis spp. from Scotland.

Under this title I shall briefly describe or mention certain British *Bothriolepis*-remains which cannot be referred to the species dealt with above, or which are indeterminable.

A. A detached premedian plate figured by Duff in 1842 (pl. 7, fig. 1) and interpreted by him as a plate of *Holoptychius nobilissimus*. This plate, which belongs to the Royal Scottish Museum in Edinburgh, is fairly large, about 3,9 cm long and about 4,3 cm broad. As to its general shape the plate is mostly suggestive of the corresponding plate in *B. alvesiensis* (text-figs. 247–249) or *B. leptocheira* (cf. Traquair 1894–1906, pl. 29, fig. 1). The plate is from the Upper Old Red Sandstone of Scaat Craig, Elgin, Scotland.

B. A deficient centro-nuchal plate and a postpineal plate in their natural connection with one another (text-fig. 258). These two plates, which belong to the British Museum in London (B.M. specimen No. P. 8278), differ clearly from the corresponding plates in *B. alvesiensis* (text-figs. 247–249) and *B. gigantea* (text-figs. 252, 253A, E), but remind somewhat of those of *B. obesa* in the Harelaw material (cf. pp. 479, 499). The centro-nuchal plate is of a comparatively long and narrow type, and the postpineal plate is unusually short and narrow. The plates are from the Upper Old Red Sandstone of Scaat Craig, near Elgin, Scotland.

C. The somewhat deficient anterior median dorsal plate reproduced by Traquair in 1894–1906 in pl. 30, fig. 3 and shown restored in text-fig. 263 above in this work. This plate, which belongs to the Royal Scottish Museum in Edinburgh, is of a young individual. It is hardly referrible to *B. hydrophila* as supposed by Traquair (1894–1906, p. 126), but must probably be of some other species (cf. pp. 505, 510 above). At any event it is indeterminable at present. It is from the Upper Old Red Sandstone of Clashbennie in Perthshire, Scotland.

D. A left mixilateral plate figured by Traquair in 1894–1906 in pl. 25, fig. 3. This mixilateral plate, which is in the possession of the Elgin Museum, seems to be too large to belong to *B. alvesiensis*, but cannot either be of *B. gigantea*, for its lateral lamina is much higher in proportion to its length than in that species. The plate is from the Upper Old Red Sandstone of Alves, near Elgin, Scotland.

E. The pieces of pectoral fins described by Agassiz (1845, p. 134, pl. 30a, figs. 20–23) under the species name of *Placothorax paradoxus*. These remains, which are from large individuals, are quite indeterminable for the time being. They belong to the Royal Scottish Museum in Edinburgh, and, according to their labels, are from Scaat Craig, near Elgin, Scotland.

Belgian species.

The only Belgian *Bothriolepis*-species that will be treated here is *B. lohesti* Leriche (1931, pp. 15–19). The other *Bothriolepis*-remains from Belgium recorded by Leriche (1931, p. 19) under the little of *Bothriolepis* sp. are not properly described and have not been figured, on account of which nothing can be said of them here.

22. **Bothriolepis lohesti** Leriche.

For list of synonyms see Leriche 1931, p. 15.

Diagnosis. – Species presumably of fairly small size. Dorsal wall of trunk-armour conceivably attaining a length of about 7–8 cm only. This

wall on the whole unknown as to shape, but its median part certainly fairly flat. Tergal angle situated at, or close behind, the transition between the anterior and middle thirds of the anterior median dorsal plate. Dorsal median ridge weakly developed and sometimes practically absent. Postlevator thickening fairly low and obscure, but postlevator crest well developed. Anterior median dorsal plate relatively broad, in somewhat mature, and mature, individuals about as broad as long, or sometimes even a little broader than long. Its anterior margin relatively broad, at least often considerably broader than its posterior margin. Proximal segment of pectoral fin in somewhat mature, or fully mature, individuals probably at least about four times as long as broad. Ornament somewhat coarse; on the dorsal parts of the trunk-armour dissolved into tubercles and short pieces of nodose ridges, on the proximal segment of the pectoral fin mainly reticular, but with clear tubercular swellings and elevations at the points of anastomoses of the ridges.

Material. – The material described by Leriche includes four imperfect anterior median dorsal plates, a deficient left anterior dorso-lateral plate, and a few pieces of proximal segments of pectoral fins.

The lectotype of the species is an anterior median dorsal plate reproduced by Leriche in 1931 in pl. 3, fig. 4 (Gross 1932b, p. 29).

Description. – The remains present are all of fairly small individuals. The length of the anterior median dorsal plate ranges from about 4–4,7 cm, and the dorsal length of the trunk-armour may, therefore, be estimated at about 6–7 cm.

The general characters of the trunk-armour are unknown. This much is clear, however, that the median part of the dorsal wall was not high and roof-like as in *B. obesa* and the crested species, but of the normally fairly flat shape characteristic of the majority of the *Bothriolepis*-species. The tergal angle is situated either at, or a little behind, the transition between the anterior and middle thirds of the anterior median dorsal plate. The levator fossa is comparatively broad and short. The postlevator thickening seems to be low and fairly obscure, whereas the postlevator crest is well developed. The condition that the ventral median ridge and groove are complete and somewhat strongly developed indicates that the remains present are of median-sized, or fully mature, individuals.

The anterior median dorsal plate (Leriche 1931, pl. 3, figs. 1–4) is broad, about equally broad as long, or even somewhat broader than long. The anterior margin is fairly broad, considerably broader than the posterior one, and was presumably broader than the parts of the centro-nuchal plate underneath and immediately in front of it. The margin in question is imperfectly preserved, but it is likely that it was fairly straight or only slightly convex. The configuration of the lateral margin is imperfectly known, but, as far as may be judged, the postnuchal notch is often rather obscure, whereas the external postlevator process is somewhat distinct. The posterior

margin is strikingly short and characteristic of it is in addition that, at least in many cases, its median process is represented only by a slight convexity. The area overlapping the anterior dorso-lateral plate is unusually broad in its foremost part somewhat behind the external postlevator process. The plate seems very often to be abnormal in its sutural connections with the adjacent plates in such a manner that it both overlaps, and is overlapped by, the mixilateral plate. The anterior dorso-lateral plate (Leriche 1931, pl. 3, fig. 3) is represented only by an anterior part, which shows that the internal postlevator process is strongly developed.

The proximal segment of the pectoral fin (Leriche 1931, pl. 3, figs. 4–6) is deficient so that its exact length cannot be ascertained. Very likely is, however, that in mature individuals it was at least about four times as long as broad. The ventral central plate 1 is from somewhat more than two and a half times to about three times as long as broad.

The ornament is comparatively coarse. On the dorsal parts of the trunk-armour it is to a large extent subdivided into tubercles and short pieces of ridges with very few anastomoses. The pieces of ridges are clearly nodose and somewhat vermiculating. On these parts of the trunk-armour the tubercles and ridges are also more or less clearly radiatingly and concentrically disposed. The ornament on the proximal segment of the pectoral fin is on the whole reticular, but with pronounced tubercular elevations and thickenings at the points of anastomoses of the ridges. Taken as a whole the ornament of mature individuals was thus in the main tubercular.

No traces are to be seen of an anterior oblique abdominal pit-line groove. The posterior oblique abdominal pit-line groove is sometimes weakly developed or absent.

Remarks. – The material known at present seems all to be of fairly mature, or even fully mature, individuals.

B. lohesti is still too imperfectly known to be compared to other species. In the general shape of its anterior median dorsal plate it is nearest suggestive of *B. hydrophila* (cf. text-fig. 262B), whereas in its ornament it is clearly different from that species. In the development of the ornament it reminds mostly of large individuals of *B. canadensis.*

Locality and geological horizon. – Chèvremont, near Vaux-sous-Chèvremont, Province of Liège, Belgium. Upper Upper Devonian (Famennian).

Australian and Antarctic species.

The *Bothriolepis*-species to be dealt with under the above title include *B. gippslandiensis* Hills from Australia (Hills 1929, pp. 195–197, text-fig. 2, No. 4 and pl. 18, fig. 8; 1931, pp. 214–222, text-figs. 5–7 and pl. 11, figs.

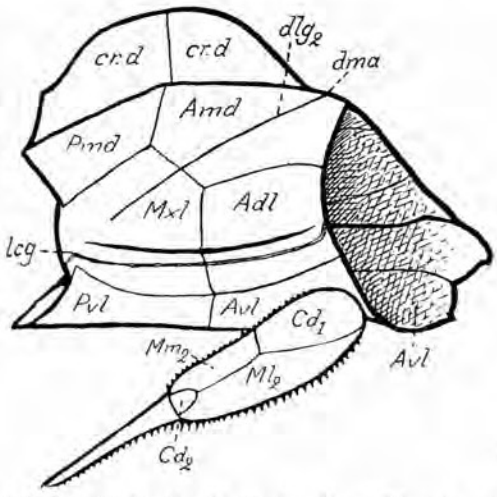
1–6) and *B. antarctica* A. S. Woodward from the Antarctic (Woodward 1921, pp. 52–54, pl. 1, figs. 3–9). In addition brief remarks will be given on certain not nearer determinable *Bothriolepis*-fragments recorded by Hills from Australia (Hills, 1932, p. 853, pl. 56, figs. 5–8; 1935, pp. 165–166, text-fig. 5 and pl. 12, fig. 3).

23. **Bothriolepis gippslandiensis** Hills.

(Text-figs. 26H, 44D, 264, 265).

1929. *Bothriolepis gippslandiensis*, Hills, pp. 195–197, text-fig. 2, No. 4 and pl. 18, fig. 8.
1931. *Bothriolepis gippslandiensis*, Hills, pp. 214–222, text-figs. 5–7 and pl. 11, figs. 1–6.
1931. *Bothriolepis gippslandiensis*, Stensiö, pp. 11, 72, 79.
1932. *Bothriolepis gippslandiensis*, Gross (1932b), p. 32.
1935. *Bothriolepis gippslandiensis*, Hills, p. 167.

Diagnosis. – Species of small size. Dorsal length of trunk-armour maximally only about 6 cm. Shape of head-shield unknown. Postpineal plate very short and broad excluding the centro-nuchal plate from the orbital fenestra. Centro-nuchal plate also very short and broad, its length : breadth ratio amounting only to 60 or thereabouts. Anterior margin of this plate occupied throughout by postpineal notch and consequently devoid of orbital facets. Lateral margin of the plate with a very short anterior division, the length of which is between a third and a fourth only of that of the posterior division. Trunk-armour fairly short and with a very high dorsal wall, meeting the lateral wall of either side at a very obtuse angle. Lateral wall relatively low. Tergal angle situated very far forwards, not so very far behind the middle of the anterior third of the anterior median dorsal plate. Dorsal median ridge elevated into a high crest. This crest extending from near behind the tergal angle backwards almost as far as to the posterior corner of the posterior median dorsal plate, and somewhat high also in its hindmost parts. Levator fossa very short and broad. Postlevator thickening strongly developed, but postlevator crest absent except most posteriorly. Anterior median dorsal plate high and invariably a little broader than long; its anterior margin concave and shorter than its posterior margin. Posterior median dorsal plate about equally broad as long. Anterior dorso-lateral and mixi-lateral plates high and short. Dorsal lamina of anterior dorso-lateral plate probably less than one and a half times as long as broad; lateral lamina of this plate probably almost two and a half times as long as high. Dorsal lamina of mixilateral plate broad, presumably only about one and a half times as long as broad. Lateral lamina of the last-mentioned plate probably from about three to about three and a half times as long as high. Ventral lamina of the anterior ventro-lateral plate about twice as long as high. Median ventral plate fairly large. Ornament changing from a reticular type in small individuals to an almost completely tubercular type in fully mature individuals.



Text-fig 264. *Bothriolepis gippslandiensis* Restoration of trunk-armour in lateral and somewhat antero-dorsal aspect From Hills 1931 (slightly altered). The restoration in certain respects not fully accurate. The dorsal crest is said by Hills himself to be a little too high. The processus obstans and the crista transversalis interna anterior are not shown. The proximal segment of the pectoral fin is probably too straight and broad and its various plates somewhat inaccurate in shape. Nat. size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; Cd_1, Cd_2, dorsal central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_2, medial marginal plate 2; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; *cr. d*, dorsal crest; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *lcg*, main lateral line groove.

Material. – The material of *B. gippslandiensis* here discussed is that treated by Hills (1929; 1931).

The holotype is a deficient impression of a head-shield (Hills 1929, p. 195, pl. 18, fig. 8).

The subsequent account is based entirely upon the descriptions by Hills, particularly the latest one, which (1931) contains several dates of interest and importance.

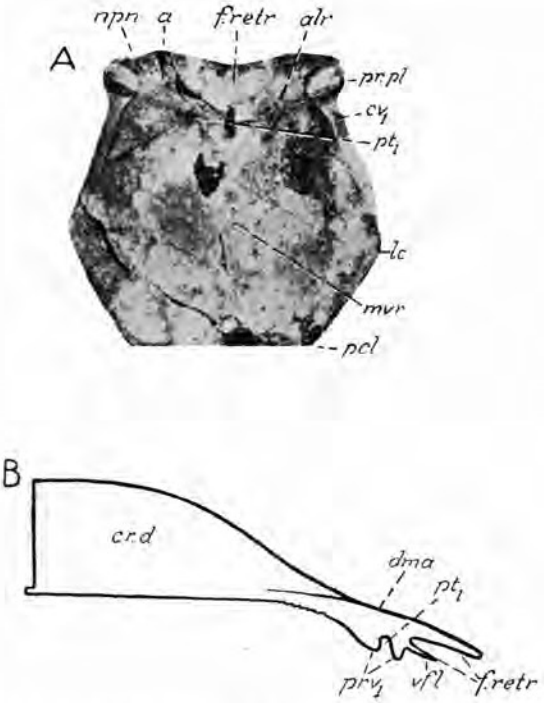
Description. – All the material known is from small individuals, and it is obvious, therefore, that *B. gippslandiensis* must be a small species. The largest anterior median dorsal plate is said by Hills to be 3,6 cm long, on account of which the maximal length of the dorsal wall of the trunk-armour may be estimated at about 5,5–6 cm.

The shape of the head-shield cannot be ascertained from the scanty material of it known for the present (the holotype).

The premedian plate is represented among the material available to Hills, but, as it has not been described in detail and as, in addition, there is no figure of it, nothing can here be said concerning its special features. Judging from a statement by Hills (1931, p. 219), it is possible that the median unpaired division of the preorbital recess extends further forwards into the plate in question than what it does in *B. canadensis* and *B. cellulosa* (cf. pp.

48–52, 235, 412 above, and text-figs. 9, 14, 15). The rostral, pineal and postpineal plates are unknown. Although preserved at least in the holotype, the lateral plate is not described and not properly figured by Hills (1929, pl. 18, fig. 8) and I am unable, therefore, to say anything about its development. The postpineal plate is not preserved, but the shape of the postpineal notch of the centro-nuchal plate indicates that this plate must have been very short and broad (text-fig. 26H). It was even so broad that it extended along the whole anterior margin of the centro-nuchal plate and thus practically alone formed the posterior boundary of the orbital fenestra. Because of this the centro-nuchal plate reached forwards to the orbital fenestra only with its very antero-lateral corners. In its lateral extent the postpineal plate was thus almost as in *Pterichthyodes*, *Gerdalepis* (Gross 1941b, text-fig. 1A), *Asterolepis*, and *Remigolepis*. The centro-nuchal plate (text-fig. 26H) is very short and broad. At least in certain cases its length:breadth ratio is only 60 or thereabouts and is thus smaller even than in very young individuals of *B. canadensis* (cf. p. 257 above, and text-figs. 88A, B, 90, 91, 93). The centro-nuchal plate is also peculiarly developed in other ways. The postpineal notch is thus shallow and very wide, so wide as to occupy the whole anterior (orbital) margin of the plate. In consequence of this condition the plate is completely devoid of orbital facets and, as pointed out, extends forwards to the orbit only with its very antero-lateral corners. The anterior division of the lateral margin of the plate is very short, its length amounting to between a third and a fourth only of the length of the posterior division. The posterior margin is presumably slightly convex and without a posterior median process. The paranuchal-marginal plate is too imperfectly preserved to show any details of interest. The postmarginal, sclerotic, prelateral and lateral plates are unknown, and so are also the dermal plates of the lower side of the head, a single undeterminable one excepted.

The trunk-armour (text-fig. 264) is strikingly short and high and in this respect, therefore, differs from that in most other species, such as *B. canadensis* (cf. text-figs. 38, 40), *B. cellulosa*, *B. maxima*, *B. alvesiensis* (text-fig. 249), *B. gigantea*, *B. cristata*, *B. groenlandica* (cf. text-fig. 287B), and *B. jarviki* (cf. text-fig. 304). The dorsal wall is strongly elevated and meets the lateral wall of either side at a very obtuse angle. On either side of the median line this wall slopes, therefore, steeply laterally towards the dorso-lateral ridge. The lateral wall, on the other hand is low, considerably lower than for instance in *B. canadensis* (text-figs. 38, 40). The tergal angle (*dma*, text-figs. 264, 265B) lies further forwards than in the other *Bothriolepis*-species in which it is known at present. More precisely, this angle is situated only a short distance behind the middle of the anterior third of the anterior median dorsal plate. From a point somewhat behind the tergal angle and backwards as far as almost to the posterior corner of the posterior me-



Text-fig. 265. *Bothriolepis gippslandiensis*. *A*, large anterior median dorsal plate in ventral aspect. Nat. size. *B*, median rostro-caudal section through an anterior median dorsal plate. × $^3/_2$. Both figures from Hills 1931.
a, antero-lateral corner; *alr*, postlevator thickening; *cr. d*, dorsal crest; cv_1, area overlapping anterior dorso-lateral plate; *dma*, approximate position of tergal angle; *f. retr*, levator fossa; *lc*, lateral corner; *mvr*, ventral median ridge (very obscure); *npn*, postnuchal notch; *pcl*, postero-lateral corner; *pr. pl*, external postlevator process; prv_1, anterior ventral process; pt_1, anterior ventral pit; *vfl*, floor of the hindmost part of the levator fossa (thi. floor probably represents the fused posterior parts of the postlevator crests of both sides).

dian dorsal plate the dorsal median ridge is raised into a high medial dorsal crest (*cr.d*, text-figs. 264, 265B), a crest which throughout its extent is of a more uniform height than the corresponding one in *B. cristata* (cf. Traquair 1894–1906, pl. 31, fig. 2). In young individuals there are clear indications of the anterior oblique abdominal pit-line groove (dlg_1), of the oblique transverse ridge (*otr*) behind that groove, and presumably also of the oblique transverse groove or depression (*otd*) above the postlevator thickening (Hills 1931, p. 219, pl. 11, fig. 4). The levator fossa (*f.retr*, text-figs. 44D, 265) is extremely short and broad, much shorter and broader than in other *Bothriolepis*-species. The postlevator thickening (*alr*) is well developed, whereas the postlevator crest seems to be represented by its hindmost parts only. On account of the small length of the levator fossa the postlevator thickening is much more transverse in position than what is the case in other species in which it has been found preserved so far. The ventral median ridge

(*mvr*, text-figs. 44D, 265A) seems to be present, at least for some distance nearest behind the anterior ventral process (prv_1), and there are perhaps also certain traces of the ventral median groove. The anterior ventral process (prv_1, text-figs. 44D, 265A, B) and the anterior ventral pit (pl_1) are situated very far forwards. The posterior part of the levator fossa is provided with a floor (*vfl*, text-fig. 265B), which probably represents posterior persisting portions of the postlevator crests of both sides. Finally, it is worthy of mention here that Hills has found a special rough area behind the posterior parts of the postlevator thickenings, an area of which there seems to be no clear equivalent in other *Bothriolepis*-species.

The plates participating into the formation of the dorsal wall of the trunk-armour are all high and short. The anterior median dorsal plate (text-figs. 44D, 264, 265) is a little broader than long. Its anterior margin, which is considerably shorter than the posterior one, is somewhat concave. The postnuchal notch (*npn*) is presty clearly marked, and the external postlevator process (*pr. pl*), at least sometimes, is fairly pronounced. The posterior margin is long and seems to be straight and completely devoid of a posterior median process. The area (cv_1) overlapping the anterior dorso-lateral plate is narrow. The posterior median dorsal plate (*Pmd*, text-fig. 264) is about as broad as long, but otherwise nothing of any importance is known concerning its development. The anterior dorso-lateral plate (*Adl*, text-fig. 264) has a broad dorsal lamina, but a relatively low lateral lamina. More precisely, the dorsal lamina seems to be less than one and a half times as long as broad, whereas the lateral lamina probably is about two and a half times as long as high. The mixilateral plate (*Mxl*, text-fig. 264) is somewhat suggestive of the corresponding plate in *B. turanica*. Its dorsal lamina is about one and a half times as long as broad, whereas its lateral lamina, which is fairly low, is about three and a half times as long as high. The anterior ventro-lateral plate (*Avl*, text-fig. 264) in most respects seems to be about as in *B. canadensis* (cf. text-figs. 51, 166). The ventral lamina of the plate is about twice as long as broad. The posterior ventro-lateral plate (*Pvl*) is very imperfectly known, but, as far as may be judged, its lateral lamina is comparatively low and the subanal division of its ventral lamina extremely short. The dorsal corner of the lateral lamina is distinctly developed. The semilunar and median ventral plates are unknown, but, as shown by the development of the medial margin of the anterior ventro-lateral plate (cf. Hills 1931, pl. 11, fig. 5), the median ventral plate was large, in all probability about as large as in *B. maxima*.

The pectoral fin is imperfectly preserved. This much is obvious however, that the proximal segment is somewhat arched in the normal way (not straight as in the restoration by Hills shown in text-fig. 264 in the present work) and that it is provided with well developed lateral and medial spines.

Hills has pointed out (1931, pp. 216–217, 222) that the ornament underwent a corresponding change during the growth of the individuals as it did in *B. canadensis* and *B. groenlandica* (cf. pp. 169–171, 376–386, 581–585). In young individuals the ornament thus is reticular, whereas in fully mature individuals it consists mainly of tubercles. These tubercles are "rather widely spaced and fairly rounded".

The sensory canal system seems to be as normally in the genus. As has already been pointed out above (p. 519), the anterior oblique abdominal pit-line groove (dlg_1) seems normally to be present in young individuals.

Remarks. – As has already been clearly pointed out by Hills (1931) and as has also been emphasized above, *B. gippslandiensis* differs considerably from other *Bothriolepis*-species known in any detail as to the shape and relations of the postpineal and centro-nuchal plates, which are nearest as in *Pterichthyodes, Gerdalepis, Asterolepis* and *Remigolepis*. As in all other characters known to us it agrees with *Bothriolepis* it must at least at present, however, be retained in this genus.

In the general shape of its trunk-armour and in the presence of a high dorsal crest *B. gippslandiensis* is suggestive of the Scottish species *B. cristata* (cf. pp. 511–512 above); in the general shape of its trunk-armour it resembles also *B. obesa* and *B. turanica* (cf. pp. 462, 492–499 above) and to a certain extent also such species as *B. maxima, B. gigantea*, and *B. groenlandica*.

Localities and geological horizon. – Pheasant Gully, Freestone Creek, somewhat north of Briagolong, Victoria, and Blue Hills, Taggerty; Victoria, Australia. – Upper Devonian.

24. **Bothriolepis antarctica** A. S. Woodward.

For list of synonyms etc. see Gross 1932b, pp. 32–33.

Diagnosis. – No proper diagnosis can be given of *B. antarctica*. The most distinctive characters of this species known so far are as follows. Species of fairly small or, perhaps, moderate size. Lateral lamina of anterior ventro-lateral plate somewhat high, presumably about three times as long as high. Ventral lamina of anterior ventro-lateral plate about twice as long as broad, with a fairly straight anterior margin, but probably without an antero-lateral corner. Ornament in all probability reticular in young individuals, but more or less completely tubercular in mature individuals.

Remarks. – The species here in question was erected and described by Woodward in 1921 (pp. 52–54, pl. 1, figs. 3–9) on a material consisting only of a few detached fragments. As pointed out by Woodward, it is most likely that it is referrible to *Bothriolepis*, but further material is needed for a definite decision that this actually is true.

The relationships of *B. antarctica* to other *Bothriolepis*-species cannot be made out on the material known at present.

Locality and geological horizon. – Granite Harbour, Antarctica. – "Beacon Sandstone", probably Upper Devonian.

25. **Bothriolepis sp. from Australia.**

Under the above heading a few undeterminable *Bothriolepis*-remains described by Hills (1932; 1935) will be commented. These remains are not referrible to *B. gippslandiensis*. They represent in all probability one or two new *Bothriolepis*-species.

A. Two centro-nuchal plates figured by Hills in 1932 in pl. 56, figs. 5 and 6. The smaller one of these plates, which is of a young individual, is short and broad. Its postpineal notch is of the normal *Bothriolepis*-type and is thus not as in *B. gippslandiensis*. Orbital facets are developed. Contrary to what seems to be the case in *B. gippslandiensis*, a posterior median process is clearly present. The larger one of the two plates is very deficient, but there is reason to suspect that it was of a comparatively long and narrow shape and that its postpineal notch was narrow.

As may easily be gathered from the above statements, the two plates under consideration here cannot be of *B. gippslandiensis*, but must represent one or perhaps two other species.

The smaller plate is from Harvey's Range, north-east of Parkes N. S. Wales; the other plate is from an unknown locality in N. S. Wales, Australia. – Upper Devonian with *Phyllolepis, Remigolepis,* and *Holoptychius*.

B. A nearly perfect mixilateral plate reproduced by Hills in 1932 in pl. 56, fig. 8. This plate, which is represented by an impression of its external face, is of a small individual, in all probability of a deep-bodied species. The plate is somewhat suggestive of the corresponding plate in *B. gippslandiensis*, but its dorsal lamina is narrower and its lateral lamina higher than in that species. The ornament is delicate and reticular.

The find-locality of this plate is the western flank of the Canoblas Mts, N. S. Wales, Australia. – Upper Devonian.

C. Remains of a large plate figured by Hills in 1932 inp l. 56, fig. 7. This plate is quite indeterminable, and as pointed out later on by Hills himself (1935, p. 168), it is even very uncertain whether it belongs to *Bothriolepis* at all.

The plate is from Jemalong Gap, near Forbes, N. S. Wales, Australia. – Upper Devonian.

D. A posterior part of a right anterior ventro-lateral plate and a distal part of a proximal segment of a left pectoral fin. These two remains, which were dealt with by Hills in 1935 (pp. 165–166;

text-fig. 5 and pl. 12, fig. 3), are of large individuals. The latter one of the two remains is clearly of *Bothriolepis*. The dorsal central plate (Cd_2) is short and broad. This plate and the adjacent distal parts of the lateral and medial marginal plates 2 are ornamented with fairly coarse and somewhat irregular sharp-edged ridges, most of which run in a proximo-distal direction.

Both the remains mentioned under *D* are from South Blue Range, near Mansfield, Victoria, Australia. – Upper Devonian with *Phyllolepis*.

Greenland species.

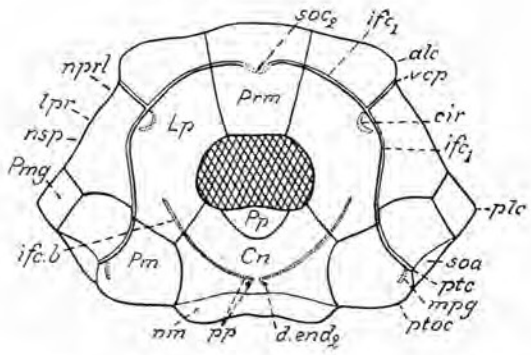
Of the two species *B. groenlandica* Heintz (Heintz 1930, pp. 42–45; 1932, pp. 14–17; Stensiö 1931, pp. 161–165; Gross 1932b, p. 29) and *B? ymeri* (Stensiö 1931, pp. 165–166) previously described only the former is maintainable. *B? ymeri* has turned out to be based on a piece of a lateral plate of a Remigolepid and has thus to be dropped.

The researches now carried out on the large material of *Bothriolepis* brought home from East Greenland since 1931 shows that, besides *B. groenlandica* another two *Bothriolepis*-species, *B. jarviki* n. sp. and *B. nielseni* n. sp., are represented in the Upper Devonian of East Greenland. All these three Greenland species will be described below (pp. 536–606) in the special chapter dealing with the Greenland material.

Genus Grossilepis n. g.

In his work on the *Bothriolepis*-species of the *Cellulosa*-Marl of Latvia Gross (1941a, pp. 32–57) described a *Bothriolepis*-species, *B. tuberculata* Gross, which in certain of its characters differs so considerably from the other *Bothriolepis*-species that a new genus must be erected for it. This new genus will be named *Grossilepis* in honour of Dr. Gross, who has given so many important contributions to our knowledge of the Devonian vertebrate faunas of the Baltic States and Germany.

The *diagnosis* which can be given of the genus *Grossilepis* is as follows. *Bothriolepinae* of relatively small or moderate size. Anterior median dorsal plate normally of an almost uniform breadth behind the external postlevator processes and thus about equally broad across its lateral corners as towards its anterior and posterior ends. This plate normally overlapping both the anterior dorso-lateral and mixilateral plates, but sometimes also meeting the mixilateral plate with its very lateral edge, or slightly overlapped by that plate. Posterior median dorsal plate strikingly uniform in breadth throughout its extent. Anterior dorso-lateral and mixilateral plates also fairly uniform in breadth throughout their length. Dorsal lamina of mixi-



Text-fig. 266. *Grossilepis tuberculata*. Restoration of head-shield in dorsal aspect. From Gross 1941a. × 3/2.
Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner; *cir*, semicircular pit-line groove; *d. end*$_2$, external opening of canal for endolymphatic duct; *ifc*$_1$, upper infraorbital groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *nprl*, prelateral notch (for prelateral plate); *nsp*, supraspiracular notch; *plc*, postero-lateral (preobstantic) corner; *pp*, posterior pit-line groove of skull-roof; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median section of supraorbital sensory canal groove (the anterior median pit-line); *vcp*, vertical pit-line groove of the cheek.

lateral plate about as broad as exposed area of dorsal lamina of anterior dorso-lateral plate. Ornament delicate; in immature individuals probably reticular; in mature individuals consisting principally of somewhat pointed tubercles, mostly completely separated from each other, but in certain plates united by ridges more or less well developed.

Grossilepis is closely related to *Bothriolepis* and has certainly arisen from some late middle Devonian representative of that genus. At present it comprises only a single species *G. tuberculata* Gross, but material from Esthonia available to the writer seems to show that in the Baltic States it is represented also by a second species distinguished inter alia by a somewhat different and more reticular ornament.

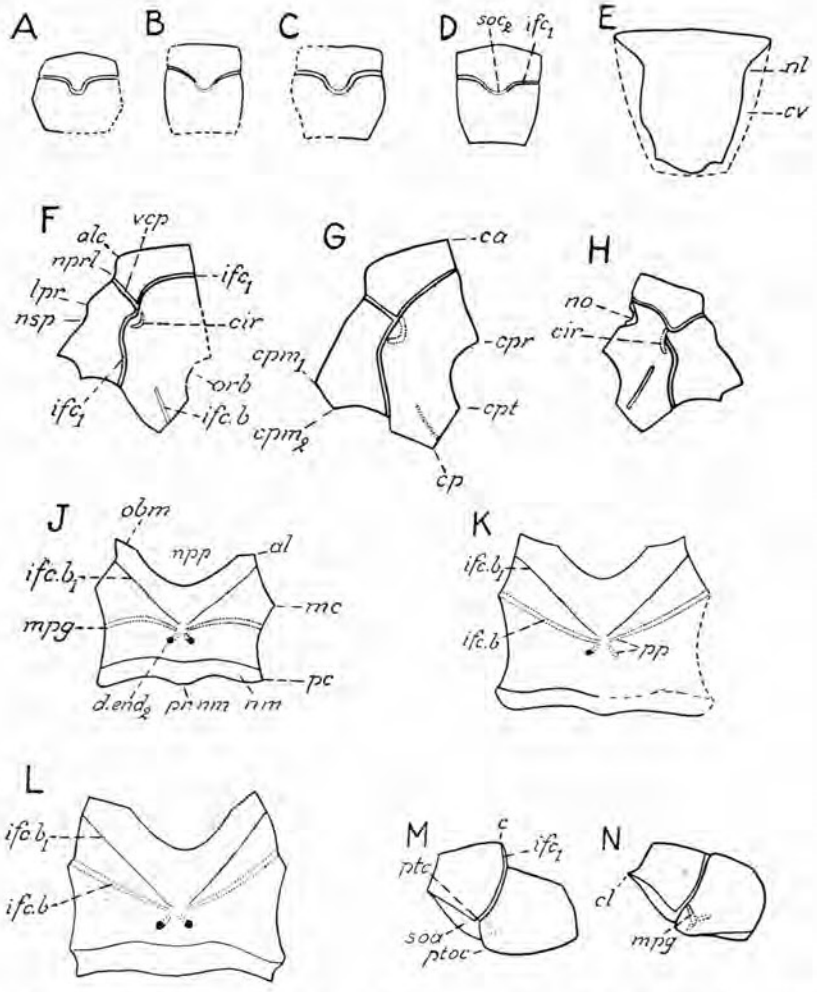
26. **Grossilepis tuberculata** (Gross).

(Text-figs. 26L, 28E, 35F, 36C–E, 39D, 41D, 43E, 44F, 45H, 47D, 48D, 53D, 266–271).
1932. *Bothriolepis cellulosa*, Gross (1932b), p. 24 (in part).
1933. *Bothriolepis cellulosa*, Gross (1933a), pp. 36–39, pl. 4, fig. 5 (in part).
1941. *Bothriolepis tuberculata*, Gross (1941a), pp. 32–57, text-figs. 25–43, pls. 18–28.

G. tuberculata has recently been described by Gross (1941a, pp. 32–57), and as in addition it has also been dealt with above in the general part of this work little needs to be said of it in this connection.

Diagnosis. – The diagnosis at present is the same as that of the genus *Grossilepis*.

Material. – The material available so far includes a few deficient head-



Text-fig. 267. *Grossilepis tuberculata*. *A–D*, four premedian plates in dorsal aspect. From Gross 1941a. Nat. size. *E*, premedian plate in ventral aspect. From Gross 1941a, slightly altered. × 2. *F–H*, three lateral plates in dorsal aspect. From Gross 1941a. *F*, × $^{2}/_{3}$, *G*, *H*, nat. size. *J–L*, three centro-nuchal plates in dorsal aspect. From Gross 1941a. *J*, $^{3}/_{2}$, *K*, *L*, × 2. *M–N*, two paranuchal-marginal plates in dorsal aspect. From Gross 1941a. Nat. size.

al, antero-lateral corner of centro-nuchal plate; *alc*, antero-lateral corner of lateral plate; *c*, anterior corner of paranuchal-marginal plate; *ca*, antero-medial corner of lateral plate; *cir*, semicircular pit-line groove; *cl*, lateral corner of paranuchal-marginal plate; *cp*, posterior corner of lateral plate; *cpm*$_1$, *cpm*$_2$, anterior and posterior postmarginal corners respectively of lateral plate; *cpr*, preorbital corner of lateral plate; *cpt*, postorbital corner of lateral plate; *cv*, area overlapping lateral plate; *d. end*$_2$, external opening of canal for endolymphatic duct; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc. b*$_1$, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mc*, lateral corner of centro-nuchal plate; *mpg*, probably middle pit-line groove of skull-roof; *nl*, ventral lateral notch (of premedian plate); *nm*, obtected nuchal area; *no*, occasional notch in antero-medial margin of lateral plate; *npp*, postpineal notch; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *obm*, orbital facet of centro-nuchal plate; *orb*, orbital notch; *pc*, postero-lateral corner of centro-nuchal plates *sp*, posterior pit-line groove of skull-roof; *pr.nm*, posterior median process of centro-nuchal plate; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area; *soc*$_2$, anterior median section of supraorbital sensory canal groove (the anterior median pit-line groove); *vcp*, vertical pit-line groove of cheek.

shields, a considerable number of detached plates of head-shields and trunk-armours, a few complete proximal segments of pectoral fins, and several detached plates of pectoral fins (Gross 1941a, pls. 18–28).

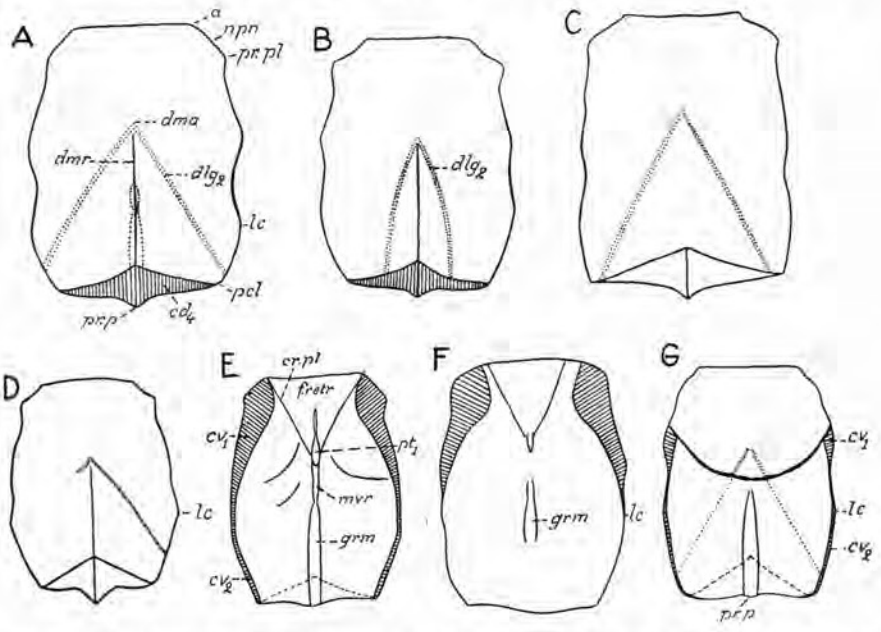
The holotype is a complete anterior median dorsal plate (Gross 1941a, p. 55, pl. 21, fig. 1), which is in the possession of the Swedish Museum of Natural History in Stockholm.

Description. – The specsie here in question attained only a comparatively small size. The maximal dorsal length of the armour (length of head-shield + dorsal length of trunk-armour) may be estimated at about 10–11 cm. The head-shield is maximally about 4 cm long. The dorsal wall of the trunk-armour seems to have attained a maximal length of about 6,5–7 cm.

Head-shield.

The head-shield (text-fig. 266) differs from that in *Bothriolepis* only in certain minor features. It may be mentioned for instance, that the fenestra suborbitalis and the otico-occipital depression are longer and narrower relatively (cf. Gross 1941a, pl. 18, fig. 2) than what seems normally to be the case in *Bothriolepis* (cf. text-figs. 11, 12, 15A, B).

The individual plates of the head-shield in most respects are much as in *Bothriolepis*. The premedian plate (*Prm*, text-figs. 266, 267A–E) varies considerably in shape. However, in medium-sized and fully mature individuals it is normally about as long as broad, or a little longer than broad. Indications of a rostral angle are often met with. The ventral lateral notch (*nl*, text-fig. 267E) is fairly deep and lies far forwards. The dorsal posterior margin is slightly concave and devoid of a nasal process and notch. The ventral posterior margin at least sometimes (Gross 1941a, pl. 18, fig. 2) is produced into an obtuse median process (text-fig. 267E). The median division (*prh*) of the preorbital recess (Gross 1941a, pl. 18, fig. 1) is of a shape similar to that in *Bothriolepis canadensis* and *B. cellulosa* (cf. text-figs. 9, 14, 15), but seems to extend somewhat further forwards than what is normally the case in those two species. The rostral and pineal plates are unknown. The lateral plate (*Lp*, text-figs. 266, 267F–H) shows no special characters of interest. The postpineal plate has not been found preserved, but, as is seen from the shape of the postpineal notch (*npp*, text-fig. 267J, K, L; cf. also text-fig. 266) of the centro-nuchal plate, it must have been broad and short, about as in young individuals of *B. canadensis* (cf. text-fig. 93A–E). The centro-nuchal plate (*Cn*, text-figs. 26L, 266, 267J, K, L) is usually fairly long and narrow, its breadth : length ratio ranging between 70–83. In this respect it is thus nearest as in medium-sized and large individuals of *B. canadensis* and *B. cellulosa*. On the other hand, in the relatively shallow postpineal notch (*npp*), in the presence of a broad obtuse posterior median process (*pr. nm*), and in the persistence of



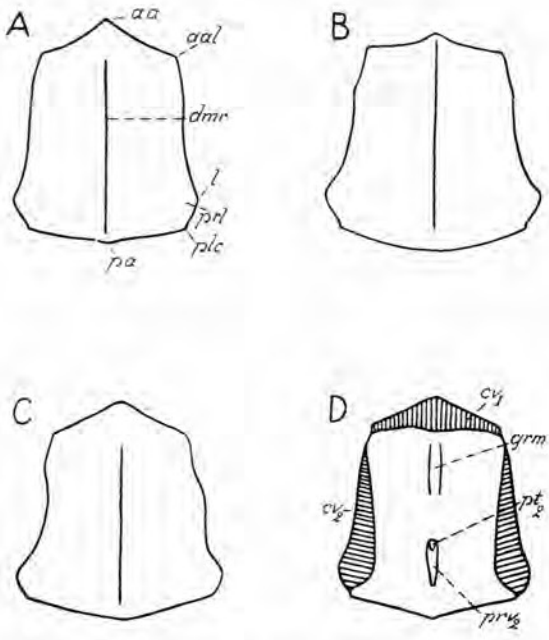
Text-fig. 268. *Grossilepis tuberculata*. *A–D*, four anterior median dorsal plates in dorsal aspect. *E*, *F*, two anterior median dorsal plates in ventral aspect. *G*, an anterior median dorsal plate in ventral aspect but with the anterior part preserved as an impression of the dorsal side. From Gross 1941a. Somewhat diminished.
a, antero-lateral corner; cd_4, area overlapped by posterior median dorsal plate; *cr. pl*, postlevator crest; cv_1, area overlapping anterior dorso-lateral plate; cv_2, area overlapping mixilateral plate; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *pcl*, postero-lateral corner; *pr. p*, posterior median process; *pr. pl*, external postlevator process; pt_1, anterior ventral pit.

vestiges of the anterior oblique cephalic pit-line groove (*ifc.* b_1) the plate is suggestive of the corresponding plate in young individuals of the *Bothriolepis*-species in general (cf. text-figs. 93A–E, 278A). Characteristic of this plate is otherwise that its lateral (*mc*) and postero-lateral (*pc*) corners are fairly slightly pronounced and that the anterior division of the lateral margin is shorter than the posterior division of the same margin. The paranuchal-marginal plate (*Pm*, text-figs. 28E, 266, 267M, N) shows no special characteristic features; its lateral division is generally broad. The postmarginal plate (*Pmg*, text-fig. 266) is about as in *B. cellulosa*.

The mental plate (text-fig. 35F) in all essentials is as in *Bothriolepis*. The inferognathal (text-fig. 36C–E) is shorter and more robust than in *B. canadensis* and differs also from that in *B. canadensis* in its ornament and in the more distinctly developed cusps or teeth on its upper margin.

Trunk-armour.

The trunk-armour was presumably not particularly high. The dorsal wall was probably low or only slightly elevated. As far as may judged (text-fig.

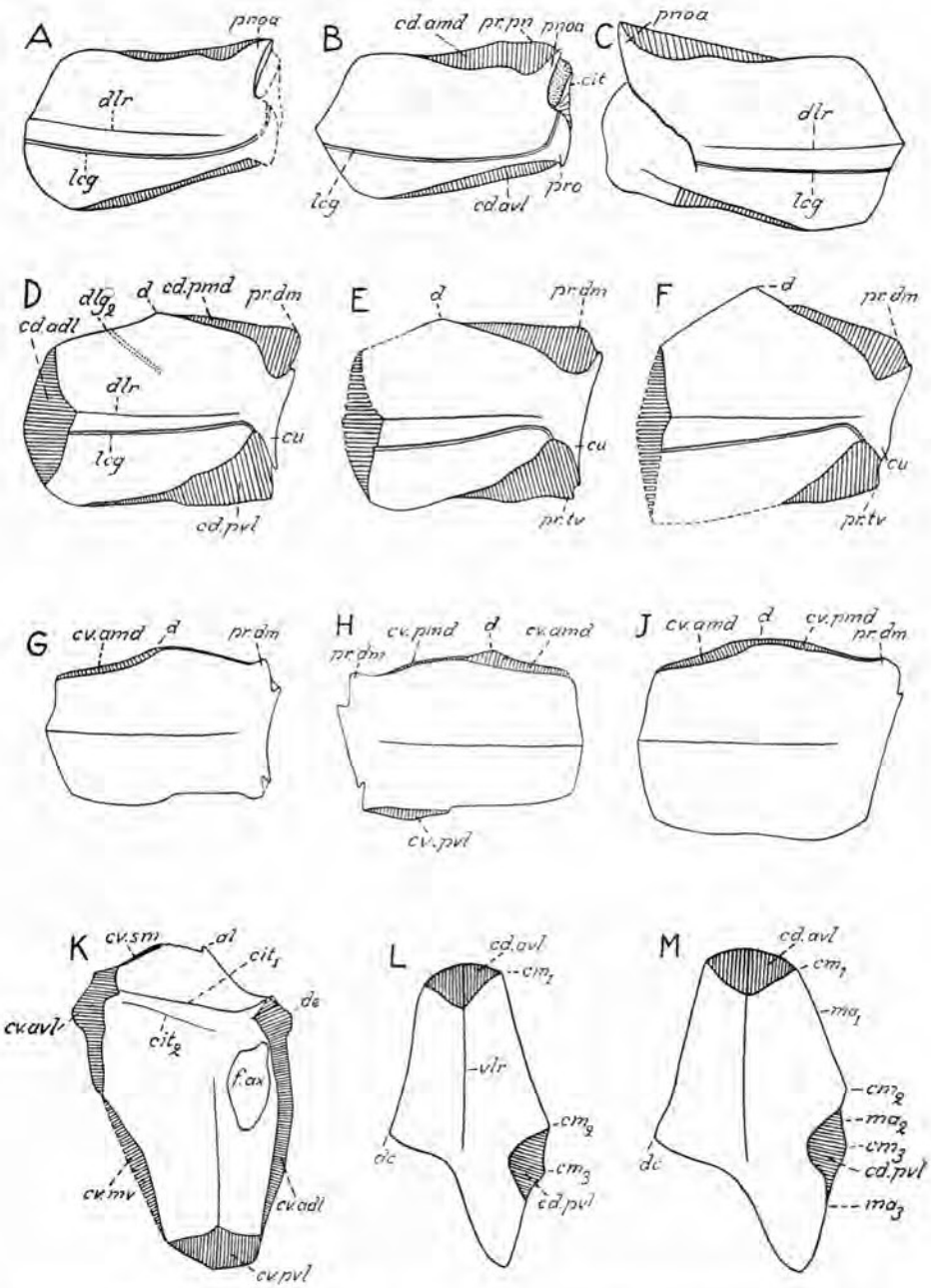


Text-fig. 269. *Grossilepis tuberculata*. *A–C*, three posterior median dorsal plates in dorsal aspect. *D*, a posterior median dorsal plate in ventral aspect. From Gross 1941 a. Nat. size, *aa*, anterior corner; *aal*, antero-lateral corner; cv_1, area overlapping anterior median dorsal plate; cv_2, area overlapping mixilateral plate; *dmr*, dorsal median ridge; *grm*, ventral median groove; *l*, lateral corner; *pa*, posterior corner or angle; *plc*, posteri-. lateral corner; *prl*, lateral process; prv_2 posterior ventral process; pl_2, posterior ventral pit.

39D), this wall was fairly broad, almost as broad as in *B. canadensis* (cf. text-figs. 39A, B, 179–183). The lateral walls were no doubt comparatively high. The tergal angle (*dma*, text-figs. 39D, 43E, 268A–D, G) is situated at the transition between the anterior and middle thirds, or in the hindmost part of the anterior third, of the anterior median dorsal plate. The dorsal median ridge (*dmr*, text-figs. 39D, 45H, 268A–D, 269A–C) is normally well developed from the tergal angle backwards about to the posterior corner of the posterior median dorsal plate. The dorso-lateral and ventro-lateral ridges are also well pronounced. The median dorsal part of the crista transversalis interna posterior which is situated on the posterior median dorsal plate is vestigial. The levator fossa (*f.retr*, text-figs. 44F, 268E, F) is comparatively long and narrow. The postlevator thickening (*alr*) is present, but is low and often obscure. The postlevator crest (*cr.pl*, text-figs. 44F, 268E, F), on the other hand, is normally fairly pronounced. The ventral median ridge (*mvr*) and ventral median groove (*grm*) are present (text-figs. 44F, 47D, 268E, F, 269D), but the former of these two structures sometimes seems to be very low or absent nearest behind the anterior ventral process (prv_1). The ventral tuberosity is absent (text-figs. 47D, 269D).

Particularly characteristic of the trunk-armour is that all the plates participating in the formation of its dorsal wall, that is to say the anterior and posterior median dorsal plates and the anterior dorso-lateral and mixilateral plates, are of a strikingly uniform width throughout their rostro-caudal extent (text-figs. 39D, 268, 269, 270A–J) and that the exposed area of the dorsal lamina of the mixilateral plate does not extend much further dorso-medially than the exposed area of the corresponding lamina of the anterior dorso-lateral plate (text-fig. 39D).

The anterior median dorsal plate (*Amd*, text-figs. 39D, 43E, 44F, 268A–G) is narrow, its breadth : length ratio ranging between 69–79 only. From the external postlevator process (*pr. pl*) backwards to its postero-lateral corners (*pcl*) the plate retains a fairly uniform breadth, and in contradistinction to what is the case in *Bothriolepis*, it is, therefore, mostly not broader, or only slightly broader, across its lateral corners than towards its ends. The lateral corners (*lc*) are slightly pronounced and sometimes even as obscure as not be clearly identifiable. The lateral margin is often somewhat undulating, particularly in its anterior parts. The posterior margin is broad, and is often produced into a strong posterior process (*pr. p*) suggestive of that in young individuals of *B. canadensis* (cf. text-fig. 121A–H). In contradistinction to what is the case in *Bothriolepis* the plate normally overlaps not only the anterior dorso-lateral plate, but in addition the mixilateral plate. The area (cv_2) by means of which it overlaps the last-mentioned plate is narrow (text-figs. 44F, 268E, G). In some cases the plate overlaps only the anterior dorso-lateral plate, whereas it either abuts against the mixilateral plate with its very lateral margin only (text-fig. 268F) or else is slightly overlapped by the last-mentioned plate. The posterior median dorsal plate (text-figs. 39D, 45H, 47D, 258) is normally narrower than long, but may occasionally also be about as broad as long, or a little broader than long. Its breadth:length ratio is 81–101, mostly, however, 81–95. From its antero-lateral corners (*aal*) backwards as far as to its lateral processes (*prl*) the plate widens only rather slightly and is, therefore, strikingly uniform in breadth in its by far longer anterior part. The lateral process (*prl*) is normally fairly short. The anterior corner is mostly angular. The posterior corner (*pa*) varies much in its development, sometimes being fairly distinct, sometimes much rounded off and obscure. In its general shape this plate reminds nearest of the corresponding one in *B. panderi* (cf. text-figs. 47D, 231D). The anterior dorso-lateral plate (*Adl*, text-figs. 39D, 48D, 270A–C) is of a long and narrow type somewhat similar to that in *B. maxima* or *B. groenlandica* (cf. text-figs. 238C, D, 288). Its dorsal lamina seems to be from about two and a half to about three times as long as broad, whereas its lateral lamina conceivably is from more than two and a half to more than three times as long as high. The mixilateral plate (*Mxl*, text-figs. 39D, 50D, 270D–J) is decidedly of a more uniform breadth than normally in



Text-fig. 270. *Grossilepis tuberculata*. *A–C*, three flattened anterior dorso-lateral plates in external aspect. *A*, *B*, right plates, *C*, left plate somewhat deficient anteriorly. *D–F*, three flattened left mixilateral plates in lateral aspect. *G*, *H*, *J*, three flattened mixilateral plates, one (*H*) left plate, and two right (*H*, *J*) plates, in medial aspect. *K*, a flattened right anterior ventro-lateral plate seen from the internal side; *L*, *M*, two flattened right posterior ventro-lateral plates in external aspect. From Gross 1941a. All the restorations in nat. size.

Bothriolepis, and in connection with this its dorsal corner (*d*) is generally obtuse and often also little conspicuous. The dorsal lamina of the plate is mostly narrow, whereas the lateral lamina is comparatively high. The anterior ventro-lateral plate (*Avl*, text-figs. 41D, 270K) in several of its characters is much as in *Bothriolepis* and so is also the posterior ventro-lateral plate (*Pvl*, text-figs. 41D, 53D, 270L, M). The stretches along which the anterior ventro-lateral plate and the posterior ventro-lateral plate are suturally connected with their antimeres respectively in the ventral wall of the trunk-armour are short, shorter than what is normally the case in *Bothriolepis*. The area on the right posterior ventro-lateral plate (*cd. pvl*, text-fig. 270L, M) that is overlapped by the posterior ventro-lateral plate is even very short, extending only slightly backwards on to the subanal division of the ventral lamina of the plate. The subanal divisions of the posterior ventro-lateral plates were connected, therefore, principally by their very medial margins and by ligaments only. Finally, it may also be mentioned that the posterior part of the anterior ventro-lateral plate and the anterior part of the posterior ventro-lateral plate that lie laterally to the median ventral plate are unusually narrow. The semilunar plate (*Sm*, text-fig. 41D) is still unknown, but it is evident that it was small and of a shape similar to that in *Bothriolepis*. Finally the median ventral plate (*Mv*, text-fig. 41B) has also not been found preserved, but it is obvious, however that this plate must have been very large, larger even than in *B. maxima* among the *Bothriolepis*-species.

Pectoral fin.

The pectoral fin is fairly slender, though not so slender as in certain of the *Bothriolepis*-species, for instance *B. jarviki* (cf. text-fig. 306). The prox-

al, antero-lateral corner of anterior ventro-lateral plate; *cd. adl*, area overlapped by anterior dorso-lateral plate; *cd. amd*, area overlapped by anterior median dorsal plate; *cd. avl*, areas overlapped by anterior ventro-lateral plate; *cd. pmd*, area overlapped by posterior median dorsal plate; *cd. pvl*, areas overlapped by posterior ventro-lateral plate; cm_1, cm_2, cm_3, anterior, middle and posterior corners of ventral lamina of posterior ventro-lateral plate; *cu*, postero-ventral ornamented corner; *cv. adl*, area overlapping anterior dorso-lateral plate; *cv. amd*, area overlapping anterior median dorsal plate; *cv. avl*, area overlapping left anterior ventro-lateral plate; *cv. mv*, area overlapping median ventral plate; *cv. pmd*, area overlapping posterior median dorsal plate; *cv. sm*, area overlapping semilunar plate; *cv. pvl*, area overlapping posterior ventro-lateral plate; *cit*, cit_1, cit_2, parts of the crista transversalis interna anterior; *d*, dorsal corner of mixilateral plate; *dc*, dorsal corner of posterior ventro-lateral plate; *de*, dorsal corner of anterior ventro-lateral plate; *dlr*, dorso-lateral ridge; dlg_2, posterior oblique abdominal pit-line groove; *f. ax*, foramen axillare; *lcg*, main lateral line groove; ma_1, anterior division of medial of the ventral lamina of posterior ventro-lateral plate, attached to median ventral plate; ma_2, posterior division of ventral lamina of posterior ventro-lateral plate, attached to posterior ventro-lateral plate of opposite side; ma_3, hindmost division of medial margin of ventral lamina of posterior ventra-lateral plate (connected with the corresponding division of the opposite ride by its very edge); *pnoa*, postnuchal ornamented corner; *pro*, processus obstans; *pr. dm*, medial dorsal process; *pr. pn*, internal postlevator process; *pr. tv*, postero-ventral process or corner of mixilateral plate.

imal segment (text-fig. 271A, B) in medium-sized and large individuals is from somewhat more than four and a half to slightly more than five times as long as broad. As in *Bothriolepis*, the segment is provided with spines both on its lateral and dorso-medial margins. The spines are numerous, small, closely set and fairly obtuse. The medial ones situated on the dorsal central plate 1 and on the adjacent proximal part of the medial marginal plate 2 point upwards, which, as we have seen, is also the case in several of the *Bothriolepis*-species. The distal segment is deficiently preserved, but the remains present of it indicate clearly (Gross 1941a, pp. 53–54, text-fig. 43C–H) that it was comparatively narrow.

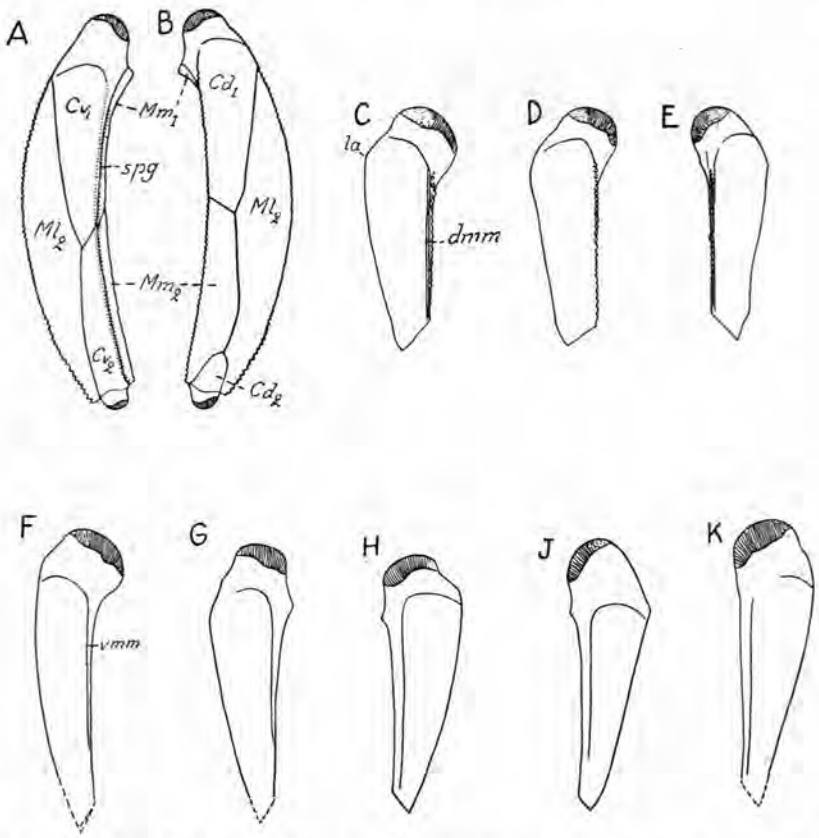
The various plates of the pectoral fin-armour (text-fig. 271C–K; cf. Gross 1941a, text-figs. 38–43) are mostly long and slender.

Ornament.

The ornament in medium-sized and large individuals is very characteristic. It consists principally of numerous fairly closely and irregularly set tubercles, which are fairly pointed and in places somewhat stellate at their bases. In several places there are more or less vestigial ridges which radiate from the tubercles. Several of these ridges end already a short distance from the tubercles, whereas others are longer and pass over into other ones issuing from reighbouring tubercles. Accordingly the ornament is clearly reticular in places, with low anastomosing ridges and well pronounced tubercles at the points of anastomosis of the ridges. A more or less reticular ornament of this type is mostly found on the anterior and lateral parts of the head-shield, on the lateral and ventral sides of the trunk-armour, and on the proximal segment of the pectoral fin, but may sometimes also be met with on the dorsal side of the trunk-armour. The lateral plates of the head-shield may not rarely present a quite typical reticular ornament, which is highly suggestive of that in *B. cellulosa*. The fact that the ornament in medium-sized and large individuals thus partly has a reticular disposition must certainly involve that the ornament in *Grossilepis* during the growth of the individuals underwent a change corresponding to that in *Bothriolepis* (cf. pp. 169–171). We may be justified in concluding, therefore, that in very young individuals of *Grossilepis* the ornament was entirely or principally reticular in character, but that then, in the following stages of growth, it was so highly transformed that it became principally purely tubercular.

Sensory canal system.

The sensory canal system in all essentials is as in *Bothriolepis*. It is interesting is, however, that in contrast to what is generally the case in the *Bothriolepis*-species (cf. pp. 177–178, 211–214 above) the anterior oblique cephalic pit-line groove (*ifc.*b_1, text-figs. 26L, 267J, K, L; cf. also



Text-fig. 271. *Grossilepis tuberculata*. *A*, *B*, restorations of the proximal segment of a right pectoral fin in ventral and dorsal aspects respectively. Nat. size. *C–E*, two left and one right dorsal central plate 1 in dorsal aspect. *F–K*, two right and three left ventral central plates 1 in ventral aspect. From Gross 1941a.

Cd_1, Cd_2, dorsal central plates 1 and 2 respectively; Cv_1, Cv_2, ventral central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_1, Mm_2, medial marginal plates 1 and 2 respectively; *dmm*, dorso-medial margin with its row of spines; *vmm*, ventro-medial margin; *sgp*, pectoral pit-line groove.

Gross 1941a, pl. 19, figs. 10–14, 17) persisted even in medium-sized and large individuals, whereas vestiges of the anterior oblique abdominal pit-line groove are only rarely to be observed in individuals of these two stages of growth (Gross 1941a, pl. 21, fig. 1). The supratemporal pit-line groove is normally obscure (Gross 1941a, pl. 19, figs. 11, 14) or absent.

Remarks. – As already pointed out by Gross (1941a, pp. 55–57, 69–71), *G. tuberculata* is a Bothriolepine form closely related to the *Bothriolepis*-species. On account of this, and because of the fact that its anterior median dorsal plate sometimes may be suturally connected with the adjacent plates in a *Bothriolepis*-like manner, *G. tuberculata* was provisionally retained by Gross in the genus *Bothriolepis*.

Localities and geological horizon. – *G. tuberculata* is known with

certainty only from the *Cellulosa*-marl of Kokenhusen and Stockmannshof on the river Düna, Latvia, where it occurs associated with *Bothriolepis cellulosa*. The deposits from which it comes belong to the lowermost part of the Upper Devonian (Gross 1942a, pp. 392–409).

Discription of the Bothriolepis-material from Eeast Greenland.

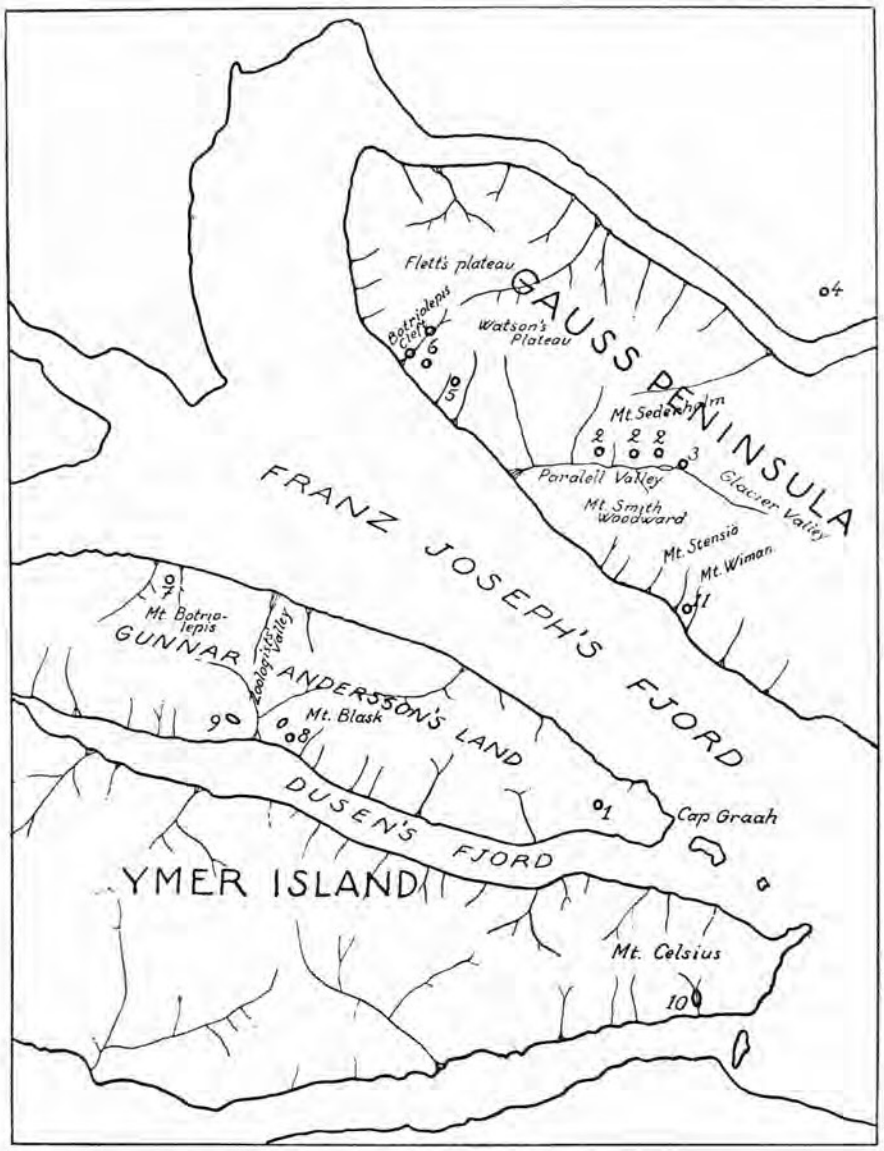
General remarks.

The *Bothriolepis*-material from East Greenland described below comes mainly from the W. half of Gauss Peninsula and the N. part of Ymer Island north of Dusén Fjord (text-fig. 272). A few remains have also been found north of Moskus Ox Fjord, and at Mt. Kongeborgen on Trail Island (cf. Stensiö 1931, text-fig. 1).

The three *Bothriolepis*-species, *B. jarviki*, *B. groenlandica* and *B. nielseni* known so far from East Greenland are all of Upper Devonian age. *B. jarviki* occurs in the lower, and *B. groenlandica* in the higher, parts respectively of the *Phyllolepis*-series (Säve-Söderbergh 1934, pp. 40–42, table on p. 43), whereas *B. nielseni* has been found only in the lowermost red division of the *Remigolepis*-series (Säve-Söderbergh 1934, pp. 42–44), slightly above the *Phyllolepis*-series. In the same part of the *Phyllolepis*-series as *B. jarviki* are found: an underterminable Selachian fin-spine; a tooth of *Cladodus* sp., and numerous remains of *Holoptychius (H. nobilissimus?, H. giganteus?)*. *B. groenlandica* is associated with remains of *Phyllolepis orvini*, *Onychodus* sp. (Stensiö 1936, p. 8, pl. 16, figs. 1, 2) and *Holoptychius (H. nobilissimus?, H. giganteus?)*. Finally, *B. nielseni* is associated with a larger vertebrate fauna including among others the following forms: *Phyllolepis nielseni* (Stensiö 1939a, pp. 3, 20–26), *Remigolepis* spp, *Holoptychius (H. nobilissimus?, H. giganteus?)*, Rhizodontid Crossopterygians, possibly one or a few ordinary Dipnoans, long snouted Dipnoans, and Ichthyostegid Stegocephalians.

As has already been mentioned (p. 523), the species *B? ymeri*, erected by the present writer in 1931 (Stensiö 1931, pp. 165–166), has turned out to be based on a lateral plate of a *Remigolepis*-species, on account of which it is not retainable.

The *Bothriolepis*-material from East Greenland here treated is comprehensive, but is on the whole poorly preserved. Despite its poor state of preservation it is of considerable interest. It widens our knowledge of the *Bothriolepis*-fauna of the Upper Devonian of East Greenland and throws much new light on all the *Bothriolepis*-species of this fauna, particularly, however, on



Text-fig. 272. Sketch-map showing the position of the *Bothriolepis*-localities on Gauss Peninsula and on Ymer Island. 1) Orvin's locality (the type locality of *B. groenlandica*). 2) The various localities on Mt. Sederholm. 3) The localities in Glacier Valley. 4) The locality W. of Mt. Anchor. 5) Locality about 4 km W. of Parallel Valley. 6) Locality discovered by Kulling and referred to by him (1931) and by the writer (Stensiö 1931, text-fig. 1) as localities 7–9; this locality named „*Bothriolepis* cleft" by Säve-Söderbergh in 1934 (p. 30 and text-fig. 11). 7) Mt. Bothriolepis (the type locality of *B. jarviki*). 8) Mt. Blask. 9) W. side of Zoologists' Valley (Profiles *A* and *B*, measured by E. Nielsen in 1936). 10) Locality W. of Cape Humboldt (Heintz 1930, p. 44). 11) Locality on the etrraces at the foot of Mt. Wiman (the only locality of *B. nielseni*). – The locality at Mt. Kongeborgen not shown in the map.

B. groenlandica. Besides, it is also of importance in that it helps in elucidating the range of variation of the *Bothriolepis*-species, and in that it exhibits certain features of interest from a general anatomical point of view.

The approximate position of the various find-localities of *Bothriolepis*-remains on Ymer Island, on Gauss Peninsula, and N. of Moskus Ox Fjord is shown in the sketch-map reproduced in text-fig. 272. Detailed information concerning these localities are given in the descriptions of the various species (pp. 586–587, 600–601, 606).

Description of the species.

27. **Bothriolepis groenlandica** Heintz.

(Text-figs. 1B, 13, 20A, 23J, 24F, 26I, J, 28D, 43C, 44E, 45F, G, 47C, 273–282, 283A, D, 284–302; pls. 1–13, 15–42; pl. 43, figs. 1–3; pls. 44–57; pl. 58, fig. 1; pls. 59–69).

1930. *Bothriolepis groenlandica*, Heintz, pp. 42–44; pl. 1.
1931. *Bothriolepis groenlandica*, Stensiö, pp. 161–165; pl. 1, figs. 2, 3 (not fig. 1); pl. 2, fig. 2 (in part).
1932. *Bothriolepis groenlandica*, Heintz, pp. 14–17; pl. 3, figs. 1, 3; pl. 4, figs. 1–3 (? fig. 4).
1932. *Bothriolepis groenlandica*, Gross (1932b), p. 29 (in part).
1932. *Bothriolepis groenlandica*, Säve-Söderbergh, pp. 20, 21, 27, 29 (in part).
1933. *Bothriolepis groenlandica*, Säve-Söderbergh, p. 23 (in part).
1934. *Bothriolepis groenlandica*, Säve-Söderbergh, pp. 41–43 (in part).

Diagnosis. – Species attaining a considerable size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) amounting to about 35–36 cm. Maximal dorsal length of trunk-armour about 25–26 cm. Head-shield with a breadth:length ratio of 130–147, and fairly flat in its preorbital division. Rostral margin of head-shield shorter than posterior margin of head-shield, usually slightly convex, and sometimes with vestiges of a rostral angle. Lateral margins of head-shield generally much converging forwards, mostly shorter, but in certain cases longer, than distance between lateral corners of centro-nuchal plate. Obstantic margin of either side directed much laterally and fairly long, ending anteriorly at, or slightly behind, a transverse plane through the posterior boundary of the orbital fenestra. Median division of preorbital recess ending anteriorly with a marked median angle, and lateral division of the same recess produced much laterally, ending in a pointed angle above the middle narrow part of the spiracular groove. Premedian plate generally with a nasal process, and in large individuals normally broader than long. Pineal plate somewhat longer than broad and pierced by a pineal opening; its anterior margin convex, and its postero-lateral corners slightly produced. Postpineal plate with a slightly concave or almost straight anterior (orbital) margin. Centro-nuchal plate with a length : breadth ratio of 76–98 (when this ratio amounts to 96–98 the posterior median process of the plate is very long). Lateral division of paranuchal-marginal plate narrow with a usually fairly short lateral mar-

gin. Postmarginal plate equally broad as long, or broader than long. Trunk-armour fairly low and long with a high dorsal and low lateral walls. Dorsal wall somewhat rounded in its median most elevated part, but sloping fairly steeply laterally in its lateral parts and meeting the lateral wall of either side at an angle of about 120–130°. Tergal angle at the transition between the anterior and middle thirds of the anterior median dorsal plate or, more frequently, a little anteriorly to that place. Dorsal median ridge in large individuals weakly developed and often partly absent. The median dorsal part of crista transversalis interna posterior situated on posterior median dorsal plate fairly low. Postlevator thickening, and often also postlevator crest, well developed. Ventral tuberosity present though fairly low. Anterior median dorsal plate very variable as to shape and proportions; its breadth: length ratio with a total range of 75–100 (75–87 in small and medium-sized individuals, and about 100 in very large individuals); anterior margin of the plate normally somewhat concave, but not rarely fairly straight and in some cases even somewhat convex; posterior margin of the plate short, above all in small individuals. Posterior median dorsal plate narrow in its anterior part; its breadth : length ratio with a total range of 78–100 (78–84 in small individuals; 80–96 in medium-sized individuals; and about 100 in very large individuals); posterior corner of the plate slightly developed or rounded off. Anterior dorso-lateral plate fairly long and low in lateral aspect; dorsal lamina from somewhat more than twice to about two and a half times as long as broad; lateral lamina from somewhat more than three to about three and a half times as long as high. Mixilateral plate fairly variably as to shape and proportions; dorsal lamina from somewhat less than twice to more than two and a half times as long as broad; lateral lamina from somewhat more than three to nearly four and a half times as long as high. Lateral lamina of anterior ventro-lateral plate about three and a fourth times as long as high; ventral lamina of this plate from not fully twice to somewhat more than twice as long as broad. Posterior ventro-lateral plate with its dorsal corner produced into a distinct dorsal process situated in a ventrally opening pit in the lateral lamina of the mixilateral plate. Lateral lamina of posterior ventro-lateral plate presumably about twice, or somewhat more than twice, as long as high; ventral lamina from somewhat more than twice to about two and a half times as long as broad. Pectoral fin fairly slender. Proximal segment from about six (in very small individuals) to about four times (very large individuals) as long as broad. Distal segment comparatively robust proximally, but usually comparatively slender in its distal parts. Lateral spines of proximal segment fairly strongly developed, but are somewhat stronger relatively in small individuals than in large ones. Medial spines of proximal segment numerous, closely set and small; the proximal ones of these spines, situated on the dorsal central plate 1 and on the adjacent proximal part of the medial marginal plate 2, directed dorsally, or dorso-medially

and generally more or less completely fused together into a crest. Dorsal central plate 1 3,1–2,9 times as long as broad. Ventral central plate 1 4–3,1 times as long as broad. Ornament of a fairly uniform coarseness on head-shield and trunk-armour, and in all stages of growth of the individuals consisting of a regular fine-meshed network of anastomosing ridges, normally without tubercular swellings and elevations. Independent tubercles absent.

Material.

The material here referred to *B. groenlandica* is fairly comprehensive, including more than 200 specimens (Nos. 166, 344, 370, 373, 376, 377, 396, 402, 404, 410, 422, 435, 463, 467, 482, 484, 486, 488, 489, 491, 972, 996–1200). The vast majority of these specimens are detached plates. Only comparatively few specimens consist of two or more plates in natural connection with each other. Among these latter specimens there are more or less complete head-shields, ventral and lateral parts of trunk-armours with pectoral fins, and proximal and distal segments of pectoral fins. On the other hand, there are no specimens exhibiting coherent parts of the dorsal wall of the trunk-armour.

The holotype is a detached anterior median dorsal plate of a medium-sized individual (Heintz 1930, pl. 1, fig. 1).

Description.

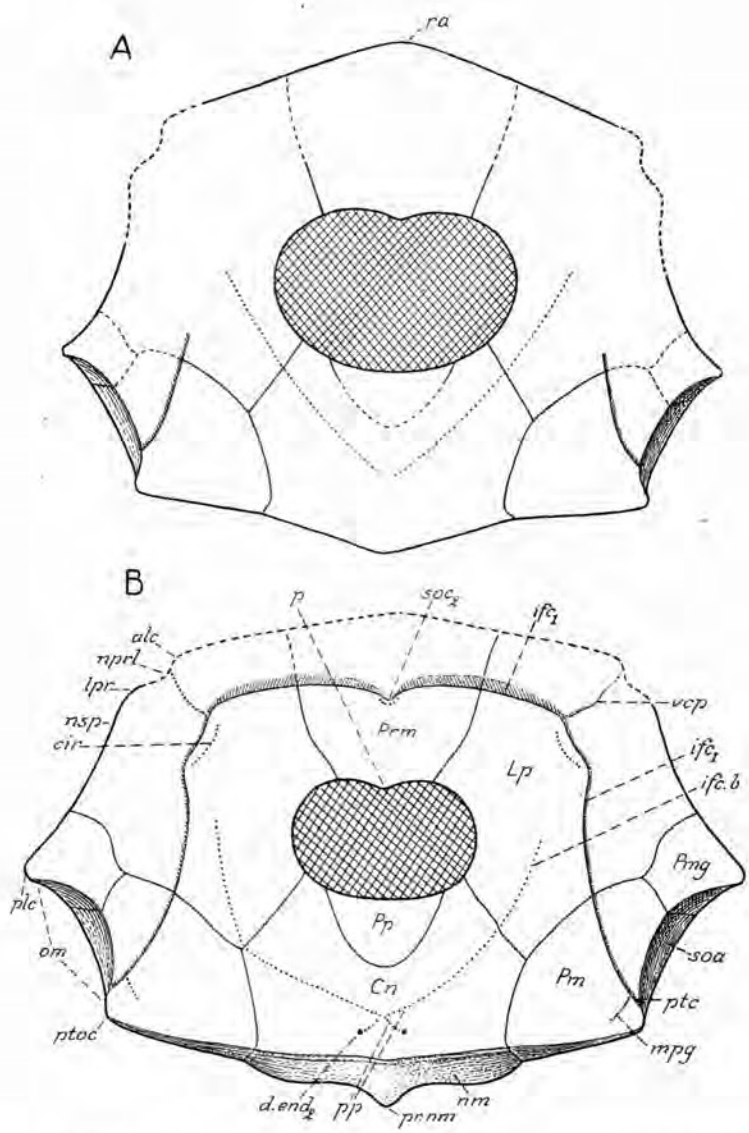
Size and general proportions.

The material of *B. groenlandica* available is from individuals of very different stages of growth. More Precisely, it is from individuals in which the dorsal length of the trunk-armour is at the minimum about 4,6 cm and at the maximum about 26 cm. The maximal dorsal length of the armour (length of head-shield + dorsal length of trunk-armour) may be estimated at least at about 35–36 cm. The smallest head-shield preserved is 2,3 cm long and about 3 cm broad, whereas the largest one is 10,1 cm long and 14,6 cm broad. The largest anterior and posterior median dorsal plates are respectively about 15 and 11,7 cm long. In several cases the proximal segment of the pectoral fin attained a length of about 15–18 cm or even somewhat more. As is thus obvious from the measurements given, *B. groenlandica* did not attain fully the same maximal size as *B. gigantea*, but is nevertheless one of the largest *Bothriolepis*-species known at present.

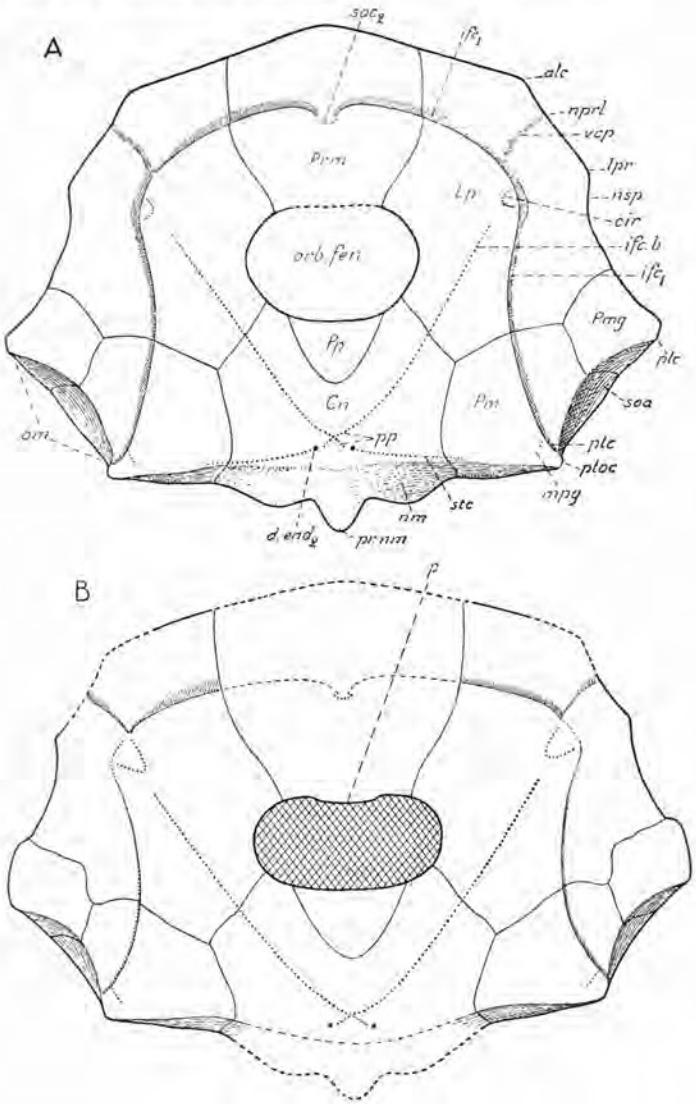
Head-shield and dermal bones of the cheek and visceral skeleton.

As normally in the *Bothriolepis*-species, the head-shield (text-figs. 13, 273, 274; pls. 1–3; pl. 5, figs. 1, 2; pls. 6, 12; pl. 13, fig. 1) varies somewhat

with regard to shape and proportions. Its breadth : length ratio, calculated with full, or at least reasonable, certainty in six cases, ranges between 130 –147 and is thus very nearly as in *B. canadensis*. The shield narrows fairly much forwards in front of its postero-lateral (preobstantic) corners (*plc*); its preorbital division is comparatively slightly arched both in rostro-caudal and transverse directions, and in this respect is thus much as in *B. maxima* and *B. gigantea*. As in other *Bothriolepis*-species, the orbital fenestra is larger in young individuals (text-fig. 273A) than in medium-sized and large individuals (text-figs. 13, 273B, 274); in large individuals (text-figs. 13, 274B) this fenestra is also strikingly short in proportion to its breadth. The various margins of the head-shield are developed as follows. The rostral margin is shorter than the posterior margin; normally it is only slightly convex and resembles usually, therefore, the corresponding margin in *B. maxima* and *B. gigantea* (cf. text-figs. 233A, 253A); in certain cases (text-fig. 274A; pl. 12, fig. 1; pl. 13, fig. 1), however, it may be fairly strongly convex. In young individuals (text-fig. 273A; pl. 6) the margin in question is provided with a distinct rostral angle which may persist in a vestigial condition in mature individuals. The antero-lateral corner (*alc*, text-figs. 13, 273, 274, 277) is generally distinct. The lateral margins converge fairly strongly forwards, about as in *B. canadensis*, *B. cellulosa*, *B. panderi* and *B. alvesiensis* (cf. text-figs. 9–12, 82–84, 219, 229, 247, 249). These margins are generally shorter than the distance between the lateral corners of the centronuchal plate, but may in some cases exceed that distance in length. The prelateral notch (*nprl*, text-fig. 277) varies considerably in shape and extent. The supraspiracular process (*lpr*, text-figs. 13, 273, 274, 277) lies far forwards, about opposite the middle or posterior parts of the premedian plate. The supraspiracular notch (*nsp*) is always distinct. The postero-lateral (preobstantic) corner (*plc*) is mostly produced into a short, lateral process, but may in certain cases be without such a process. The obstantic margin of either side (*om*) is comparatively long, extending forwards as far as to, or a little beyond, a transverse plane through the posterior boundary of the orbital fenestra; this margin is also as a whole directed decidedly more laterally than in most other *Bothriolepis*-species. The subobstantic area (*soa*, text-figs. 13, 273, 274, 279) is broader in its foremost parts than in *B. canadensis* (cf. text-figs. 28, 29, 100). As in *B. cellulosa*, *B. maxima* and *B. gigantea*, the posterior margin is clearly somewhat more convex than in *B. canadensis* (cf. text-figs. 82–84). In small individuals the posterior margin bears a broad angular median corner (*pr.nm*, text-figs. 273A, 278A; pl. 6, fig. 2) which then in medium-sized and large individuals (text-figs. 273B, 274, 278B–K; pl. 3, fig. 2; pl. 5, figs. 1, 2; pl. 7, figs. 4, 5; pl. 11, figs. 1–3; pl. 12; pl. 13, fig. 1) was mostly transformed into a real posterior median process. However, in certain cases the median angular corner persisted as such even in large individuals (text-fig. 13; pl. 1). As we thus see, the posterior median



Text-fig. 273. *Bothriolepis groenlandica*. Restorations of two head-shields in dorsal aspect. *A*, of a young individual (cf. pl. 6). × $^{8}/_{4}$. *B*, of a medium-sized individual (cf. pl. 3, fig. 2). × $^{15}/_{16}$. *Cn*, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; *d. end*$_2$, external opening of canal for ductus endolymphaticus; *ifc*$_1$, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *om*, obstantic margin; *p*, nasal process; *plc*, postero-lateral (preobstantic) corner of head-shield; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process of centro-nuchal plate; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *ra*, rostral angle; *soa*, subobstantic area; *soc*$_2$, anterior median section of supraorbital sensory canal grooves, the anterior median pit-line; *vcp*, vertical pit-line groove of cheek.



Text-fig. 274. *Bothriolepis groenlandica*. Restorations of two head-shields in dorsal aspect. *A*, of a medium-sized individual (cf. pl. 2, fig. 1; pl. 13, fig. 1). $^9/_8$. *B*, of a large individual (cf. pl. 12). $\times\ ^3/_4$.

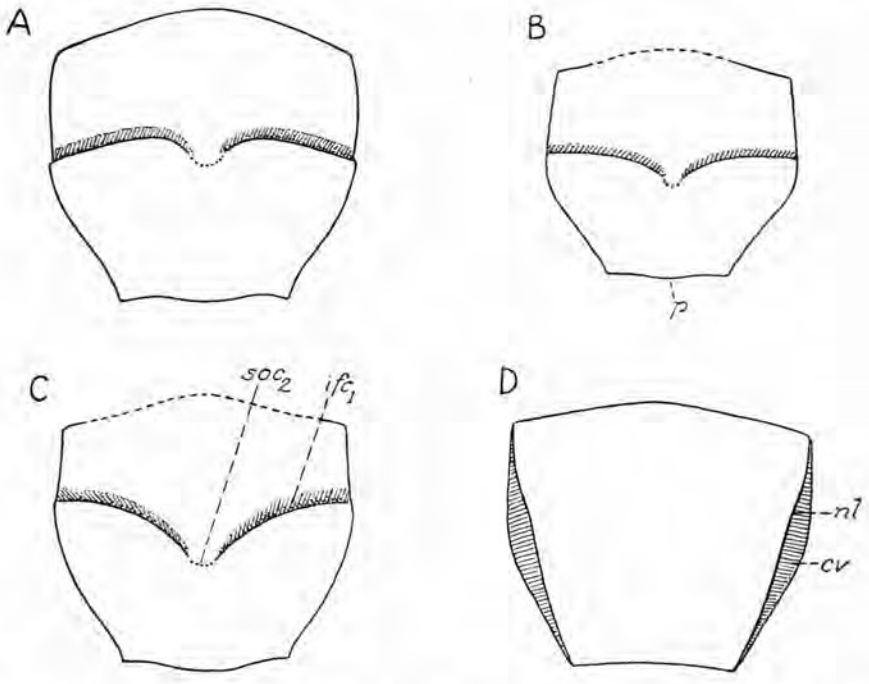
Cn, centro-nuchal plate; *Lp*, lateral plate; *Pm*, paranuchal-marginal plate; *Pmg*, post-marginal plate; *Pp*, postpineal plate; *Prm*, premedian plate; *alc*, antero-lateral corner of head-shield; *cir*, semicircular pit-line groove; *d. end_2*, external opening of canal for ductus endolymphaticus; *ifc_1*, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mpg*, middle pit-line groove of skull-roof; *nm*, obtected nuchal area; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *om*, obstantic margin; *orb. fen*, orbital fenestra; *p*, nasal process; *plc*, postero-lateral (preobstantic) corner of head-shield; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process of centro-nuchal plate; *plc*, cephalic division of main lateral line groove; *ploc*, postobstantic corner; *soa*, subobstantic area; *soc_2*, anterior median section of supraorbital sensory canal grooves, anterior median pit-line; *stc*, supra-temporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

process generally during the growth of the individuals underwent a change in shape corresponding to that in *B. canadensis* (cf. above pp. 75–76, 257–258; cf. also text-fig. 93A–E). When typically developed this process is bounded laterally on either side by a more or less pronounced concavity, which in its turn is flanked by a paired convexity (text-figs. 273B, 274, 278B–K). Generally the process is moderately developed, but in certain cases it may be strikingly long, considerably longer than in other species where it is known in any detail at present (text-figs. 26I, 274A, 278H; pl. 3, fig. 2; pl. 5, fig. 2; pl. 7, figs. 4, 5; pl. 11, figs. 2; pl. 12, fig. 1; pl. 13, fig. 1). The obtected nuchal area (*nm*, text-figs. 13, 273, 274, 278) is normally broader than in *B. canadensis* (cf. text-figs. 82–84, 93) and most other species and reminds in this respect nearest of the corresponding area in *B. maxima* (cf. text-figs. 236A, 237B).

The preorbital recess (*prh*, prh_1, text-figs. 13, 277F; pl. 1; pl. 8, figs. 4, 5; pl. 9, fig. 5; pl. 10, figs. 2, 4) is of a type similar to that in *B. maxima* (text-fig. 233A). It is thus not only larger, but also of a shape different from that in *B. canadensis*, *B. cellulosa* and *Grossilepis* (cf. pp. 48–52, 235–237, 439–440; cf. also text-figs. 9, 14, 15). The median unpaired division (*prh*) is produced forwards so that it forms a median well-marked angle (text-fig. 13, pl. 8, fig. 4) situated about midway between the anterior and posterior margins of the premedian plate. This division is imperfectly subdivided dorsally into a right and a left half by a rostro-caudal ridge (*rd*, text-fig. 13; pl. 1) situated on the inside of its dorsal wall. The lateral paired division (prh_1) of the recess is much longer than in *B. canadensis* and *B. cellulosa*, extending laterally and somewhat forwards to a point in the lateral plate situated above the middle narrow part of the spiracular groove (*spg*), close in front of the anterior end of the depression (*pr. po*) caused by the postorbital process of the endocranium (text-figs. 13, 277F; pl. 8, fig. 4). Its distal end is pointed. The median and lateral divisions of the recess are in open connection with each other only furthest posteriorly, nearest to the orbital chamber, whereas their other more anteriorly situated parts are separated by bone tissue.

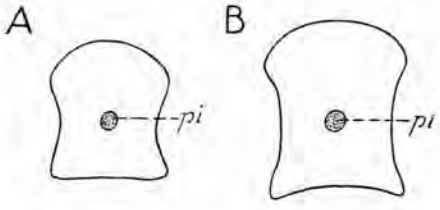
The lower side of the head-shield (text-fig. 277; pl. 1; pl. 8, figs. 3–5; pl. 10, figs. 1–4, 6; pl. 11, figs. 2, 4, 5) is essentially as in *B. canadensis* (pp. 47–62, 235–237 above; cf. also text-figs. 11, 12, 15A, B). However, the oblique premedian ridge (*ri*) seems normally to be absent. In certain cases there is a short, unpaired median rostro-caudal ridge (*rv*) on the posterior part of the premedian plate underneath the median division of the preorbital recess.

As in *B. canadensis*, the premedian plate (text-figs. 13, 20A, 273–275; pls. 1–3; pl. 5, figs. 1, 2; pl. 6; pl. 7, figs. 1, 2; pl. 8, figs. 3–5; pl. 9, fig. 2; pl. 12, fig. 1; pl. 13, figs. 1, 2) is clearly broader in young individuals than in older individuals (cf. pp. 64, 211–214; cf. also text-figs. 85, 86). However, it is of a somewhat broader type than in *B. canadensis*, being broader than

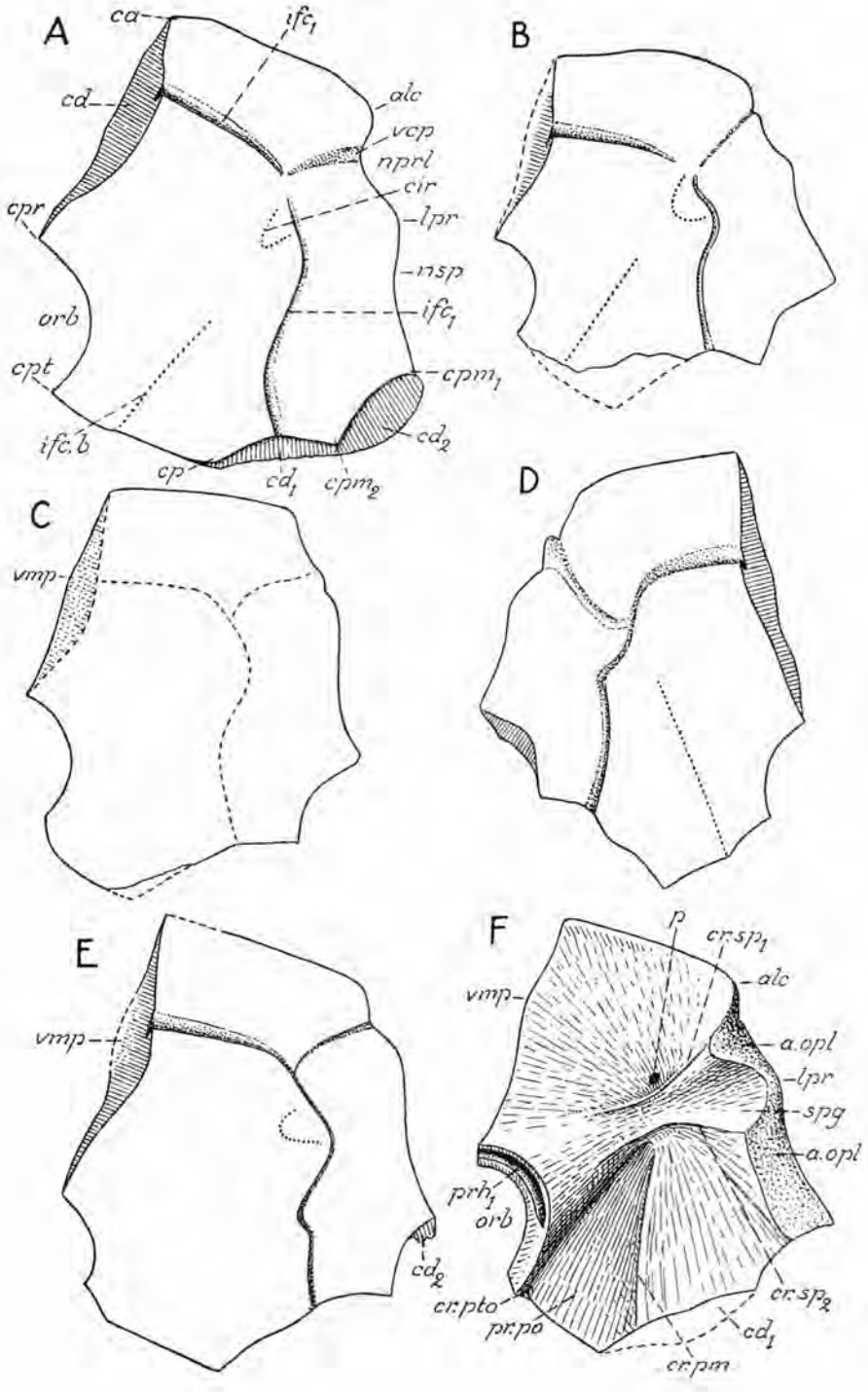


Text-fig. 275. *Bothriolepis groenlandica*. *A–C*, restorations of three premedian plates of medium-sized and fairly large individuals. Dorsal aspect. *A*, × 3/2; *B*, *C*, nat. size. *D*, restoration of a premedian plate of a fairly large individual. Ventral aspect. Nat. size. *cv*, area overlapping lateral plate; ifc_1, upper infraorbital sensory groove; *nl*, ventral lateral notch; *p*, nasal process; soc_2, median unpaired section of supraorbital sensory canal grooves (the anterior median pit-line groove).

long both in medium-sized and comparatively large individuals. Only in very large individuals it is somewhat narrower than long (text-fig. 20A; pl. 7, fig. 1). Its breadth : length ratio, which could be ascertained in seven specimens, was as follows: in a very small individuals about 140; in four medium-sized and large individuals 104–117; and, finally in one very large specimen about 92. As in the other *Bothriolepis*-species, the plate is very varyable as to shape. In most cases it is broadest at, or somewhat behind,



Text-fig. 276. *Bothriolepis groenlandica*. *A*, *B*, restorations of two pineal plates in dorsal aspect. × 2.
pi, pineal foramen.


A
ca
ifc1
cd
alc
vcp
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cir
cpr
lpr
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ifc.b
cd2
cp
cd1
cpm2
B
C
vmp
D
E
vmp
cd2
F
p
cr.sp1
alc
vmp
a.opl
lpr
spg
a.opl
prh1
orb
cr.sp2
cr.pto
pr.po
cd1
cr.pm

the sensory canal groove (ifc_1), thence decreasing only very slightly in breadth forwards. Sometimes, however, it seems to be broadest across its rostral end. Posteriorly it may often be strikingly narrow, and its posterior dorsal and ventral margins in many cases are much shorter, therefore, than its rostral margin. The posterior dorsal margin exhibits mostly a broad more or less distinct nasal process (*p*), but may also be devoid of such a process. The ventral lateral notch (*nl*, text-fig. 275D; pl. 8, figs. 3–5) is slightly marked or absent. The sensory canal grooves (soc_2, ifc_2) pass as a rule strikingly far behind the rostral margin of the plate.

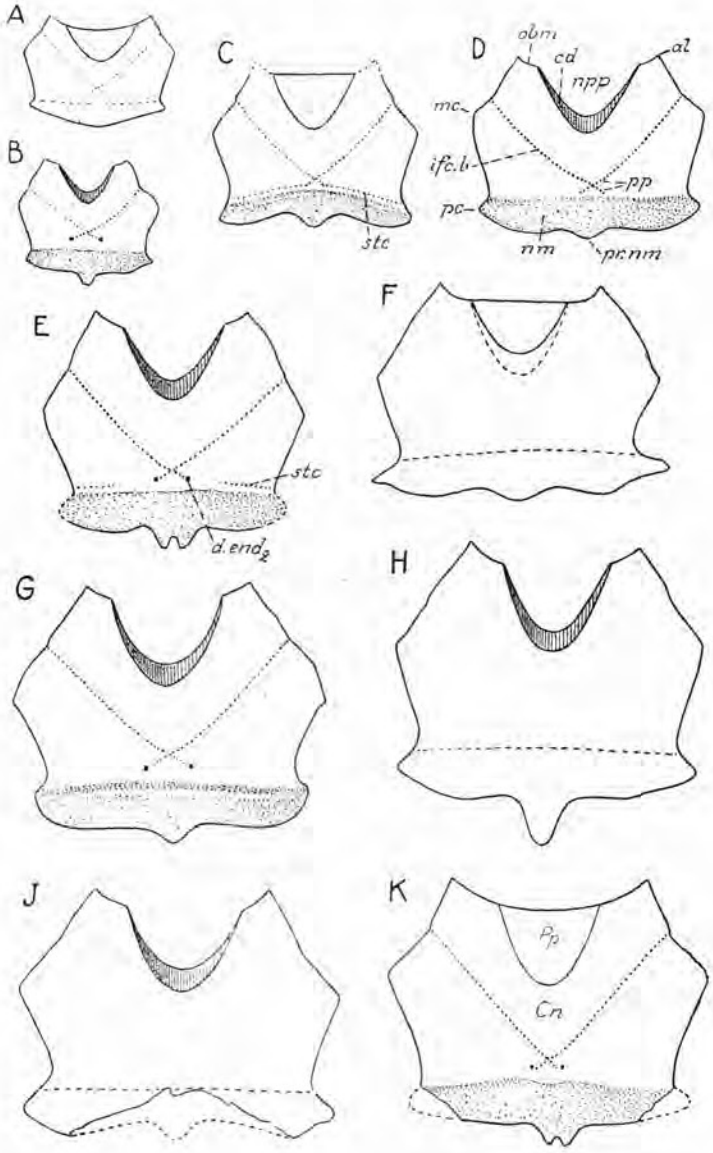
The rostral plate is still unknown. The pineal plate (text-figs. 23J, 276; pl. 5, figs. 3–5) is of a characteristic shape (cf. text-figs. 23, 230). It is longer than broad. The postero-lateral processes are short, and because of this the plate is about equally broad anteriorly as posteriorly. The anterior margin is not straight or somewhat concave, but strongly convex. Finally, it deserves to be mentioned that, as in *B. panderi*, the plate is pierced by a pineal foramen (*pi*).

The lateral plate (*Lp*, text-figs. 13, 24F, 273, 274, 277; pls. 1–4; pl. 5, figs. 1, 2; pl. 6; pl. 7, figs. 3, 5; pl. 8, figs. 1, 2; pl. 9, figs. 1, 3–5; pls. 10, 12; pl. 13, fig. 1) is mostly rather suggestive of the corresponding plate in *B. gigantea* (cf. text-figs. 24E, 252, 253A, C, D). As in that species, it is mostly comparatively short and broad with a long rostral margin and a well-marked prelateral notch (*nprl*). In several cases it is provided posteriorly with more or less extensive areas (cd_1, cd_2, text-figs. 24F, 277A, E; pl. 9, figs. 3, 4) overlapped by the paranuchal-marginal and postmarginal plates.

The postpineal plate (*Pp*, text-figs. 13, 273, 274, 278A, C, F, K; pls. 3, 4; pl. 5, figs. 1, 2; pl. 6; pl. 7, figs. 4, 5; pl. 8, fig. 2; pl. 9, fig. 6; pl. 11, fig. 3; pl. 12, fig. 1; pl. 13, fig. 1) is clearly shorter and broader in young individuals than in older individuals. In medium-sized and large individuals the plate is mostly of a normal size in proportion to the centro-nuchal plate, about as in *B. canadensis, B. cellulosa, B. panderi, B. maxima, B. alvesiensis* etc., but it may also sometimes be shorter and narrower (text-fig. 278K;

Text-fig. 277. *Bothriolepis groenlandica*. *A–E*, restorations of five lateral plates from individuals of different size. Dorsal aspect. *A*, × 2. *B–E*, nat. size. *F*, restoration of a lateral plate in ventral aspect. Nat. size.

alc, antero-lateral corner; *a. opl*, area of attachment for extralateral (opercular) plate; *ca*, antero-medial corner; *cd*, area overlapped by premedian plate; cd_1, area overlapped by postnuchal-marginal plate; cd_2, area overlapped by postmarginal plate; *cir*, semicircular pit-line groove; *ep*, posterior corner; epm_1, epm_2, anterior and posterior postmarginal corners respectively; *epr*, preorbital corner; *epl*, postorbital corner; *cr. pm*, paramarginal crest; *cr. pto*, postorbital crista; *cr.* sp_1, prespiracular crista; *cr.* sp_2, postspiracular crista; ifc_1, upper infraorbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *nprl*, prelateral notch; *nsp*, supraspiracular notch; *orb*, orbital notch; *p*, prespiracular pit; prh_1, lateral division of preorbital recess; *pr. po*, antero-lateral corner of otico-occipital depression (developed for postorbital process of endocranium); *vcp*, vertical pit-line groove of cheek; *vmp*, ventral medial process (fitting into the ventral lateral notice of the premedian plate).

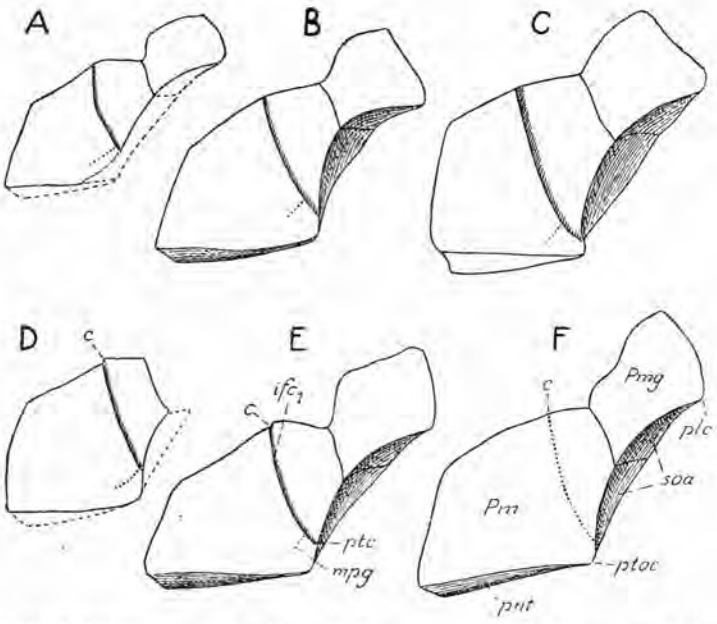


Text-fig. 278. *Bothriolepis groenlandica*. *A–K*, ten centro-nuchal plates in dorsal aspect (in four cases with postpineal plate attached). *A*, of a very small individual. × $^{8}/_{5}$. *B–K*, of fairly small, medium-sized, and large individuals. × $^{4}/_{5}$.

Cn, centro-nuchal plate; *Pp*, postpineal plate; *al*, antero-lateral corner; *cd*, area overlapped by postpineal plate; *d. end*$_2$, canal for ductus endolymphaticus (external opening); *ifc. b*, posterior oblique cephalic pit-line groove; *mc*, lateral corner; *nm*, obtected nuchal area; *npp*, postpineal notch; *obm*, orbital facet of anterior margin; *pc*, postero-lateral corner; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process; *stc*, supratemporal pit-line groove.

pl. 7, figs. 4, 5; pl. 11, fig. 2), so that it reminds somewhat of the corresponding plate in *B. obesa* (p. 497 above; cf. also text-fig. 258). The anterior (orbital) margin of the plate is somewhat concave or practically straight, and as to its development this margin is thus nearest as in *B. maxima* (p. 440 above; cf. also text-figs. 235C–H, 236B).

The centro-nuchal plate (*Cn*, text-figs. 13, 273, 274, 278; pls. 1–4; pl. 5, figs. 1, 2; pl. 6; pl. 7, figs. 4, 5; pl. 8, fig. 2; pl. 9, fig. 7; pls. 11, 12; pl. 13, fig. 1) is of a fairly long or even very long type, but, as normally in the genus, it is relatively shorter and broader in very small individuals than in medium-sized and large individuals. Its length : breadth ratio, which could be ascertained with full, or reasonable, certainty in fourteen cases, is as follows. In the smallest specimen (text-fig. 278A; pl. 6) it is 76, whereas in medium-sized and large specimens it ranges between 76–98. In those cases when it amounts to about 96–98 the posterior median process (*pr. nm*) is very long, and the excessive length of the plate is, therefore, to some extent due to the strong development of the said process. In this connection it deserves to be stressed that the plate of this long type is found in particularly long and narrow head-shields. The paramedian length of the plate is normally smaller than the total median one, but the reverse condition is sometimes also met with. The maximum breadth of the plate is sometimes across the lateral (*mc*), sometimes across the postero-lateral (*pc*) corners. In others cases the plate is equally broad across its lateral corners as it is across its postero-lateral corners. As in *B. canadensis* and *B. cellulosa* (cf. pp. 75, 211–214; cf. also text-figs. 93, 222), the postpineal notch (*npp*) became deeper and narrower during the growth of the individuals. The anterior division of the lateral margin of the plate is a little shorter in young individuals than in older individuals, where it is about equally long as the posterior division of the same margin. The latter division is strongly concave with its deepest concavity far backwards, just in front of the postero-lateral corner (*pc*), and, as in *B. ornata* (text-figs. 26B, 215) and often *B. maxima* (text-figs. 26E, 233A, 236A, B, 237A, B), the plate is therefore strikingly narrow immediately in front of its postero-lateral corners. These corners are well developed and may sometimes be fairly much produced in a lateral direction. The posterior margin in young individuals has only a broad angular posterior median corner representing the posterior median process (text-fig. 278A; pl. 6), and accordingly, as pointed out, is fundamentally as in individuals of the corresponding stage of growth of *B. canadensis* (cf. pp. 75–77, 257). With regard to its general configuration the plate is obviously nearest comparable to the corresponding plate in *B. ornata* and *B. maxima*. It must be left undecided for the present to what extent it differs from the corresponding plate in *B. ornata*; from that in *B. maxima* it is well distinguished by its greater relative length and by the shape of its posterior margin in medium-sized and large individuals.



Text-fig. 279. *Bothriolepis groenlandica*. *A–F*, restorations of six paranuchal-marginal plates, five of which have the postmarginal plate attached to it. *B*, *C*, × 6/5. *A*, *D–F*, × 4/5. *Pm*, paranuchal-marginal plate; *Pmg*, postmarginal plate; *c*, anterior corner of paranuchal-marginal plate; ifc_1, upper infraorbital sensory canal groove; *mpg*, middle pit-line groove of the skull-roof; *plc*, postero-lateral (preobstantic) corner of postmarginal plate (and of head-shield); *pnt*, paranuchal trochlea; *ptc*, cephalic division of main lateral line groove; *ploc*, postobstantic corner; *soa*, subobstantic area.

The paranuchal-marginal plate (*Pm*, text-figs. 13, 28D, 273, 274, 279; pls. 1–4; pl. 5, figs. 1, 2; pl. 6; pl. 8, figs. 1, 2; pl. 9, fig. 1; pl. 11, fig. 6; pl. 12; pl. 13, fig. 1) has a length : breadth ratio ranging between 66–80. The medial division is often shorter than broad, but may also be longer than broad, or about equally long as broad. The lateral division, which, as normally in the genus, usually decreased somewhat in breadth during the growth of the individuals, is narrow, its breadth ranging from somewhat more than one half (in small individuals) to about, or even somewhat less than, one third (in large individuals) of the breadth of the medial division. The lateral margin of this division is usually much shorter than the sensory canal groove forming the medial boundary of the division.

The postmarginal plate (*Pmg*, text-figs. 13, 28D, 273, 274, 279; pls. 1–4; pl. 5, figs. 1, 2; pl. 8, fig. 1; pl. 12; pl. 13, fig. 1) is broader than in other *Bothriolepis*-species in which it is known for the present, its breadth equalling, or even exceeding, the length. The plate extends far forwards in front of the paranuchal-marginal plate, in fact even so far that about with its anterior half it is situated in front of the paranuchal-marginal plate. The postero-lateral corner of the plate is normally not, or only slightly, rounded

off and, as pointed out above, may often be produced laterally into a short process. This corner, which forms the postero-lateral (preobstantic) corner (*plc*) of the head-shield is, therefore, more marked and projects often also more laterally than what it usually does in other *Bothriolepis*-species. It may also be mentioned here that the plate participates to a larger extent into the formation of the subobstantic area (*soa*) than what is the case at least in *B. canadensis* and *B. cellulosa* (cf. text-figs. 9, 14, 29, 82–84, 219B).

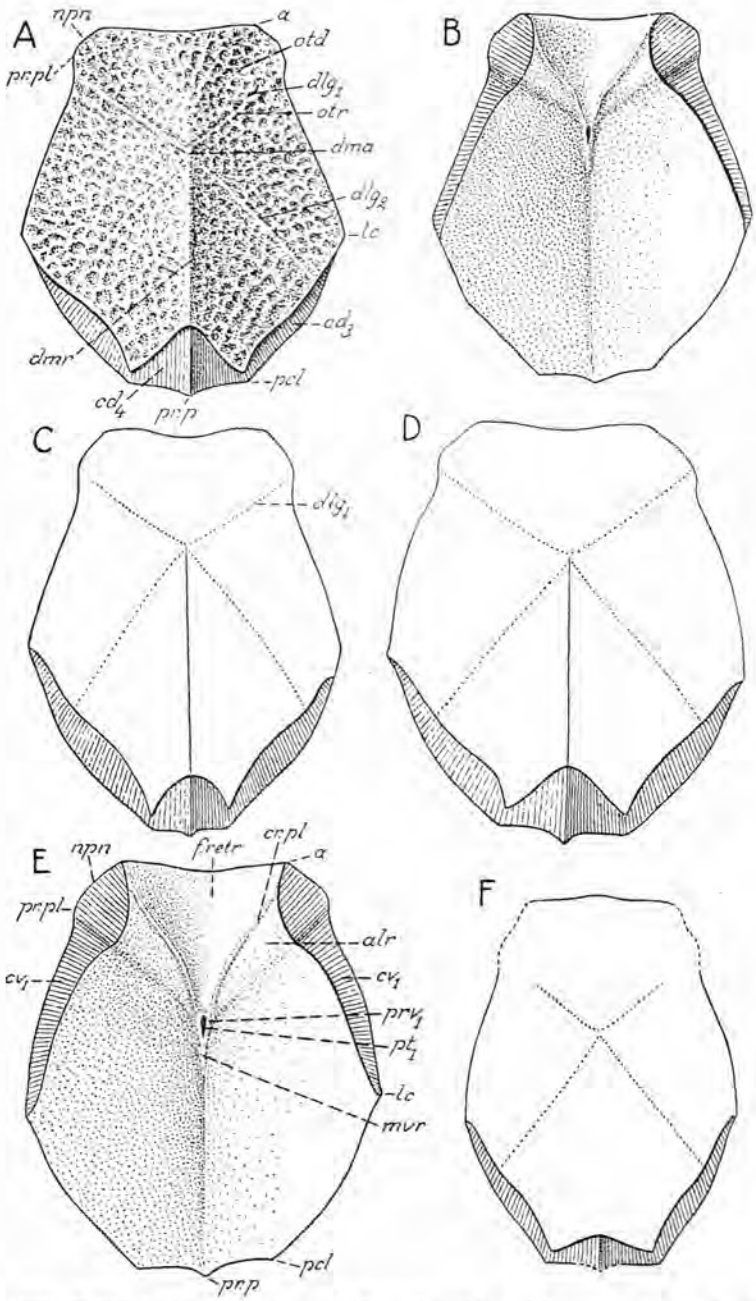
In one of the most complete specimens at hand (pls. 15, 16) there is a small paired bone plate (*Ifg*?) which may be either a part of an inferognathal or else a plate of the submandibular series. This specimen shows also a long median unpaired subhyoideal bone (*Sh*).

Finally, it is worthy of mention that in the smallest head-shield available there is a small detached bone in the hind part of the orbital fenestra, a bone (*E*, pl. 6, fig. 1) which presumably lay in the foremost part of the interorbital wall (cf. pp. 25–26). The bone in question is displayed in section, probably a transverse section, and it is clearly seen that in this section it is Y-shaped. One may assume, therefore that it consisted of a ventral unpaired lamina, presumably situated in the lower part of the interorbital wall, and a dorsal paired lamina, conceivably covering the outside of the dorsal part of the interorbital wall. The space between its dorsal laminae may be suspected to have housed the foremost part of the cranial cavity or the canals for the olfactory tracts.

Trunk-armour.

The trunk-armour (text-figs. 283D, 287B) in its general shape reminds of that in *B. maxima* and *B. gigantea* (cf. pp. 448, 486–487; cf. text-fig. 243H, J). As in those two species, it was long and low, with a high dorsal wall and low lateral walls. The dorsal wall was somewhat rounded off in its median most elevated part from where it sloped fairly steeply laterally so that it met the lateral wall of either side at an angle of about 120–130°. No calculations of the breadth and length of the dorsal wall can be made on the basis of the material available. The lateral wall was about, or probably even somewhat more than, four times as long as high, and was thus much lower than in *B. canadensis* (cf. text-figs. 38, 40) and *B. jarviki* (cf. text-fig. 304). The ventral wall (text-fig. 292; pls. 15–18) is of the normal type characteristic of the genus. Its breadth:length ratio is about 40–50.

The tergal angle (*dma*, text-figs. 43C, 280A, C, D, F, 281A, B, 283A, 284, 285, 287B, 302; pl. 13, fig. 3; pl. 20, fig. 1; pl. 24, fig. 2; pl. 25; pls. 27–31, 33; pl. 34, figs. 1, 4; pl. 35, figs. 1, 3) has a very varying position. It lies mostly in the foremost part of the middle third of the anterior median dorsal plate, but may also frequently be situated further forwards or backwards. The dorsal median ridge (*dmr*) is normally complete and somewhat strongly developed in small and smaller medium-sized individuals only (text-

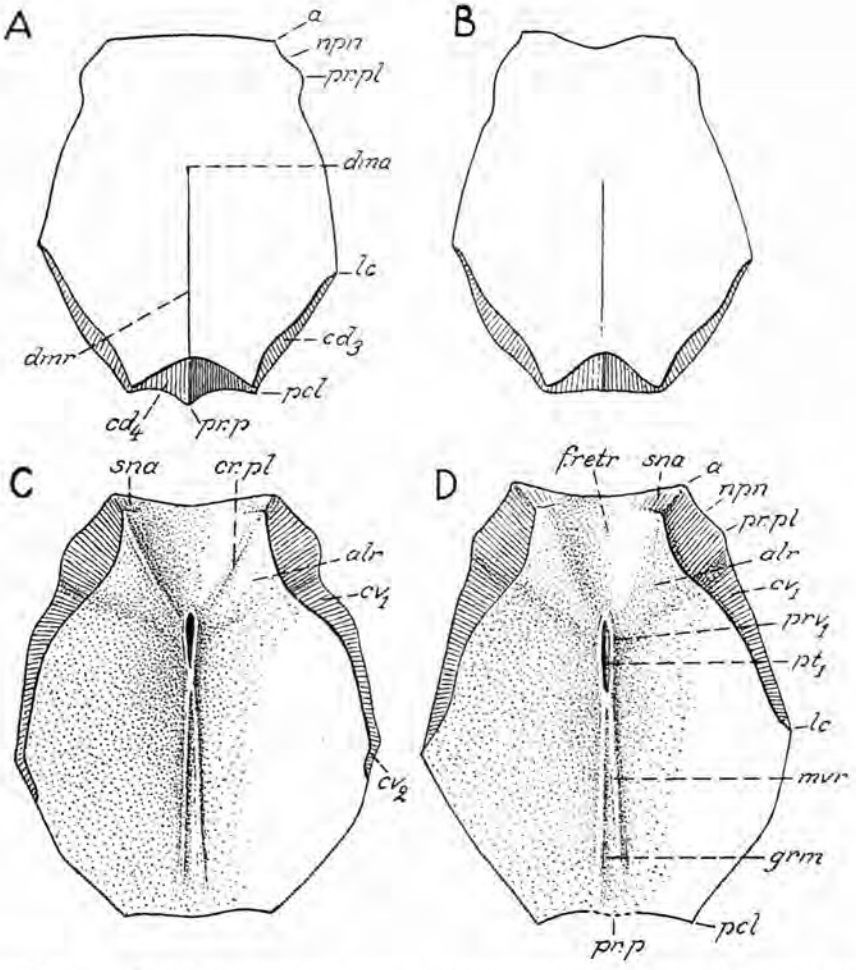


Text-fig. 280. *Bothriolepis groenlandica*. *A–F*, restorations of four anterior median dorsal plates. *A*, *B*, plate of a small individual in dorsal and ventral aspects respectively. × $^{6}/_{5}$. *C*, small plate in dorsal aspect. × $^{6}/_{5}$. *D*, *E*, small plate in dorsal and ventral aspects respectively. × $^{6}/_{5}$. *F*, plate of a small medium-sized individual. Dorsal aspect. × $^{4}/_{5}$. *a*, antero-lateral corner; *alr*, postlevator thickening; cd_3, cd_4, areas overlapped by mixilateral and posterior median dorsal plates respectively; *cr. pl*, postlevator crista; cv_1, area overlapping anterior dorso-lateral plate; dlg_2, anterior oblique abdominal pit-line

figs. 280A, C, D, F, 286A–E, 302; pl. 13, fig. 3; pl. 34, fig. 4; pl. 35, figs. 1–3; pl. 42, fig. 1; pl. 43, fig. 3), whereas in larger medium-sized and large individuals it is often more or less obscure and reduced in its middle part (text-figs. 281A, B, 283D, 284, 285, 286F–L, 287A; pl. 20, fig. 1; pls. 22, 25, 27–31; pl. 32, fig. 1; pl. 33; pl. 34, fig. 1). The dorso-lateral ridge (*dlr*, text-figs. 283D, 287B, 288, 289; pl. 44, figs. 2, 3; pl. 45, fig. 2; pl. 46, fig. 1; pl. 47, fig. 2; pls. 48, 49) is well developed and so is also the ventro-lateral ridge (*vlr*, text-figs. 282D, 291, 292B; pl. 55, figs. 2, 3). The obliquely transverse depression (*otd*, text-figs. 280A, 283A, 302; pl. 24, fig. 1; pls. 25, 29, 31; pl. 34, figs. 1, 4; pl. 35, fig. 1) above the postlevator thickening (*alr*) is regularly present in young individuals, but persist also normally more or less well marked in older individuals. On the other hand, the depression (*dp*, pl. 42, fig. 4) above the dorsal median part of the crista transversalis interna posterior is absent in medium-sized and large individuals. The oblique transverse ridge (*otr*) and the anterior oblique abdominal pit-line groove (dlg_1) are normally met with in small individuals (text-figs. 280A, C, D, 302; pl. 13, fig. 3; pl. 34, fig. 4; pl. 35, figs. 1, 3), where they are mostly comparatively complete and somewhat distinct, while, as in most other *Bothriolepis*-species, they persist only rarely and in a vestigial condition in larger medium-sized and large individuals (text-figs. 43C, 280F; pl. 20, fig. 1; pl. 34, fig. 1).

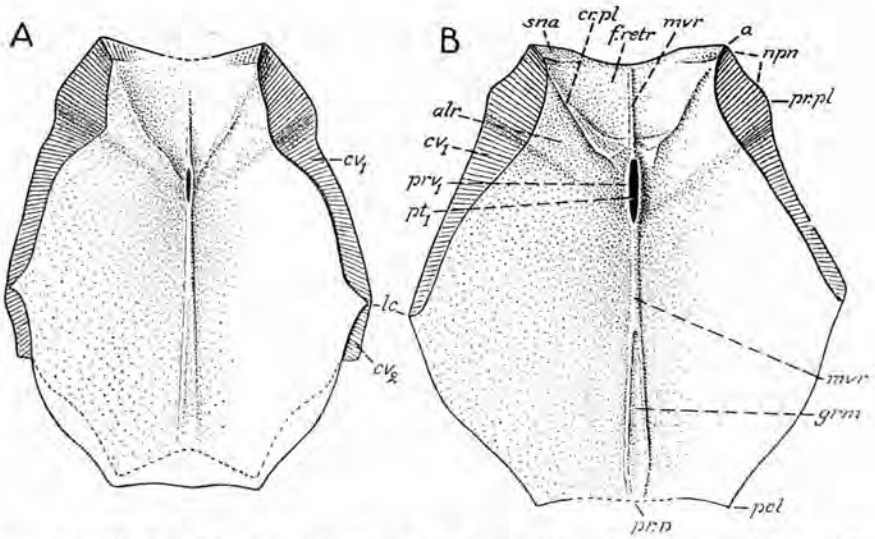
The ventral division of the crista transversalis interna anterior (*cit*) situated on the ventral wall of the trunk-armour is mostly divided into two crests (cit_1, cit_2, pls. 15–17, 50, 54), an anterior transverse crest, the postbranchial crest (cit_1), and a posterior likewise transverse crest, the crista transversalis interna proper, both of which are about equally strongly developed. The posterior one of these two ventral crests is not rarely met with also in *B. cellulosa*, but seems generally to be absent in other *Bothriolepis*-species (cf. p. 108 above). The crista transversalis interna posterior (*crtp*, text-figs. 47C; pls. 16, 17; pl. 42, figs. 1–3; pl. 43, fig. 2; pl. 46, fig. 2; pl. 47; pl. 48, fig. 1; pl. 49, fig. 1; pls. 52, 54; pl. 56, fig. 1) is low in its dorsal median part which is situated on the posterior median dorsal plate, whereas it is well developed in its lateral and ventral parts. The levator fossa (*f. retr*, text-figs. 280B, E, 281C, D, 282; pl. 19, fig. 1; pl. 20, fig. 2; pls. 21, 23; pl. 26, fig. 1; pl. 32, fig. 2; pl. 34, fig. 3; pl. 35, fig. 2) varies somewhat more in its relative proportions than what it does in *B. canadensis* or *B. cellulosa*, but is otherwise in the whole as in those two species. The postlevator thickening (*alr*, text-figs. 280B, E, 281C, D, 282; pl. 19, fig. 1; pl. 20, fig. 2; pls. 21, 23; pl. 26, fig. 1; pl. 32, fig. 2; pl. 34, fig. 3; pl. 35, fig. 2) is well

groove; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *f. retr*, levator fossa; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *otd*, obliquely transverse depression above postlevator thickening; *otr*, oblique transverse ridge behind groove dlg_1; *pcl*, postero-lateral corner; *pr. p*, posterior median process; *pr. pl*, external postlevator process; prv_1, anterior ventral process; pl_1, anterior ventral pit.



Text-fig. 281. *Bothriolepis groenlandica*. *A–D*, restorations of four plates of medium-sized individuals. *A*, *B*, in dorsal aspect; *C*, *D*, in ventral aspect. × 1/2.
a, antero-lateral corner; *alr*, postlevator thickening; cd_3, cd_4, areas overlapped by mixilateral and posterior median dorsal plates respectively; *cr. pl*, postlevator crista; cv_1, area overlapping anterior dorso-lateral plate; cv_2, area overlapping mixilateral plate; *dma*, tergal angle; *dmr*, dorsal median ridge; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *pcl*, postero-lateral corner; *pr. p*, posterior median process; *pr. pl*, external postlevator process; prv_1, anterior ventral process; pt_1, anterior ventral pit; *sna*, supranuchal area.

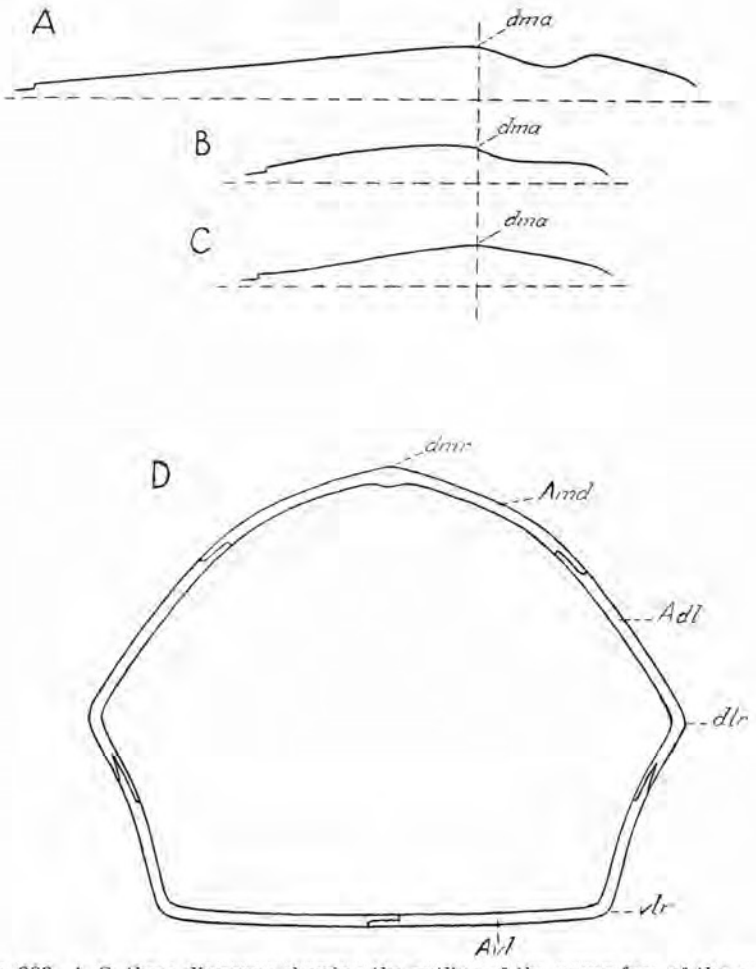
marked. The postlevator crest (*cr. pl*) is mostly present, but seems often to be more or less reduced in medium-sized and large individuals. The median ventral ridge (*mvr*) is as normally in the *Bothriolepis*-species. In small individuals it is thus very short and developed only nearest behind and around the anterior ventral process and pit (text-fig. 280B, E; pl. 34, fig. 3; pl. 35, fig. 2; pl. 36, fig. 2), whereas in medium-sized and large individuals, on the other hand, it extends backwards on to about the middle of the posterior



Text-fig. 282. *Bothriolepis groenlandica*. *A*, *B*, restorations of two large anterior median dorsal plates. Ventral aspect. Approximately × $^{4}/_{10}$.
a, antero-lateral corner; *alr*, postlevator thickening; *cr. pl*, postlevator crista; cv_1, area overlapping anterior dorso-lateral plate; cv_2, area overlapping mixilateral plate; *f. retr*, levator fossa; *grm*, ventral median groove; *lc*, lateral corner; *mvr*, ventral median ridge; *npn*, postnuchal notch; *pcl*, postero-lateral corner; *pr. p*, posterior median process; *pr. pl*, external postlevator process; prv_1, anterior ventral process; pt_1, anterior ventral pit; *sna*, supranuchal area.

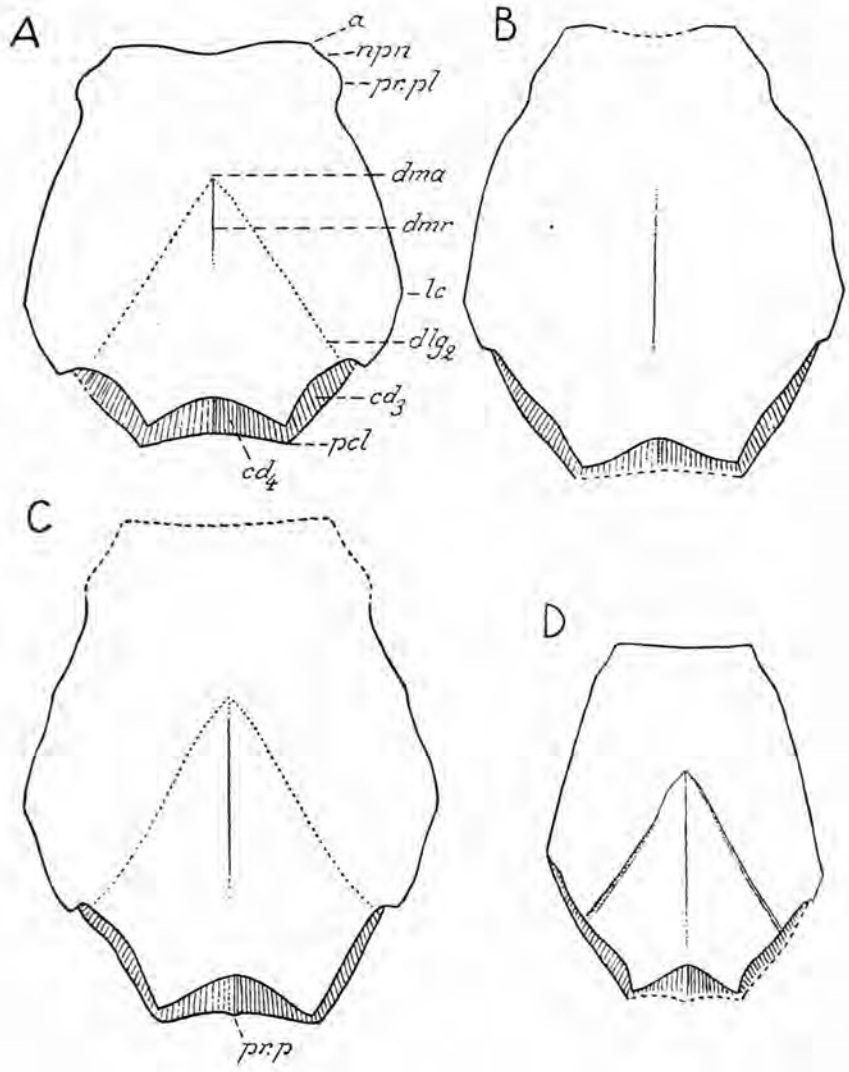
median dorsal plate (text-figs. 44E, 47C, 281C, D, 282; pl. 19; pl. 20, fig. 2; pls. 21, 23; pl. 24, fig. 1; pl. 26, fig. 1; pl. 32, fig. 2; pl. 35, fig. 4; pl. 36, figs. 3, 4; pl. 37, fig. 2; pl. 43, fig. 2). In several cases in medium-sized and large individuals it reaches also far forwards into the levator fossa, sometimes even as far as practically to the anterior end of that fossa. As normally in the genus, the ventral median groove (*grm*) is found only in those individuals in which the ventral median ridge has grown backwards so much that it extends fairly far behind the anterior ventral process and pit. The anterior and posterior ventral processes (prv_1, prv_2), and the anterior and posterior ventral pits (pt_1, pt_2), present no particularly characteristic features. The ventral tuberosity (*tb*, text-fig. 47C; pl. 36, figs. 3, 4; pl. 37, fig. 2; pl. 42, figs. 1, 3; pl. 43, fig. 2; pl. 54) is invariably present, but is lower and less clearly defined than in *B. canadensis*; in several cases its peripheral parts consist only of scattered tubercles. As in other *Bothriolepis*-species, the supranuchal area (*sna*, text-figs. 281C, D, 282; pl. 19, fig. 1; pl. 20, fig. 2; pl. 23) is generally present in medium-sized and large individuals only.

The anterior median dorsal plate (text-figs. 43C, 44E, 280–282, 283A, D, 284, 285, 287B; pl. 13, fig. 3; pls. 19–35; cf. also Heintz 1930, pl. 1, fig. 1) is narrower than long except in certain cases in very large individuals, where it is approximately equally broad as long. Its breadth: length ratio, which could be calculated in twenty specimens, is 75–100. In four



Text-fig. 283. *A–C*, three diagrams showing the outline of the upper face of the anterior median dorsal plate in a median longitudinal section. *A*, of *B. groenlandica*, *B*, *C*, of *B. canadensis* (in *B* with the groove *old* persisting, in *C* with the groove *old* absent). *A–C*, × 4/5. *D*, *B. groenlandica*. Probable shape of the trunk-armour in transverse section a little behind the tergal angle (*dma*). *D*, dimished.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *old*, oblique transverse groove above postlevator thickening (*alr*); *vlr*, ventro-lateral ridge.

small specimens this ratio is 75–88, whereas in the remaining sixteen specimens, all of which are from medium-sized and large individuals, it is 78–100. In no less than about one half of the specimens belonging to the last-mentioned two categories of size, however, it amounts only to 77–87, a condition which shows that often in medium-sized and large individuals the plate retained a comparatively narrow shape. As to the proportion between its breadth and length the plate seems thus to be nearest as in *B. ornata*, *B. cellulosa*, *B. panderi* and *B. alvesiensis*. In most of its characters, particularly the configuration of its margins, the plate is clearly much more vari-



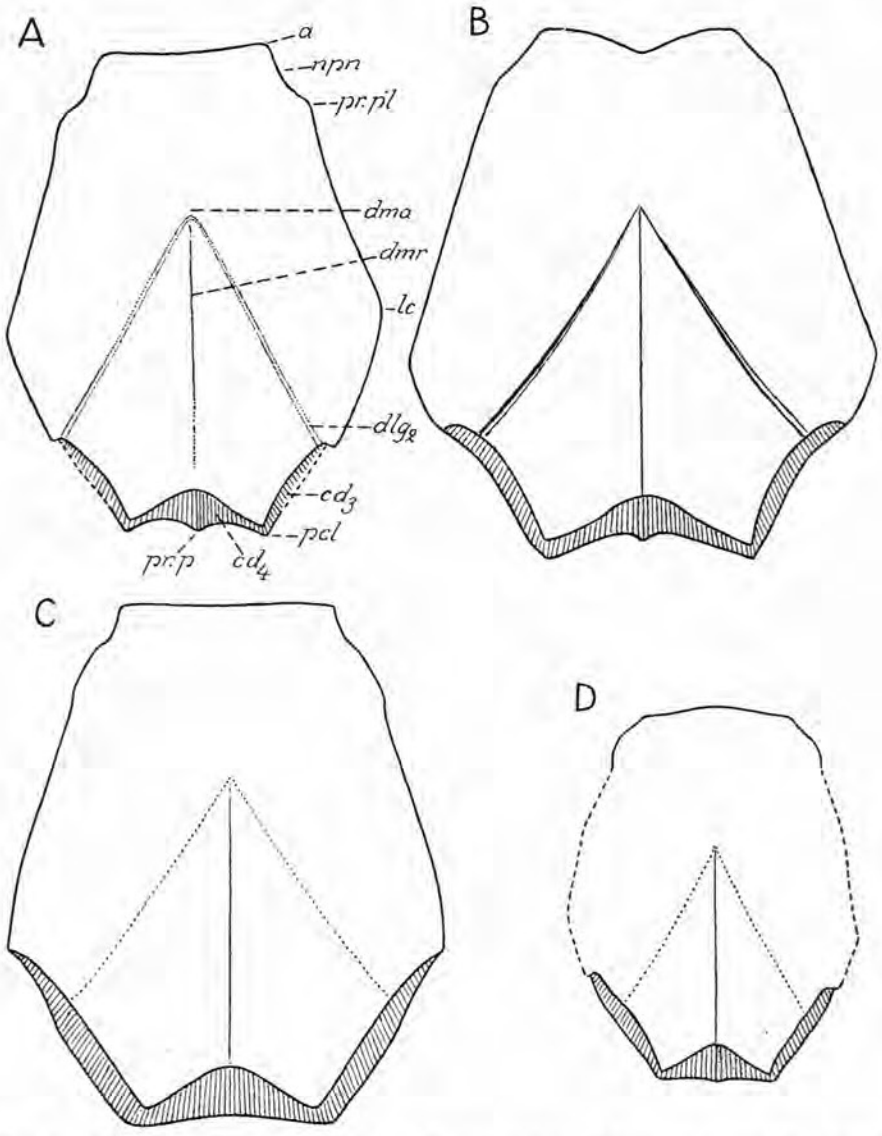
Text-fig. 284. *Bothriolepis groenlandica*. *A–D*, restorations of four plates of medium-sized and fairly large individuals. Dorsal aspect. × $^1/_2$.
a, antero-lateral corner; cd_3, cd_4, areas overlapped by mixilateral and posterior median dorsal plates respectively; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *lc*, lateral corner; *npn*, postnuchal notch; *pr. p*, posterior median process; *pr. pl*, external postlevator process.

able than in *B. canadensis* and *B. cellulosa* (cf. text-figs. 118–126, 224). With regard to these variations we may for the description distinguish three types of the plate, three types which will be referred to as types *A*, *B* and *C* respectively. As transitions are found between them these three types are not always clearly distinguishable from each other.

Type *A* (text-figs. 44E, 280A, B, D, E, 281A, D, 282, 284A; pl. 20,

fig. 2; pls. 21–25; pl. 26, fig. 1; pl. 27, fig. 2; pl. 34, fig. 3; pl. 35, figs. 1, 2, 4) is the most common one of the three. Its most important features may be summarized as follows. The breadth : length ratio seems regularly to exceed 80 and may amount to about 100. The tergal angle (*dma*) is mostly situated in the anterior third of the plate, but may sometimes be found a little further backwards. Because of this position of the tergal angle comparatively far anteriorly the levator fossa is usually not particularly long. The anterior margin in small individuals is generally considerably longer than the posterior margin, but in medium-sized and large individuals it may often equal that margin in length. As to its configuration the anterior margin is mostly more or less concave, but in certain cases it may also be practically straight or slightly convex. The anterior division of the lateral margin, that is to say the part of the lateral margin in front of the lateral corner (*lc*), is fairly constant in its configuration, being approximately as normally in *B. canadensis*. The postnuchal notch (*npn*) is well-marked and is clearly bounded both anteriorly and posteriorly. The external postlevator process (*pr. pl*) is well developed, rounded off, and bounded posteriorly by a marked concavity. Behind that concavity the division of the lateral margin in question may be somewhat convex, practically straight, a little convex, or slightly undulating. The lateral corner (*lc*) is usually fairly conspicuous, but may sometimes be somewhat rounded off. The posterior division of the lateral margin, i.e. the division of the lateral margin behind the lateral corner (*lc*), is as a whole somewhat convex with the maximal convexity approximately at its middle; it may often show a slight concavity anteriorly or posteriorly or both anteriorly and posteriorly. The posterior margin in small individuals, is normally very short and as a whole somewhat convex. Characteristic of the posterior margin in small individuals is also that often, or probably as a rule, it is produced into a short posterior median process (*pr. p*). This margin in medium-sized and large individuals may retain much of its immature shape; in individuals of these two stages of growth it is generally, however, longer relatively than in small individuals, sometimes even about equally long as the anterior margin; in addition in medium-sized and large individuals it is normally also somewhat concave with slight or no indications of a posterior median process.

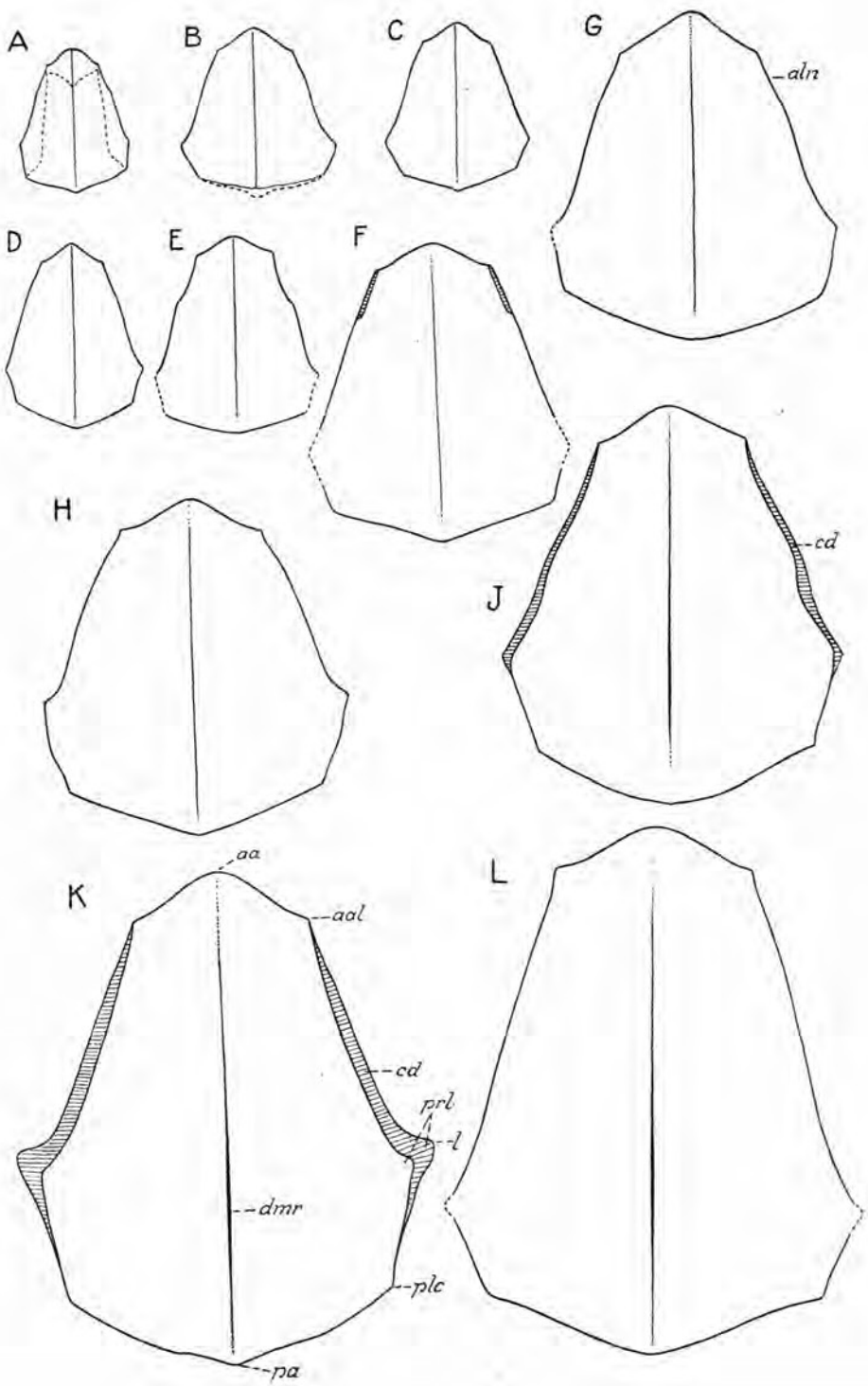
Type *B* of the plate (text-figs. 43C, 281C, 284B, C; pl. 19; pl. 20, fig. 1; pl. 31; pl. 32, fig. 1) is rare, being represented only by three specimens, all of which are from fairly large individuals. This type differs from type *A* mainly in the following respects. The tergal angle (*dma*) is situated in the foremost part of the middle third of the plate, and on account of this the levator fossa is relatively a little longer than in type *A*. The postnuchal notch (*npn*) is not so clearly bounded off from the external postlevator process (*pr.pl*) as in type *A*, and the anterior division of the lateral margin behind the external postlevator process is more undulating than in that type. The



Text-fig. 285. *Bothriolepis groenlandica*. *A–D*, restorations of four anterior median dorsal plates of medium-sized and large individuals. Dorsal aspect. Somewhat less than half the natural size.

a, antero-lateral corner; cd_3, cd_4, areas overlapped by mixilateral and posterior median dorsal plates respectively; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *lc*, lateral corner; *npn*, postnuchal notch; *pr. p*, posterior median process; *pr. pl*, external postlevator process.

posterior margin is concave or fairly straight with slight or no indications of a posterior median process (*pr.p*). The plate shown in text-fig. 281 B and pl. 27, fig. 2 is to some extent transitional in shape between types *A* and *B*, and so may possibly be the case also with the plate reproduced in pl. 35, fig. 4.


A
B
C
G
aln
D
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cd
K
aa
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L

Type *C* of the plate (text-figs. 280F, 284D, 285A–C; pl. 27, fig. 1; pls. 28–30; pl. 32, fig. 2; pl. 34, figs. 1, 2, 4; pl. 35, fig. 3) is more frequently met with than type *B*, but is not as common as type *A*. It occurs in individuals of all stages of growth, and, as it includes both comparatively narrow and comparatively broad plates its breadth : length ratio has a wider range of variation than in the two other types. More precisely, its breadth : length ratio is 75–96. The tergal angle (*dma*) is mostly situated in the foremost part of the middle third of the plate, but may also sometimes be situated further forwards. On account of this mostly somewhat remote position of the tergal angle, the levator fossa (*f. retr*, pl. 32, fig. 2) is somewhat longer proportionally than in type *A* (cf. text-figs. 280B, E, 281C, D, 282), but presumably as long proportionally as in type *B*. The anterior margin, which may vary considerably in length and which in large plates (text-fig. 285B; pl. 29) may be shorter than the posterior margin, is mostly fairly straight or slightly concave, but may also occasionally be strongly concave. The postnuchal notch (*npn*) is fairly distinct, whereas the external postlevator process (*pr. pl*) is often slightly marked or even obscure. The concavity behind the external postlevator process is often shallow or absent, and the whole posterior part of the anterior division of the lateral margin behind the said process is nearly straight. The posterior division of the lateral margin may be as in type *A*, but may also be a little convex in its anterior part and more or less strongly concave in its posterior parts. Both as to the variations of its length and in other respects the posterior margin is essentially as in types *A* and *B*. However, the posterior median process seems never to be of the broad rounded off shape that is fairly often met with in type *A*. Judging from the figure given of it by Heintz (1930, pl. 1, fig. 1), the holotype is nearest referribel to type *C*. Several of the plates here considered to belong to type *C* are more or less transitional in shape between types *A* and *B*.

A fairly large deficient plate shown in pl. 33 and tentatively restored in text-fig. 285D in several respects is intermediate between types *A*, *B* and *C*. As its anterior margin is convex, it differs, however, from all these types and may, therefore, probably represent a type of its own.

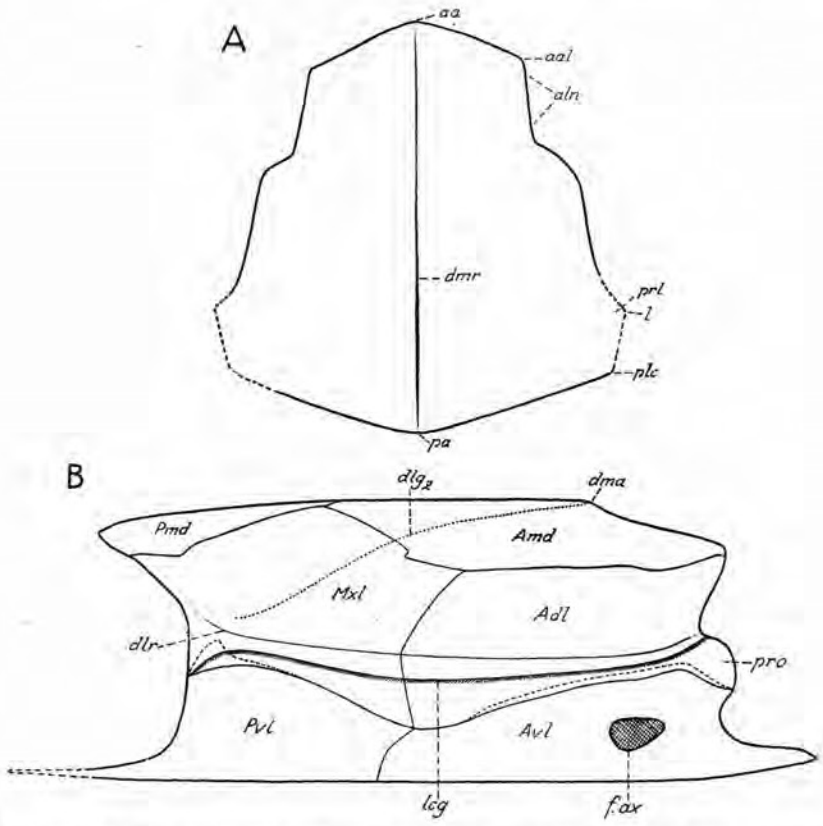
The anterior median dorsal plate in small individuals is suturally connected with the anterior dorso-lateral and mixilateral plates in the normal way characteristic of *Bothriolepis*, whereas in medium-sized and particularly in large individuals it has often an abnormal sutural connection with the mixilateral plate. This abnormal sutural connection is of the *Remigolepis*-type (text-figs. 281C, 282A, 284A–C, 285A, B, D; cf. pp. 120–121 above),

Text-fig. 286. *Bothriolepis groenlandica*. Restorations of eleven posterior median dorsal plates. Dorsal aspect. Somewhat less than $^3/_4$ of the natural size.
aa, anterior angle or corner; *aal*, antero-lateral corner; *aln*, mixilateral notch; *cd*, area overlapped by mixilateral plate; *dmr*, dorsal median ridge; *l*, lateral corner; *pa*, posterior corner; *plc*, postero-lateral corner; *prl*, lateral process.

and occurs so frequently that it is found in about 36% of the total number of specimens examined. The overlapped areas (cd_3, cd_4) of the plate are generally comparatively broad (cf. ext-figs. 43, 121–124).

The posterior median dorsal plate (text-figs. 45F, G, 47C, 286, 287A; pl. 36, figs. 2–6; pl. 37, figs. 1, 2; pls. 38–42; pl. 43, figs. 1–3) is as a rule narrower than long. In very large individuals, however, it is about equally broad as long. Its breadth : length ratio, which could be calculated for twenty cases, ranges between 78–100. In the four smallest specimens available it is 78–84, whereas in fourteen medium-sized and large specimens it is 80–96. In two very large specimens it amounts to about 100 or perhaps even a little more. As is thus obvious, the plate is normally comparatively narrow in proportion to its length. In this character it is nearest as in *B. ornata* (cf. p. 403 above, and text-fig. 217), *B. panderi* (cf. p. 446; cf. text-figs. 47B, 231D), *B. jarviki* (cf. p. 594 below, and text-fig. 305D) and *Grossilepis* (cf. text-fig. 269). In a few cases, in large individuals (text-fig. 287A), the plate is comparatively broad anteriorly. In small and medium-sized individuals, and also as a rule in large individuals, it narrows more forwards in front of the lateral processes (*prl*) than what is the case in most other *Bothriolepis*-species, and in consequence of this it is normally unusually narrow in its anterior parts (cf. text-fig. 45). As to this character it agrees in a striking way with the corresponding plate in *B. ornata* (cf. text-fig. 217), which is also unusually narrow in its anterior parts. The anterior margin is somewhat produced into a marked anterior angle or corner (*aa*) which generally is more distinctly pointed in small individuals than in medium-sized and large individuals. The division of the lateral margin situated in front of the lateral process may be slightly concave or practically straight, but is often also slightly convex in its middle part. As in *canadensis* and *B. alvesiensis*, in the anterior part of this division of the lateral margin there is sometimes a more or less deep mixilateral notch (*aln*). The posterior division of the lateral margin lying on the lateral process (*prl*) is always somewhat long, on account of which the lateral corner (*l*) and the postero-lateral corner (*plc*) never coincide as they sometimes do in *B. canadensis* and *B. cellulosa*. The posterior corner or angle (*pa*) is usually slightly pronounced and rounded off, but may sometimes be clearly angular (text-figs. 45G, 286A, C).

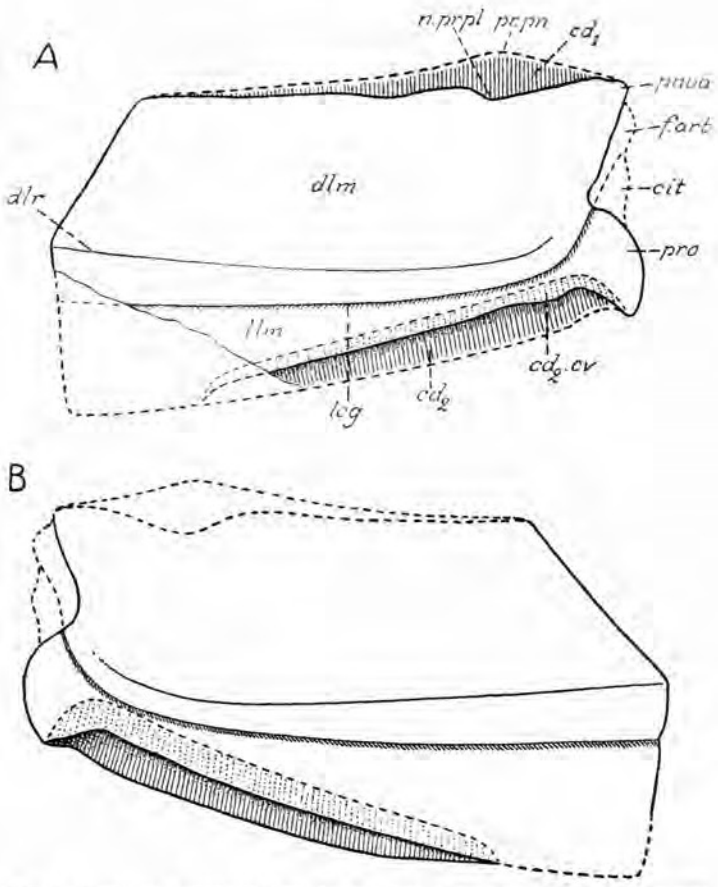
As normally in other *Bothriolepis*-species, the posterior median dorsal plate overlaps both the anterior median dorsal and mixilateral plates. In certain cases it is clearly seen, however, that along its lateral margin it has a more or less long area (*cd*, text-fig. 286F, J, K; pl. 38, fig. 2; pl. 41, fig. 1) which was overlapped by the mixilateral plate. It is obvious, therefore, that in certain cases it both overlapped the mixilateral plate and was more or less overlapped by that plate. A corresponding abnormal sutural connection between the anterior median dorsal plate and the mixilateral plate occurs



Text-fig. 287. *Bothriolepis groenlandica*. *A*, restoration of a posterior median dorsal plate of a very large individual. Dorsal aspect. × 1/2. *B*, attempted restoration of trunk-armour in lateral aspect. The extent of the dorsal overlapped parts of the anterior and posterior ventro-lateral plates indicated with broken lines. × 1/2.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; *aa*, anterior corner or angle of *Pmd*- plate; *aal*, antero-lateral corner of *Pmd*-plate; *aln*, mixilateral notch; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *dma*, tergal angle; *dmr*, dorsal median ridge; *f. ax*, foramen axillare; *l*, lateral corner of *Pmd*- plate; *lcg*, main lateral line groove; *pa*, posterior corner of *Pmd*-plate; *plc*, postero-lateral corner of *Pmd*-plate; *prl*, lateral process of *Pmd*-plate; *pro*, processus obstans.

occasionally, as we have seen, also in *B. cellulosa* (p. 419 above, and text-figs. 45E, 225E) and *B. canadensis* (p. 306 above).

The anterior dorso-lateral plate (text-figs. 287B, 288; pls. 44, 45) is represented only by six deficient specimens all of which are from large individuals. As in *B. maxima* and *B. gigantea* (cf. text-fig. 238C, D), the plate is comparatively long and low in lateral aspect. Its dorsal lamina is from somewhat more than twice to about two and a half times as long as broad, and its lateral lamina from somewhat more than three times to about



Text-fig. 288. *Bothriolepis groenlandica*. *A*, *B*, restorations of a right and a left anterior dorso-lateral plate in lateral and somewhat dorsal aspect. Both plates of fairly large individuals; Approximately × $^2/_3$.

cd_1, area overlapped by the anterior median dorsal plate; cd_2, area overlapped by anterio-ventro-lateral plate; cd_2cv, part of lateral lamina (dotted) both overlapped by and overlapping anterior ventro-lateral plate; *cit*, vertical part of crista transversalis interna anterior forming an anterior transverse lamina; *dlm*, dorsal lamina; *dlr*, dorso-lateral ridge; *f. art*, articular fossa; *lcg*, main lateral line groove; *llm*, lateral lamina; *n. prpl*, notch in dorsal margin of ornamented area for external postlevator process (*pr. pl*) of *Amd*-plate; *pnoa*, postnuchal ornamented corner; *pro*, processus obstans; *pr. pn*, internal postlevator process.

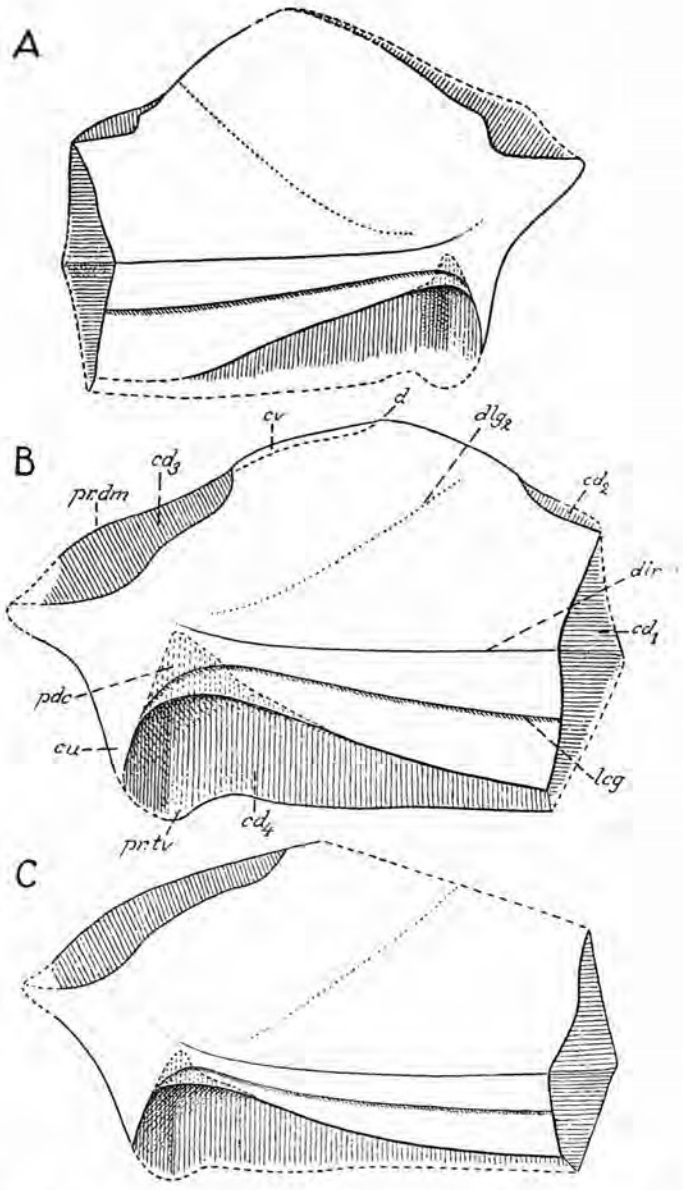
three and a half times as long as high. The latter lamina is thus considerably longer and lower than in *B. canadensis* and *B. cellulosa* (cf. text-figs. 48C, 144A, 145B, 226) and approaches in this respect nearest the corresponding lamina in *B. maxima* and *B. gigantea* (cf. text-fig. 238). The processus obstans (*pro*) is fairly long and extends further antero-ventrally than in *B. canadensis* and *B. cellulosa*.

As has already been pointed out above (p. 560), the anterior median dorsal plate seems always to have been overlapped along its entire dorso-

medial margin by the anterior median dorsal plate. No abnormal sutural connection between it and the anterior median dorsal plate has been observed hitherto. The sutural connection of the plate with the anterior ventro-lateral plate was somewhat complicated. The lateral lamina in its longer anterior part is split up ventrally into a lateral and a medial lamella (text-fig. 288) between which the lateral lamina of the anterior ventro-lateral plate is wedged in. In its longer anterior part the plate in question is thus not only overlapped by the anterior ventro-lateral plate but at the same time overlaps also this plate for a considerable stretch backwards. The overlapping lamella varies in bredth but extends never as far downwards as does the overlapped lamella (text-fig. 288). Furthest posteriorly the anterior dorso-lateral and antero-ventro-lateral plates abut against one another only with the very edges of their lateral laminae.

The condition that the anterior dorso-lateral plate here is split ventrally so as to embrace the anterior ventro-lateral plate from the lateral and medial sides is not unique, but is met with also in other *Bothriolepis*-species, e.g. *B. canadensis* (text-figs. 48C, 144A, C) and *B. maxima*, though in them it is generally less pronounced.

The mixilateral plate (text-figs. 287B, 289; pl. 36, fig. 1; pls. 47–49) is more abundantly met with among the material available than the anterior dorso-lateral plate and is represented by specimens of varying size. Seen straight from the lateral side the plate is higher and shorter than in *B. canadensis* (cf. text-figs. 38, 40, 153A, B). With regard to its appearance in lateral view it is, therefore, somewhat as in *B. maxima*, *B gigantea* (cf. text-fig 256) and, *B. obesa* (cf. text-fig 259B). The plate is much more variable than in *B. canadensis* (cf. p. 319 above) not only as to its proportions as a whole, but also as to the proportions of its dorsal and lateral laminae. The dorsal lamina is from slightly less than twice to more than two and a half times as long as broad, the lateral lamina from somewhat more than three times to nearly four and a half times as long as high. The latter lamina is thus of a very long and low type similar to that in *B. maxima* and *B. gigantea* (cf. pp. 453, 488 above, and text-fig. 256). As in *B. obesa* (cf. text-fig. 259B), but in contrast to what is the case in *B. canadensis* and *B. cellulosa* (cf. text-figs. 50C, 153F, G, 227), this lamina is highest across its posterior part, at a transverse plane through the postero-ventral process. This process (*pr. lv*) descends somewhat below the level of the anterior parts of the ventral margin of the lateral lamina and seems to have been obtuse and much rounded off. The postero-ventral ornamented corner (*cu*) is long and pointed. The area (cd_4) overlapped by the posterior ventro-lateral plate extends forwards as far as to the anterior margin of the lateral lamina and seems normally to be higher in its foremost part than in *B. canadensis* and *B. cellulosa*. Straight above the postero-ventral process (*pr. lv*), and immediately above the posterior part of the overlapped area (cd_4) just referred

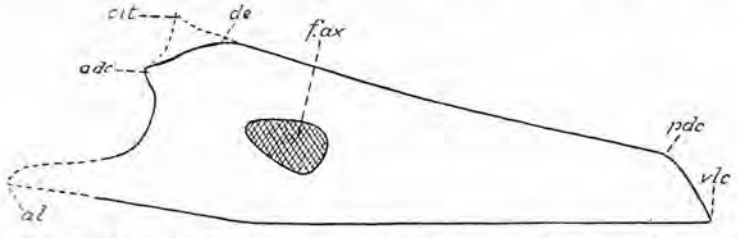


Text-fig. 289. *Bothriolepis groenlandica*. *A–C*, restorations of three mixilateral plates in lateral and somewhat dorsal aspect. All the plates of fairly large, or large, individuals. Approximately × 3/5.

cd_1, area overlapped by anterior dorso-lateral plate; cd_2, area overlapped by anterior median dorsal plate; cd_3, area overlapped by posterior median dorsal plate; cd_4, area overlapped by posterior ventro-lateral plate; *cu*, postero-ventral ornamented corner; *cv*, extent of an area of the lower side of the dorsal lamina overlapping the posterior median dorsal plate; *d*, dorsal corner; dlg_2, posterior oblique abdominal pit-line groove; *dlr*, dorso-lateral ridge; *lcg*, main lateral-line groove; *pdc*, pit developed for dorsal corner of posterior ventro-lateral plate; *pr. dm*, medial dorsal process; *pr. lv*, postero-ventral process.

to, there is a more or less deep and broad pocket-like pit (*pdc*) which opens downwards. This pit lodged the dorsal process (*dc*, text-fig. 292A) of the posterior ventro-lateral plate (cf. also p. 568 below).

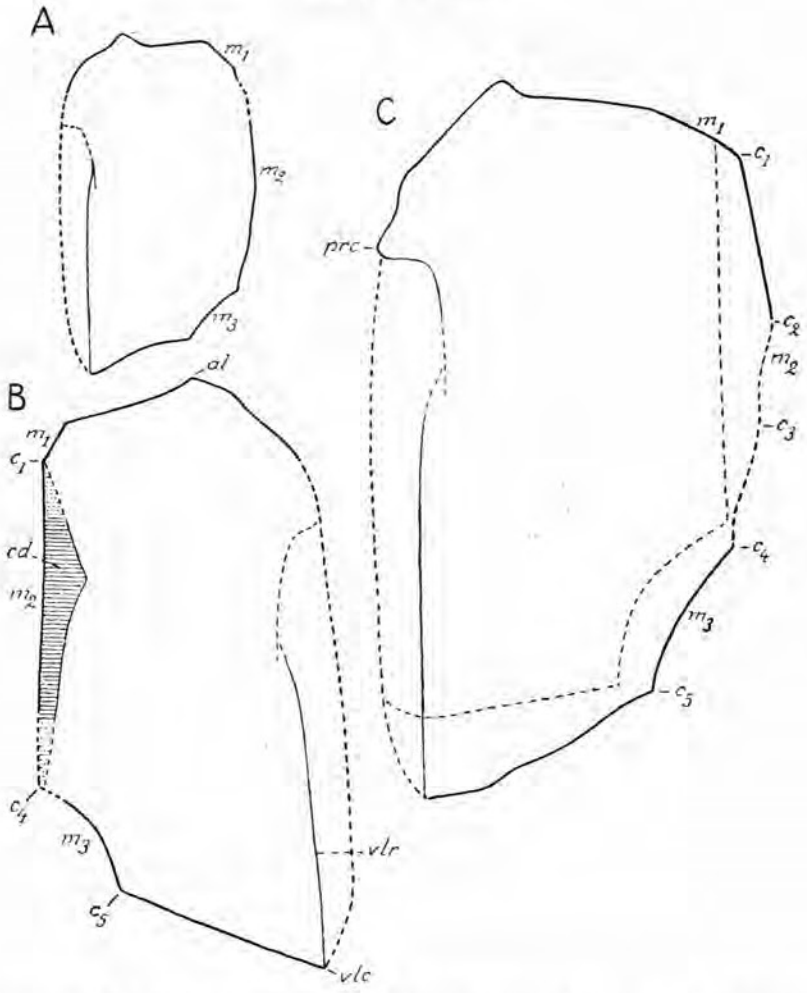
As to its sutural connection with the posterior ventro-lateral plate the mixilateral plate seems to differ from the corresponding plate in other species in the presence of the ventrally opening pit just described for the dorsal process of the posterior ventro-lateral plate. In its sutural connection with the anterior median dorsal plate it shows often, as in several of the other



Text-fig. 290. *Bothriolepis groenlandica*. Outline of the lateral lamina of a left anterior ventro-lateral plate of a medium-sized individual. Lateral view. × 5/6.
adc, antero-dorsal corner; *al*, antero-lateral corner of subcephalic division of ventral lamina; *cit*, crista transversalis interna anterior; *de*, dorsal corner or angle; *f. ax*, foramen axillare; *pdc*, postero-dorsal corner of lateral lamina; *vlc*, posterior ventro-lateral corner.

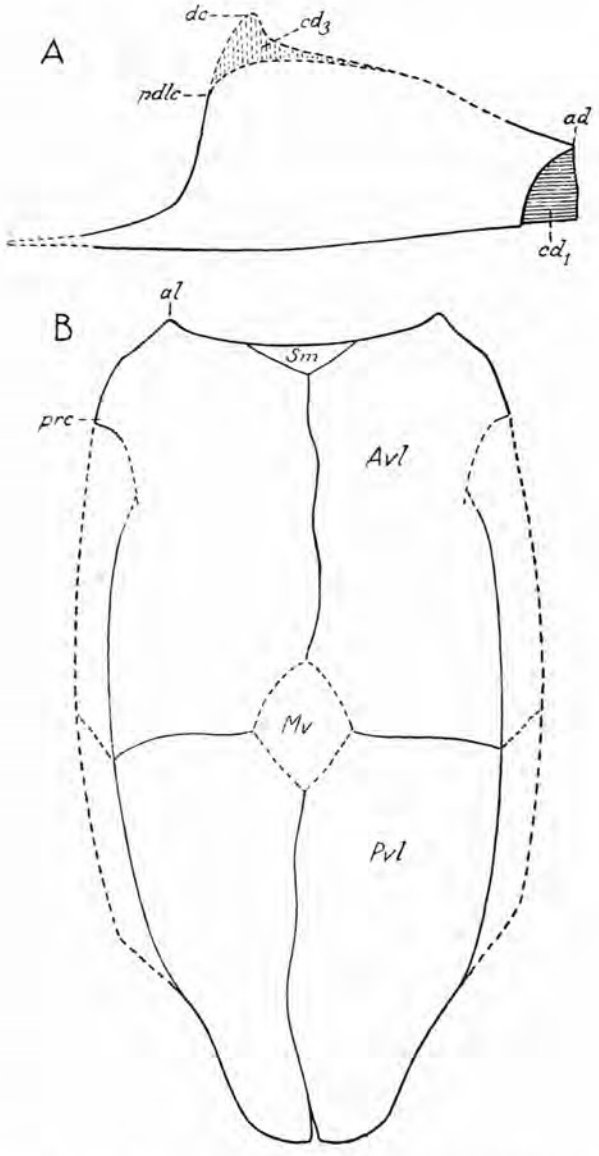
species, a more or less *Remigolepis*-like condition (cf. pp. 120, 124, 133). The plate is normally overlapped by the posterior median dorsal plate in the ordinary way, but, as in *B. maxima* (cf. pp. 133, 453 above), it may also sometimes be split up into lamellae along the posterior division of its dorso-medial margin so that it both is overlapped by and overlaps the posterior median dorsal plate.

The anterior ventro-lateral plate (*Avl*, text-figs. 287B, 290, 291, 292B; pls. 15–18, 50–54; pl. 55, fig. 1) is somewhat common in the material available, but is mostly represented only by its ventral lamina, its lateral lamina generally being very deficient or entirely missing. In the fairly few cases in which it is found more or less in its natural connection with the adjacent plates of the trunk-armour (pls. 15–18, 53) it varies in length in proportion to the posterior ventro-lateral plate in a manner corresponding to that in *B. canadensis* (cf. p. 126 above). The lateral lamina (text-figs. 287B, 290; pl. 55, fig. 1) is completely preserved only in a single specimen, where it is about three and a fourth times as long as high. Though it must have varied a good deal in its length and breadth it is nevertheless fully evident from this that the lateral lamina of the plate must normally have been of a longer and lower shape than for instance in such species as *B. canadensis*, *B. cellulosa*, *B. maxima*, *B. obesa*, *B. cristata*, *B. gipsslandiensis* and *B. jarviki* (cf. pp. 327, 436, 453, 496, 511, 520, 595; cf. also text-figs. 38, 40, 51A, 166E, F, 264, 304). The ventral lamina is from not fully twice to somewhat more than twice as long as broad, and the subcephalic division



Text-fig. 291. *Bothriolepis groenlandica*. *A–C*, restorations of three anterior ventro-lateral plates in ventral aspect. *A*, *C*, right plates; *B*, left plate. × 4/5.
al, antero-lateral corner of subcephalic division of ventral lamina; c_1, corner between anterior (m_1) and middle (m_2) divisions of medial margin of ventral lamina; c_2, c_3, corners on middle division (m_2) of ventral lamina; c_4, corner between middle (m_2) and posterior (m_3) divisions of medial margin of ventral lamina; c_5, posterior medial corner of ventral lamina (posterior ventro-medial corner of the plate as a whole); *cd*, area overlapped by right anterior ventro-lateral plate; m_1, anterior division of medial margin of ventral lamina connected with semilunar plate; m_2, middle division of medial margin of ventral lamina connected with anterior ventro-lateral plate of opposite side; m_3, posterior division of medial margin of ventral lamina connected with median ventral plate; *vlc*, posterior ventro-lateral corner; *vlr*, ventro-lateral ridge.

constitutes 20–28 % of its total length. The free margins of the lateral lamina in their configuration agree essentially with the corresponding margins in *B. canadensis*. The free lateral margin of the ventral lamina, that is to say the lateral margin of the subcephalic division of the ventral lamina, in dorsal or ventral aspect is often strongly convex, with a more or less distinct



Text-fig. 292. *Bothriolepis groenlandica*. *A*, restoration of a right posterior ventro-lateral plate in lateral aspect. *B*, restoration of the ventral wall of the trunk-armour in ventral aspect. × $^5/_8$.

Avl, anterior ventro-lateral plate; *Mv*, median ventral plate; *Pvl*, posterior ventro-lateral plate; *Sm*, semilunar plate; *ad*, antero-dorsal corner of lateral lamina of *Pvl*-plate; *al*, antero-lateral corner of subcephalic division of *Avl*-plate; cd_1, area overlapped by anterior ventro-lateral plate; cd_3, area overlapped by mixilateral plate; *dc*, dorsal corner of lateral lamina of *Pvl*-plate; *pdlc*, postero-dorsal corner of lateral lamina of *Pvl*-plate; *prc*, pre-pectoral corner.

rounded angle somewhere in its middle parts. In front of, or behind, this angle in several specimens it shows a more or less distinct concavity. The antero-lateral corner (*al*) is present and may often be a little produced into a short process which points straightly, or fairly straightly, forwards, whereas the corresponding process in *B. canadensis* and *B. cellulosa* (cf. text-figs. 41 A–C, 51 B, C, 166 A–D) is often curved so as to point more or less antero-medially. The anterior margin of the ventral lamina may be practically straight, a little concave, or a little convex and presents no clear indications of the notch that is often to be found in *B. canadensis* and *B. cellulosa* immediately medially to the antero-lateral corner (*al*). The medial margin of the ventral lamina in its essential characters is as normally in *Bothriolepis* and varies to about the same extent as in other *Bothriolepis*-species (cf. text-figs. 41 A–C, 51 B, C, 52, 166 A–D; cf. also Gross 1941 a, text-fig. 14). Finally, the posterior margin of the ventral lamina may be somewhat concave, nearly straight, somewhat convex and a little undulating, or a little convex in its medial part and somewhat concave in its lateral part. The fossa articularis pectoralis and the brachial process are very poorly preserved, but it is obvious that in essentials they must have been much as in *B. canadensis* and *B. maxima* (cf. text-figs. 4, 40 A, 51 A, 52, 166 E, F). The foramen axillare (*f.ax*) is completely preserved only in one specimen (text-fig. 290; pl. 55, fig. 1) where it is lower than long.

The posterior ventro-lateral plate (*Pvl*, text-figs. 287 B, 292; pls. 15–18, 52, 53; pl. 55, figs. 2–4; pl. 56, fig. 1) is fairly common among the material at my disposal, but it is generally deficient, being represented by its ventral lamina only. Though the uppermost parts of the lateral lamina have not been found preserved it may nevertheless be inferred from the development of the mixilateral plate (cf. pp. 563–565 and text-fig. 289) that the lateral lamina of the plate must have been somewhat as shown in text-fig. 292 A. As is seen from this figure, the lamina in question was low anteriorly, but increased considerably in height backwards as far as to its dorsal corner (*dc*). This corner was produced dorsally into a distinct dorsal process fitting into the pocket-like ventrally opening pit (*pdc*, text-fig. 289) in the posterior part of the lateral lamina of the mixilateral plate. As far as may be judged, the lamina must have been about twice, or somewhat more than twice, as long as it is high at the dorsal corner, and about two and a half times, or somewhat more than two and a half times, as long as the height of its exposed area below the dorsal corner. The ventral lamina is from a little more than twice to about two and a half times as long as broad. The length of its subanal division is between a fourth and a third of the total length of the lamina. The anterior margin of the lateral lamina seems normally to be somewhat convex, about as in *B. cellulosa*, not concave as in *B. canadensis*. The dorsal margin of the lateral lamina was presumably somewhat convex throughout its extent in front of its dorsal corner, whereas

the corresponding margin in *B. canadensis* and *B. cellulosa* as a whole is slightly concave. The margins of the ventral lamina show no distinctive characters, but are essentially as in *B. canadensis*.

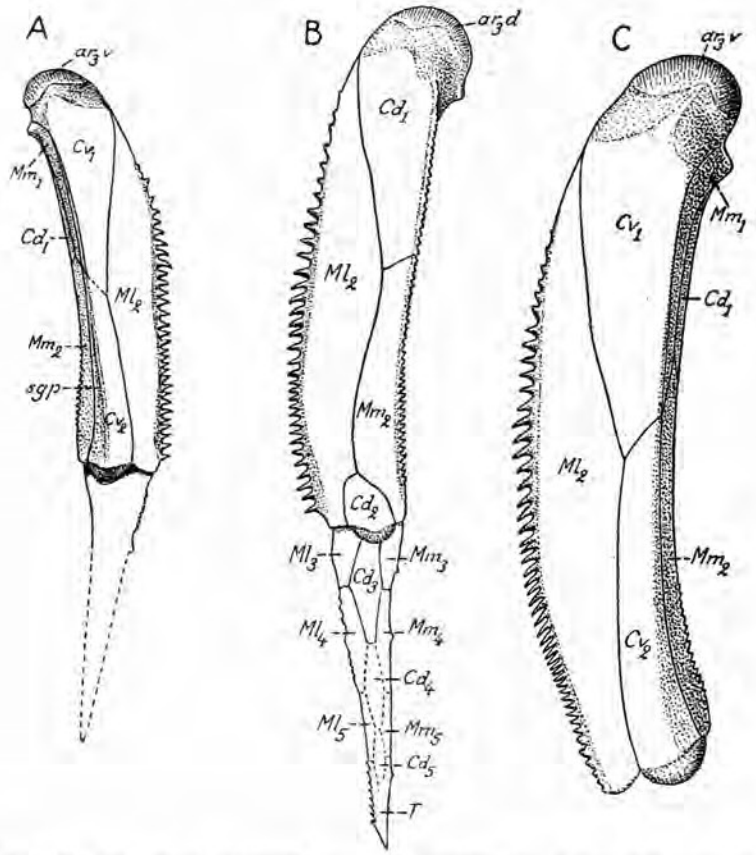
In its sutural connections with the adjacent plates the posterior ventro-lateral plate is as normally in the *Bothriolepis*-species, with the exception, however, that, as we have seen, its dorsal corner is situated within a pit in the mixilateral plate. When in its natural position in this pit the dorsal corner was not visible either on the outside or on the inside of the trunk-armour.

The semilunar plate (*Sm*, text-fig. 292B; pls. 15, 16) is small and is of the normal type characteristic of the *Bothriolepinae*.

The median ventral plate (*Mv*, text-fig. 292; pls. 15, 16, 18; pl. 56, figs. 2–4; pl. 57, fig. 1) as to its size is somewhat as in *B. canadensis* and *B. cellulosa* (cf. text-fig. 41 A–C) and is thus comparatively small in proportion to the length and breadth of the ventral wall of the trunk-armour. In the few specimens (pls. 15–18) where it is in its natural connection with the anterior and posterior ventro-lateral plates the plate is very poorly preserved, and so nothing can be said of its exact shape in these specimens. In consequence of this, and for other reasons as well, the plate when it is detached cannot be orientated with full certainty for the present as regards which one of its median corners that is directed anteriorly or posteriorly. The plate is longer than broad and may in some cases even be fairly long and narrow (pl. 56, fig. 3). All its four corners are pronounced, and the lateral corners may in certain cases be somewhat produced into short lateral processes. The margins of the plate are mostly somewhat convex in their middle parts and a little concave towards their ends (pl. 56, fig. 2). The plate is either equally long on both sides of the transverse axis through its lateral corners or else somewhat longer on one side of the said axis than on the other side. In the latter cases, as in *B. canadensis* (cf. pp. 141, 342 above, and text-fig. 41 A, B), it is presumably the anterior division of the plate that is longest.

Pectoral fin.

The pectoral fin (text-figs. 293–295; pls. 15–18, 52–54; pl. 58, fig. 1; pls. 59, 60; pl. 61, figs. 1, 2; pl. 67, fig. 7; pls. 68, 69) is slender, in general proportions and shape reminding of that in *B. maxima*, *B. gigantea*, *B. leptocheira* and *B. jarviki* (cf. text-figs. 243 A–D, 257, 306). In a fully adducted position, alongside the lateral side of the body, the fin extends only slightly backwards beyond the posterior end of the ventral wall of the trunk-armour. As to its length in proportion to the trunk-armour, therefore, it is as normally in other *Bothriolepis*-species. Fully adducted to the body the proximal segment extends backwards as far as to opposite the posterior parts of the mixilateral plate and the middle of the posterior ventro-lateral plate and is thus a little longer in proportion to the trunk-armour than in *B. canadensis*

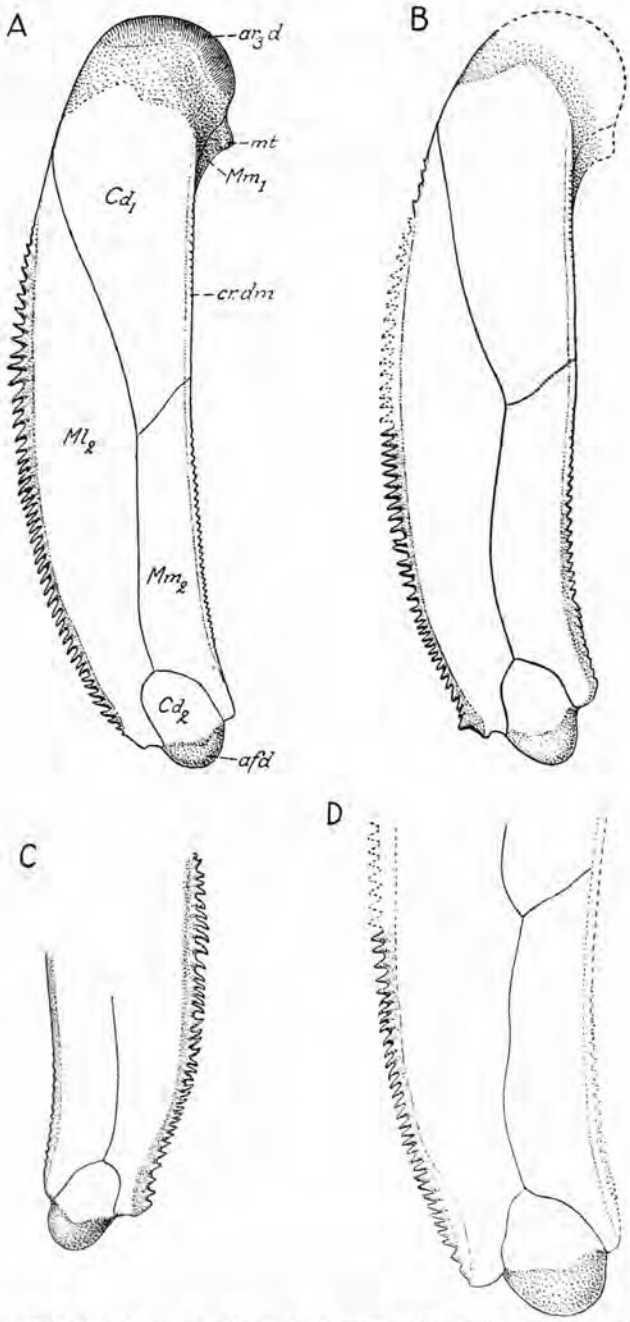


Text-fig. 293. *Bothriolepis groenlandica*. *A*, *B*, restorations of two left pectoral fins of somewhat small medium-sized individuals. *A*, in ventral and *B*, in dorsal aspect. *C*, restoration of the proximal segment of a right pectoral fin of a medium-sized individual. Ventral aspect. All the restorations × 5/6.

Cd_1–Cd_5, dorsal central plates 1–5; Cv_1–Cv_2, ventral central plates 1 and 2 respectively; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_1–Mm_5, medial marginal plates 1–5; *T*, terminal plate; ar_3d, external articular area of dorsal central plate 1; ar_3v, external articular area of ventral central plate 1; *sgp*, pectoral pit-line groove.

(cf. p. 359 above and text-figs. 38, 40B, 41B). The distal segment is somewhat shorter relatively than in *B. canadensis*, its length amounting only to about 55–65% of the length of the proximal segment.

The proximal segment (text-figs. 293, 294; pls. 15–18, 52, 54; pl. 58, fig. 1; pls. 59–61; pl. 62, figs. 1, 2) is always curved in the normal way so that it is somewhat convex along its lateral margin and correspondingly concave on its medial face. As far as may be seen, it is usually broadest about at, or a little in front of, its middle, not in its posterior half, as in *B. canadensis* (cf. text-figs. 194, 195). Quite as in *B. canadensis* (cf. p. 359 above; cf. also text-fig. 194), it is normally broader in proportion to its length in large than in small individuals. In the smallest individual known,



Text-fig. 294. *Bothriolepis groenlandica*. *A*, *B*, restorations of two left proximal segments of large medium-sized individuals. Dorsal aspect. *C*, distal part of a right pectoral fin of a medium-sized individual. Dorsal aspect. *D*, distal half of a left pectoral fin of a large individual. Dorsal aspect. All the restorations × $^2/_3$.

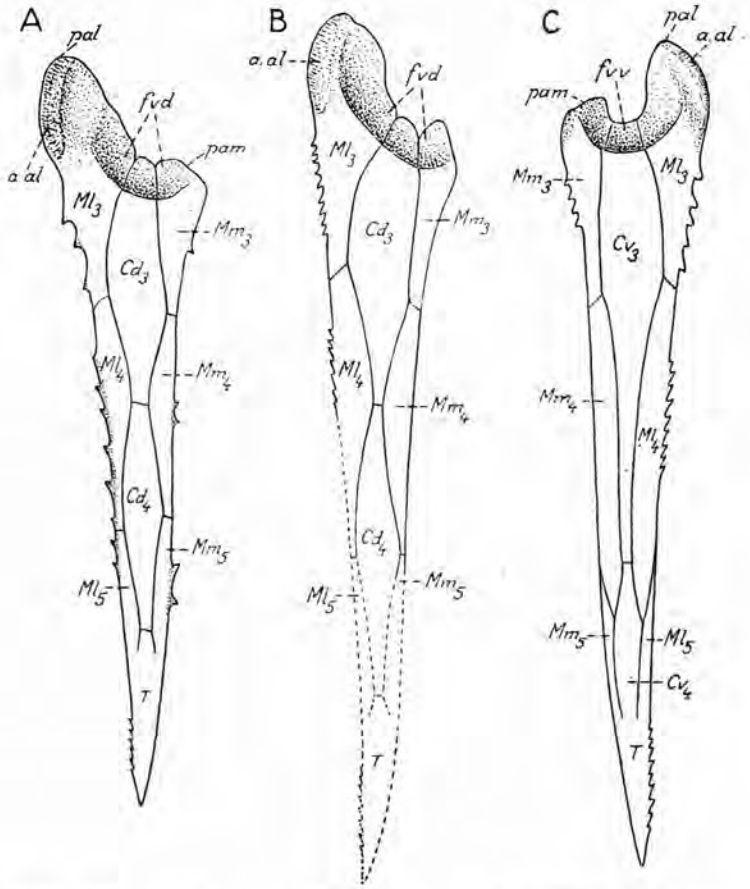
Cd_1, Cd_2, dorsal central plates 1 and 2 respectively; Ml_2, lateral marginal plate 2; Mm_1, Mm_2, medial marginal plates 1 and 2 respectively; *afd*, external articular area of dorsal central plate 2; ar_3d, external articular area of dorsal central plate 1; *cr. dm*, medial crest formed by fusion of medial spines; *mt*, postarticular thickening.

where it is imperfect distally, it seems to have been about six times as long as broad; in medium-sized individuals it is from somewhat more than five times to about four and a half times as long as broad; and, finally, in very large individuals it is only from between five and four times to about four times as long as broad. As in other *Bothriolepis*-species, the ventro-medial margin of the segment is well developed proximally, but becomes gradually more obscure in a distal direction. This margin is decidedly stronger throughout its extent, however, than what it is in *B. maxima* (cf. p. 457, and text-fig. 243B–D).

The distal segment (text-figs. 293A, B, 295; pls. 15–17; pl. 58, fig. 1; pl. 67, fig. 7; pls. 68, 69) is to a certain extent intermediate in shape between the corresponding segment in *B. canadensis* and *B. cellulosa* on the one hand (cf. text-figs. 41B, 98, 195, 198, 228C–E) and that in *B. maxima* (cf. Gross 1941a, text-fig. 44A–D; pl. 29, figs. 1–3) on the other. The segment is comparatively broad in its proximal part nearest to its articulation with the proximal segment, but usually fairly slender in its distal parts. In transverse section in its distal parts it is rounder than in *B. canadensis* and *B. cellulosa*, but not as round as in *B. maxima*. In contradistinction to what in the case in *B. canadensis*, the longitudunal dorsal and ventral grooves along the lateral and medial margins of the segment seem to be obscure or absent.

The pectoral fin is provided with lateral and medial spines which, as in *B. canadensis*, are relatively stronger developed in small individuals than in large individuals. The lateral spines of the proximal segment are decidedly stronger developed than in several other *Bothriolepis*-species (cf. text-figs. 98, 180A, 181C, 182, 184, 186–189, 194, 195, 228, 243C, 246), but, as in *B. canadensis*, the spines of this segment are more numerous, shorter and blunter in large individuals than in small and medium-sized individuals. The lateral spines of the distal segment are comparatively few in number. The medial spines of the proximal segment are much shorter than the lateral spines of this segment. Those of them which belong to the dorsal central plate 1, and to an adjacent proximal part of the medial marginal plate 2, are normally more or less completely fused together into a crest (*cr.dm*), but may also, in many individuals, remain fairly independent (text-figs. 293A, 294A, B, 296, 301); these medial spines are all directed dorso-medially, and so is also the crest formed by them. The remaining more distally situated medial spines of the proximal segment, that is to say the medial spines on the longer distal part of the medial marginal plate 2, are all independent, at least towards their points; whereas the proximal ones of them are directed dorso-medially the others gradually change their position in such a manner that ultimately on the distal most parts of the segment they point straight medially. Finally, those of the spines of the medial row which lie on the distal segment are few in number or almost absent.

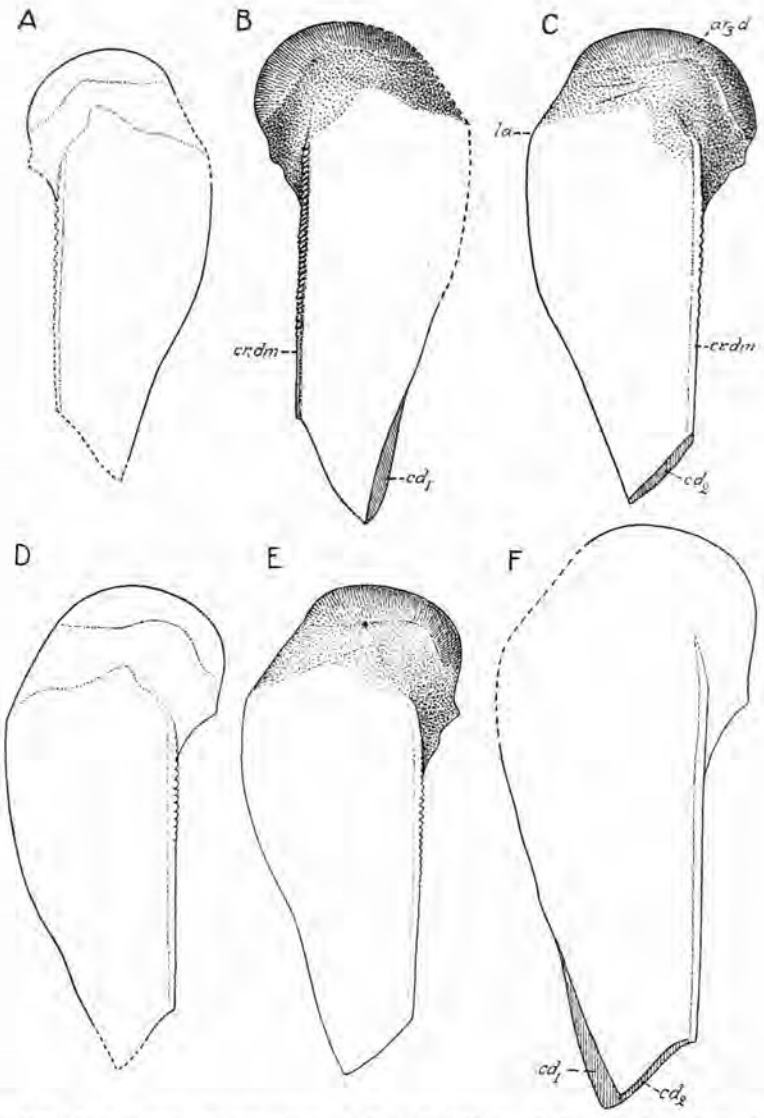
The dorsal central series of plates (Cd_1–Cd_4, text-figs. 293B, 294,



Text-fig. 295. *Bothriolepis groenlandica*. Restorations of three left distal segments. *A*, of a medium-sized individual in dorsal aspect. × 5/3. *B*, of a large individual in dorsal aspect. × 5/6. *C*, of a large individual in ventral aspect. × 5/6.
Cd_3, Cd_4, dorsal central plates 3 and 4 respectively; Cv_3, Cv_4, ventral central plates 3 and 4 respectively; *T*, terminal plate; *a. al*, lateral area of „Siebknochen" on lateral anconeal process; *fvd*, articular fovea of dorsal side of distal segment; *fvv*, articular fovea of ventral side of distal segment; *pal*, lateral anconeal process; *pam*, medial anconeal process.

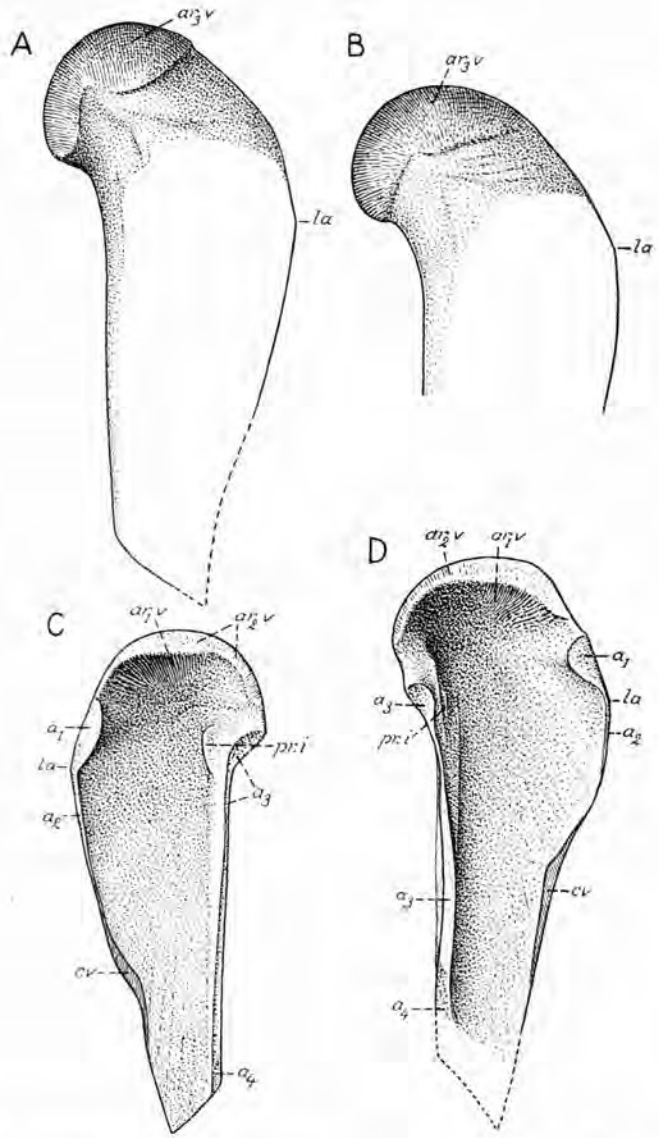
295A, B; pls. 52, 54; pl. 58, fig. 1; pls. 59, 61; pl. 68, figs. 1–3, 5; pl. 69, figs. 1, 2, 5) seems normally to consist of four independent plates. A fifth potential plate of the series is represented by a median dorsal process of the terminal plate. Probably as a rule the series is thus composed of the same number of independent elements as in *B. cellulosa* and *B. maxima*, but shows also indications of a fifth element. In the latter respect it approached somewhat *B. canadensis* (cf. text-figs. 198A–E, 228C, D; cf. also Gross 1941a, text-fig. 44C, D).

The dorsal central plate 1 (Cd_1, text-figs. 293B, 294A, B, 296; pls. 51, 52, 54; pl. 57, fig. 3; pl. 58, fig. 1; pls. 59, 61; pl. 62, figs. 3, 4; pl. 63; pl. 64,

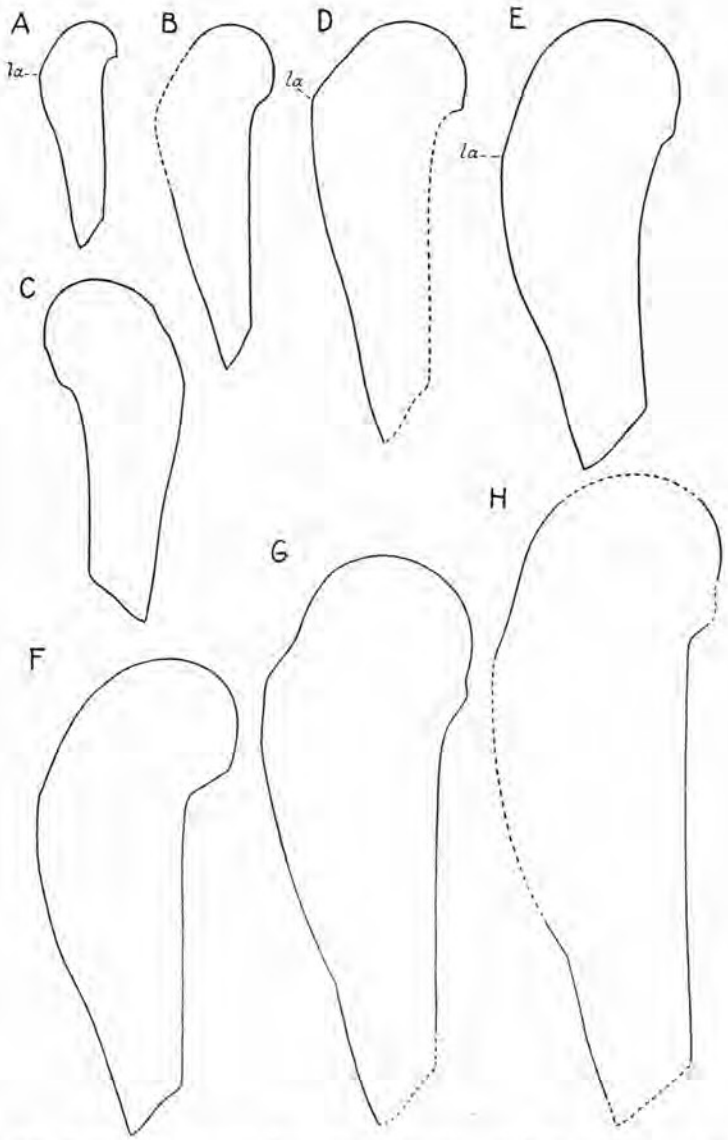


Text-fig. 296. *Bothriolepis groenlandica*. *A–F*, restorations of six dorsal central plates 1 in dorsal aspect. Ornament omitted. *A*, *B*, two right plates; *C–F*, four left plates. All the plates of fairly large and large individuals. × $^2/_3$.
ar_3d, external articular area; cd_1, area overlapped by lateral marginal plate 2; cd_2, area overlapped by medial marginal plate 2; *cr*, *dm*, medial crest formed by fusion of medial spines; *la*, lateral angle or corner.

fig. 1) is somewhat longer and narrower than in *B. canadensis*, *B. cellulosa* and *B. panderi*. In small medium-sized individuals it is about 3,1 times, and in large medium-sized and large individuals about 3–2,9 times, longer than it is broad. With regard to its length:breadth ratio this plate is thus most suggestive of *B. maxima*, *B. leptocheira* and *B. jarviki* (cf. pp. 457, 503, 597).



Text-fig. 297. *Bothriolepis groenlandica*. *A*, restoration of a large left ventral central plate 1 in ventral aspect. Ornament omitted. *B*, proximal part of a large left ventral central plate 1 in ventral aspect. Ornament omitted. *C*, *D*, restorations of two ventral central plates 1, left and right respectively, from the inside. All the restorations × $^2/_3$. a_1, thickened part of lateral margin connected with dorsal central plate 1; a_2, part of lateral margin connected with lateral marginal plate 2; a_3, part of medial margin connected with medial marginal plate 1; a_4, part of medial margin connected with the ventral central plate 2; ar_1v, ar_2v, ar_3v, internal marginal and external articular areas respectively; *cv*, area overlapping lateral marginal plate 2; *la*, lateral corner or angle; *pr. i*, internal process.



Text-fig. 298. *Bothriolepis groenlandica*. Outline sketches of eight ventral central plates 1. A, of a young individual. × $^4/_3$. *B–H*, of medium-sized and large individuals. × $^2/_3$. *la*, lateral corner or angle.

The dorsal central plate 2 (Cd_2, text-figs. 293B, 294; pls. 52, 54; pl. 58, fig. 1; pl. 59; pl. 60, fig. 5; pl. 61) is also normally broader in large individuals than in smaller individuals. More precisely, in medium-sized individuals it is mostly between 1,7–1,5 times longer than broad, whereas in very large individuals it is only about 1,4–1,3 times longer than broad. As to its outlines the plate is usually more suggestive of the corresponding plate in *B.*

maxima (cf. text-fig. 245B) and *B. cellulosa* (cf. text-fig. 228A) than of that in *B. canadensis* (cf. text-fig. 194).

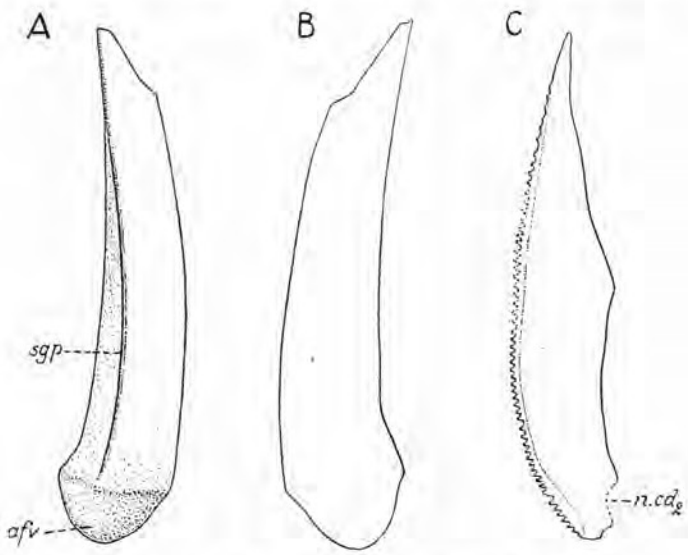
The dorsal central plates 3 and 4 (Cd_3, Cd_4, text-figs. 293B, 295A, B; pl. 58, fig. 1; pl. 60, figs. 4, 5; pl. 68, figs. 1–3; pl. 69, figs. 1, 2, 5) are relatively longer than in *B. canadensis* and *B. cellulosa* and in this respect resemble mostly the corresponding plates in *B. maxima*. Judging from the development of the terminal plate, it is conceivably that a dorsal central plate 5 may sometimes have been developed as an independent element.

The ventral central series of plates (Cv_1–Cv_4, text-figs. 293A, C, 295C; pls. 15–18; pl. 60, figs. 2–4; pl. 61, fig. 1; pl. 62, figs. 1, 2; pl. 67, fig. 7; pl. 68, fig. 4; pl. 69, figs. 3, 4) consists normally of three fully independent elements. Besides these three elements it includes, however, also a fourth potential element (Cv_4), which normally is continuous with the terminal plate only at its very distal end. This distalmost potential element may probably sometimes be completely divided off from the terminal plate, and it may be suspected, therefore, that in certain cases the series consisted of as many as four independent elements. As to the number of its independent elements the series is thus agrees normally with the corresponding series in *B. cellulosa* (cf. text-fig. 228D), but may sometimes probably be as in *B. canadensis* (cf. text-figs. 41B, 195) and *B. maxima* (cf. Gross 1941a, text-fig. 44A, B).

The ventral central plate 1 (Cv_1, text-figs. 293A, C, 297, 298; pls. 15–18, 50, 51, 53, 54; pl. 60, fig. 2; pl. 61, fig. 1; pl. 62, figs. 1, 2; pl. 64, figs. 2–4; pl. 65; pl. 66, figs. 1–3) is strikingly long in proportion to its breadth. In small and small medium-sized individuals it is 4–3,2 times, mostly, however, about 3,8–3,3 times, longer than broad, whereas in larger medium-sized and large individuals it is about 3,3–3,1 times longer than broad. It is thus somewhat longer than in *B. maxima* (cf. p. 457), somewhat shorter than in *B. jarviki* (cf. p. 597), but approximately as long as in *B. gigantea* (cf. p. 489, and text-fig. 257). The external articular area (ar_3v, text-fig. 297A, B; pl. 66, fig. 1) is broader and stronger developed than normally in the *Bothriolepis*-species. At least in some of the large specimens this area shows a marked notch in its distal margin, a notch by which it is imperfectly divided into an anterior narrower and a posterior broader division. This notch may also be met with in other *Bothriolepis*-species, but is there usually shallow and slightly pronounced. In *B. maxima*, however, it may sometimes (cf. text-fig. 245D) be almost as conspicuous as in the species here under description. With regard to the development of its margins the plate agrees on the whole with the corresponding plate in *B. canadensis* in that both its lateral and medial margins are thickened anteriorly at those places immediately behind the anterior brachial aperture where they are connected with the dorsal central plate 1 (a_1, text-fig. 297C, D) and the foremost part of the medial marginal plate 1 (a_3, text-fig. 297C, D). Also with regard to its internal face

the plate is much as in *B. canadensis*, the foremost part of the medial lamina being provided with an internal process (*pr. i*, text-fig. 297C, D; pl. 64, figs. 2–4; pl. 65, fig. 3).

The ventral central plate 2 (Cv_2, text-figs. 293A, C, 299A, B; pls. 15–18; pl. 37, fig. 3; pl. 60, figs. 3, 4; pl. 61, fig. 1; pl. 62, fig. 2; pl. 66, figs. 4–6) is longer and narrower than in *B. canadensis* (cf. text-figs. 41B, 195) and



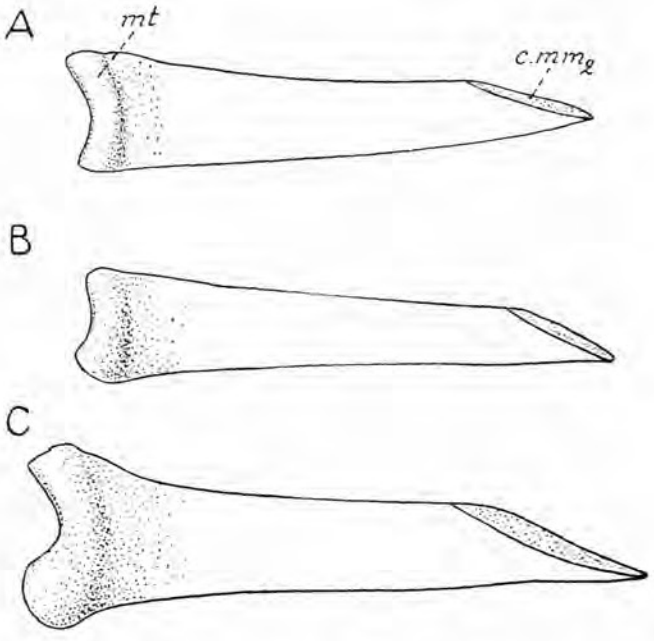
Text-fig. 299. *Bothriolepis groenlandica*. *A*, left ventral central plate 2 in external aspect. × 5/6. *B*, outlines of a right ventral central plate 2. × 5/6. *C*, left lateral marginal plate 2 in dorsal aspect. × 5/12.
afv, external articular area of ventral central plate 2; *n.cd*, notch for dorsal central plate 2; *sgp*, pectoral pit-line groove.

B. cellulosa (cf. text-fig. 228B; cf. also Gross 1941a, text-fig. 22E–Y) and in its general proportions, therefore, is nearest as in *B. maxima*, *B. gigantea* (cf. text-fig. 257, 244B, C), *B. jarviki* (cf. text-fig. 306) and *Grossilepis* (cf. text-fig. 271A). On its outside, about at the transition between its ventral and medial faces, there is often a narrow pectoral pit-line groove (*sgp*).

The ventral central plate 3 (Cv_3, text-fig. 295C; pl. 60, fig. 3; pl. 67, fig. 7; pl. 68, figs. 1, 3, 4; pl. 69, figs. 3, 4) is much longer than in any other species in which it is known for the present, its length amounting to six times, or even between six and seven times, its breadth. The potential ventral central plate 4 (Cv_4, text-fig. 295C, pl. 68, figs. 3, 4; pl. 69, figs. 3, 4), which is continuous with the terminal plate, is also of a long and narrow shape.

The lateral marginal series of plates (Ml_2–Ml_5, text-figs. 293–295, 299C; pls. 15–18, 52–54; pl. 58, fig. 1; pl. 59; pl. 60, figs. 2–5; pl. 61; pl. 62, figs. 1, 2; pl. 67, fig. 7; pls. 68, 69) is made up of three fully independent elements (Ml_2–Ml_4) and a fourth potential element (Ml_5), which is

continuous with the terminal plate in all the specimens at my disposal. As in *B. cellulosa*, the series seems thus usually to comprise fewer independent elements than what is normally the case in *B. canadensis* and *B. maxima* (cf. text-figs. 41B, 98, 182, 194, 195, 198, 228C–E; cf. also Gross 1941a, text-fig. 44A–H).

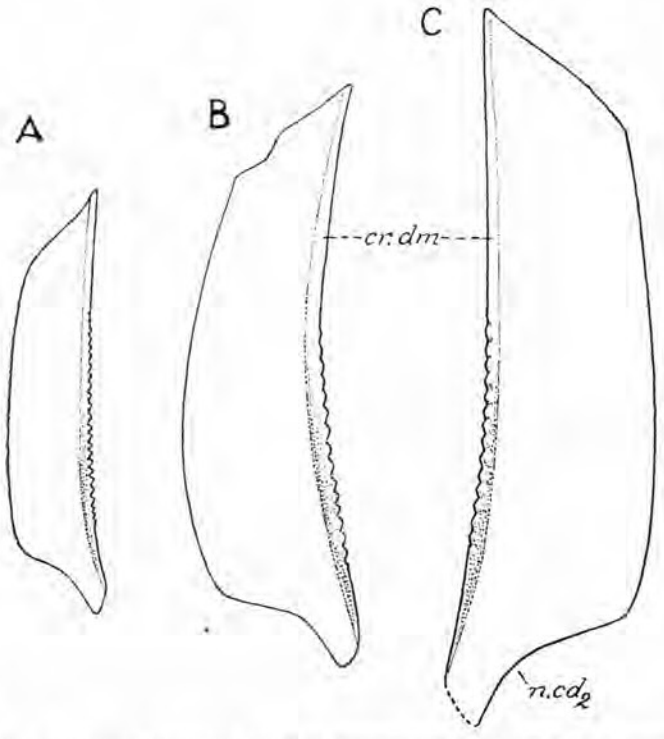


Text-fig. 300. *Bothriolepis groenlandica*. *A–C*, restorations of three right medial margina plates 1. External aspect. Nat. size.
c. mm$_2$, postero-dorsal margin suturally connected with the medial marginal plate 2; *mt*, postarticular thickening.

The lateral marginal plate 2 (*Ml*$_2$, text-figs. 293, 294, 299C; pls. 15–18; pl. 37, fig. 3; pls. 50–54; pl. 57, fig. 2; pl. 58, fig. 1; pl. 59; pl. 60, figs. 2–5; pl. 61; pl. 62, figs. 1, 2) is clearly broader in proportion to its length in large individuals than what it is in small individuals. It is somewhat longer and more slender than in *B. canadensis* and *B. cellulosa* (cf. text-figs. 41B, 98, 182, 194, 195), but not as slender as in *B. maxima* (cf. text-fig. 246). It differs also clearly from the corresponding plate in *B. maxima* in that its distal parts are about as broad as in *B. canadensis* and *B. cellulosa*. It is not impossible that it will turn out to be of a shape approximately similar to that in *B. gigantea* (cf. text-fig. 257).

The lateral marginal plate 3 (*Ml*$_3$, text-figs. 293B, 295; pl. 58, fig. 1; pl. 60, figs. 3–5; pl. 67, fig. 7; pl. 68, figs. 1–4; pl. 69, figs. 1, 2, 5) in all fundamental characters agrees nearest with the corresponding element in *B. canadensis* and *B. cellulosa* (cf. text-figs. 198, 229C–E), but its anconeal

process, the lateral anconeal process (*pal*), is often broader than in the said two species. The lateral area of "Siebknochen" (*a. al*) is often well displayed, and it is clearly seen that it may vary considerably in extent and shape.



Text-fig. 301. *Bothriolepis groenlandica*. *A–C*, restorations of three medial marginal plates 2 in dorsal aspect. *A–B*, of two left plates; *C*, of a right plate of a large individual. All the restorations in nat. size.
cr. dm, medial crest formed by fusion of medial spines; *n. cd*$_2$, notch for dorsal central plate 2.

The lateral marginal plates 4 and 5 (Ml_4, Ml_5, text-figs. 293 B, 295; pl. 60, fig. 3; pl. 67, fig. 7; pls. 68, 69) are long and slender, but show otherwise no characters of taxonomic importance.

The medial marginal series of plates (Mm_1–Mm_5, text-figs. 293–295, 300, 301; pls. 52–54; pl. 58, fig. 1; pl. 59; pl. 60, figs. 3–5; pl. 61, figs. 2, 3; pls. 67–69) consists of four completely independent elements (Mm_1-Mm_4) and a distal element (Mm_5) which, like the corresponding element of the lateral side (Ml_5), is continuous with the terminal plate at its distal end only and, therefore, may be suspected sometimes to be fully independent. With regard to the number of elements composing it the series here under consideration seems thus to be as the corresponding one in *B. cellulosa*.

The medial marginal plate 1 (Mm_1, text-figs. 293 A, C, 300; pl. 62, fig. 2; pl. 67, figs. 1–3) is found preserved in seven cases, and in two of these cases

it is in its natural connection with the adjacent plates of the proximal segment. The plate is of the normal long type characteristic of the *Bothriolepis*-species. As in *B. cellulosa* (cf. Gross 1941a, text-fig. 20A), it is longer and lower than in *B. canadensis* (cf. text-figs. 190B, C, 191D, 196B). Its proximal end is very variable both as to height and shape. The postarticular thickening (*mt*) is pronounced. None of the specimens of the plate available exhibits any traces of the pectoral pit-line groove (*sgp*). Hence it follows that this pit-line groove normally must have lain ventrally to the plate in question, on the medial lamina of the ventral central plate 1. In most cases the plate, is suturally connected with the dorsal central plate 1 (Cd_1), the ventral central plate 1 (Cv_1) and the medial marginal plate 2 (Mm_2), but in some cases it may in addition also abut against the proximo-medial corner of the ventral central plate 2. In its sutural connections with the adjacent plates it varies thus in a manner similar to that in *B. canadensis* and *B. cellulosa*.

The medial marginal plate 2 (Mm_2, text-figs. 293B, 294, 301; pls. 52–54; pl. 58, fig. 1; pl. 59; pl. 60, figs. 2, 5; pl. 61, figs. 2, 3; pl. 62, fig. 2; pl. 67, figs. 4–6) in the whole agrees fairly well with the corresponding plate in *B. canadensis* and *B. cellulosa* (cf. text-figs. 98, 180A, 181C, 182, 194, 196, 228A, B), and so does also the medial marginal plate 3 (Mm_3, text-figs. 293B, 295; pl. 60, figs. 3–5; pl. 67, fig. 7; pl. 68, figs. 1–4; pl. 69, figs. 1, 2, 5). The medial marginal plates 4 and 5 (Mm_4, Mm_5, text-figs. 293B, 295; pl. 60, figs. 3–5; pl. 67, fig. 7; pls. 68, 69) are long and slender.

Finally, the terminal plate (*T*, text-figs. 293B, 295; pl. 68; pl. 69, figs. 3, 4) is not of the special *Bothriolepis*-type as defined by Gross (1941a, pp. 60–63 and text-fig. 45E, F). As pointed out above in the descriptions of the various longitudinal series of plates, it is usually provided with long proximal processes representing the dorsal central plate 5 (Cd_5), the ventral central plate 4 (Cd_4), the lateral marginal plate 5 (Ml_5), and the medial marginal plate 5 (Mm_5) respectively.

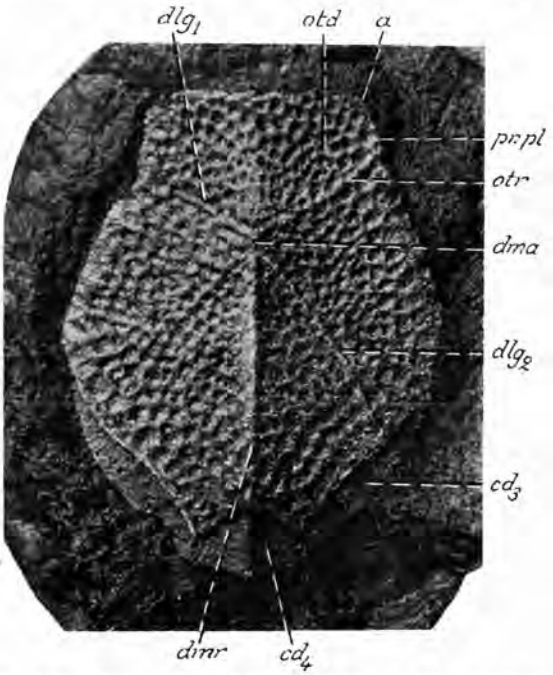
As may be gathered from the above, the ordinary number of independent elements in the dorsal central, ventral central, lateral marginal, and medial marginal series of the distal fin segment is 2, 1, 2, 2 respectively. With regard to the number of elements in its four longitudinal series the distal segment thus agrees nearest with that in *B. cellulosa*. If, however, its potential elements continuous with the terminal plate are also taken into account the segment in question is fundamentally nearest as in *B. maxima*.

Ornament.

The ornament, which could be examined in remains from individuals of very varying size, underwent a transformation during the growth of the individuals fundamentally corresponding to that in *B. canadensis* and *B. gippslandiensis* (cf. pp. 211–214, 376, 521). As its transformation did not by a long way proceed as far as in the said two species, the difference between

the immature and mature types of ornament is fairly slight, slighter even than in *B. maxima*.

In small individuals (text-figs. 280A, 302; pl. 6, fig. 1; pl. 13, fig. 3; pl. 34, fig. 4; pl. 35, figs. 1, 3; pl. 43, fig. 3) the ornament consists of a regular fine-meshed net-work of anastomosing ridges. In contrast to what is the case in *B. canadensis* (cf. text-figs. 199–203, 205) the ridges are devoid of



Text-fig. 302. *Bothriolepis groenlandica*. Squeeze showing the ornament of an anterior median dorsal plate of a young individual (the specimen in pl. 35, fig. 3). × $^3/_2$.
a, antero-lateral corner; cd_3, cd_4, areas overlapped by mixilateral and posterior median dorsal plates respectively; dlg_1, anterior oblique abdominal pit-line groove (the ridge behind the groove is distinct; dlg_2, posterior oblique abdominal pit-line groove; *dma*, tergal angle; *dmr*, dorsal median ridge; *otd*, depression above postlevator thickening; *otr*, ridge behind the pit-line groove dlg_1; *pr.pl*, external postlevator process (imperfectly preserved).

tubercular thickenings and elevations at their points of anastomoses. The meshes of the net-work may be three-sided to six-sided; on the head-shield and trunk-armour they are mostly about equal in length and breadth, whereas on the pectoral fin-armour they are often longer than broad. In most cases they are wider than the ridges bounding them, but not rarely, particularly on certain of the plates, e.g. the anterior median dorsal plate, they may also be about equally wide as, or narrower than, these ridges. As normally in *B. canadensis*, the ornament in small individuals is not radiatingly or concentrically disposed.

The ornament in medium-sized and large individuals (pls. 2–5; pl. 7; pl. 8, figs. 1, 2; pl. 9; pl. 10, fig. 5; pl. 11, fig. 1; pl. 12; pl. 13,

fig. 1; pls. 15–20, 22, 24, 25, 27–33; pl. 34, fig. 1; pls. 36–42; pl. 43, figs. 1, 4; pls. 44–49, 51–57, 59, 62, 63, 65–67, 69) in most respects retains an immature character. In smaller medium-sized individuals it is normally as in young individuals, except that it is often somewhat less regular and begins to show a radiating and concentric disposition. In larger medium-sized and large individuals these differences are still more pronounced and in individuals of these stages of growth the ridges on the dorsal side of the trunk-armour may sometimes also show a slight tendency towards a subdivision into shorter pieces; otherwise they may also to some extent be without anastomoses. No indications of real tubercles, or of tubercular thickenings and elevations, are to be found either in medium-sized or large individuals.

In all stages of growth the ornament is of a fairly uniform coarsness on the whole armour. As in other *Bothriolepis*-species, however, it varies considerably in coarsness in different individuals.

The head-shield is ornamented throughout its extent and so is as a rule also the trunk-armour. A deficient large anterior median dorsal plate (pl. 26, fig. 2), which is quite smooth, shows, however, that the dorsal wall of the trunk-armour in large individuals may fortuitously be completely without ornament. The proximal segment of the pectoral fin is generally ornamented only on its dorsal and ventral faces, whereas its medial face is smooth (pl. 67, figs. 1–3). In small and small medium-sized individuals the dorsal and ventral faces of the segment are often, or perhaps as a rule, ornamented in the by far larger part of, or practically throughout, their extent (pls. 15–18; pl. 60, fig. 2; pl. 62, fig. 2); in large medium-sized and large individuals, on the other hand, they are ornamented principally only in their proximal and lateral parts (pls. 51, 54; pl. 57, figs. 2, 3; pl. 59; pl. 62, figs. 2, 3, 4; pl. 63; pl. 65, fig. 1; pl. 66, fig. 1; pl. 67, figs. 4, 5). Everything goes thus to prove that the ornament of the two faces in question became partly reduced during the growth of the individuals. As regards the persistance of ornament on these faces in large medium-sized and large individuals the proximal segment reminds much of the corresponding segment in *B. maxima* (cf. text-figs. 244A, 245A, B, D, E, 246) and *B. gigantea* (cf. text-fig. 257). In certain cases the ornament of the distal part of the proximal segment is more or less clearly transformed into concentric ridges (pl. 54). The distal segment is usually smooth on both its dorsal and ventral faces. Its dorsal face may sometimes, however, show vestiges of longitudinal, slightly undulating (pl. 69, fig. 5) ridges.

As may be gathered from the above description, the ornament in *B. groenlandica* reminds mostly of that in *B. ornata*, *B. maxima*, *B. gigantea*, and *B. leptocheira*. Its most important characters are as follows. It retains its immature reticular type fairly unchanged both in medium-sized and large individuals. It is of a practically uniform coarsness on the head-shield, trunk-armour, and proximal seg-

ment of the pectoral fin. It is devoid of distinct tubercular thickenings and elevations. The ridges retain their anastomoses to a large extent still in medium-sized and large individuals. The ornament on the proximal segment of the pectoral fin in fully mature individuals is usually confined mainly or entirely to the proximal and lateral parts of the dorsal and ventral faces of the segment. The distal segment is smooth, or presents vestiges of ornament on its dorsal face only.

Sensory canal system.

The sensory canal system differs from that in *B. canadensis* only in certain minor details.

The anterior median section of the supraorbital sensory canal grooves (*soc*$_2$, text-figs. 20A, 24F, 273B, 274, 275A–C, 277A–E) and the foremost part of the upper infraorbital groove (*ifc*$_1$) pass mostly far behind the rostral margin of the head-shield.

The anterior part of the upper infraorbital groove (*ifc*$_1$) is normally strikingly broad, but decreases in bredth postero-laterally. At the vertical pit-line groove of the cheek (*vcp*) this part of the upper infraorbital groove is usually continuous with its posterior part situated on the caudal parts of the lateral plate and on the paranuchal marginal plate, but in certain cases these parts of the upper infraorbital groove are without connection with each other. The posterior part of the upper infraorbital sensory canal groove (*ifc*$_1$, text-figs. 24F, 28D, 273, 274, 277A–E) passes fairly far from the lateral margin of the head-shield and varies considerably as to its width.

The anterior oblique cephalic pit-line groove (*ifc. b*$_1$) has not been observed. Whether it is normally absent, or whether it disappeared already in quite young individuals is impossible to say. The posterior oblique cephalic pit-line groove (*ifc. b*, text-figs. 24F, 26I, J, 273, 274, 277A–E, 278) may occasionally be absent on one side.

The semicircular pit-line groove (*cir*, text-figs. 24F, 273B, 274, 277A–E) is rarely absent. It varies much in shape. Mostly it is more or less curved, but sometimes it may be almost straight.

The vertical pit-line groove of the cheek (*vcp*, text-figs. 24F, 273B, 274, 277A–E) is known only on the very head-shield, where it is usually comparatively long and often somewhat arched. In several cases it is wider in its ventro-lateral than in its dorso-medial parts. At its dorso-medial end it is continuous with the upper infraorbital groove (*ifc*$_1$), except in those cases where there is an interruption between the anterior and posterior parts of the latter sensory canal groove (text-fig. 277A, B).

The middle (*mpg*) and posterior (*pp*) pit-line grooves of the skull-roof (text-figs. 26I, J, 28D, 273B, 274, 278, 279) are as normally in the *Bothriolepis*-species. The middle pit-line groove may perhaps some-

times be completely developed (*mpg*?, pl. 9, fig. 1). The supratemporal pit-line groove (*stc*, text-figs. 274A, 278C, E; pl. 5, figs. 1, 2; pl. 8, fig. 2; pl. 12; pl. 13, fig. 1) is not met with as often as in *B. canadensis* and is also more obscure than in that species.

The main lateral line groove (*lcg*, text-figs. 287B, 288, 289) on the trunk-armour passes fairly close below the dorso-lateral ridge.

The anterior oblique abdominal pit-line groove (dlg_1, text-figs. 43C, 280A, C, D, F, 302) is normally present in small individuals, and it may now and then be represented by a dorso-medial part also in medium-sized and fairly large individuals.

The posterior oblique abdominal pit-line groove (dlg_2, text-figs. 43C, 280A, C, D, F, 284, 285, 287B, 289) may sometimes be imperfectly developed or absent in large individuals, but is often clearly shallower in such individuals than in smaller ones. In many cases it is considerably wider in its middle parts than towards the tergal angle and towards its posterior end.

Finally, the pectoral pit-line groove (*sgp*, text-figs. 293A, 299A) is sometimes to be seen on the proximal segment, but is always very narrow. Its proximal part is situated on the medial lamina of the ventral central plate 1, whereas its distal part lies on the lower part of the medial lamina of the ventral central plate 2, where it runs along the ventro-medial margin of the segment. As is thus obvious, the pectral pit-line groove on the whole has a somewhat more ventral position on the proximal segment than in *B. canadensis* (cf. text-figs. 190B, C, 196B) and *B. cellulosa* (cf. text-fig. 228B).

Remarks.

The three specimens reproduced by the writer in 1931 (Stensiö 1931) in pl. 1, fig. 1 and pl. 2, figs. 1, 3 have turned out not to belong to *B. groenlandica*. They are now referred to the new species *B. jarviki* (cf. pp. 587–601 below).

B. groenlandica as here defined is more variable than *B. canadensis*. It is not impossible, therefore, that it may include material of two closely related species, or at least of two subspecies.

In its size, in the shape of its head-shield, in the general shape of its trunk-armour, in the development of its pectoral fins, and in its ornament *B. groenlandica* reminds much of *B. maxima* and *B. gigantea*, but is clearly distinguished, however, from both these species. In the shape and proportions of its anterior and posterior median dorsal plate and in its ornament *B. groenlandica* agrees strikingly well with *B. ornata*. Unfortunately it cannot for the present be nearer compaired to that species, which, as we have seen (cf. pp. 401–405 above), is still very imperfectly known. It may be strongly suspected, however, that among the species known to us for the present, it

will turn out to be nearest akin to *B. ornata*. Finally, it is worthy of mention that *B. groenlandica* is also somewhat suggestive of *B. leptocheira*.

Localities and geological horizons.

The new material of *B. groenlandica* here dealt with has been collected at the following localities (cf. text-fig. 272 and pp. 534–536 above).

A. Orvin's locality at Cape Graah on Ymer Island (type locality). Hard reddish sandstones, often darkly spotted. (Locality 1 on the map in text-fig. 272.)

B. Mt. Sederholm. Parallel Valley, Gauss Peninsula. (Locality 2 on the map in text-fig. 272.)

a) East of Profile Ravine, between that ravine and profile I. Scree. About 526, 530, 545 m. Dark or blackish, hard or shaly sandstone, brown in a weathered condition. Greyish sandstone, reddish in a weathered condition. Hard reddish sandstone. A large part of the material comes from this place.

b) South side of Profile Ravine. Scree, 535–541 m. Same types of rocks as in *a*.

c) West of Profile Ravine, between that ravine and Crossopterygian Ravine. Scree, 480–550 m. Dark or blackish, hard or shaly sandstone, brownish when weathered. Greyish sandstone, reddish when weathered.

d) Somewhat East of Crossopterygian Ravine. Scree, 543 m. Greyish sandstone, reddish in a weathered condition.

From this place are the most complete specimens reproduced in pls. 15–18.

e) The spur East of Crossopterygian Ravine. Scree, about 545 m. Dark somewhat shaly sandstone, brownish when weathered.

C. Glacier Valley, near Parallel Valley. Gauss Peninsula. (Locality 3 on the map in text-fig. 272.)

a) Bend of the brook. W. slope of the ravine. Horizon, 422 m. Grey sandstone rich in lime, reddish when weathered.

b) West side of the valley. Above the brook-ravine. Scree, 401–403 m. Dark, somewhat shaly sandstone, yellow-brown or reddish-brown when weathered.

D. North side of the Moskus-ox Fjord. W. of Mt. Anchor. 70 m. Reddish hard sandstone somewhat similar to that occurring at localities 2 *a* and 2 *b*. (Locality 4 on the map in text-fig. 272.)

E. According to Heintz (1930, p. 44) *B. groenlandica* has also been found on Ymer Island, West of Cape Humboldt. (Locality 10 on the map in text-fig. 272.)

The entire material of *B. groenlandica* here described comes from the uppermost part of the Lower Sandstone Complex with *Phyllolepis orvini* (cf. pp. 534–536 above).

28. **Bothriolepis jarviki** n. sp.

(Text-figs. 26K, 303–307; pl. 14; pl. 43, figs. 4, 5; pl. 58, figs. 2, 3; pls. 70–73).

1931. *Bothriolepis groenlandica*, STENSIÖ 1931, pp. 161–165; pl. 1, fig 1; pl. 2, figs. 1, 3 (in part).

1932. *Bothriolepis groenlandica*, GROSS (1932b), p. 29 (in part).

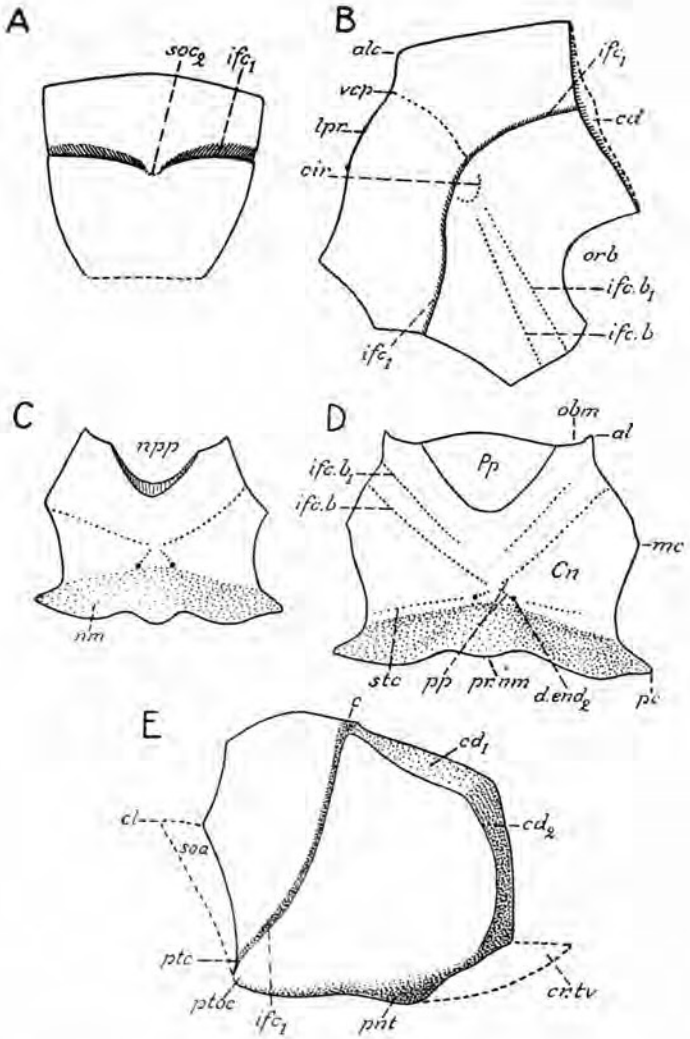
1932. *Bothriolepis groenlandica*, SÄVE-SÖDERBERGH, pp. 20, 28, 29 (in part).

1934. *Bothriolepis groenlandica*, SÄVE-SÖDERBERGH, pp. 41, 43 (in part).

1934. *Bothriolepis* n. sp., SÄVE-SÖDERBERH, pp. 41, 43.

B. jarviki is named after Dr. Erik Jarvik, Stockholm, member of Dr. Lauge Koch's expeditions to East Greenland in the summers of 1932 and 1934. Jarvik has above all taken part in the collecting of Upper Devonian vertebrates made during these two summers.

Diagnosis. – Species attaining a somewhat large size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) presumably amounting to about 26–27 cm. Dorsal wall of trunk-armour maximally about 18–19 cm long. Head-shield conceivably with a slightly convex rostral margin and comparatively strongly laterally directed obstantic margins. Premedian plate probably not particularly broad. Postpineal plate comparatively short with a convex anterior (orbital) margin. Length : breadth ratio of centro-nuchal plate 77–89. Lateral division of paranuchal-marginal plate fairly narrow. Trunk-armour comparatively high and short; both its dorsal and its lateral walls high. Dorsal wall somewhat flat or rounded in its median parts, but sloping steeply laterally in its lateral parts and meeting the lateral wall of either side at an angle of about 120–130°. Lateral wall about two and a half times as long as high. Tergal angle situated in the anterior half of the middle third of the anterior median dorsal plate. Dorsal median ridge in mature individuals often little conspicuous and partly absent. The dorsal median part of the crista transversalis interna posterior situated on the posterior median dorsal plate low and obscure. Levator fossa long and narrow. Postlevator thickening well developed, and postlevator crest normally present. Ventral tuberosity well-marked. Anterior median dorsal plate of a narrow shape, its breadth : length ratio amounting only to about 68–80; anterior margin normally more or less convex and about equally long as, or not much longer than, posterior margin. Posterior median dorsal plate also of a narrow shape and normally also narrow in its anterior parts. Anterior dorso-lateral plate fairly short and high; its lateral lamina more than twice, presumably about two and a half times, as long as high. Mixilateral plate also fairly short and high; its dorsal lamina from not fully twice to somewhat more than twice as long as broad; its lateral lamina



Text-fig. 303. *Bothriolepis jarviki* n. sp. *A*, premedian plate in dorsal aspect. × $^{8}/_{5}$. *B*, left lateral plate in dorsal aspect. × $^{8}/_{5}$. *C*, *D*, restorations of two centro-nuchal plates in dorsal aspect. The plate in fig. *C* restored with the postpineal plate in position. × $^{6}/_{5}$. *E*, somewhat deficient left paranuchal-marginal plate in dorsal aspect. × $^{8}/_{5}$.

Cn, centro-nuchal plate; *Pp*, postpineal plate; *al*, antero-lateral corner of centro-nuchal plate; *alc*, antero-lateral corner of lateral plate (and of head-shield as a whole); *c*, anterior corner of paranuchal-marginal plate; *cd*, area overlapped by premedian plate; cd_1, cd_2, areas attached to lateral plate and centro-nuchal plate respectively; *cir*, semicircular pit-line groove; *cl*, lateral corner of paranuchal-marginal plate; *cr. tv*, transverse nuchal crest; *d. end*$_2$, external opening of canal for ductus endolymphaticus; ifc_1, upper infra-orbital sensory canal groove; *ifc. b*, posterior oblique cephalic pit-line groove; *ifc.* b_1, anterior oblique cephalic pit-line groove; *lpr*, supraspiracular process; *mc*, lateral corner of centro-nuchal plate; *nm*, obtected nuchal area; *npp*, postpineal notch; *obm*, orbital facet of anterior margin of centro-nuchal plate; *orb*, orbital notch; *pc*, postero-lateral corner of centro-nuchal plate; *pnt*, paranuchal trochlea; *pp*, posterior pit-line groove of skull-roof; *pr. nm*, posterior median process of centro-nuchal plate; *ptc*, cephalic division of main lateral line groove; *ptoc*, postobstantic corner; *soa*, subobstantic area; soc_2, unpaired anterior median section of supraorbital sensory canal grooves (the anterior median pit-line groove); *stc*, supratemporal pit-line groove; *vcp*, vertical pit-line groove of cheek.

somewhat more than twice as long as high. Lateral lamina of anterior ventro-lateral plate about two and a half times as long as high. Lateral lamina of posterior ventro-lateral plate comparatively short and high. Pectoral fin slender and at least sometimes so long that in an adducted position it reaches fairly far behind the subanal division of the ventral wall of the trunk-armour. Proximal segment in small medium-sized individuals at least about six times as long as broad. Distal segment fairly robust in its proximal part, but slender in its distal parts. Lateral spines of proximal segment fairly strong. Medial spines of proximal segment fairly small, closely set; those belonging to dorsal central plate 1 and to proximal parts of medial marginal plate 2 pointing almost straight medially and not rarely fused into a crest. Dorsal central plate 1 presumably somewhat more than three times as long as broad. Ventral central plate 1 long and slender, from about 4,2–3,3 times as long as broad. Ornament reticular, but ridges of head-shield and trunk-armour in medium-sized and large individuals to some extent without anastomoses and somewhat subdivided into shorter pieces and tubercles. Ridges with tubercular thickenings and elevations particularly at their points of union. Anterior oblique cephalic pit-line groove sometimes persisting well developed still in medium-sized individuals.

Material.

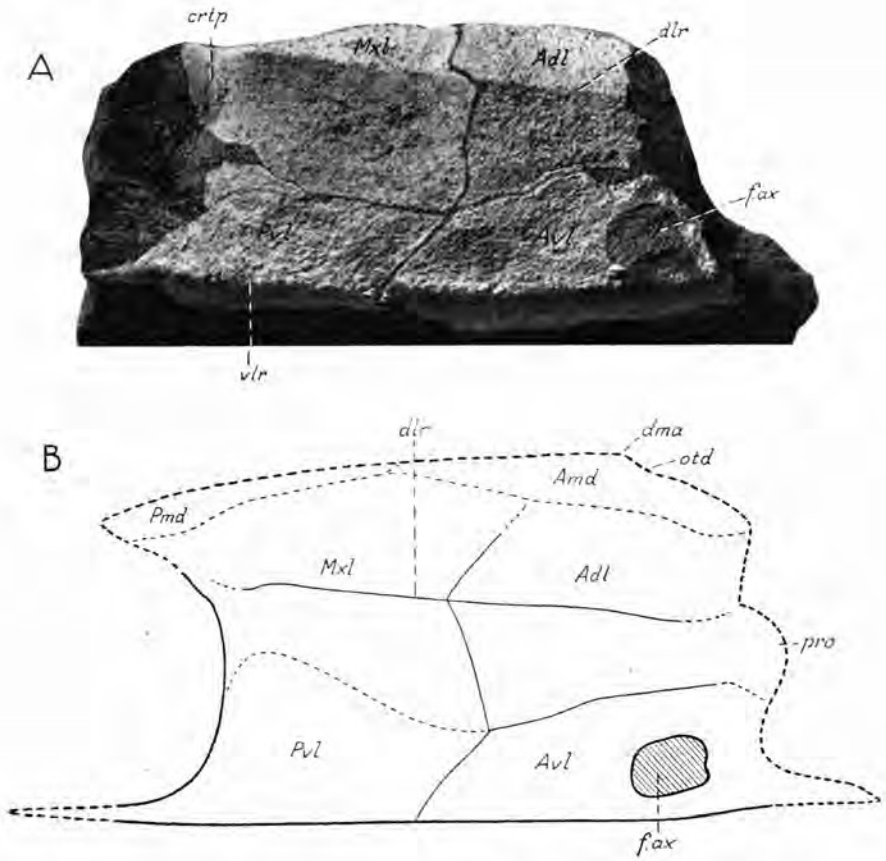
The material here referred to *B. jarviki* includes a deficient ventral wall of a trunk-armour with one of the pectoral fins attached (specimen No. 150), a part of the right half of a trunk-armour (specimen No. 149), and a number of detached, more or less deficient plates of head-shields and trunk-armours (specimens Nos. 147, 497, 641, 1201–1218, 1230–1242).

As a holotype of the species is chosen the anterior median dorsal plate shown in pl. 72, fig. 1 (No. 1201).

Description.

Size and general proportions.

The remains available are from individuals of different size. The specimen shown in text-fig. 304 is from a young individual, in which the dorsal length of the trunk-armour may be estimated at about 5,5 cm, whereas the largest anterior median dorsal plate (pl. 71, fig. 1), which is 10,7 cm long and about 8,2 cm broad, is from a large individual, in which the dorsal length of the trunk-armour amounted to 18–19 cm or thereabouts. Accordingly the maximal dorsal length of the armour (length of head-shield + dorsal length of trunk-armour) may be estimated at about 27–28 cm. As may be gathered from these statements, *B. jarviki* attained approximately the same size as *B. alvesiensis*.



Text-fig. 304. *Bothriolepis jarviki* n. sp. *A*, deficient trunk-armour of a young individual seen from the right side. The various plates preserved mainly as impressions of their internal faces. Specimen No. 149 (figured by Stensiö in 1931 in pl. 2, fig. 1). *B*, attempted restoration of the trunk-armour in lateral aspect. Approximately natural size.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Avl*, anterior ventro-lateral plate; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *Pvl*, posterior ventro-lateral plate; *crtp*, crista transversalis interna posterior (impression); *dlr*, dorso-lateral ridge; *f. ax*, foramen axillare; *dma*, tergal angle; *otd*, obliquely transverse depression above postlevator thickening; *pro*, processus obstans.

Head-shield.

Judging from the few detached remains available of it, the head-shield was conceivably of a shape somewhat similar to that in *B. groenlandica*. Its rostral margin was certainly slightly convex, and the obstantic margins must have been long and directed much laterally (text-fig. 303A, B, E).

The premedian plate (text-fig. 303A; pl. 14, fig. 1) is represented only by a single specimen which is somewhat broader than long and broadest across its anterior end. The breadth : length ratio is about 106. The lateral plate is also represented only by a single specimen (text-fig. 303B;

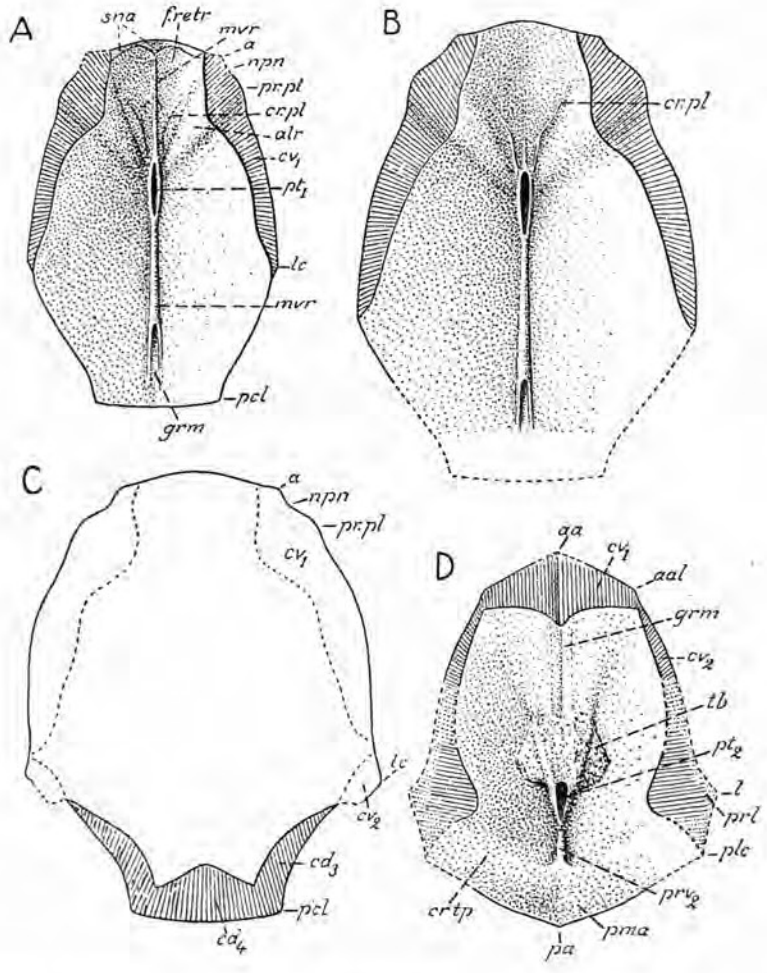
pl. 14, fig. 2). The plate is broad and of a shape similar to that in *B. maxima*, *B. gigantea* and *B. groenlandica* (cf. text-figs. 13, 24D, E, 234A, 252, 253A, D, 273, 274, 277). Its lateral division, however, is unusually broad, much broader even than in *B. groenlandica*. The rostral and pineal plates are unknown. The postpineal plate (*Pp*, text-fig. 303D; pl. 14, fig. 3) is preserved only in one case in which it is in its natural connection with a centro-nuchal plate. As is clearly seen both from this single specimen and from the development of the postpineal notch of a second centro-nuchal plate (*npp*, text-fig. 303C; pl. 14, fig. 4) the plate in question is strikingly short in proportion to the length of the centro-nuchal plate, shorter than normally in the *Bothriolepis*-species, but not quite as short as in *B. obesa* (cf. p. 497 above) and a not nearer determinable species from Scaat Craig in Scotland (cf. text-fig. 258, and p. 513 above). The length:breadth ratio is only about 58 and is thus exceeds only slightly that in small individuals of *B. canadensis* (cf. p. 255 above, and text-fig. 93). In contrast to what is the case in *B. groenlandica* the anterior (orbital) margin of the plate is clearly convex. The centro-nuchal plate (text-fig. 303C, D; pl. 14, figs. 3–5) is represented by two fairly complete specimens and a posterior part of a third specimen. In its general aappearance this plate is fairly suggestive of the corresponding plate in *B. groenlandica* (cf. text-fig. 278) with the difference, however, that its posterior median process (*pr.nm*) seems mostly to be much shorter. The maximal breadth may be either across the middle corners (*mc*) or across the postero-lateral (*pc*) corners. The length:breadth ratio could be calculated only for two of the specimens in which it is 77 and 89 respectively. The postpineal notch (*npp*) is fairly shallow. The antero-lateral corner (*al*) seems normally to be somewhat produced into a short, pointed, anterior process. The anterior and posterior divisions of the lateral margin are about equally long, and the posterior one of these two divisions is fairly strongly concave with its deepest concavity in its posterior part, near the postero-lateral corner of the plate. This corner (*pc*) is often much produced. Finally, the obtected nuchal area (*nm*) is fairly broad. The paranuchal-marginal plate (text-fig. 303E; pl. 14, figs. 6, 7) is represented by two deficient specimens. This plate shows clearly that the obstantic margin of the head-shield must have been about as long, and directed as much laterally, as in *B. groenlandica* (cf. text-figs. 13, 273, 274, 279). The lateral division of the plate is narrow and comparatively short at its lateral margin. More precisely, the breadth of the lateral division in medium-sized individuals amounts to about one half, or even to less than one half, of the breadth of the medial division of the plate. The postmarginal plate is unknown.

Trunk-armour.

The trunk-armour (text-fig. 304) is shorter and higher than in most other *Bothriolepis*-species (cf. text-figs. 38, 40, 283D, 287B). As in *B. obesa*

(cf. pp. 493, 497), both its dorsal and lateral walls are high. The dorsal wall was not, however, roof-like as in *B. obesa*, but somewhat flattened and rounded off in its median highest part in a manner similar to that in *B. maxima* (text-fig. 243H, J), *B. gigantea,* and *B. groenlandica* (cf. text-fig. 283D). In its lateral parts the dorsal wall slopes fairly steeply laterally and, quite as in the last-mentioned three species, it meets the lateral wall of either side at an angle of about 120–130°. The lateral wall is only about two and a half times as long as high, whereas in *B. groenlandica* it is at least four times as long as high. As to its length and height this wall is thus somewhat as in *B. canadensis* (cf. text-figs. 38, 40). The tergal angle (*dma*) has a fairly remote position, being situated in the anterior half of the middle third of the anterior median dorsal plate. At least in larger individuals the dorsal median ridge (*dmr*) is often slightly developed and often also partly absent. As in *B. groenlandica,* the obliquely transverse depression (*otd*) above the postlevator thickening (*alr*) persists often, or perhaps even normally, in medium-sized and large individuals. The crista transversalis interna anterior seems to be represented ventrally by the postbranchial crest only. The dorsal median part of the crista transversalis interna posterior (*crtp*, text-fig. 305D; pl. 72, fig. 4) is low and obscure. The levator fossa (*f. retr*, text-fig. 305A, B; pl. 71; pl. 72, fig. 1) is of a longer and narrower shape than in *B. groenlandica* and most other *Bothriolepis*-species (cf. text-figs. 44, 280B, E, 281C, D, 282) and is bounded by a well developed postlevator thickening (*alr*). The postlevator crest (*cr. pl*) is generally present, but is low and slightly pronounced. The ventral median ridge (*mvr*) and the ventral median groove (*grm*) are as in the majority of other *Bothriolepis*-species (text-fig. 305A, B, D; pl. 43, fig. 4; pl. 71, fig. 2; pl. 72, figs. 1, 3, 4). The anterior ventral process and pit (pl_1) are usually fairly much extended in a rostro-caudal direction, whereas the posterior ventral process and pit (prv_2, pl_1) are about as normally. The ventral tuberosity (*tb*, text-fig. 305D; pl. 72, fig. 4) is stronger developed and clearer defined than what is the case in *B. groenlandica* (cf. text-fig. 47C). Finally, the supranuchal area (*sna*, text-fig. 305A; pl. 72, fig. 1) is probably as a rule present in medium-sized and large individuals.

The anterior median dorsal plate (*Amd*, text-figs. 304B, 305A–C; pl. 43, fig. 4; pl. 71; pl. 72, figs. 1, 3) is of a decidedly narrow shape, being narrower than the corresponding plate in *B. groenlandica*. Even in large individuals it is considerably narrower than long. Its breadth : length ratio could be calculated with reasonable certainty only in two specimens, a medium-sized and a large one, in which it is 68 and 80 respectively. The anterior margin is relatively short and is usually about equally long as, or only slightly longer than, the posterior margin; as a rule it is more or less strongly convex and without any evidence of a median notch. The postnuchal notch (*npn*) and the external postlevator process (*pr. pl*) are distinct, and so is also the notch behind the external postlevator process. The hindmost part



Text-fig. 305. *Bothriolepis jarviki*. *A*, *B*, restorations of two anterior median dorsal plates, a medium-sized and a large plate, in ventral aspect. *C*, restoration of a large anterior median dorsal plate in dorsal aspect. *D*, restoration of a large posterior median dorsal plate in ventral aspect. Somewhat more than $^1/_2$ of the natural size.

a, antero-lateral corner of anterior median dorsal plate; *aa*, anterior corner of posterior median dorsal plate; *aal*, antero-lateral corner of posterior median dorsal plate; *alr*, postlevator thickening; cd_3, cd_4, areas overlapped by mixilateral and posterior median dorsal plates respectively; cv_1, cv_2, overlapping areas; *cr. pl*, postlevator crest; *crtp*, dorsal median part of crista transversalis interna posterior; *f. retr*, levator fossa; *grm*, ventral median groove; *l*, lateral corner of posterior median dorsal plate; *lc*, lateral corner of anterior median dorsal plate; *mvr*, ventral median ridge; *npn*, postnuchal notch; *pa*, posterior corner or angle of posterior median dorsal plate; *pcl*, postero-lateral corner of anterior median dorsal plate; *plc*, postero-lateral corner of posterior median dorsal plate; *pma*, posterior marginal area of posterior median dorsal plate; *prl*, lateral process of posterior median dorsal plate; *pr. pl*, external postlevator process; prv_2, posterior ventral process; pt_1, pt_2, anterior and posterior ventral pits respectively; *sna*, supranuchal area; *tb*, ventral tuberosity.

of the anterior division of the lateral margin, i.e. the part of the lateral margin nearest in front of the lateral corner (*lc*), as in *B. leptocheira* (cf. text-fig. 260), faces decidedly more laterally than in most other *Bothriolepis*-species and so is practically parallel with that of the opposite side. The posterior margin is often slightly convex and without a posterior median process, but may also sometimes be provided with such a process (pl. 72, fig. 3). The area (cv_1) overlapping the anterior dorso-lateral plate is usually a little broader in its posterior parts than in most other species (cf. text-figs. 44, 125, 126, 224G–J, 254B, 260, 280B, E, 281C, D, 282), and, as in *B. groenlandica*, the overlapped areas (cd_3, cd_4) of the plate are comparatively broad throughout their extent.

Most of the specimens of the anterior median dorsal plate available were connected with the anterior dorso-lateral and mixilateral plate in the normal way characteristic of *Bothriolepis*. One of the large plates at hand (text-fig. 305C; pl. 71, fig. 1), however, overlapped an anterior part of the mixilateral plate, whereas further backwards it was overlapped by that plate. It is thus obvious that at least a *Remigolepis*-like abnormal sutural connection between the antero-median dorsal plate and the mixilateral plate may sometimes occur in the species in question.

As may be gathered from the description just given, the anterior median dorsal plate is clearly distinguishable from the corresponding plate in *B. groenlandica*. As to its general shape and proportions the plate reminds somewhat of the corresponding plate in *B. leptocheira* (cf. p. 502, and text-fig. 260).

The posterior median dorsal plate (*Pmd*, text-figs. 304B, 305D; pl. 72, fig. 4) is represented by two deficient specimens, both of large individuals. It is clearly seen that this plate is of a narrow shape, that it was narrow in its anterior parts, and that even in large individuals it was narrower than broad. In its general configuration the plate seems to have been nearest as in *B. ornata*, *B. panderi*, *B. leptocheira* and *B. groenlandica* (cf. pp. 403, 446, 503, 560; cf. also text-figs. 47B, 217, 231D, 286). Its posterior corner or angle (*pa*) is distinct.

The anterior dorso-lateral plate (*Adl*, text-fig. 304) has been found preserved only in a fairly small individual, in which it is in its natural connection with the adjacent plates of the lateral wall of the trunk-armour. The plate is fairly short and high in lateral view. The dorsal lamina is so imperfectly developed that its shape and proportions cannot be made out. The lateral lamina must have been at least somewhat more than twice, perhaps two and a half times, as long as high. This lamina is thus proportionally about as high as in *B. canadensis* and *B. cellulosa* (cf. pp. 311, 419; text-figs. 40, 48C, 144A, 145B, 226), but considerably higher than the corresponding lamina in *B. maxima* (cf. p. 450, and text-fig. 238C, D), *B. gigantea* (cf. p. 488), and *B. groenlandica* (cf. p. 561, and text-figs. 287B, 288). The

processus obstans (*pro*, text-fig. 304B) was in all probability of a relatively long shape similar to that in *B. groenlandica*. The detailed development of sutural connection of the anterior dorso-lateral plate with the anterior ventro-lateral plate is unknown.

The mixilateral plate (*Mxl*, text-fig. 304; pl. 73, fig. 1) is represented by three specimens, all of which are deficient. Like the anterior dorso-lateral plate, it is of a fairly short and high type. The dorsal lamina is from somewhat less than twice as long as broad up to somewhat more than twice as long as broad. The lateral lamina is somewhat more than twice as long as high. The latter lamina is thus considerably shorter and higher than in *B. maxima* (cf. p. 453), *B. gigantea* (cf. p. 488, and text-fig. 256), and *B. groenlandica* (cf. p. 563, and text-figs. 287B, 289), owing to which it reminds nearest of the corresponding lamina in *B. canadensis* (cf. p. 319, and text-fig. 153F, G) and *B. obesa* (cf. p. 496, and text-fig. 259B). As has already been pointed out above (p. 594), the sutural connection between the mixi-lateral and anterior median dorsal plates was sometimes developed in a *Remigolepis*-like manner. The sutural connection of the mixi-lateral plate with the posterior ventro-lateral plate is unknown as to details.

The anterior ventro-lateral plate (*Avl*, text-fig. 304; pl. 70; pl. 73, fig. 3) is found preserved both in its natural connection with the adjacent plates entering in the formation of the lateral wall of the trunk-armour and in a detached condition. However, it is so deficient that many of its features cannot be made out. Its lateral lamina is about two and a half times as long as high and is thus considerably higher and shorter than in *B. groenlandica* (cf. p. 565, and text-figs. 287B, 290). Its ventral lamina seems to be about twice as long as broad. The various margins of the plate are imperfectly preserved, but, as far as may be seen, they present no particularly characteristic features.

The posterior ventro-lateral plate (*Pvl*, text-fig. 304; pl. 70) is not rarely met with among the material examined, but because of its deficient state of preservation only little can be said of its shape. The lateral lamina was certainly fairly short and hight; the exact configuration of the dorsal margin cannot be ascertained. The ventral lamina seems to have been somewhat more than twice as long as broad.

The semilunar plate (*Sm*, pl. 70) at least sometimes is relatively short and broad.

Finally, the median ventral plate (*Mv*, pl. 70) is of a relative size somewhat similar to that in *B. canadensis*. Also as to its general shape it seems to have been essentially as in that species, for, as far as may be seen, its anterior part connected with the anterior ventro-lateral plates is a little longer than its posterior part connected with the posterior ventro-lateral plates.

Pectoral fin.

The subsequent description of the pectoral fin is to a large extent based on the two fairly small pectoral fins shown in pl. 58, figs. 2, 3, both of which belong to one and the same individual (pl. 70). The left one of these two fins is in its natural connection with the trunk-armour, whereas the right one is detached and lies somewhat behind the trunk-armour (*D*, pl. 70). Besides these two complete specimens the fin is represented by a few detached plates.

The pectoral fin (text-fig. 306; pl. 58, figs. 2, 3; pl. 70) is of a long and slender shape. When alongside the body wall the fin reaches somewhat further caudally beyond the posterior end of the subanal division of the trunk-armour than what it does in *B. canadensis* (cf. p. 359, and text-figs. 38, 40B, 41B) and *B. groenlandica* (cf. p. 569, and pls. 15–18) and thus at least sometimes is a little longer than in most other *Bothriolepis*-species. The proximal segment is also longer than in most other *Bothriolepis*-species, because of which the joint between it and the distal segment lies strikingly far backwards. More precisely, when the fin is adducted to the body wall this joint is situated somewhat behind a transverse plane through the middle of the posterior ventro-lateral plate, and accordingly is further caudally than in *B. canadensis* (cf. text-figs. 38, 40B, 41B) and other *Bothriolepis*-species, *B. macrocephala* probably excepted (cf. p. 511 above).

As has been pointed out just above, the proximal segment (text-fig. 306; pl. 58, figs. 2, 3; pl. 70) is strikingly long in proportion to the length of the trunk-armour. Moreover, it is also slender, slenderer than in *B. groenlandica*, and of a fairly uniform breadth throughout its length. It is unknown in small individuals; in small medium-sized individuals it is more than six times, more precisely about six and a fifth times, as long as broad; in large medium-sized and large individuals it was shorter, but the proportions between its length and breadth in individuals of this category of size is unknown. The ventro-medial margin of the segment is fairly well-marked even in its distal part.

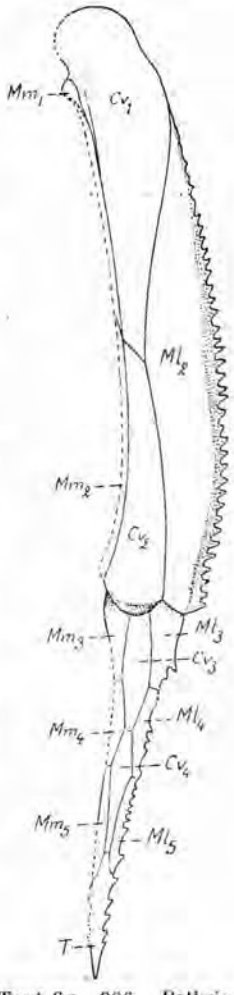
The distal segment (text-fig. 306; pl. 58, figs. 2, 3; pl. 70) is moderately long, its length amounting to about 60% of the length of the proximal segment. As in *B. groenlandica* (cf. text-figs. 293A, B, 295), the segment is somewhat broad in its most proximal part and comparatively slender in its more distal parts, and so is intermediate in shape between the corresponding segment in *B. canadensis* and *B. cellulosa* on the one hand (cf. text-figs. 41B, 98, 180A, 181C, 182, 192, 195, 198, 228C–E) and that in *B. maxima* (cf. Gross 1941a, text-fig. 44; pl. 29, figs. 1, 4) on the other. As the corresponding segment in *B. groenlandica*, it is also rounder in transverse sections than that in *B. cellulosa* and *B. canadensis*.

The lateral spines of the proximal segment are well developed, but are

not quite as powerfull as in *B. groenlandica* (cf. text-figs. 293, 294), whereas, on the other hand, the lateral spines of the distal segment are somewhat strongly-developed and, besides, also more numerous than in that species. Concerning the lateral spines of the proximal segment it deserves also to be pointed out here that these spines are straighter and more decidedly laterally pointing than in *B. groenlandica*. The medial spines of the proximal segment are shorter and mostly also more obtuse than the lateral ones. Those of the medial spines which belong to the dorsal central plate 1 and the adjacent proximal parts of the medial marginal plate 2 (text-fig. 307 A; pl. 72, fig. 2; pl. 73, fig. 2) have their points practically straightly medially directed; these spines are often independent, but may also in many cases be completely fused into a medial crest (*cr.dmm*). The medial spines of the distal segment are known only nearest to the distal end of the segment, where they are small and almost straight.

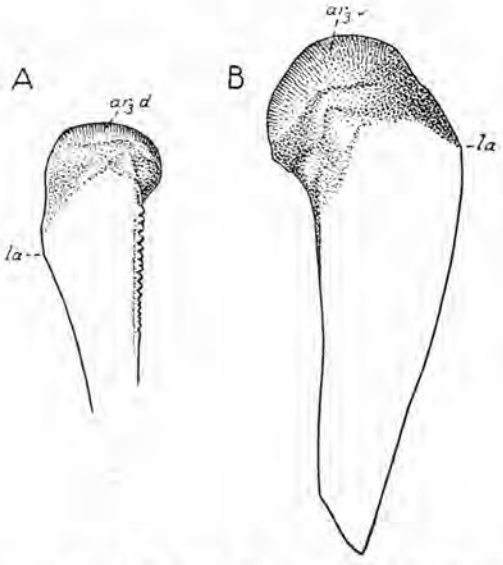
Of the dorsal central series of plates it is only the dorsal central plate 1 that has been found preserved. This plate (text-fig. 307 A; pl. 72, fig. 2; pl. 73, figs. 2, 4) is long and narrow and is presumably slightly longer than the corresponding plate in *B. groenlandica*. A fairly large, somewhat complete specimen of the plate (pl. 73, fig. 4) seems to have been a little more than 3,1 times as long as broad.

The ventral central series of plates (text-fig. 306; pl. 58, figs. 2, 3; pl. 70) consists of four completely independent elements. The ventral central plate 1 (Cv_1, text-figs. 306, 307 B; pl. 58, figs. 2, 3; pl. 70; pl. 73, fig. 5) is of a long and narrow shape and is presumably normally a little longer than in *B. groenlandica*. In a fairly small specimen it is about 4,2 times as long as broad, whereas in a large specimen it is only about 3,3 times as long as broad. Though low distally the medial lamina is clearly present along the whole medial margin of the plate. The external articular area (ar_3v), at least in large individuals, is developed much in the same way as in *B. groenlandica* (cf. p. 577, and text-fig. 297 A, B). A somewhat abnormally developed ventral central plate 1, presumably belonging to *B. jarviki*, is shown in pl. 73, fig. 6. The ventral central plate 2 (Cv_2, text-fig. 306; pl. 58, figs. 1, 2; pl. 70)



Text-fig. 306. *Bothriolepis jarviki* n. sp. Restoration of a left pectoral fin of a fairly small individual. Ventral aspect. × 9/8.
Cv_1–Cv_4, ventral central plates 1–4; Ml_2–Ml_5, lateral marginal plates 2–5; Mm_1–Mm_5, medial marginal plates 1–5; *T*, terminal plate.

is about as in *B. groenlandica*. The ventral central plate 3 (text-fig. 306; pl. 58, fig. 3) is considerably shorter than in *B. groenlandica* (cf. text-fig. 295C) and in shape and proportions is nearest as the corresponding plate in *B. canadensis* (cf. text-figs. 41B, 195, 198F) and *B. maxima* (cf. Gross 1941a, text-fig. 44A, B). The ventral central plate 3 (Cv_3) is also much as in *B. canadensis* and *B. maxima*.



Text-fig. 307. *Bothriolepis jarviki* n. sp. *A*, restoration of a left dorsal central plate 1 of a medium-sized individual. Dorsal aspect. *B*, restoration of a left ventral central plate 1 of a large individual. Ventral aspect. Both restorations × 4/5.
ar_3d, external articular area of dorsal central plate 1; ar_3v, external articular area of ventral central plate 1; *la*, lateral corner or angle.

The lateral marginal series of plates (Ml_2–Ml_5, text-fig. 306; pl. 58, figs. 2, 3; pl. 70) is represented by four independent elements. The lateral marginal plate 2 (Ml_2) is strikingly narrow, whereas the lateral marginal plate 3 (Ml_3) seems to be comparatively broad. The lateral marginals 4 and 5 (Ml_4, Ml_5) are shorter than in *B. groenlandica*.

The medial marginal series of plates (Mm_1–Mm_5, text-fig. 306; pl. 58, figs. 2, 3; pl. 70) is composed of five independent elements. The medial marginal plates 1 and 2 (Mm_1, Mm_2, text-fig. 306) are very imperfectly known and nothing can be said of their shape. The medial marginal plate 3 (Mm_3, text-fig. 306; pl. 58, fig. 3) is as normally in other *Bothriolepis*-species. The medial marginals 4 and 5 (Mm_4, Mm_5, text-fig. 306; pl. 58, fig. 3) are shorter than in *B. groenlandica* and are on the whole much as in *B. canadensis*.

Finally, he terminal plate (*T*, text-fig. 306; pl. 58, fig. 3) was presumably of the type normally characteristic of *Bothriolepis* (cf. p. 157 above; cf. also Gross 1941a, pp. 60–63 and text-fig. 45E, F).

As may be gathered from the statements here given the distal segment is composed of a comparatively large number of independent elements. The exact number of elements in its dorsal central series is unknown. Its ventral central, lateral marginal, and medial marginal series consist of 2, 3, 3 independent elements respectively. Each one of the lastmentioned series is thus composed of one more independent element than what is normally the case in *B. groenlandica*.

As is obvious from the above description the pectoral fin differs from the corresponding fin in *B. groenlandica* in a somewhat more slender shape, in a slightly greater length and more slender shape of its proximal segment, in a somewhat different development of its lateral and medial rows of spines, in a somewhat longer and narrower shape of the elements of its proximal segment, in a greater number of fully independent elements in its distal segment, and in a shorter shape of most of the elements of the distal segment.

Ornament.

The ornament (pl. 14; pl. 43, figs. 4, 5; pl. 71, fig. 1; pl. 72, fig. 2; pl. 73, figs. 2, 3, 5) is poorly preserved, but in spite of this it is fully obvious, that it differs in certain respects from that in *B. groenlandica*. As in *B. canadensis* and *B. groenlandica* (cf. pp. 211–214, 581, and text-figs. 199–206, 302), in young individuals it is conceivably of a regular fine-meshed reticular type; and, just as in *B. canadensis*, it is presumably also provided with tubercular thickenings and elevations at the points of unions of the ridges. In medium-sized and large individuals it retains in the main a reticular character, except that its ridges in places may often fail to anastomose; in addition in medium-sized and large individuals the ridges are often to a certain extent subdivided into shorter pieces and tubercles, and, as normally, have also a radiating and concentric disposition. The pectoral fin in large individuals seems to have been ornamented to a greater extent than what is mostly the case in *B. groenlandica*. The ornament of the distal segment consists of distinct longitudinal ridges.

As may thus be gathered, the ornament differs from that in *B. groenlandica* in the presence of clear tubercular formations. Besides, in large individuals it is also somewhat more modified than what is the case in individuals of the corresponding stage of growth in *B. groenlandica*. The ornament in large individuals of *B. jarviki* is even a little more modified than in large individuals of *B. maxima* and *B. gigantea*.

Sensory canal system.

The anterior median section of the supraorbital sensory canal groove and the upper infraorbital sensory canal groove pass strikingly far from the rostral and lateral margins of the head-shield (soc_2, ifc_1, text-fig. 303 A, B; pl. 14, figs. 1, 2). The anterior oblique cephalic

pit-line groove (*ifc.*b_1, text-fig. 303B, D; pl. 14, figs. 2, 3) persists now and then also in medium-sized and fairly large individuals. The posterior pit-line groove of the skull-roof (pp. 180–184) does not meet and anastomose with that of the opposite side (*pp*, text-fig. 303C, D; pl. 14, figs. 3–5). Indications of the supratemporal pit-line groove are sometimes to be observed (*stc*, text-fig. 303D; pl. 14, fig. 3). The part of the vertical pit-line groove of the cheek that is situated on the head-shield (*vcp*, text-fig. 303B; pl. 14, fig. 2) is strikingly long. The posterior oblique abdominal pit-line groove (*dlg*$_2$) is sometimes largely or entirely absent in large individuals (text-fig. 305C).

Remarks.

The material referred by the writer in 1931 to *B. groenlandica* inter alia included three specimens (Nos. 148, 149 and 150) which have now been grouped under *B. jarviki*. These three specimens, which were reproduced on that occasion (Stensiö 1931) in pl. 1, fig. 1 and pl. 2, figs. 1 and 3, differ so considerably from *B. groenlandica* that they cannot possibly belong to that species. The two most complete ones of them (Nos. 149 and 150; text-fig. 304A; pl. 70 in the present work), which display considerable parts of the trunk-armour and the pectoral fins, have been exhaustively treated above in the description of *B. jarviki*. Whether the three specimens in question actually belong to *B. jarviki* is a question that cannot be decided with full certainty for the present.

B. jarviki as here defined in several of its characters is somewhat suggestive of *B. groenlandica*. However, it is clearly distinguished from that species in the following characters: 1) the smaller size; 2) the much higher and shorter trunk-armour; 3) the different shape of several of the plates of the trunk-armour; 4) the somewhat longer and more slender pectoral fin; 5) the somewhat different development of the lateral and medial rows of spines of the pectoral fin; 6) the greater number of independent elements in the various longitudinal series of the pectoral fin; 7) the longer and narrower shape of several of the elements in the proximal segment of the pectoral fin; and finally, 8) also in certain characters of the ornament.

As to the shape of certain of the plates of its trunk-armour *B. jarviki* reminds also somewhat of *B. ornata*, *B. panderi* and *B. leptocheira*, but it cannot be made out for the present whether actually it is directly related to anyone of these three species.

Localities and geological horizons.

The material here referred to *B. jarviki* is from the following localities (cf. text-fig. 272 and pp. 534–536 above).

A. South coast of Gauss Peninsula, about 4 km West of Parallel Valley.

The fossils are here found in a rather soft, mainly reddish sandstone. (Locality 5 on the map in text-fig. 272.)

B. South coast of the Western part of Gauss Peninsula. This locality is the one that was referred to as localities 7–9 in my description in 1931 (Stensiö 1931, text-fig. 1 and p. 165); it was then named "*Bothriolepis* Cleft" by Säve-Söderbergh (1934). The three specimens previously included in *B. groenlandica* (cf. p. 600 above) are all from here. The rock is a hard grey and reddish-violet sandstone. (Locality 6 on the map in text-fig. 272.)

C. North coast of Ymer Island, Mt. Bothriolepis. 292 m, between the profiles A and B measured by Säve-Söderbergh in 1934. This is the type-locality of *B. jarviki*. The rock is here a greenish-grey sandstone in part conglomeratic. (Locality 7 on the map in text-fig. 272.)

D. N. side of Dusén Fjord, Mt. Blask (Säve-Söderbergh 1932; profile C measured by E. Nielsen 1936). Grey sandstone. (Locality 8 on the map in text-fig. 272.)

E. N. side of Dusén Fjord W. of Mt. Blask and W. of Zoologists' Valley. (Locality 9 on the map in text-fig. 272.)

a) Profile *A*, measured by Nielsen 1936.
Horizon 435 m, in a greenish-grey conglomeratic sandstone, and in a whitish-grey sandstone.
Horizon 977 m, in a greyish rather soft sandstone.

b) Profile *B*, measured by Nielsen in 1936.
Horizon 77 m, in a greyish somewhat shaly sandstone.
Horizon 860 m, in a greyish conglomeratic sandstone and greenish-grey sandstone.
Horizon 944 m, in a grey and reddish sandstone.
Horizon 977 m, in red and grey banded sandstone.

F. Mt. Kungaborgen. Trail Island. Greenish-grey sandstone.

All the material is from the lower parts of the Lower Sandstone Complex below the *Phyllolepis*-bearing layers. As is obvious from the statements given above, it comes from several different horizons (Säve-Söderbergh 1934, pp. 40–42, tables on pp. 43 and 48; Johansson 1935, table on p. 32).

29. **Bothriolepis nielseni** n. sp.
(Text-fig. 308; pls. 74, 75)

This species is named after Dr. Eigil Nielsen, Copenhagen, who has taken part in the collecting of the vertebrates from the Devonian of East Greenland and otherwise has brought together an excellent material of fossils from East Greenland.

Diagnosis. – Species of fairly small size. Total dorsal length of armour (length of head-shield + dorsal length of trunk-armour) about 11–12 cm. Dorsal wall of trunk-armour about 8,1 cm long. Trunk-armour probably

with a fairly low and flat dorsal wall and at least somewhat high lateral walls. Dorsal wall with a breadth : length ratio of about 88. Tergal angle in foremost part of middle third of anterior median dorsal plate. Median dorsal part of crista transversalis interna posterior on posterior median dorsal plate somewhat pronounced. Postlevator thickening obscure, but postlevator crest fairly well marked. Ventral tuberosity present, but slightly developed. Anterior median dorsal plate somewhat narrower than long, its breadth : length ratio probably about 88. Posterior median dorsal plate nearly as broad as long. Dorsal lamina of anterior dorso-lateral plate conceivably one and a half times as long as broad. Dorsal lamina of mixilateral plate not fully twice as long as broad. Lateral lamina of anterior ventro-lateral plate at least somewhat high. Lateral lamina of posterior ventro-lateral plate probably about twice as long as high; its dorsal corner produced into a marked dorsal process. Ventral lamina of posterior ventrolateral plate presumably about two and a half times as long as broad. Median ventral plate comparatively large. Pectoral fin of a somewhat robust shape; proximal segment nearly four and a half times as long as broad; distal segment comparatively robust and somewhat rounded in transverse sections. Lateral spines present both on proximal and distal segments, but their development little known. Medial spines of proximal segment small and those of them situated on the dorsal central plate 1, and on the proximal parts of the medial marginal plate 2, fused together into a low, chiefly medially directed medial crest. Plates of proximal segment comparatively broad and short. Ornament on lateral and ventral sides of trunk-armour consisting of a delicate net-work of anastomosing ridges with tubercular thickenings and elevations at the points of anastomoses of the ridges. Dorso-lateral ridge with a series of numerous closely set pointed tubercles or short spines. Dorsal and medial sides of proximal segment of pectoral fin with an ornament consisting chiefly of fairly pointed tubercles and short, sharp-edges ridges. Dorsal side of distal segment with longitudinal short ridges, somewhat irregularly disposed and not quite parallel.

Material.

B. nielseni is represented only by the holotype, which consists of a much crushed and dorso-ventrally flattened trunk-armour with certain inconsiderable posterior parts of the head-shield and a large part of the right pectoral fin (specimen No. 617; pls. 74, 75).

Description.

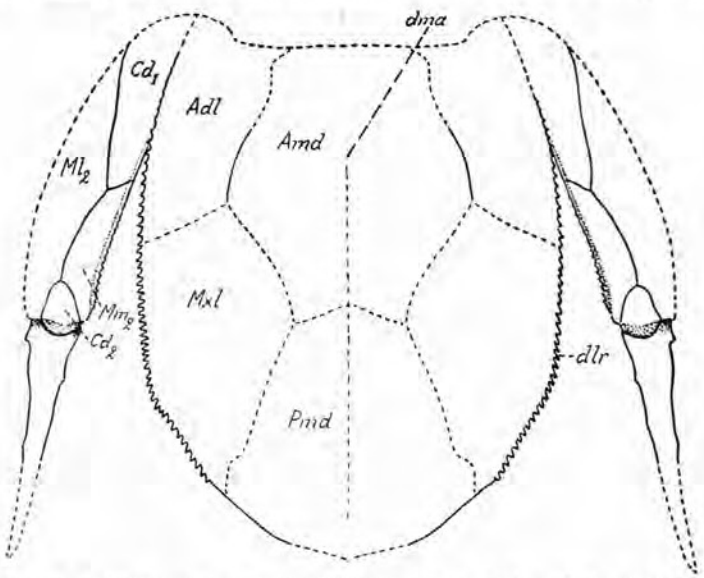
The dorsal wall of the trunk-armour is about 8,1 cm long and the total tal dorsal length of the armour may be estimated, therefore, at about 11–12 cm. Since, as shown by several characters, the holotype is an at least somewhat mature individual, it is very likely that the species attained only a moderate size.

Head-shield.

The head-shield is represented by fragments of the centro-nuchal and paranuchal-marginal plates (*Cn*, *Pm*, pl. 74), but these fragments are very poor and exhibit no characters of interest.

Trunk-armour.

The trunk-armour is in a too much flattened and crushed condition (pls. 74, 75) to enable any definitive conclusion as to its exact shape. As far as



Text-fig. 308. *Bothriolepis nielseni* n. sp. Attempted restoration of the trunk-armour and pectoral fins in dorsal aspect. × $^5/_6$.
Adl, anterior dorso-lateral plate; *Amd*, anterior median dorsal plate; *Cd1*, *Cd2*, dorsal central plates 1 and 2 respectively; *Ml2*, *Mm2*, lateral marginal plate 2 and medial marginal plate 2 respectively; *Mxl*, mixilateral plate; *Pmd*, posterior median dorsal plate; *dlr*, dorso-lateral ridge; *dma*, tergal angle.

may be seen, however, it was presumably not particularly high. The dorsal wall seems to have been low and flat, but was probably not quite as flat as in *B. canadensis*. The length : breadth ratio of this wall is about 88. The lateral walls may have been moderately high, probably about as high as in *B. canadensis* and *B. jarviki*. The tergal angle (*dma*, text-fig. 308) is situated in the foremost part of the middle third of the anterior median dorsal plate. The dorsal median ridge is not preserved. The dorso-lateral ridge (*dlr*, text-fig. 308; pl. 74) is characteristically developed in that it is provided with a row of numerous, closely set tubercles, or short spines, which gradually decrease in size forwards towards the anterior parts of the anterior dorso-lateral plate. In the presence of this dorso-lateral row of spines *B. nielseni* has a character by which it is distinguished from all other *Bothriolepis*-species nearer known to us. The ventro-lateral ridge (*vlr*, pl. 75) is well marked, but

is not spine-bearing. The median part of the crista transversalis interna posterior (*crtp*, pl. 74) situated on the posterior median dorsal plate is fairly pronounced. The levator fossa is comparatively long. The postlevator thickening (*alr*) is very low and badly defined, whereas the post-levator crest (*cr.pl*) is distinct. The ventral median ridge (*mvr*) and ventral median groove (*grm*) are present, a condition which indicates that we cannot be concerned here with a quite young individual. Finally, it may be mentioned that there are also certain indications of the ventral tuberosity (*tb*) which, however, seems to have been low and fairly obscure.

The anterior median dorsal plate (*Amd*, text-fig. 308; pl. 74) is narrower than long. Its breadth : length ratio may be estimated at about 88. As to its general shape otherwise the plate is also much as normally in *Bothriolepis*. The external postlevator process (*pr. pl*) and the notch behind this process are clearly shown. The posterior margin is at least somewhat long. The area (cv_1) overlapping the anterior dorso-lateral plate is strikingly broad throughout its length. The posterior median dorsal plate (*Pmd*, text-fig. 308; pl. 74) is very deficient, but, as far as may be seen, it is fairly broad, almost as broad as long. The anterior dorso-lateral plate (*Adl*, text-fig. 308; pl. 74) is represented mainly by its dorsal lamina, which is broad. This lamina was presumably only about one and a half times as long as broad. The internal postlevator process (*pr.pn*, pl. 74) is strongly developed. The area (cd_1, pl. 74) overlapped by the anterior median dorsal plate is broader than normally in the *Bothriolepis*-species (cf. text-figs. 48A, B, D, 144B, 145C, 226, 238C, 288). The mixilateral plate (*Mxl*, text-fig. 308; pl. 74) shows also only the dorsal lamina, which is not fully twice as long as broad. The anterior ventro-lateral plate (*Avl*, pl. 75) is imperfect, wanting the dorsal parts of its lateral lamina and a considerable anterior part of its ventral lamina. The remains present suffice to prove, however, that the lateral lamina must be shorter and higher than in *B. groenlandica* (cf. text-fig. 290); this lamina was probably even about as high as in *B. canadensis*, *B. cellulosa* and *B. jarviki* (cf. text-figs. 40, 166E, F, 304). The posterior parts preserved of the ventral lamina present no characters of any interest. The posterior ventro-lateral plate (*Pvl*, pl. 75) displays considerable parts of both its laminae. The lateral lamina is about twice as long as high, and its dorsal corner (*dc*) is produced into a marked dorsal process in much the same way as in *B. obesa* (cf. Traquair 1894–1906, pl. 28, fig. 4) and *B. groenlandica* (cf. text-fig. 292A). The ventral lamina seems to have been about two and a half times as long as broad or thereabouts. The semilunar plate is unknown. Judging from the length of the area (*cv.m*, pl. 74) of the anterior ventro-lateral plate that overlapped it, the median ventral plate must have been comparatively large, larger than in *B. canadensis* and *B. cellulosa* (cf. text-fig. 41A–C), but not as large as in *B. maxima* (cf. text-fig. 52) or *Grossilepis* (cf. text-fig. 41D).

Pectoral fin.

The pectoral fin (text-fig. 308; pl. 74) is of a fairly robust shape similar to that in medium-sized individuals of *B. canadensis* (cf. text-figs. 98, 180C, 181A, 195A). When the fin is alongside the body wall the articulation between its proximal and distal segments, as in *B. canadensis*, seems to have lain somewhat in front of the middle of the length of the mixilateral plate and about opposite the anterior parts of the posterior ventro-lateral plate.

The proximal segment is deficient laterally so that its exact shape cannot be ascertained. Everything goes to proove, however, that it must have been about four and a half times as long as broad. With regard to its length : breadth ratio this segment seems thus to have been nearest as in medium-sized individuals of *B. canadensis*.

The distal segment lacks a considerable distal part, but it is likely that, as shown in text fig. 308, it was fairly long. As to its general shape it seems to have been about as in *B. canadensis* and *B. cellulosa*, but is decidedly rounder in transverse sections than in those two species.

Both lateral and medial spines are present. The lateral spines are preserved only on the distal segment where they are few and fairly robust. As in *B. groenlandica* and *B. jarviki*, the medial spines of the proximal segment are small. Those of the medial spines which belong to the dorsal central plate 1, and to the adjacent proximal parts of the medial marginal plate 2, are completely fused with each other into a medially directed medial crest, whereas the medial spines on the posterior parts of the medial marginal plate 2 are independent, at least towards their points. The medial spines of the distal segment are few in number and are pretty robust. The plates of the proximal segment are comparatively short and broad and on the whole agree fairly well with the corresponding plates in *B. canadensis* and *B. cellulosa* (cf. text-figs. 41B, 98, 180A, 181C, 182A, 193–195, 197, 228A, B). The dorsal central plate 1 (Cd_1, text-fig. 308; pl. 75) is about 2,6 times longer than broad. The dorsal central plate 2 (Cd_2) is clearly of a comparatively broad type. The ventral central plate 1 lacks a distal part, but its length may be estimated at about three times its breadth. The distal segment shows no sutures, in consequence of which nothing can be said of the elements entering in the formation of its exoskeleton.

Ornament.

The ornament is unknown both on the head-shield and on the dorsal side of the trunk-armour. On the lateral and ventral sides of the trunk-armour it consists of a very fine-meshed net-work of delicate ridges with tubercular thickenings and elevations at the points of anastomoses of the ridges. The dorsal and medial sides of the proximal segment of the pectoral fin are ornamented througout their extent with small somewhat pointed tubercles and short sharp-edged ridges, more or less irregularly set; the

ornament of the ventral side of this segment is unknown. The dorsal side of the distal segment has an ornament of short longitudinal ridges, fairly coarse, sharp-edged, somewhat irregularly set, and not quite parallel. The ornament is thus of a fundamentally immature type on the lateral and ventral sides of the trunk-armour, but in a highly advanced stage of modification on the pectoral fins.

As has already been pointed out above, a particularly characteristic feature of the species is that the dorso-lateral ridge bears a series of numerous closely set pointed tubercles or short spines.

Remarks.

B. nielseni is clearly distinguished from other *Bothriolepis*-species known for the present above all by the spine-bearing dorso-lateral ridge of its trunk-armour. With regard to the general characters of its trunk-armour and pectoral fins and the development of its various plates it is on the whole nearest suggestive of such species as *B. canadensis* and *B. cellulosa*.

The species is of a particular interest in that it is probably the latest representative of its genus that is known for the time being. In these circumstances one might expect that it would be highly specialized and aberrant from the normal type of the *Bothriolepis*-species, but, as we have seen, this is not so. Instead in all its characters known it approaches the geologically oldest species, e.g. *B. canadensis* and *B. cellulosa*. In this respect it is thus a parallel to the geologically youngest Arthrodire so far known, *Groenlandaspis mirabilis* Heintz, from the uppermost Upper Devonian of East Greenland, which at least in several of its characters agrees nearest with Lower Devonian Acanthaspids (cf. Stensiö 1939, pp. 26–27).

Locality and geological horizon.

The holotype, which is the only specimen available of *B. nielseni*, has been collected at the lower terraces on the south side of Mt. Wiman, Gauss Peninsula (locality 11; cf. text-fig. 272). It comes from the lowermost red division of the *Remigolepis*-series, that is to day from deposits a little above those which contain *B. groenlandica* and *Phyllolepis orvini* (cf. pp. 534–536 above).

SUMMARY

The subfamily *Bothriolepinae* has been dealt with in this work from both taxonomic and anatomic points of view. The most important results gained may be summarized as follows.

1. The previously described *Bothriolepis*-species have been critically treated. Among these species *B. canadensis* has been somewhat fully described on the basis of a new large material. In this species the range of variation could be made clear to some extent. *B. major* (Agassiz) has been restricted so that it comprises only the type-material. The material previously included into this species is referred in part to a new species, *B. alvesiensis*, in part to *B. gigantea* Traquair 1888. The latter species is reintroduced after being confused with other species since 1892.
2. The baltic species *B. tuberculata*, recently described by Gross (1941a) from the *Cellulosa*-Marl of Latvia, has been made the type of a new genus *Grossilepis*, which, though closely akin to *Bothriolepis*, is nevertheless clearly distinguishable from that genus. The subfamily *Bothriolepinae* thus for the present comprises two genera: *Bothriolepis* and *Grossilepis*.
3. The *Bothriolepis*-material from East Greenland, collected by the Danish expeditions under Dr. Koch's leadership has been thoroughly described and has been found to include three species: *B. groenlandica* Heintz, *B. jarviki* n. sp., and *B. nielseni* n. sp. Since it is now fully clear that it had been erected on a fragment belonging to a Remigolepid, the species *B? ymeri* Stensiö 1931 is not maintainable any longer.
4. As they are probably related to each other, the subfamilies *Bothriolepinae* and *Microbrachiinae* Stensiö 1931 have been united into a common new family *Bothriolepidae*.
5. The interrelationships of the various *Antiarchi*-forms have been discussed. and in connection with this a new classification of the *Antiarchi* is suggested. The *Antiarchi* are classified into two main groups, *Remigolepiformes* and *Asterolepiformes*. The *Asterolepiformes* are subdivided into four families: *Asterolepidae*, *Pterichthyodidae*, *Bothriolepidae* and *Ceraspi-*

dae. The *Ceraspidae* in certain respects are clearly suggestive of the *Bothriolepidae* and may, therefore, perhaps turn out to be related to them.

6. It could be established that the *Antiarchi* as to their whole organization are fundamentally as Arthrodires. Their agreements with the Arthrodires are so many and so important as clearly to prove that the *Antiarchi* must be regarded as a highly specialized group of Arthrodires. More precisely, it is now obvious that the *Antiarchi* are highly specialized Arthrodires, in all probablity derived from early primitive Euarthrodires.
7. On account of their very close affinities to the Arthrodires the *Antiarchi* have henceforth to be classified as Arthrodires. A provisional new classification of the Arthrodires, with the *Antiarchi* included, has, therefore, been given here (pp. 220-222).
8. The endocranium of the *Bothriolepinae* and *Antiarchi* in general has been foound to be of a modified Arthrodiran type.
9. It has been proved that the nasal apertures of the *Antiarchi* are actually situated on the dorsal side of the head in the foremost part of the orbital fenestra and thus close in front of the eyes (cf. Stensiö 1942).
10. It has been shown that the nasal apertures and nasal capsules of the *Antiarchi* were of the Arthrodiran type, and that as to their position in relation to the endocranium they were fundamentally as in Arthrodires. Their position on the dorsal side of the cranium, far behind the tip of the snout, is secondarily and due to an excessive outgrowth of a mass of tissue primarily situated ventrally and postero-ventrally to the nasal apertures, between them and the mouth opening, and postero-dorsally to the mouth opening. The excessive outgrowth of the said mass of tissue resulted in the formation of the whole preorbital division of the cranium and thus effected the development of a long, broad, secondary snout, projecting immediately below and in front of the nasal apertures and the primary rostral tip of the snout. The whole ethmoidal region, with its dermal bones, and the adjacent anterior parts of the cheek, with its dermal bones, were highly influenced by this development of a secondary snout and are, therefore, higbly modified as compared to the corresponding parts of the head in Arthrodires.
11. In connection with the formation of the secondary snout the jaw apparatus of the *Antiarchi*, that is to say the palatoquadrate, Meckel's cartilage, and their dermal bones, migrated forwards so as ultimately to be situated underneath the preorbital division of the cranium. By this migration forwards of the jaw apparatus the mouth opening was much shortened in a direction from behind forwards, so that on the whole it became transverse. It did not, however, migrate forwards to the tip of the secondary snout, but retained a ventral position.
12. The palatoquadrate in the *Antiarchi* must have been a short and fairly

high skeletal element, probably nearest suggestive of that in Ptyctodontid Arthrodires.

13. Meckel's cartilage in the *Antiarchi* was long and low. Its position in relation to the inferognathal (mandibular bone) wos exactly as in Brachythoracid Arthrodires.
14. A vestigial spiracule persisted in the *Antiarchi*. It opened outwards through a fairly small spiracular opening, situated between the lateral margin of the lateral plate and the upper margin of the extralateral (opercular) plate.
15. The sensory canal system in *Antiarchi* has been thoroughly investigated. Certain new pit-lines have been detected. Altough modified in several respects the sensory canal system in the *Antiarchi* is of fundamentally the same type as in Arthrodires. In this connection it should also be mentioned that new interpretations are given here of several of the sensory canal grooves in the *Antiarchi*. (Cf. Addenda below).
16. The dermal bones of the armour In the *Bothriolepinae* have been carefully examined from all points of view, inter alia with regard to their range of variation in certain of the species.
17. The dermal bones of the head and trunk-armour in the *Antiarchi* have been compared to those in the Arthrodires. It could be shown that these bones agree fundamentally with those of the Arthrodires (cf. Addenda below). In fact, the dermal bones in *Antiarchi* described in this work as the rostral, pineal, postpineal, postmarginal, inferognathal, anterior dorso-lateral, posterior dorso-lateral, posterior lateral, posterior ventrolateral, and median ventral plates are all strictly homologous with the correspondingly termed bones in Arthrodires. Others of the dermal bones in *Antiarchi* may easily be derived from Arthrodiran bones, or from components of Arthrodiran bones. As to the dermal bones of the head and trunk-armour the *Antiarchi* thus show an extensive agreement with the Arthrodires.
18. Certain new bones have been detected in the head and in the trunk-armour of *Bothriolepis*. It was also shown that the postmarginal (sufflaminal) plate of the *Bothriolepinae* may be subdivided into two plates.
19. In the *Bothriolepinae* there are two transverse series of dermal bones on the lower side of the head. One of these series, the submandibular series, is connected with Meckal's cartilage whereas the other series, the subhyoideal series, is presumably developed in relation to the lower part of the hyoid arch.
20. The pectoral fin of the *Antiarchi* is mesorhachic and stenobasal, whereas that of the Arthrodires is generally pleurorhachic and eurybasal (Gross 1941a, pp. 67–69). This differencc as regards the pectoral fin in the *Antiarchi* and *Arthrodira*, however, is not of such a profound nature as has been assumed hitherto, but the pectoral fin of the *Antiarchi* may very

well have arisen from a pectoral fin of a primitive Arthrodiran type (cf. Addenda below).

21. Undoubted remains of pelvic fins are met with in the *Bothriolepinae*; pelvic fins are presumably present also in the *Pterichthyodidae*.
22. In *B. canadensis* vestiges of the squamation persist both on the lower parts of the body, nearest behind the trunk-armour, and along that part of the main lateral line which lies on the body axis of the caudal fin.
23. The various *Bothriolepis*-species underwent several changes during their growth. Young individuals, therefore, always differ in certain characters from mature individuals of the same species. In several species the difference between young and fully mature individuals is even very considerable. The detailed knowledge now gained of the changes which the *Bothriolepis*-species thus underwent during their growth is of great importance from a taxonomic point of view in that it enables a more accurate determination as to species than what has prevoiusly been possible.
24. As the *Antiarchi*, so the Rhenanid Arthrodires have a secondary snout which projects forwards in front of the primary snout and the nasal apertures. The secondary snout of the Rhenanids, however, differs in several respects from that of the *Antiarchi* and has obviously arisen independently of it. In the presence of a secondary snout the Rhenanids thus exhibit a clear parallelism with the *Antiarchi*.

ADDENDA

The manuscript of the present work was sent to the press in Copenhagen already in the beginning of 1943, but because of the war the printing was delayd about four years. In these circumstances the papers on the *Bothriolepinae* and Arthrodires in general published in, and after, 1943 could not be properly considered. In order to complete the work in this respect certain of the results put forward in those papers will be reviewed and discussed here.

Gross in 1932 (1932a, pp. 54–55) classified the *Brachythoraci* and *Acanthaspida* into a common order, *Euarthrodira*. In the present work the term Euarthrodires is used as thus defined by Gross. In a recent paper the writer (Stensiö 1944, pp. 73–76) has given this order a higher systematic rank and included in it all the Arthrodire groups with the exception of the *Antiarchi* and *Rhenanida* (see p. 222).

In this connection it deserves also to be pointed out that the Arthrodire group previously known as the *Acanthaspida* cannot retain this name any longer, since it has been shown that *Acanthaspis* is a Petalichthyid (Stensiö 1944, foot-note 2 on p. 2). This group of Arthrodires has therefore been termed the *Dolichthoraci* (Stensiö 1944; 1945).

Researches recently carried out by the writer, on the *Brachythoraci*, *Dolichthoraci*, *Acanthothoraci* (Stensiö 1942; 1944; 1945) and *Rhenanida*, have thrown much new light on the organization of the Arthrodires in general and consequently are of importance also for the understanding of the *Antiarchi*.

Inter alia with regard to the dermal bones of their head and shoulder-girdle the Arthrodires do not actually differ so fundamentally from Teleostomian fishes (Stensiö 1944; 1945; Jarvik 1944) as has generally been maintained hitherto. At least certain groups of Arthrodires, e. g. the *Brachythoraci* and *Dolichthoraci*, have a true parasphenoid (Stensiö 1945, p. 67), which, as that of the *Crossopterygii* and *Palaeonisciformes*, extends backwards almost to the transition between the orbitotemporal and otic regions of the endocranium. Moreover, the external dermal bones of the head in the Euarthrodires, as now defined by the writer, during their embryonic development must have been disposed in series in relation to, and between, the sensory canal grooves in a manner corresponding to that in embryos of Teleostomian fishes. Several of these bones are even directly comparable to certain definite ones in Teleostomians (Stensiö 1945, pp. 56–60, 64–65). The rostral, pineal and central plates thus certainly in the main represent the postrostral, pineal and parietal bones respectively of the Crossopterygians. The extrascapular plates of the *Brachythoraci* are undoubtedly the true homologues of the medial extrascapular elements of the extrascapular bone series of the Teleostomians. The postmarginal plate and the ventral postmarginal plate (the "internal plate" of Heintz's descriptions) together represent the principal dorsal part of the preoperculum of the Actinopterygians. The suborbital plate includes the homologues of those of the infraorbital and postorbital elements of the Teleostomians that are developed in relation to the infraorbital sensory canal. Finally, the postsuborbital plate seems to correspond mainly to the quadrato-jugal of the Teleostomians, but may possibly also include certain ventral preopercular elements.

Concerning the exoskeletal shoulder-girdle of the Euarthrodires we know now (Stensiö 1945, pp. 5–7) that the median dorsal plate is a secondary formation arisen in consequence of the presence of the cervical (occipital) joint. Moreover, it has also been shown now (Stensiö 1944, pp. 36–66, 77–79) that the spinal plate has arisen by fusion of the scales of the foremost reduced part of the pectoral fin and is a structure which has secondarily been incorporated in the exoskeletal shoulder-girdle. Of the remaining bones of the exoskeletal shoulder-girdle the anterior lateral and anterior ventrolateral plates have such a position and such relations to the scapulo-coracoid (Stensiö 1944, loc. cit.; Jarvik 1944, foot-note on pp. 26–27) that together they must represent the cleithrum of the Teleostomians. More precisely, they correspond to the dorsal and ventral limbs respectively of the cleithrum and may thus properly be termed the dorsal and ventral cleithral plates. The

anterior dorso-lateral and posterior dorso-lateral plates are most certainly the equivalents of the posttemporal and supracleithral plates respectively of the Teleostomians, whereas the posterior lateral plate in all probability is the homologue of the anocleithral plate, recently described by Jarvik in the Teleostomians (Jarvik 1944). The antero-lateral and anterior median ventral plates correspond perfectly to the clavicle and interclavicle of the Crossopterygians.

As may thus be gathered, the plate of the *Antiarchi* termed in this work the rostral plate is actually a postrostral and the centro-nuchal plate a parieto-nuchalo-extrascapular. The postmarginal plate of the *Antiarchi*, which in all probability is strictly homologous to that of the Brachythoracids and Dolichothoracids, is to be regarded as a dorsal preopercular element incorporated in the head-shield. Judging from the position of this plate in relation to the adjoining ones (cf. Stensiö 1945, figs. 8–11), it is almost certain now that the marginal plate in the *Antiarchi* is not fused with the paranuchal plate, as assumed in the present work, but instead enters in the formation of the postero-lateral part of the lateral plate. There is thus strong reason to believe that the plate termed here the paranuchal-marginal plate is actually only a paranuchal plate, strictly equivalent to that of the *Brachythoraci* and *Dolichothoraci* (see Stensiö 1945, p. 59). Whether a preopercular component is included into the extralateral plate of the *Antiarchi* is impossible to say at present with any certainty, but it is not impossible, however, that this may be the case.

The anterior dorso-lateral, the posterior dorso-lateral, and the posterior lateral plates of the *Antiarchi*, as the correspondingly termed ones of the Euarthrodires, correspond to the posttemporal, supracleithral and anocleithral respectively of the Teleostomians. The anterior ventro-lateral plate of the *Antiarchi*, which beyond question includes the homologues of both the anterior lateral and anterior ventro-lateral plates of the Euarthrodires, must be considered as a cleithral principally corresponding to that of the Teleostomians. The semilunar plate of the *Antiarchi*, as we know, is differently developed in different *Antiarchi*-forms, being either a comparatively broad paired plate, as in *Asterolepis*, *Pterichthyodes* and *Remigolepis*, or else a median unpaired plate, as in *Bothriolepis*, *Grossilepis* and *Gerdalepis*. This plate is thus of two different types. That this is so has been difficult to explain previously, but since it has been found that the anterior median ventral plate in certain *Dolichthoraci (Kujdanowiaspis)* is paired (Stensiö 1944, figs. 15, 16B, 17D), the two types are easy to understand if we assume that the *Antiarchi* are derived from Arthrodire forms in which the anterior median ventral plate was paired. The paired type of semilunar plate must then have arisen by a fusion together of the intero-lateral plate with the adjacent anterior median ventral plate, whereas the unpaired type of semilunar plate has been formed by the fusion together of the two anterior median ventral

plates. The paired semilunar plate is thus a claviculo-interclavicle, whereas the unpaired semilunar plate is an interclavicle.

The basally much concentrated pectoral fin of the *Acanthothoraci* and *Dolichthoraci* (Stensiö 1944, pp. 66–69) represents the posterior part of a fin, which primarily extended far forwards underneath the head and presumably was of a type somewhat similar to that in the *Brachythoraci* and *Rhenanida*. The pectoral fin of the *Antiarchi* in all probability also constitutes only a posterior part of a primarily very long-based fin. In fact it is even possible that the endoskeleton of the pectoral fin of the *Antiarchi* represents chiefly only the metapterygial axis of the primary long-based fin.

In the *Acanthothoraci* (Stensiö 1944, fig. 9A) the articular area for the pectoral fin on the scapulo-coracoid is small and lies far posteriorly, in fact on the very posterior end of the scapulo-coracoid in a notch of the exoskeleton, bounded dorsally by the anterior lateral plate, laterally by the spinal plate, and ventrally by the anterior ventro-lateral plate. If these three exoskeletal plates fused together into a single plate which formed a bridge of bone also medially and behind the posterior end of the scapulo-coracoid the articular area of the scapulo-coracoid would lie in a foramen in the lateral wall of the exoskeletal shoulder-girdle. If this foramen diminished in size by a further growth and thickening of the dermal bones surrounding it the hindmost part of the scapulo-coracoid with the articular area would largely be included in dermal bone and eventually cut off from the anterior principal part of the scapulo-coracoid. As we thus see, the conditions in the *Acanthothoraci* with regard to the articulation of the pectoral fin against the scapulo-coracoid in certain respects foreshadow those in the *Antiarchi*, and the peculiar articulation between the pectoral fin and the trunk in the *Antiarchi* may thus very well be imagined to have arisen from one somewhat similar to that in the *Acanthothoraci*, in that the dermal bones of the shoulder-girdle situated nearest to the posterior end of the scapulo-coracoid fused together and grew around the articular area so that the very hindmost portion of the scapulo-coracoid was enclosed in dermal bone and cut off from the other parts of the scapulo-coracoid. As may thus be gathered, it is quite possible that the funnel pit in the processus brachialis of the *Antiarchi* actually housed a separate posterior part of the scapulo-coracoid bearing the articular area for the endoskeletal axis of the pectoral fin (cf. above pp. 148–150).

Researches which I have recently undertaken on the endocranium of the Rhenanids have proved that the interpretations of the dermal bones of the exoskeletal skull-roof of the Rhenanids given in the present work (pp. 189–211) is partly wrong. The bones which I considered as the central and paranuchal plates (C_1, C_2, *Cm*, *Pan*, figs. 69, 70) have actually such a position in relation to the sensory canal system and the endocranium that together on either side they correspond to the central plate – the parietal – in the Euarthrodires. The foremost small marginal plates (Plo_2, fig. 69), to-

gether with the foremost small plates bearing the otic part of the infraorbital sensory groove (at and somewhat behind *M* in fig. 69), represents certain posterior supraorbitals and the dermosphenotic in Teleostomians, proving that the postorbital of the Arthrodires in general is principally a dermosphenotico-supraorbital. The small marginal plates following further caudally (*Lc*, figs. 69, 70) evidently correspond to the intertemporal and supratemporal series of bone primordia in embryos of Teleostomians (Pehrson 1922; 1940; 1944a, b). The marginal plate of Arthrodires, as it bears also a long part of the preopercular sensory groove (Stensiö 1945, pp. 49–50, 58–59), is certainly an intertemporo-supratemporo-preopercular, while the paranuchal plate of the Arthrodires is a supratemporo-extrascapular (Stensiö 1945, pp. 51–55, 59). Finally, it deserves to be pointed out in this connection that the nuchal plate in such a Rhenanid form as *Asterosteus* (*N*, fig. 69) represents only a vestige of the anterior principal part of the nuchal-extrascapular plate in the *Brachythoraci* (*N*, fig. 67 A; (Stensiö 1945, pp. 51–55, 57–58). – The misinterpretations herewith corrected do not substantially influence the opinions advanced concerning the homologues of the dermal bones of the head in the *Antiarchi*.

Since their innervation is largely unknown the sensory grooves of the *Antiarchi* are partly difficult to interprete. This particularly applies to the grooves denoted with the letters soc_2 and *vcp*, and to the anterior parts of the groove i/c_1. It should be specially stressed that the interpretations of these grooves given in the present work are tentative. A more correct interpretation of these grooves is set forth in a work recently published (Stensiö 1947). This work also contains new, more correct interpretations of the dermal bones on the check an lower jaw in the *Antiarchi*.

Gross in one of his most recent papers (1942b) dealt with certain abnormities of exoskeletal plates in the *Antiarchi*. In *B. canadensis* he described two postmarginal plates and the fortuitous presence of two asymmetrically situated median ventral plates (posterior median ventral plates).

In another recent paper Gross (1942a, pp. 415–422) inter alia gave further taxonomic contributions to our knowledge of the *Bothriolepinae*, describing four new *Bothriolepis*-species from the Baltic Devonian, *B. prima* Gross, *B. obrutschewi* Gross, *B. spinosa* Gross and *B. curonica* Gross, and, besides, treated also certain other *Bothriolepis*-remains. The new *Bothriolepis*-species all seem to be retainable. *B. prima* and *B. obrutschewi* both are from the Middle Devonian, occurring in deposits which contain *Byssacanthus*, *Pterichthyodes* and several *Asterolepis*-species, whereas *B. spinosa* and *B. curonica* are from the Upper Devonian. These four species are very imperfectly known and their relationships with other species cannot, therefore, be established.

B. prima, judging from the remains known, attained but a small size. The plates of its exoskeletal shoulder-girdle are said to be comparatively

broad in proportion to their length (the anterior median dorsal plate of an at least somewhat mature specimen is as broad as long). The ornament is coarsely reticular.

B. obrutschewi seems to have been of a moderate size. The dorsal central plate 1 was probably fairly long and narrow. The lateral spines of the lateral marginal plate 2 are short and obtuse. Judging from the statements given by Gross, the ornament is reticular, but with ridges so thick that the meshes between them mostly appear as pits. The species, according to Gross, reminds one in several respects of *B. panderi*.

B. spinosa was probably of about the same size as *B. prima*. With regard to the shape of certain of its dermal bones, the sutural connection of the anterior median dorsal and mixilateral plate, and the ornament it is mostly suggestive of *Grossilepis*. The lateral spines on the proximal segment of the pectoral fin are strikingly long and pointed. As far as can be seen at present, it is fairly likely that *B. spinosa* will turn out to be closely akin to *Grossilepis*. It is not even impossible that it will reveal itself as a *Grossilepis*-species.

B. curonica attained a considerably larger size than the other three species here in question, the dorsal length of its trunk armour amounting to about 24 cm. Of the Baltic *Bothriolepis*-species *B. curonica* thus comes next after *B. maxima* in size. The orbital fenestra is narrow in proportion to the breadth of the head-shield. The postpineal plate is strikingly long and narrow. The anterior median dorsal plate is also comparatively narrow in proportion to its length. The posterior median dorsal plate, on the other hand, is fairly broad. The ornament is slightly developed and may even be almost absent on the exoskeletal shoulder-girdle. As far as our knowledge goes, this species reminds of *B. maxima*, to which it may perhaps be related.

Whether certain *Bothriolepis*-remains which Gross (1942a, pp. 421–422) described under the little of *Bothriolepis* cf. *ornata Eichwald* actually are referrible to *B. ornata* Eichwald is a question, which, as stressed by Gross himself, must be left unanswered.

Finally, Gross (1942a, pp. 420, 422) mentioned that the material from the Baltic Devonian available to him includes another two new species.

As is evident from the above review of the most recent taxonomic paper by Gross (1942a), the Baltic Devonian is much richer in *Bothriolepis*-species than what could be expected.

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