MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 96 · Nr. 4

DE DANSKE EKSPEDITIONER TIL ØSTGRØNLAND 1936–38
Under Ledelse af Lauge Koch

MIDDLE DEVONIAN VERTEBRATES FROM CANNING LAND AND WEGENERS HALVÖ (EAST GREENLAND)

PART II

CROSSOPTERYGII

BY

ERIK JARVIK

WITH 37 FIGURES IN THE TEXT AND 24 PLATES

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI
1950

CONTENTS

Page

I. Introduction 5
II. Material and methods 8
III. Description of the material 11
A. *Osteolepiformes* 11
Genus *Gyroptychius* 11
1. *Gyroptychius groenlandicus* n. sp. 11
Diagnosis 12
Type-specimen 13
Material 13
Geographical distribution and geological horizon 16
Description 16
Ornamentation, blisters, and resorbtion, reformation and growth of the dentine layer 16
Comparison with Dipnoans 31
Concluding remarks 47
Remarks on the growth of dermal bones and scales 51
Head 55
Cranial roof 56
External cheek plate 68
Lower jaw 77
Opercular and gular bones 78
Exoskeletal shoulder-girdle 90
Squamation and fins 92
Lateral-line system 93
Sensory canals 93
Pit-lines 96
Cutaneous sensory organs 98
Remarks 99
2. *Gyroptychius*? cf. *groenlandicus* n. sp. 100
B. *Porolepiformes* 100
Material 100
Remarks on previously described forms 101
Description 112
C. Undetermined Crossopterygians 116
Cleithra 116
Detached teeth 121
IV. Stratigraphical Remarks 122
V. Summary 126
VI. Bibliography 130
Plates 133

I. INTRODUCTION

In 1933 SÄVE-SÖDERBERGH (pp. 103—105; pl. 14:2) figured and described a fronto-ethmoidal shield of a Middle Devonian Osteolepid fish from East Greenland, which, together with some Osteolepid scales, had been collected the year before by NOE-NYGAARD at Vimmelskaftet on Wegeners Halvö (cf. NOE-NYGAARD 1934, pp. 21—23). The shield was shown to agree in all essentials with the fronto-ethmoidal shields of "*Diplopterus*" from Scotland figured by MILLER in 1849 (figs. 16—18) and it was included in this genus (called *Diplopterax* by SÄVE-SÖDERBERGH). Later on—during the Danish expeditions to East Greenland in 1934 and 1936 under the leadership of Dr. LAUGE KOCH—a more comprehensive collection of fossil fishes from the Middle Devonian deposits of Canning Land and Wegeners Halvö was brought together by SÄVE-SÖDERBERGH and his assistants. Of these the Placoderms have already been described by STENSIÖ (STENSIÖ & SÄVE-SÖDERBERGH 1938), whereas the Crossopterygians, which according to the original plan were to be described by SÄVE-SÖDERBERGH (cf. STENSIÖ & SÄVE-SÖDERBERGH 1938, p. 3), will be dealt with in the present paper.

In dealing with the stratigraphy of the fossiliferous Middle Devonian deposits of Canning Land and Wegeners Halvö, SÄVE-SÖDERBERGH (1937; STENSIÖ & SÄVE-SÖDERBERGH 1938; cf. BÜTLER 1948) also made some comments on the Crossopterygians. Most of the Osteolepids, which form the bulk of the material, were referred to a new genus and species, *Canningius groenlandicus*, characterizing the Series with *Canningius groenlandicus* in the geological sequence. The fronto-ethmoidal shield described in 1933 as *Diplopterax* sp. was included in this new species (SÄVE-SÖDERBERGH 1937, p. 20), but no description of the fish was given and the name *Canningius groenlandicus* has remained a *nomen nudum*. Certain scales and cranial remains distinguished by ornamentation were placed in ? *Tristichopterus* sp., and one scale found in Kollen was said to be "of a type, similar to that called *Glyptolepis baltica* by GROSS" (SÄVE-SÖDERBERGH 1937, p. 16).

In my recent revision of the taxonomy of the Middle Devonian Osteolepids of Scotland (JARVIK 1948a) the generic name *Gyroptychius*

MCCOY (1848) proved to be the correct name of the genus earlier called *Diplopterus* or *Diplopterax*. This genus comprises two definable Scottish species, *G. agassizi* (TRAILL, 1841) and *G. milleri* JARVIK, 1948. These two species differ clearly from each other in several respects but for reasons given in the paper referred to above (JARVIK 1948a, p. 269) I found it necessary to place them in the same genus. The fronto-ethmoidal shields from Scotland figured by MILLER belong to *Gyroptychius milleri*. As already pointed out, SÄVE-SÖDERBERGH could find no differences between these shields and the fronto-ethmoidal shield from East Greenland described by him in 1933 as *Diplopterax* sp. and which he in 1937 referred to *Canningius groenlandicus*. As will be demonstrated in the subsequent account, the Osteolepid remains from East Greenland collected in 1934 and 1936 are also very suggestive of *G. milleri*. As far as I can find, all Greenland Osteolepid remains hitherto known belong to a single species and that species must in fact be more closely allied to *G. milleri* than this latter species is related to *G. agassizi*. Under these circumstances the Greenland Osteolepid cannot be placed in a separate genus and consequently the generic name *Canningius* proposed by SÄVE-SÖDERBERGH (1937) must be rejected. The Greenland Osteolepid species will be described as *Gyroptychius groenlandicus* n. sp.[1]), and the geological division yielding this form will be called the Series with *Gyroptychius groenlandicus*.

The ornamented Crossopterygians from East Greenland provisionally referred to ?*Tristichopterus* sp. by SÄVE-SÖDERBERGH do not belong to this genus. In proportions and other features they agree so well with *Gyroptychius groenlandicus* that they probably constitute individuals of that species in which the external smooth and shiny sheet of the dermal bones and scales is wanting, as is often the case in Scottish Osteolepids (cf. JARVIK 1948a, pp. 24—29).

Some scales from the Series with *Asterolepis säve-söderberghi* (cf. p. 122), indistinguishable from those in *G. groenlandicus*, will provisionally be described as *Gyroptychius*? cf. *groenlandicus*.

In addition to the scale resembling the scales of *Glyptolepis baltica* GROSS mentioned by SÄVE-SÖDERBERGH, the material at my disposal contains some other similar scales and a few cranial remains of Porlepiform Crossopterygians. However, until a revision of the taxonomy of the Porolepiform Crossopterygians has been undertaken these scales

---

[1]) The specific name *groenlandicus* has been adopted from SÄVE-SÖDERBERGH, but since this name has hitherto been a nomen nudum, SÄVE-SÖDERBERGH—according to the International Rules of Zoological Nomenclature (see RICHTER 1943, p. 103)—is not the author of the species. Consequently, the name of the species should be written in the form *Gyroptychius groenlandicus* n. sp., but not *G. groenlandicus* (SÄVE-SÖDERBERGH, 1937).

and cranial remains are indeterminable as to family, genus and species.

The material to be described below thus includes only *Gyroptychius groenlandicus* n. sp. and *G.*? cf. *groenlandicus* n. sp., belonging to the *Osteolepiformes* (family *Osteolepidae*), and some indeterminable remains of *Porolepiformes*. In addition there are certain indeterminable fragmentary bones and detached teeth, probably of Crossopterygians, and very likely the Crossopterygian fauna is richer than appears from the subsequent description.

For comparative purposes one specimen of *Tristichopterus*, several specimens of various *Porolepiformes*, and some specimens of *Dipterus valenciennesi* will be briefly considered.

The material of Crossopterygians from East Greenland here under consideration belongs to the University of Copenhagen. For the privilege of studying this material I am indebted to Dr. Lauge Koch of Copenhagen, the leader of the Danish expeditions to East Greenland, and to Professor A. Noe-Nygaard and Professor R. Spärck, Directors of the Mineralogical and Zoological Museums of the University of Copenhagen, where the magnificent collections of Devonian vertebrates from East Greenland are now stored. I am also greatly indebted to Professor G. Säve-Söderbergh of Uppsala, who started the investigation of the material and who has placed several of the photographs reproduced in the plates at my disposal.

The present investigation has been elaborated in the Paleozoological Department of the Swedish Museum of Natural History, Stockholm. Technical assistance has been rendered by Miss A. Brasch (preparation of the fossils), Mr. G. Ahl (photography), Mrs. M. Liepina and Mr. S. Ekblom (retouch and drawings).

II. MATERIAL AND METHODS

The material originates mainly from the following localities (fig. 1):

Series with *Gyroptychius* ("*Canningius*") *groenlandicus.*

Canning Land.

NW. part of Hesteskoen (W. Horse-shoe Mt.), fossiliferous horizon encountered at 210 m. in profile *c* and at 234 m., a little farther S. (SÄVE-SÖDERBERGH 1937, p. 14). This thin horizon, referred to as the horizon at 210—234 m., and the talus immediately below, has yielded the bulk of the fossils described below.

Kollen (Mt. Kollen), E. and N. slopes, talus (SÄVE-SÖDERBERGH 1937, pp. 15—16).

Wegeners Halvö (Wegener Peninsula).

Kap Brown area, ridge S. of Kap Brown (ridge W. of Cape Brown Mt.; SÄVE-SÖDERBERGH 1937, p. 19).

Eastern part of Circusbjærg (Eastern Mt.), SW. corner (SÄVE-SÖDERBERGH 1937, pp. 19—20).

Cirkusbjærg (Little Circus Mt.), the north-eastern and the south-western small hills (SÄVE-SÖDERBERGH 1937, pp. 19—20).

Vimmelskaftet (SÄVE-SÖDERBERGH 1937, p. 20).

Series with *Asterolepis säve-söderberghi.*

Canning Land.

NE. part of Hesteskoen (E. Horse-shoe Mt.), the ridge and the E. slope (SÄVE-SÖDERBERGH 1937, pp. 10—11).

Southern ridge of Hesteskoen, profiles *k* and *j* (SÄVE-SÖDERBERGH 1937, pp. 11, 12).

Wegeners Halvö.

Kap Brown (Cape Brown Mt.), profile *i*, horizon at 304 m. and talus below this horizon (SÄVE-SÖDERBERGH 1937, p. 18).

Most of the fossils, including those from the horizon at 210—234 m. in the NW. part of Hesteskoen and from Kollen, which form the main part of the collection, are embedded in a dark-grey to black shaly flagstone with light-grey or yellowish-grey weathering-hue. The fossils

are more or less bituminous and usually black or dark blue or dark brown in colour. They are preserved very much as the black bituminous Middle Devonian Osteolepids from Scotland (see JARVIK 1948a), but

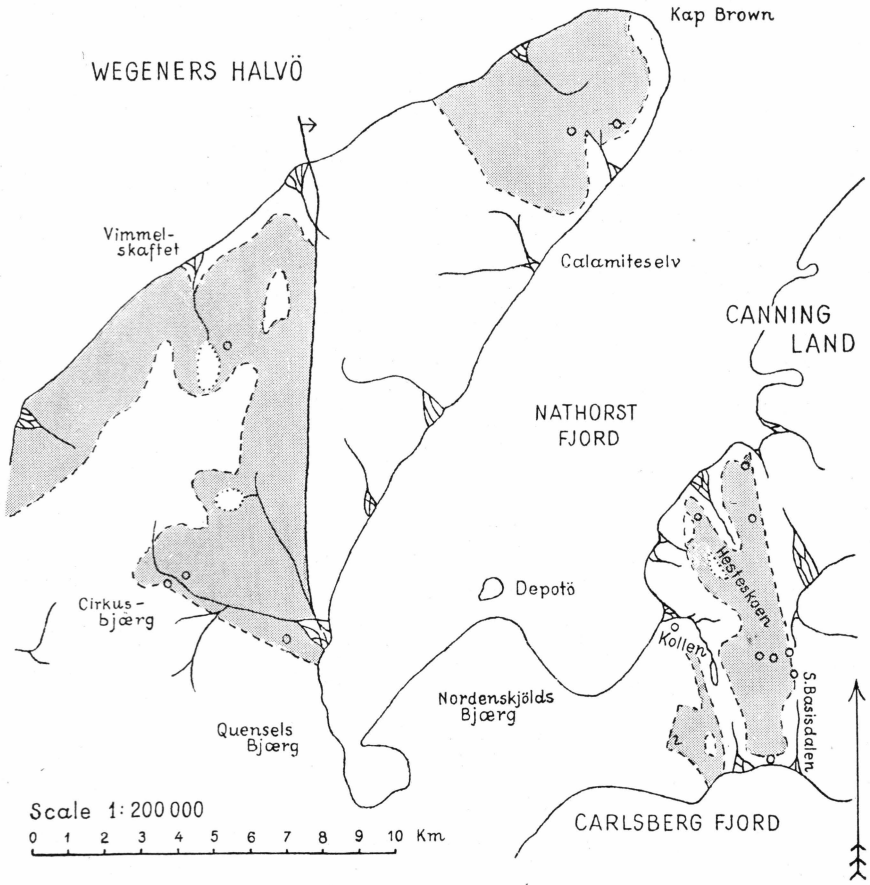


Fig. 1. Sketch-map of Wegeners Halvö and the W. part of Canning Land, East Greenland, showing the distribution of the Middle Devonian sediments. From SÄVE-SÖDERBERGH (1937, pls. 1, 2; cf. BÜTLER 1948, pls. 1—6).

-o- Fossiliferous horizon. o Fossiliferous talus.

(Correction of place-names is maked by the editor in accordance with names approved by Stednavneudvalget for Grønland. Place-names used by SÄVE-SÖDERBERGH, but now altered, are given in parentheses at p. 8.)

whereas the Scottish specimens generally (as regards *Gyroptychius milleri*, see, however, JARVIK 1948a, p. 260) show great parts of the head and body, the material from East Greenland consists almost exclusively of detached more or less complete dermal bones, complex units (fronto-ethmoidal and parietal shields, external cheek plates,

lower jaws) and scales. Only two specimens, both belonging to *G. groenlandicus*, show most of the dermal bones of the head, and the body is never well preserved. Only rarely are some scales found in their natural connection with each other, and the fins are mainly represented by detached fin-rays encountered in a few specimens only. The dermal bones of the palate and the endoskeletal structures of the head and body are too badly crushed to be considered.

In addition to these more or less bituminous fossils, the material at my disposal comprises several specimens contained in relatively coarse grey, yellow, brown or reddish sandstones and arkoses. However, these specimens, usually white or reddish-white in colour and consisting of detached scales and dermal bones, are generally too badly preserved to be described.

After the preparation most of the well-preserved specimens were photographed (generally in the magnification 3:1 and usually in a dry condition but sometimes submerged in alcohol or xylol) and with the aid of these photographs sketches of various complex units, dermal bones, and scales have been made. In order to facilitate comparisons between the various specimens of *G. groenlandicus*, the sketches of these specimens have as a rule been drawn to scale so as to make the size of each of the dermal bones or complex units approximately equal to the size of corresponding bones or units of the holotype of the species magnified 2 or 3 times (cf. JARVIK 1948a, p. 7). The photographs of the specimens reproduced in the plates generally show the size in the magnification $^{2}/_{1}$ or $^{3}/_{1}$. The ratios given in the text and tables have been calculated exactly as in my paper on the Scottish Osteolepids (JARVIK 1948a, p. 8).

All photographs of fossils reproduced in text-figures and plates have been retouched.

III. DESCRIPTION OF THE MATERIAL

Crossopterygii.

A. Osteolepiformes.

Family OSTEOLEPIDAE.

Genus **Gyroptychius** McCoy, 1848.

The history of the genus *Gyroptychius* was treated in a previous paper (Jarvik 1948a, pp. 237—241), where also the diagnosis was given (op. cit. p. 236). The genus comprises the following definable species:

G. agassizi (Traill, 1841).
G. milleri Jarvik, 1948.
G. groenlandicus n. sp.

The genus *Gyroptychius* has hitherto been known with certainty only from Scotland (see Jarvik 1948a, pp. 9—10). Whether the genus occurs also in the Middle Devonian of W. Norway, as assumed by Kiaer (1918), will be discussed in a forthcoming paper (Jarvik 1949a). *G. agassizi* (genotype) is known with certainty from the Sandwick Fish-Bed (Stromness Beds) in Orkney (Jarvik 1948a, pp. 139—141, 243), where it occurs together with *Osteolepis macrolepidotus*. *G. milleri*, like *Osteolepis panderi* and *Thursius pholidotus*, is from the Thurso Flagstone Group in Caithness and probably occurs also in the contemporaneous Rousay Beds in Orkney, which overlie the Stromness Beds (cf. table on p. 123; Jarvik 1948a, p. 260). In addition to these well-known Scottish species, the genus includes two incompletely known species, *Gyroptychius* sp. 1 and *Gyroptychius* sp. 2 (Jarvik 1948a, pp. 240—241, 270—277), represented in the Nodule Beds of the Moray Firth area in Scotland (contemporaneous with the Sandwick Fish-Bed).

1. Gyroptychius groenlandicus n. sp.

(Figs. 2, 3, 12, 13, 15—24, 28, 29; pl. 1—20; pl. 21:1—4; pl. 22; pl. 23:2—4; tables 1—6).

1933. *Diplopterax* sp. —, Säve-Söderbergh, pp. 103—107; pl. 14:2.
1937. *Canningius groenlandicus* —, Säve-Söderbergh, p. 12 (*nomen nudum*).

1938. *Canningius groenlandicus* —, STENSIÖ & SÄVE-SÖDERBERGH, pp. 6—7 (*nomen nudum*).
1939. *Canningius* —, STENSIÖ, p. 135.
1945. *Canningius* —, ROMER, p. 589.
1945. *Diplopterax* (*Diplopterus*) —, ROMER, p. 589.
1948. Undetermined Osteolepid —, JARVIK 1948a, fig. 9.
1948. *Canningius groenlandicus* —, BÜTLER, p. 52.

Diagnosis.—Fishes of moderate size, probably not exceeding 400 mm. in total length. Head broad; probably about 1.4 times longer than broad, about 1.65 times longer than high and about 3.6 times longer than the parietal shield. Cranial roof bent moderately downwards in the region above the lachrymo-maxillary notch. Fronto-ethmoidal shield about 1.40—1.53 times longer than the parietal shield. Preorbital division of the fronto-ethmoidal shield distinctly shorter than the orbital and postorbital divisions together ($r/s+t$ about 0.76—0.89). Postorbital division moderately long ($t/r+s$ ca. 0.33—0.46). Lachrymo-maxillary notch deep and angular. Preorbital corner situated postero-ventrally to the anterior end of the orbital notch. Orbital notch situated far dorsally and deep; less than twice as long as deep. Length of the orbital notch ca. 0.42—0.48 of the length of the parietal shield and ca. 0.25—0.30 of the length of the fronto-ethmoidal shield. Postorbital notch rather long (*l. i. Po*/*a* ca. 0.64—0.70) and shallow. Snout very broad (*d*/*b* ca. 0.90—1.05). Breadth of the cranial roof at the orbital notches ca. 0.81—0.86 of the length of the parietal shield and ca. 0.53—0.57 of the length of the fronto-ethmoidal shield. Parietal shield very short and broad; about as broad anteriorly as it is long (*f*/*a* ca. 0.91—1.04) and usually about 1.25—1.60 times broader than it is long at the spiracular notch. Pineal foramen usually situated in the foremost part of the postorbital division of the fronto-ethmoidal shield. External cheek plate relatively short and high; about 2.25 times longer than the parietal shield and about 2.55 times longer than it is high. Posterior part of the external cheek plate relatively long; the distance from the anterior end of the squamosal to the posterior end of the cheek plate about 1.35—1.40 times longer than the parietal shield. Lachrymal about 1.51—1.80 times longer than it is high and with distinct anterior margin. Postorbital rather long and low; its length is usually about 0.67—0.75 of the length of the parietal shield and it is about 1.65—2.08 times longer than it is high. Squamosal rather short and high (*l. Sq*/*ht. Sq* ca. 1.29—1.46). Lower jaw about 2.60—2.75 times longer than the parietal shield. Principal gular very broad; usually about 1.93—2.20 times longer than it is broad. Clavicle very broad; only the lateral half of the posterior margin meets the cleithrum. Frontal pit-line usually situated antero-laterally to the pineal foramen and medially to the

postorbital corner. Quadratojugal pit-line, when fully developed, reaching the ventral margin of the quadratojugal a little in front of the middle point of the margin. Ratio *k/m* ca. 2.35—2.50 and *p/n* ca. 0.85—1.12.

Type-specimen.—As holotype I have chosen the most complete specimen, viz. No. P. 1310 from the horizon at 210—234 m. in the NE. corner of the NW. part of Hesteskoen (Series with *Gyroptychius groenlandicus*, see pp. 122—125). The specimen shows most of the external dermal bones of the head, some of the dermal bones of the shoulder-girdle and some scales (figs. 15 A, 19 A, C, K, R, 20 A, 21 A, 22 A, 23 A, H, K, 24 A, 28 A, D; pls. 1, 2).

Material.—In addition to the holotype, another specimen, No. P. 1325 (figs. 15 C, 19 L, M, 21 B, 23 D, M, 24 C; pl. 3:1; pl. 4), also from the horizon at 210—234 m., shows the main parts of the exterior of the head, and in a third specimen from this locality, No. P. 1301 (figs. 15 B, 19 J; pl. 3:2; pl. 5:1, 2; pl. 10:1), the fronto-ethmoidal and parietal shields and the jugal are displayed.

The remaining specimens of unquestionable Osteolepids from the Series with *Gyroptychius groenlandicus* consist mainly of detached dermal bones, complex units or scales. These structures may differ somewhat from the corresponding formations in the holotype, but the range of variation is not greater than it is in each of the species of Scottish Osteolepids (cf. JARVIK 1948a) and they have therefore all been referred to *G. groenlandicus*. It deserves to be pointed out, however, that in the Scottish Middle Devonian Osteolepids the scales and some of the dermal bones and complex units of the head, e. g. the extra-scapulars, the lower jaws, the operculars, and the branchiostegal rays, have proved to be either rather similar in the different genera and species or strongly varying in each species (JARVIK 1948a, pp. 20, 106), and thus it is impossible to state with full certainty that the detached Greenland Osteolepid remains all belong to a single species.

The following specimens, all with the non-overlapped parts of the external faces of dermal bones and scales wholly or partly covered by a smooth and shiny superficial sheet of dentine and enamel, may be mentioned:

Canning Land.

NW. part of Hesteskoen, 210—234 m.

Fronto-ethmoidal shield, Nos. P. 1302 (fig. 16 A; pl. 3:3), P. 1311, P. 1326 (fig. 16 C; pl. 7:2), P. 1327 (fig. 16 B; pl. 7:1), P. 1381 (pl. 9:3).

Parietal shield, Nos. P. 1306 (fig. 17 B; pl. 8:2), P. 1352 (pl. 8:4), P. 1386 (fig. 3; pl. 8:6).

Lachrymal, No. P. 1330 (fig. 19 B; pl. 9:6).

Jugal, Nos. P. 1312 (fig. 19 D; pl. 10:7), P. 1313 (pl. 10:8), P. 1328 (fig. 19 E, F; pl. 10:5, 6), P. 1329 (fig. 19 G; pl. 10:3), P. 1348, P. 1360 (fig. 19 H; pl. 10:4), P. 1384 (pl. 12:2; JARVIK 1948a, fig. 9 B).

Postorbital, No. P. 1323 (fig. 19 N; pl. 10:9).

Posterior part of external cheek plate, Nos. P. 1300 (figs. 2, 20 B; pl. 11; pl. 12:1; pl. 13:1), P. 1307 (fig. 20 H; pl. 14:3), P. 1308 (fig. 20 C; pl. 13:5), P. 1309 (squamosal only, fig. 20 J; pl. 14:1), P. 1314 (squamosal only, fig. 20 K; pl. 14:2), P. 1322 (pl. 14:4), P. 1324 (fig. 20 D; pl. 13:6), P. 1353 (fig. 20 E; pl. 13:3, 4), P. 1359 (fig. 20 F; pl. 13:2), P. 1384 (fig. 20 G; pl. 12:2).

Maxillary, No. P. 4017.

Lateral extrascapular, Nos. P. 1338 (fig. 17 H; pl. 5:3), P. 1424.

Lower jaw, Nos. P. 1341 (fig. 21 D; pl. 14:6), P. 1342 (fig. 21 E; pl. 15:1), P. 1349 (pl. 14:5), P. 1356 (fig. 21 C; pl. 15:5), P. 1357 (fig. 21 F; pl. 15:2), P. 1370, P. 1372 (pl. 15:4), P. 1385 (pl. 15:3), P. 1392, P. 1393, P. 1409 (fig. 21 G; pl. 15:6, 7).

Opercular, Nos. P. 1315 (fig. 22 B; pl. 17:4), P. 1316 (fig. 22 C; pl. 17:6), P. 1318 (fig. 22 D; pl. 17:1), P. 1332 (fig. 22 E; pl. 17:5), P. 1376 (fig. 22 F), P. 1377 (fig. 22 G), P. 1395 (fig. 22 H; pl. 17:7), P. 1398.

Subopercular, Nos. P. 1317 (fig. 23 B; pl. 18:5), P. 1319 (fig. 23 C; pl. 18:1), P. 1335 (fig. 23 F; pl. 19:1), P. 1395 (fig. 23 E; pl. 18:2).

Branchiostegal rays, Nos. P. 1317 (fig. 23 L; pl. 18:5), P. 1348 (pl. 18:4), P. 1384 (pl. 12:2).

Principal gular, Nos. P. 1317 (fig. 24 B; pl. 18:5), P. 1321 (fig. 24 D; pl. 19:5), P. 1350 (fig. 24 E; pl. 19:6), P. 1354 (fig. 24 F; pl. 20:4), P. 1355 (fig. 24 G; pl. 20:1), P. 1358 (fig. 24 H; pl. 19:4), P. 1374 (pl. 20:2), P. 1387 (fig. 24 L).

Cleithrum, Nos. P. 1399 (pl. 21:1, 2), P. 1403 (fig. 28 B; pl. 21:3).

Scales, etc., Nos. P. 1308 (JARVIK 1948a, fig. 9 A), P. 1320 (pl. 23:3), P. 1373, P. 1400 (pl. 23:4), P. 1403, P. 1404 (pl. 22:2, 3), P. 1407 (pl. 22:6). Scales are shown also in several of the specimens listed above and in several unnumbered specimens.

Kollen.

Fronto-ethmoidal shield, Nos. P. 1303 (fig. 16 F; pl. 6:5, 6), P. 1304 (fig. 16 E; pl. 6:2—4), P. 1365.

Parietal shield, Nos. P. 1305 (fig. 17 C; pl. 8:1), P. 1362 (fig. 17 D; pl. 8:3).

Median extrascapular, No. P. 1339 (fig. 17 G; pl. 5:4).

Lower jaw, Nos. P. 1343 (pl. 16:2), P. 1344 (fig. 21 H; pl. 16:3), P. 1345, P. 1369 (fig. 21 J; pl. 16:1).

Branchiostegal ray, No. P. 1346 (pl. 18:3).

Cleithrum, No. P. 1394 (fig. 28 C; pl. 21:4).
Scales, etc., Nos. P. 1406 (pl. 22:1, 5), P. 1408 (pl. 22:7—9).

Wegeners Halvö.
Ridge S. of Kap Brown.
Fronto-ethmoidal shield, No. P. 1375 (pl. 7:6).
Principal gular, No. P. 1361.
Cirkusbjærg.
Fronto-ethmoidal shield, Nos. P. 1371 (pl. 7:3, 4), P. 1380 (pl. 7:5).
Postorbital, No. P. 1405 (fig. 19 P; pl. 10:10).
Opercular, Nos. P. 1378, P. 1396 (fig. 22 J; pl. 17:3), P. 1397.
Subopercular, branchiostegal rays and principal gular, No. P. 1390 (fig. 23 G; pl. 19:3).
Eastern part of Cirkusbjærg.
Parietal shield, No. P. 1391 (fig. 17 A; pl. 8:5).
Lower jaw, Nos. P. 1367 (fig. 21 K; pl. 16:4), P. 1368 (pl. 16:5).
Branchiostegal rays, No. P. 1366 (fig. 23 J; pl. 19:2).
Vimmelskaftet.
Fronto-ethmoidal shield, No. P. 1382 (fig. 16 D; pl. 6:1; SÄVE-SÖDERBERGH 1933, pl. 14:2).
Lower jaw, No. P. 1337 (pl. 16:6).
Opercular, No. P. 1336 (fig. 22 K; pl. 17:9).

In the specimens of *G. groenlandicus* listed above the non-overlapped parts of the external faces of scales and dermal bones are, as already pointed out, covered with a smooth and shiny sheet of enamel and dentine or are partly ornamented (cf. pp. 16—17). However, the material of Crossopterygians from the Series with *Gyroptychius groenlandicus* includes several specimens—viz. those referred to ? *Tristichopterus* sp. by SÄVE-SÖDERBERGH—in which there are no traces of a smooth and shiny external sheet and in which the non-overlapped parts of the external faces of dermal bones and scales are ornamented. As will be demonstrated below (pp. 17—19), these specimens most probably represent specimens of *Gyroptychius groenlandicus* in which the enamel and dentine layers are wanting. The ornamented specimens are as follows:

Canning Land, NW. part of Hesteskoen, 210—234 m.
Parts of cranial roof and external cheek plate, No. P. 1401 (figs. 15 D, 19 Q; pl. 9:2).
Parietal shield, Nos. P. 1340 (fig. 17 E; pl. 9:4), P. 1347 (pl. 9:1), P. 1411, P. 1453 (fig. 17 F; pl. 9:5).
Opercular, Nos. P. 1410 (fig. 22 M; pl. 17:8).
Principal gular, Nos. P. 1331 (fig. 24 J; pl. 20:5), P. 1383 (fig. 24 K; pl. 20:6).
Scales, No. P. 1411 (pl. 22:4).

Wegeners Halvö, Vimmelskaftet.

Fronto-ethmoidal shield (posterior part), No. P. 1451.

Principal gular, No. P. 1388 (fig. 24 M; pl. 20:3).

Geographical distribution and geological horizon.—*Gyroptychius groenlandicus* (as regards other species of the genus, see p. 11) is known with certainty only from the Series with *Gyroptychius* ("*Canningius*") *groenlandicus* (Upper Middle Devonian) in Canning Land and Wegeners Halvö in East Greenland (SÄVE-SÖDERBERGH 1937; BÜTLER 1948; cf. 122—125 below)[1]). Scales indistinguishable from those in *G. groenlandicus* occur also in the underlying strata (Series with *Asterolepis säve-söderberghi*) in Wegeners Halvö (Kap Brown, profile *i*, 304 m.; see SÄVE-SÖDERBERGH 1937, p. 18), but it is impossible to say whether these scales really belong to the species and they will be described provisionally as *Gyroptychius*? cf. *groenlandicus* n. sp. (p. 100). No determinable cranial remains of Osteolepids have been encountered in the Series with *Asterolepis säve-söderberghi* or in the *Heterostius* Series (cf. p. 122).

Description.

As regards the structure of the dermal bones of the head and shoulder-girdle *Gyroptychius groenlandicus* agrees well with the Scottish Middle Devonian Osteolepids dealt with in a previous paper (JARVIK 1948a), and it is therefore not necessary to enter upon a detailed description. In the subsequent account mainly the variations and the differences between *G. groenlandicus* and the Scottish species of *Gyroptychius*, especially *G. milleri*, which are of taxonomic importance, will be considered. In addition some new data will be given regarding the blisters, which are much better shown than in the Scottish Osteolepids, and the growth, resorbtion and reformation of the dentine layer in Osteolepids and Dipnoans will be discussed.

Ornamentation, blisters, and resorbtion, reformation and growth of the dentine layer.

As in the Scottish Osteolepids (see JARVIK 1948a, pp. 25—26), the parts of the clavicle and cleithrum underlying the operculars and the branchiostegal membrane—or, as is most often the case, the whole external faces of these bones—bear an ornamentation of anastomosing ridges (fig. 28 B—D; pl. 2:2; pl. 4:1; pl. 18:5; pl. 21:1—4). In some specimens parts of the external faces of certain other dermal bones may be ornamented in a similar way, whereas the remaining parts of the faces, due to the presence of the superficial sheet of enamel and

[1]) *Gyroptychius groenlandicus* is now known also from the eastern part of Gauss Halvö farther to the north (see JARVIK 1949 b).

dentine, are smooth and shiny. Thus in No. P. 1367 from the eastern part of Circusbjærg, the external face of the lower jaw is partly ornamented and partly smooth and shiny (fig. 21 K; pl. 16:4; cf. p. 19). In No. P. 1395, which shows the opercular and subopercular (figs. 22 H, 23 E; pl. 17:7; pl. 18:2), part of the external face of each of these bones is ornamented, and in No. P. 1325 (fig. 23 D; pl. 4:1) a small distinctly ornamented area is found along the posterior part of the dorsal margin of the opercular. In some specimens, e. g. in No. P. 1404 (pl. 22:2, 3), one or more of the scales are ornamented, whereas the external faces of the surrounding scales are smooth and shiny.

In some other specimens (Nos. P. 1401, P. 1340, etc.; see pp. 15—16) there are no traces of the enamel and dentine layers, and the non-overlapped parts of the external faces of all the dermal bones and scales bear an ornamentation of the same type or a type similar to that in the specimens mentioned above. These wholly ornamented specimens were provisionally referred to ?*Tristichopterus* by SÄVE-SÖDERBERGH (1937), but as we now shall see at least most of them represent specimens of *Gyroptychius groenlandicus* in which the superficial layers of the dermal bones and scales are wanting, so that the bony ridges and tubercles of the trabecular layer are disclosed.

Five of the ornamented specimens, Nos. P. 1340 (fig. 17 E; pl. 9:4), P. 1347 (pl. 9:1), P. 1401 (fig. 15 D; pl. 9:2), P. 1411 and P. 1453 (fig. 17 F; pl. 9:5), all originating from the horizon at 210—234 m. in the NW. part of Hesteskoen, show parts of the parietal shield. No. P. 1401 presents, in addition, the posterior part of the fronto-ethmoidal shield and parts of the external cheek plate, and in No. P. 1411 some scales are shown (pl. 22:4).

These five specimens should be referred to *Gyroptychius groenlandicus*, inter alia for the following reasons:

1) The ornamentation of the dermal bones is of exactly the same type as on the cleithrum and clavicle and on parts of other dermal bones of *G. groenlandicus*.

2) The scales associated with specimen No. P. 1411 (pl. 22:4), and very likely belonging to the same individual as the parietal shield, agree well with the scales of *Gyroptychius groenlandicus* as regards shape, size and other particulars, and their ornamentation is exactly as in the ornamented scales of No. P. 1404 of that species (cf. pl. 22:2, 3 and pl. 22:4).

3) The parietal shield, most completely shown in Nos. P. 1340 and P. 1401, agrees with the corresponding shield in typical *G. groenlandicus* as regards shape, size (see col. 1, table 1), and proportions (col. 14, 15, tab e 1).

4) Judging from the configuration of the lateral margin of the parietal shield (see *i. Et*, fig. 15 D, 17 E, F; pl. 9:1, 2, 4, 5), an extratemporal was developed, though this bone, as is often the case in Osteolepids (cf. JARVIK 1948a, p. 61), is missing in the fossils. In Rhizodontids, at any rate in *Eusthenopteron* (see JARVIK 1944a; 1948a, fig. 16 B), which certainly is closely allied to *Tristichopterus* (JARVIK 1937, pp. 65—68), there is no notch for the extratemporal in the lateral margin of the parietal shield[1]). In this form there is instead a postspiracular plate which lies further back than the extratemporal in Osteolepids and which probably is not strictly homologous with that bone (cf. JARVIK 1948a, pp. 61—62).

5) The part preserved of the fronto-ethmoidal shield in No. P. 1401 (fig. 15 D; pl. 9:2) also agrees well with the corresponding part of that shield in typical specimens of *G. groenlandicus* (see col. 6, 12, 14, table 1; figs. 15 A—C), and the postorbital (*Po*, fig. 19 Q; pl. 9:2) and quadratojugal (*Qj*, pl. 9:2) are developed as in this form (col. 7—9, table 2; col. 3, 4, table 3). The postorbital, as in other Middle Devonian Osteolepids (JARVIK 1948a, pp. 87—88), ends posteriorly distinctly in front of the spiracular fenestra, whereas in *Eusthenopteron* (see JARVIK 1944a, figs. 1 D, 2 A, C, 10 B, D) and apparently also in *Tristichopterus* (see TRAQUAIR 1875; pl. 32:1) it extends posteriorly to that fenestra.

6) The sensory canals in the ornamented parietal shields have a very superficial position and in some of the specimens (fig. 17 E, F; pl. 9:4, 5) the dorsal parts of the sensory canals, including the tubes and pores, are wanting. Unless the tubes and dorsal parts of the sensory canals have been situated in the skin, which is very unlikely, these conditions must mean that a superficial sheet of the parietal shield—conceivably the enamel and dentine layers—is missing. The tubes when preserved (see fig. 15 D; pl. 9:1, 2) are relatively short and moderately branching or unbranching, as they generally are in the Middle Devonian Osteolepids (cf. p. 96; JARVIK 1948a, p. 123). In *Tristichopterus* the tubes of the sensory canals are unknown, but in *Eusthenopteron* they are long and frequently bifurcate, opening with numerous pores on the external faces of the dermal bones (see JARVIK 1944a, fig. 17).

The incomplete posterior part of the fronto-ethmoidal shield in No. P. 1451 (see p. 16) is very suggestive of the fronto-ethmoidal shield in No. P. 1401 (see Point No. 5 above) and therefore also this specimen very likely belongs to *G. groenlandicus*.

The opercular shown in No. P. 1410 (fig. 22 M; pl. 17:8) is of the same type as in *G. groenlandicus* and since, as we have seen (p. 17),

[1]) The parietal shields of Rhizodontids from the uppermost Upper Devonian in East Greenland at my disposal in this respect agree with *Eusthenopteron* (cf. JARVIK 1948b, p. 5).

the opercular of this form may sometimes be partly ornamented, the bone probably belongs to this species (cf., however, p. 13; JARVIK 1948a, p. 20).

The remaining ornamented specimens consist mainly of detached principal gulars. The following specimens have been figured: Nos. P. 1331 (fig. 24 J; pl. 20:5) and P. 1383 (fig. 24 K; pl. 20:6) from the NW. part of Hesteskoen, 210—234 m. and No. P. 1388 (fig. 24 M; pl. 20:3) from Vimmelskaftet. A fourth ornamented principal gular not listed above (p. 15), No. P. 1450 from Kollen, is less well preserved. These four plates, which are all preserved as impressions of the external face, agree with the principal gular of *Gyroptychius groenlandicus* as regards size, shape, proportions (table 6), development of the overlapped areas, and the position and extent of the pit-line of the bone (or the position of the centre of radiation), and most probably all, or most of them, belong to this species (cf. pp. 86—90). That they cannot belong to *Tristichopterus* is quite evident, since the principal gular in this form is of a much longer and narrower type (see p. 87).

The presence of this type of ornamentation in *G. groenlandicus* and in Osteolepids in general (cf. GROSS 1935, p. 42; WESTOLL 1936; JARVIK 1948a) is no doubt due to the fact that an external sheet of the dermal bones and scales—the enamel layer and probably also the whole dentine layer—is missing. The ornamentation thus probably consists of bony ridges and tubercles formed by the outer part of the trabecular layer. As regards the clavicle and cleithrum, the absence of the smooth and shiny external sheet and the presence of ornamentation is certainly attributable to the fact that these bones were largely concealed by the branchiostegal membrane. The ornamentation of other dermal bones and of scales must obviously have other reasons. Referring to specimens of Middle Devonian Scottish Osteolepids described in a previous paper (JARVIK 1948a, p. 29), I arrived at the conclusion that—as far as these specimens are concerned—the absence of the enamel and dentine layers and in consequence of this the presence of ornamentation is most probably due to post-mortem changes (rubbing before the fossilisation, splitting, weathering, etc.), and it is possible that this explanation applies also to the partly or wholly ornamented specimens of *G. groenlandicus*. This supposition is supported by the fact that the enamel and dentine layers of the scales and dermal bones in some of the partly ornamented specimens (e. g. in No. P. 1404; pl. 22:2) is fragile and is easily removed by mechanical action (e. g. with the aid of a needle), and that in some specimens, for example in No. P. 1367 (fig. 21 K; pl. 16:4), those parts which before the preparation were covered by stone have retained the enamel and dentine layers, whereas those which were exposed when the fossil was collected are ornamented.

Similar conditions were found also in several specimens of *Latvius grewingki* (see JARVIK 1948a, p. 281) from Kokenhusen in Latvia.

However, in one of the Kokenhusen specimens, viz. in the opercular shown in fig. 4 A (cf. p. 28), and in at least one (fig. 9 A) but probably in several of the specimens of *Dipterus valenciennesi* dealt with below (p. 32), the dentine and enamel layers certainly had been partly removed before the fossils became embedded in the stone. It seems likely that in these cases the absence of the said layers has something to do with the periodical resorbtion of the dentine layer, which no doubt took place both in Osteolepids and Dipnoans (see WESTOLL 1936, BYSTROW 1942, JARVIK 1948a, pp. 21—33). One possible explanation would be that during, or shortly before, the periods of resorbtion these layers became loosened and that they were more liable to fall off during than between these periods (cf. pp. 28, 47).

According to WESTOLL (1936; cf. BYSTROW 1942) both the resorbtion of the dentine and enamel layers and the formation of new such layers started marginally, proceeding towards the central regions of the individual dermal bones and scales, where according to him small patches of dentine, so-called blisters, are sometimes found. The blisters were regarded by WESTOLL to be remnants of the old sheet of dentine and enamel, but as demonstrated in a previous work (JARVIK 1948a, pp. 29—33, fig. 8 A—D) the structure and disposition of the blisters in the Osteolepid material at my disposal and the presence of certain other structures strongly contradict both this interpretation of the blisters and the assumption that the resorbtion started marginally. The new opinions as to the nature of the blisters and the mode of resorbtion and reformation of the dentine and enamel layers set forth in that work were to a great extent founded on the material of Osteolepids from East Greenland now under consideration. It is therefore appropriate to give here a more detailed description of the blisters and associated structures than I had reason to do in my previous work. For comparative purposes similar structures in Baltic Osteolepids and in Dipnoans will be considered.

The blisters (*bli*, fig. 2) in *Gyroptychius groenlandicus*, which are often situated in rough areas, supposed to be areas of resorbtion, are most common in the material from the horizon at 210—234 m. in the NW. part of Hesteskoen, about 60 % of the well preserved specimens from this horizon showing blisters, but they are shown also in several specimens from Kollen and in one specimen from Cirkusbjærg. The following specimens with blisters or areas of resorbtion have been figured: Nos. P. 1300 (fig. 2; pl. 11; pl. 12:1; pl. 13:1), P. 1301 (pl. 3:2; pl. 5:1, 2), P. 1302 (pl. 3:3), P. 1306 (pl. 8:2), P. 1308 (pl. 13:5; JARVIK

1948a, fig. 9 A), P. 1310 (pl. 1:1; pl. 2:1), P. 1312 (pl. 10:7), P. 1314 (pl. 14:2), P. 1317 (pl. 18:5), P. 1323 (pl. 10:9), P. 1328 (pl. 10:5), P. 1342 (pl. 15:1), P. 1348 (pl. 18:4), P. 1350 (pl. 19:6), P. 1360 (pl. 10:4), P. 1374 (pl. 20:2), P. 1384 (pl. 12:2; JARVIK 1948a, figs. 8 A, 9 B), P. 1386 (fig. 3; pl. 8:6), and P. 1409 (pl. 15:6), all from the horizon at 210—234 m. in the NW. part of Hesteskoen, Nos. P. 1303 (pl. 6:5, 6) and P. 1346 (pl. 18:3) from Kollen, and No. P. 1390 (pl. 19:3) from Cirkusbjærg.

In the material from the other localities (cf. pp. 13—15) no traces of blisters or of such rough areas as may be suspected to have been formed by resorbtion have been found, and as described elsewhere (JARVIK 1948a) these structures are rare in the material of Scottish Osteolepids studied by me. It may be pointed out in this connection that blisters sometimes occur also in the Norwegian Osteolepid described by KIAER (see JARVIK 1949a) and in Osteolepids from the Baltic Devonian area (see pp. 27—28). In *Dipterus valenciennesi* blisters and rough areas are frequently found both on the independent dermal bones and on the continuous sheet of enamel and dentine covering the snout (see p. 39). In primitive *Porolepiformes* (*Porolepis*), in which the histological structure of the dermal bones and scales is very similar to that in Osteolepids and early Dipnoans (see GROSS 1935; BYSTROW 1942; cf. JARVIK 1948a, p. 10, footnote 1), neither blisters nor rough areas have been described, and no such or similar structures in the dentine layer have been observed so far in the available, rather comprehensive material of *Porolepis* from Spitzbergen (as regards the Trematapids see footnote 1 on p. 47).

The blisters (*bli*, fig. 2 and the plates listed above; also JARVIK 1948a, figs. 8 A—D, 9) form small or larger, distinctly bounded elevations on the smooth and shiny external faces of dermal bones or scales. They are mainly or wholly made up of a simple layer of dentine capped with enamel (fig. 3; cf. figs. 5, 10) and they accordingly have a smooth and shiny external face which like that of the surrounding continuous dentine layer (except on the very small blisters; cf. p. 22) is pitted by small foramina (*f. vc*, fig. 2, pl. 11; pl. 12:1; cf. figs. 5, 7 B, 10, 11 A). The dentine in the blisters is sometimes a little lighter in colour than the surrounding dentine. In most cases the blisters are situated in distinctly bounded rough areas (*ar. res*), assumed to be areas of resorbtion, which form more or less narrow, irregular grooves round the blisters (see also figs. 4 A, 5). When surrounded by such rough areas the blisters are situated partly below the level of the external face of the surrounding dentine sheet, and their dorsal faces, which are convex or more or less plane, rise only a little above that level (see figs. 4 A, 5; JARVIK 1948a, fig. 8 C). Sometimes, however, the blisters are not inserted in the

continuous dentine sheet but have a more superficial position, lying wholly above the level of the external face of that sheet (fig. 3; pl. 3:2; pl. 5:1, 2; pl. 8:6), and, as far as could be ascertained, they are not surrounded by any continuous rough area. In the latter case the blisters may be easily removed, which we shall see (p. 25; fig. 3), is due to the fact that the surrounding dentine sheet continues and is only partly destroyed by resorbtion underneath the blisters. Two types of blisters are thus distinguishable, inserted and superficial.

The disposition of the blisters is irregular. As may be gathered from the figured specimens listed above (pp. 20—21), the blisters are numerous in some specimens, whereas in others only one or two blisters are found, and they may be numerous on one or several scales or dermal bones of one and the same individual, whereas the adjoining bones or scales show no or only a few blisters. Thus, in specimen No. P. 1300 (fig. 2; pl. 11; pl. 12:1; pl. 13:1), which displays the posterior part of the external cheek plate, the blisters are numerous on the squamosal (*Sq*), relatively few on the preopercular (*Pop*), and absent on the quadrato-jugal (*Qj*). The position of the blisters on the individual dermal bones or scales is also subject to strong variations, and when numerous they are irregularly scattered (fig. 2). In the specimen shown in pl. 19:3 most of the pores of the preoperculo-mandibular sensory canal on the posterior part of the lower jaw are surrounded by a small blister, and in some specimens (see e. g. fig. 2) the pit-lines are interrupted by the blisters and the rough areas associated with them. In specimen No. P. 1303 (pl. 6:5, 6) the main antero-lateral part of the frontal pit-line (*pl. Fr.*) is situated on a blister, whereas its postero-medial end lies partly in the rough area, partly in the sheet of enamel and dentine surrounding the blister. Blisters situated along the very margin of the dermal bones or scales are rare in the material available, and in this case they usually continue to an adjoining bone crossing the suture. In the holotype (pl. 1:1; pl. 2:1; cf. pl. 8:6) a blister is thus found on the posterior part of the suture between the parietals, the suture being interrupted at the blister (cf. pp. 30—31).

The size of the blisters is also very variable, and they may be of very different size on one and the same scale or dermal bone. Thus in No. P. 1300 referred to above (fig. 2; pl. 11; pl. 13:1) one of the blisters on the squamosal attains a considerable size, whereas the remaining blisters are relatively small. Some of them are very minute structures, being invisible to the naked eye. These very small blisters are devoid of foramina (*f. vc*) on the external face and probably each of them represents a single dermal tooth (cf. pp. 47, 53 and figs. 7, 11 A). Sometimes, the blisters are large and occupy half or more of the external faces of the dermal bones or scales. Thus, in No. P. 1306 (pl. 8:2), a

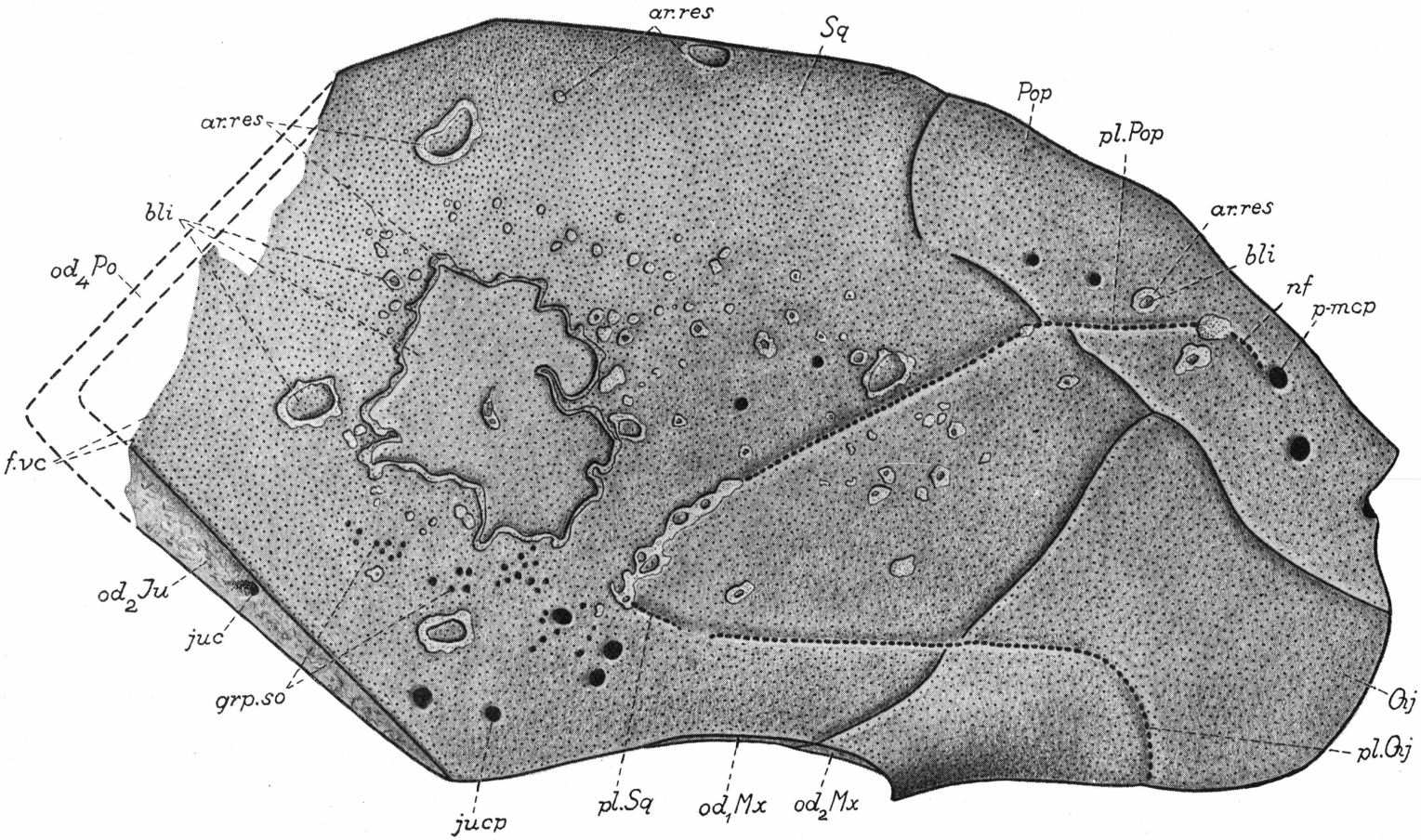


Fig. 2. *Gyroptychius groenlandicus* n. sp. Posterior part of the external cheek plate in outer view, showing inter alia the pit-lines of the cheek, blisters and areas of resorbtion. Specimen No. P. 1300. Same specimen as in pl. 11; pl. 12:1 and pl. 13:1. Ca. $^{9}/_{1}$.

Pop, preopercular; *Qj*, quadratojugal; *Sq*, squamosal. — *ar. res*, rough areas, probably representing areas of resorbtion; *bli*, blisters, probably representing patches of new dentine and enamel laid down in the areas of resorbtion; *f. vc*, openings of canals of trabecular layer; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *juc*, jugal sensory canal; *jucp*, pores of ditto; *nf*, foramina for nerves to sensory organs (neurcmasts) of pit-lines; $od_1 Mx$, area of squamosal overlapped by maxillary; $od_2 Ju$, area of squamosal overlapped by jugal; $od_2 Mx$, area of quadratojugal overlapped by maxillary; $od_4 Po$, area of squamosal overlapped by postorbital; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *p-mcp*, pores of preoperculo-mandibular sensory canal.

large blister is found on the part of the supratemporal situated behind the supratemporal pit-line and on the adjoining part of the parietal laterally to the posterior oblique parietal pit-line (cf. also JARVIK 1948a; pl. 32:1, *bli*).

The shape of the blisters is also subject to strong variations. In many cases they are more or less rounded, but often they have a very irregular shape, and sometimes such irregular blisters appear to have been formed by the fusion of two or more blisters (see e. g. the large blister in fig. 2 and JARVIK 1948a, figs. 8 A, 9 B).

As pointed out above, the blisters are in most cases situated in irregular rough areas, assumed to be areas of resorbtion. These rough areas (*ar. res*, fig. 2; pl. 3:3; pl. 6:6; pl. 8:2, 6; pl. 10:5; pls. 11, 12; pl. 13:5; pl. 15:1; pl. 18:3—5; pl. 19:6; pl. 20:2; JARVIK 1948a, figs. 8 A—D, 9 B), like the blisters varying considerably in position, size, and shape, consist of shallow pits, in which the enamel layer and the whole or, at any rate, the main part of the dentine layer is missing (cf. p. 28 and fig. 5). Generally each rough area contains only one blister, but in many cases such areas are found without blisters and sometimes each area contains two or more blisters. In the latter case the areas often have the appearance of being formed by the union of two or more adjoining such areas (see fig. 2; JARVIK 1948a, fig. 8 A). The rough areas containing each a very small blister, though relatively small, are usually much larger than the blister, which thus does not by far fill up the area (fig. 2). The specimens showing such small blisters generally present also very small rough areas without blisters. When the blisters are large they generally occupy the main part of the rough area, which in those cases forms a narrow but irregular groove surrounding the blister (cf. the Westoll-lines in Dipnoans, pp. 32—34).

As regards the minute structure of the blisters only little can be said. The specimens with blisters from East Greenland are more or less black and bituminous and therefore not very suitable for histological investigations and only one useful section has been made. The sectioned specimen is No. P. 1386 (pl. 8:6), which presents a considerable part of the parietal shield. The section shows the main part of the blister denoted with *bli* in pl. 8:6, which is situated on the parietal not far from the median suture between the parietals.

The sectioned blister (*bli*, fig. 3), like at least most of the other blisters in the sectioned specimen (pl. 8:6), is of the superficial type (p. 22) and is situated wholly above the level of the external face of the surrounding sheet of enamel and dentine (*en. l. 1*, *de. l. 1*). As is clearly seen on the section, the blister consists of a layer of trabecular bone-tissue (*tr. l. 2*) covered by a continuous layer of dentine (*de. l. 2*) capped with enamel (*en. l. 2*). The dentine and enamel layers along the

margin of the blister are distinctly separated from the sheet of dentine (*de. l. 1*) and enamel (*en. l. 1*) covering the main part of the parietal shield, and this latter sheet is clearly seen to continue underneath the blister, where several denticles capped with enamel are found. In the region of the blister the parietal is thus made up of two layers of dentine, both capped with enamel, an outer layer (*de. l. 2*) confined to the blister, and an inner layer (*de. l. 1*) represented also outside the blister. The latter layer is not quite complete in the region of the blister, being

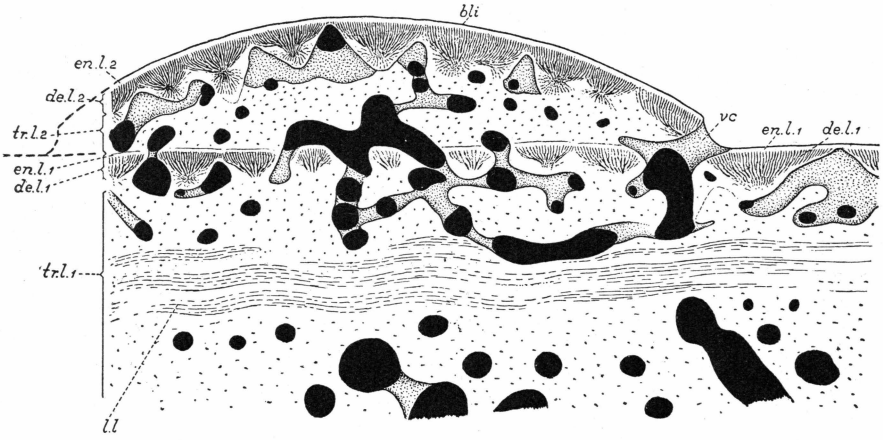


Fig. 3. *Gyroptychius groenlandicus* n. sp. Diagrammatic section of part of parietal, showing blister deposited upon the old sheet of enamel and dentine. Specimen No. P. 1386. Same specimen as in pl. 8:6. After a microphotograph. Section No. S. 819 Stockh. Ca. $^{140}/_{1}$.

bli, blister; *de. l. 1*, old dentine layer; *de. l. 2*, dentine layer of blister; *en. l. 1*, old enamel layer; *en. l. 2*, enamel layer of blister; *l. l*, laminated layer; *tr. l. 1*, main trabecular layer of parietal; *tr. l. 2*, trabecular layer of blister; *vc*, vascular canal.

pierced by several vascular canal (*vc*). Conceivably these canals have been formed, or at any rate widened, by resorbtion.

In the sectioned specimen, and probably in other specimens with blisters of the superficial type as well, the blisters obviously consist of patches of new material deposited on an older sheet of dentine and enamel. As regards this type of blisters, the opinion expressed by Westoll that the blisters are remnants of an old generation of dentine and that the surrounding dentine represents newly deposited material is thus incorrect (cf. pp. 20, 28). The old sheet of dentine and enamel has to a considerable extent been retained underneath the blister, being only partly resorbed there, inter alia to allow the passage of the vessels necessary for the formation of the new material in the blister. In the sectioned specimen a strong

canal (*vc*, fig. 3) for such a vessel penetrates the old dentine layer just at the margin of the blister, a condition possibly indicating that the deposition of new material was not completed at the death of the animal.

Since the dermal bones and scales in Osteolepids, at least as far as it is known (see e. g. PANDER 1860, pl. 5:4a, 6b, 7a, 8; GOODRICH 1907, pl. 43:5; GROSS 1930, pl. 4:7; pl. 5:4, 12; 1935, pl. 7:1; BYSTROW 1942; JARVIK 1948a, fig. 4), generally are covered by a single sheet of dentine and enamel, it seems likely that the presence of double sheets in the sectioned specimen does not represent a normal condition, and it is doubtful whether blisters of the superficial type grew so much as to fuse with adjoining blisters and form a continuous sheet of dentine and enamel upon the old one. It is also difficult to say whether the formation of patches of new dentine upon the old dentine layer has any bearing on the question of the periodical resorbtion and reformation of the old dentine layer which presumably took place in the Osteolepids. Be this as it may, however, it is of much interest to find that there is at least a tendency to the formation of double dentine layers in Osteolepids, for as is well known the dermal bones and scales in *Porolepiformes* (see e. g. PANDER 1860; pl. 5:22; GROSS 1930, pl. 4:2, 3, 5, 8, 9; 1935, fig. 14; pl. 6:1; BYSTROW 1939, figs. 2 B, 10 D; cf. also the conditions in certain *Coelacanthiformes*, GROSS 1935, fig. 17 A; ROUX 1942, fig. 6) often contain two or more layers of dermal teeth, the one upon the other.

As described above, many of the blisters are inserted in distinct rough areas and are therefore seemingly lower than the superficial blisters deposited upon the old sheet of dentine. However, also the blisters of this inserted type rise a little above the level of the external face of the surrounding sheet of dentine and enamel (JARVIK 1948a, fig. 8 C), a fact which must mean that they—like the superficial ones—represent patches of newly deposited material. Moreover, the fact that they are inserted in rough areas, in which the enamel, and probably also the dentine, layer is missing and thus partly are situated below the level of the external face of the surrounding sheet of enamel and dentine demonstrates that —contrary to conditions in the sectioned specimen (fig. 3)—they cannot have been deposited upon that sheet. We are thus led to the conclusion that the old sheet of dentine (and enamel) has been wholly or at least mainly resorbed in the region of the blisters of the inserted type and that the rough areas surrounding these blisters, like the very similar areas or small pits not containing blisters, represent areas of resorbtion.

These conclusions are strongly supported by the conditions in the opercular of an undetermined form, most probably an Osteolepid (*Latvius grewingki*?), from Kokenhusen in Latvia.

The external face of this opercular (fig. 4 A) is partly ornamented (cf. p. 20) and partly covered by a smooth and shiny sheet of dentine capped with enamel. In the postero-dorsal part there is a large blister (*bli*, *de. 2*), which, exactly like the blisters of the inserted type in the

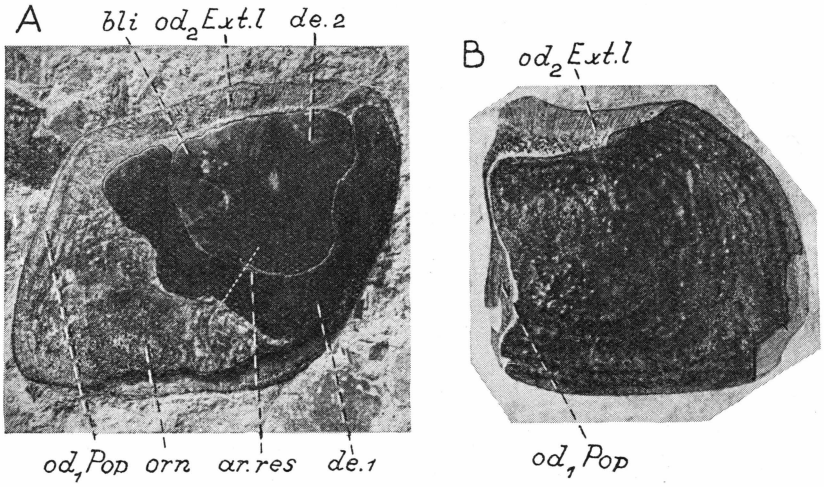


Fig. 4. Opercular of two undetermined forms (*Latvius grewingki*?) from Kokenhusen, Latvia, in external view. $^5/_2$. *A*, specimen No. P. 4197 Stockh. A section of part of this bone is shown in fig. 5. The position of this section denoted with an interrupted line on the figure. *B*, specimen No. P. 4212 Stockh.

ar. res, narrow rough area, probably formed by resorbtion; *bli*, blister; *de. 1*, zone of old dentine (and enamel); *de. 2*, zone of new dentine (and enamel) forming the blister; $od_1 Pop$, area of opercular overlapped by preopercular; $od_2 Ext. l$, area of opercular overlapped by lateral extrascapular; *orn*, ornamented part of bone.

Greenland material, rises a little above the surrounding, rather narrow zone of dentine (*de. 1*) and is separated from that zone by a rough area. This rough area (*ar. res*), as a whole, is narrow and suggestive of the Westoll-lines in Dipnoans (cf. pp. 32—42). It is a little broader and more distinct ventrally to, than in front of, and behind, the blister, where the latter in some places reaches and probably slightly overlaps the zone of dentine surrounding the blister.

A section through part of the opercular has been made (the position of the section is indicated by an interrupted line on fig. 4 A). This section (fig. 5), which crosses the relatively broad part of the rough area, demonstrates the following conditions of interest in this connection:

1. The dentine and enamel layers are completely wanting both in the rough area (*ar. res*) and on the ornamented part of the bone (*orn*, fig. 4 A), the rough (ornamented) external face of the trabecular layer being exposed.

2. The enamel-capped dentine layer is single both in the blister (*bli*, *de. 2*) and in the surrounding zone of dentine (*de. 1*).

3. The dentine layer in the blister is distinctly thicker than the dentine in the surrounding zone of dentine and the fact that the blister rises a little above the external face of that zone is due exclusively to this condition.

This section thus clearly demonstrates that the blister, and conceivably also the blisters of a similar (inserted) type in other Osteolepids, is made up of new material—dentine capped with enamel—deposited directly upon the ornamented external face of the trabecular layer, and that the blister belongs to a younger generation of dentine (*de. 2*) than the dentine in the zone (*de. 1*) surrounding the blister. No traces of destruction of the pulp cavities of the individual dermal teeth nor any other distinct signs of resorbtion of the old dentine layer could be observed in the section (cf., however, pp. 45—47). The assumption that the old dentine layer underneath the blisters of the inserted type and in the parts of the rough areas surrounding the blisters has been removed by resorbtion is thus not yet definitely proved. However, judging from the position and development of the rough areas and blisters in *Gyroptychius groenlandicus* it is almost certain that such a resorbtion took place. As already pointed out, the dentine layer on the ornamented part of the opercular shown in fig. 4 A was wanting when the fossil became embedded, and it is possible, therefore, that the absence of that layer in this case is due to resorbtion (cf. pp. 20, 47).

In this connection the conditions in another similar but smaller Osteolepid-like opercular from Kokenhusen may be briefly considered (fig. 4 B). In this case the non-overlapped part of the bone is covered by a continuous sheet of dentine. However, the external face of this layer is not quite smooth, showing several alternating rings of depressions and elevations, concentric with regard to the centre of radiation of the bone, and other irregularities. This condition seems to be due to the fact that the dentine layer is very thin and reflects the ornamentation of the external face of the trabecular layer (cf. GROSS 1935, p. 42; pl. 5:1). Possibly this thin layer is the first, or one of the first, dentine layers of the bone (cf. pp. 45, 48).

Since the blisters found in the rough areas (blisters of the inserted type) no doubt consist of newly deposited enamel and dentine and

since the rough areas almost certainly represent areas in which the old sheet of enamel and dentine has been completely or almost completely destroyed by resorbtion, it may be assumed that—in accordance with views expressed in a previous work (JARVIK 1948a, pp. 30—33, fig. 8 A—D)—the periodical resorbtion and redeposition of the dentine and enamel layers in the Osteolepids took place somewhat as follows.

The resorbtion of each old sheet of dentine and enamel presumably started with the formation of diminutive rough areas (*ar. res*) of the

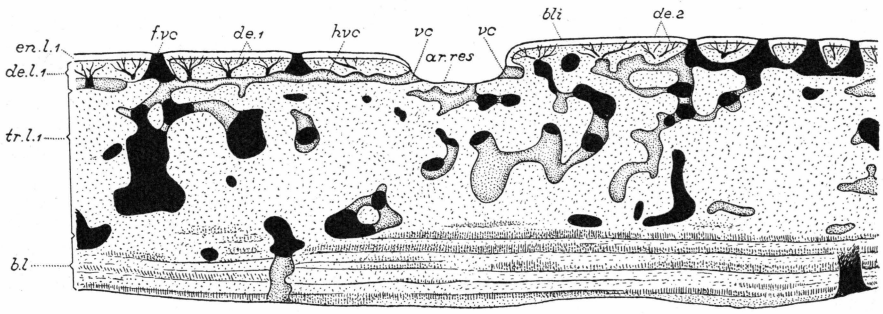


Fig. 5. Diagrammatic section of part of the opercular shown in fig. 4 A. After a microphotograph. Section No. S. 812 Stockh. $^{100}/_{1}$.

ar. res, rough area, probably formed by resorbtion; *b. l*, basal layer of bone; *bli*, blister; *de. l. 1*, old dentine layer; *de. 1*, old zone (generation) of dentine and enamel; *de. 2*, new zone (generation) of dentine and enamel forming the blister; *en. l. 1*, enamel layer of old zone of dentine and enamel; *f. vc*, opening of vascular canal of bone; *hvc*, horizontal vascular canal of bone; *tr. l*, trabecular layer; *vc*, vascular canals.

type frequently found in the Osteolepid material available (see e. g. fig. 2; JARVIK 1948a, figs. 8 A—D, 9). During the resorbtion these areas gradually became enlarged but very soon a small patch of new material, consisting mainly of dentine capped with enamel, that is a blister (*bli*), was laid down in each area. The dentine in the blister, which belongs to a new generation of dentine, grew a little higher than that of the old sheet and accordingly the external face of each blister became situated at a somewhat higher level than the outer face of the surrounding old sheet of enamel and dentine (see fig. 5). Each blister, which most probably originally consisted of a single dermal tooth only (cf. pp. 22, 47), at first increased rather rapidly in areal extent, probably by successive apposition of irregular, marginal zones of new material (independent dermal teeth, cf. pp. 38-39, 53, fig. 11 A), until it almost filled the rough area in which it was situated, whereupon the enlargement of the rough area and its blister generally proceeded at about the same rate. As is evidenced by the shape and disposition of the rough areas

(see p. 24 and fig. 2) the gradual enlargement of these areas soon led to two or more neighbouring rough areas meeting and becoming confluent, forming large irregular complex areas. Each of these relatively large areas, at least to begin with, contained two or more blisters, but soon these blisters grew together and formed large irregular blisters of the type frequently found in the available material (see p. 24). As may be readily understood, a further enlargement of the rough areas by resorbtion and areal growth of the blisters and fusion into still more complex structures would ultimately lead to the whole old sheet of dentine and enamel of the individual dermal bones and scales being removed and replaced by a new and thicker sheet. The resorbtion of the old dentine layer and the formation of a new one at each of the successive periods of resorbtion thus implies a growth in thickness of the dentine layer and of the individual dermal bones or scales as a whole.

Since several rough areas and blisters are often found on one and the same scale or dermal bone (see e. g. fig. 2), it is to be assumed that both the resorbtion and the reformation of the dentine layer started at several places (centres) on each bone or scale, and judging by the disposition of the blisters and rough areas it is evident that these processes generally did not begin either at the margins of the dermal bones and scales proceeding towards the central parts (as assumed by WESTOLL; cf. p. 20), or at the centre of radiation proceeding towards the periphery. Moreover, these processes no doubt took place independently of the growth of the bones or scales as a whole (cf. p. 45). The fact that several of the dermal bones or scales show both small and large rough areas and blisters and that these structures may be numerous on certain dermal bones or scales of one and the same individual but rare or absent on others (see p. 22 and fig. 2) indicates that the processes of resorbtion and reformation usually did not start quite simultaneously over the whole individual. However, since there is reason to believe that the dentine layer in the Osteolepids was resorbed and reformed periodically (see WESTOLL 1936), we may assume that these processes took place during a relatively short period (annual season?). The fact that the blisters and rough areas are common in material from the thin fossiliferous horizon at 210—234 m. in the NW. part of Hesteskoen, but rare or absent in specimens from other localities both in East Greenland and Scotland (see pp. 20—21) supports this view, and probably the fishes preserved in that horizon died during such a period of resorbtion and reformation of the dentine layer.

As pointed out above (p. 22), the suture between the parietals in the holotype of *Gyroptychius groenlandicus* (pl. 1:1; pl. 2:1) is inter-

rupted by a blister which occupies parts of both the parietals. Provided now that this blister, in accordance with the views expressed above, grew and fused with adjoining blisters until the parietal shield was covered by a new and thicker sheet of enamel and dentine, these processes would lead to a complete, or at any rate to a partial, obliteration of the suture between the parietals. This explains why the sutures between the dermal bones in individuals of one and the same species are sometimes very distinct, sometimes obscure or not visible at all, and as already stressed (JARVIK 1948a, p. 47) differences in the development of the sutures are of no or only little taxonomic importance.

Comparison with Dipnoans.

The dermal bones and scales in Osteolepids and early Dipnoans (*Dipterus*) have a very similar histological structure (see e. g. PANDER 1858; 1860; GROSS 1930; 1935; BYSTROW 1939; 1942) and it is therefore to be expected that the growth of the individual dermal bones and scales and the resorbtion and redeposition of the dentine layer took place in a similar way in these two groups. As we have now seen, the development and disposition of the blisters and rough areas in the available material of Greenland, Baltic, and Scottish Osteolepids has led us to the assumption that both the resorbtion and the redeposition of the dentine (and enamel) layer in these forms could start anywhere and generally at several centres at about the same time on the individual dermal bones or scales. In early Dipnoans (*Dipterus*), on the other hand, both these processes according to BYSTROW (1942, pp. 280—287, figs. 15—17; cf. WESTOLL 1936; JARVIK 1948a, p. 24, fig. 8 E, F) started along the periphery of the individual dermal bones or scales, thence proceeding towards the central parts. In this way irregular concentric zones of dentine were formed and BYSTROW maintained that each zone grew by apposition of new material along the inner margin. Very often two or more such zones are developed on one and the same dermal bone. These zones, which are separated from each other by distinct concentric lines, by BYSTROW called Westoll-lines, according to him represent different generations of dentine. The dermal teeth (Hautzähne) of each new generation of dentine are said to be about double as large as those belonging to the preceding generation, and the external face of the individual bones with Westoll-lines is terraced and rises suddenly at the Westoll-lines from the central parts, where in BYSTROW's opinion the oldest generation of dentine is found, towards the periphery.

Judging solely from the Osteolepid material available and from BYSTROW's investigations on Dipnoans one would thus be inclined to conclude that the growth of the dentine layer and the processes of

resorbtion and reformation of that layer took place in a different manner in these two groups of fishes. In order to check whether this is really so, I have found it advisable to deal also with the structure of the dentine layer in early Dipnoans.

The material at my disposal for that purpose consists of 19 well-preserved specimens of *Dipterus valenciennesi* from Scotland[1]), all showing irregular grooves in the dentine layer or other structures which may be suspected to be significant with regard to the growth of that layer and the processes of resorbtion and reformation. In addition, some detached plates of an undetermined form, probably a Dipnoan, from the lowermost Upper Devonian at Kokenhusen in Latvia, in which the structures presented by the dentine layer are very similar to those found in *Dipterus*, will be described. Since the material of *Dipterus* could not be used for microscopical studies, the subsequent account is based mainly on studies of the external face of the bones in great magnification (up to ca. 50 ×). In order to verify the results thus obtained one of the plates from Kokenhusen has been sectioned.

As evidenced by this material there are certainly some differences between Osteolepids and Dipnoans as regards the development of the dentine layer, but as far as could be established these differences are not of fundamental importance and the mode of resorbtion and the growth of the dentine layer were most probably very much the same in the two groups (see pp. 47—51).

Let us first turn to the cranial roof in *Dipterus*, which is shown in 18 of the available specimens. The nomenclature of the individual dermal bones is the provisional one used by FORSTER-COOPER (1937) and by GRAHAM-SMITH & WESTOLL (1937).

The distinct lines in the enamel-capped dentine layer known as Westoll-lines (*w. l*, figs. 6, 7, 8 C; cf. footnote 1 on p. 40) are represented in all these specimens except three. Two of these latter specimens are too strongly weathered to show such lines. The third specimen without Westoll-lines (No. 1901.152.2 Edinb.) but in which the dentine layer is well preserved shows irregular concentric rings of the type described below (p. 39). The Westoll-lines, which appear as narrow but distinct grooves in the shiny dentine layer, are in all specimens found only on the independent bones of the postethmoidal part of the cranial roof; no traces of such lines are seen in the continuous sheet of dentine

[1]) The material includes the following specimens: Nos. P. 6507, P. 7834, 33178 Brit. Mus.; Nos. 53371, 53372, 53390, 53405, 53703 Geol. Surv. London; Nos. 64 (738; figured by MILLER 1849, fig. 20), 93, 94, 780?, 1878.5.164, 1878.5.172; 1897.54.6, 1898.163.6, 1901.152.2 R. Scottish Mus., Edinb.; No. L. 8450 Manch. Mus.; and one unnumbered specimen.

covering the snout (cf. p. 50). They may be developed on most of the bones as in specimen No. P. 7834 (fig. 6), in which the Westoll-lines and other structures described below are well displayed, or only on a few bones, and each bone may show one, two or more such lines. In many cases they form complete or almost complete concentric rings or more or less broad U-shaped figures, but quite often they have an irregular course (cf. p. 40 and fig. 8 A).

The Westoll-lines divide the dentine layer into two or more distinctly separate areas or zones (figs. 6, 7, 8 C). When two or more concentric Westoll-lines are developed on one and the same dermal bone, the external face of the second zone of dentine from within is generally situated at a distinctly higher level than the adjoining marginal part of the external face of the innermost zone. Whether this condition means that the dermal teeth in the innermost zone of dentine are lower and belong to an older generation of dentine than those in the next outer zone is difficult to decide without sections. Possibly it is sometimes so (cf. p. 31 and Bystrow 1942), but, as may be easily understood from the conditions in the sectioned plate from Kokenhusen described below (pp. 44-45, figs. 9 C—E, 10), it is also possible that the dentine layer as a whole is thicker and thus probably younger in the innermost zone than in the zone following next outside to it. The fact that the external face of the dentine layer of the innermost zone on many bones (e. g. on the bones denoted *B*, *C*, *I*, *J* in fig. 6), exactly as in the Kokenhusen-plate just referred to, is distinctly convex (cf. fig. 9), the central parts being situated at a higher level than the marginal ones, and other facts mentioned below (pp. 39-44) speak in favour of the latter alternative. As regards the other zones of dentine on bones with more than one concentric Westoll-line, the second zone from within sometimes rises a little above the zone following next outside it (e. g. on bone *B* in fig. 6) but otherwise no distinct differences in height are discernible macroscopically. As will be demonstrated below, the dentine layers in the two outermost zones—when only one Westoll-line is developed (see fig. 7) in both zones—sometimes seem to be of the same height, that is they probably belong to one and the same generation of dentine.

The innermost Westoll-line generally forms a complete ring of varying size. In specimen No. P. 7834 (fig. 6) this ring is thus relatively wide on some of the bones, namely on the unpaired bone *B* and on bones *C* and *J* of the left side and on bone *I* of the right side, but relatively narrow on the corresponding paired bones of the other side. In the former case the innermost zone of dentine covering the central parts of the bone is relatively large, in the latter relatively small. In consequence of these variations the annular zone of dentine following

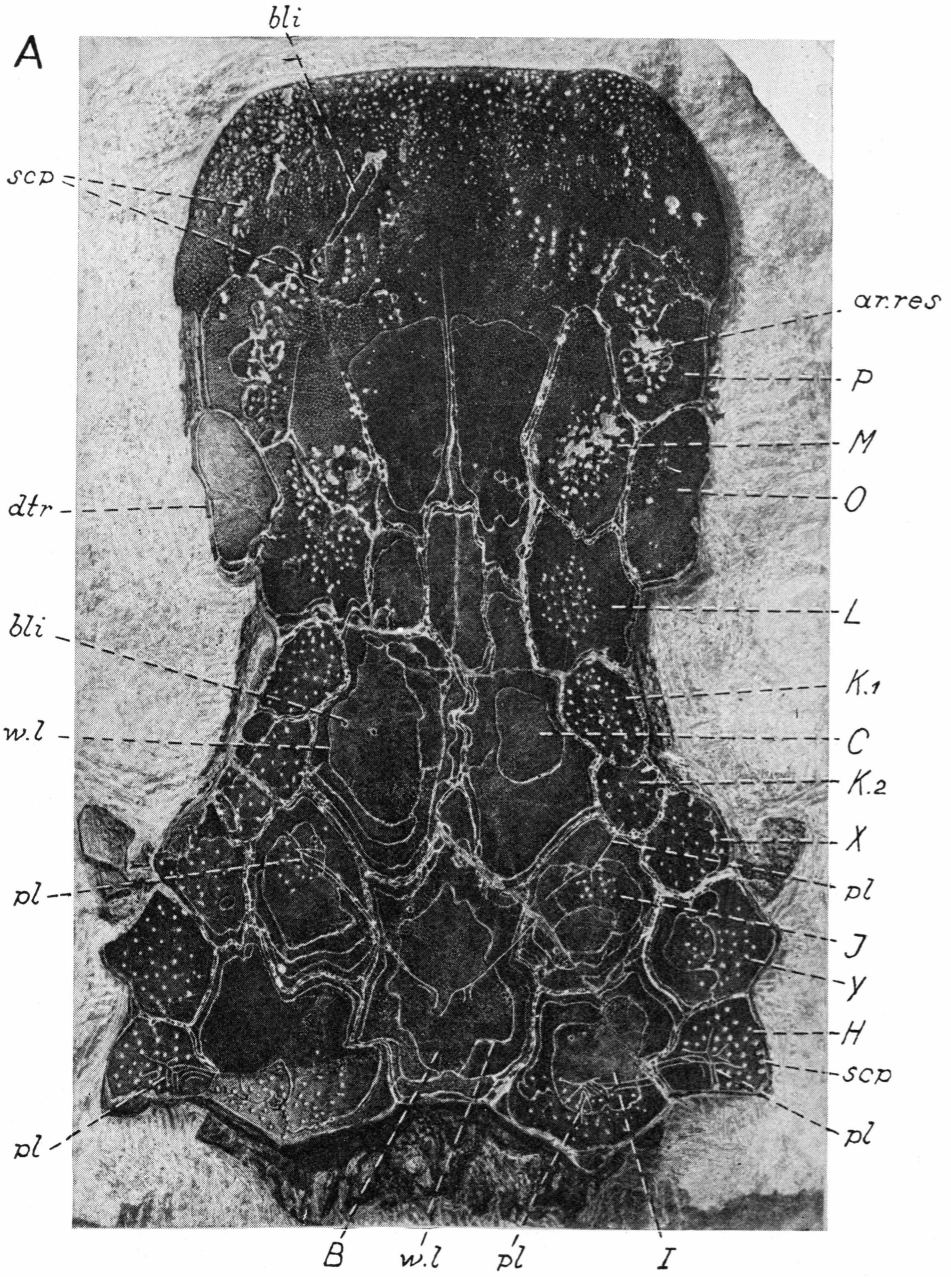


Fig. 6. *Dipterus valenciennesi*. Imperfect cranial roof in dorsal view, showing Westoll-lines, blisters, areas of resorbtion, and concentric rings in the dentine layer. Specimen No. P. 7834 Br. Mus. *A*, photograph. $^{2}/_{1}$. *B*, restoration. The pores of the sensory canals omitted. $^{8}/_{3}$.

B, *C*, *D*, *E*, *H* (in error for *Y. 2*), *I*, *J*, *K. 1*, *K. 2*, *L*, *M*, *O*, *P*, *X*, *Y* (in error for *Y. 1*), dermal bones (terminology according to FORSTER-COOPER 1937).

ar. res, rough areas, probably representing areas of resorbtion; *bli*, blisters; *cr*, concentric rings in dentine layer; *dt*, independent or partly independent dermal teeth; *dtr*, rows of incompletely fused dermal teeth; *pl*, pit-lines; *scp*, pores of sensory canals; *sut*, suture; *w. l*, Westoll-lines.

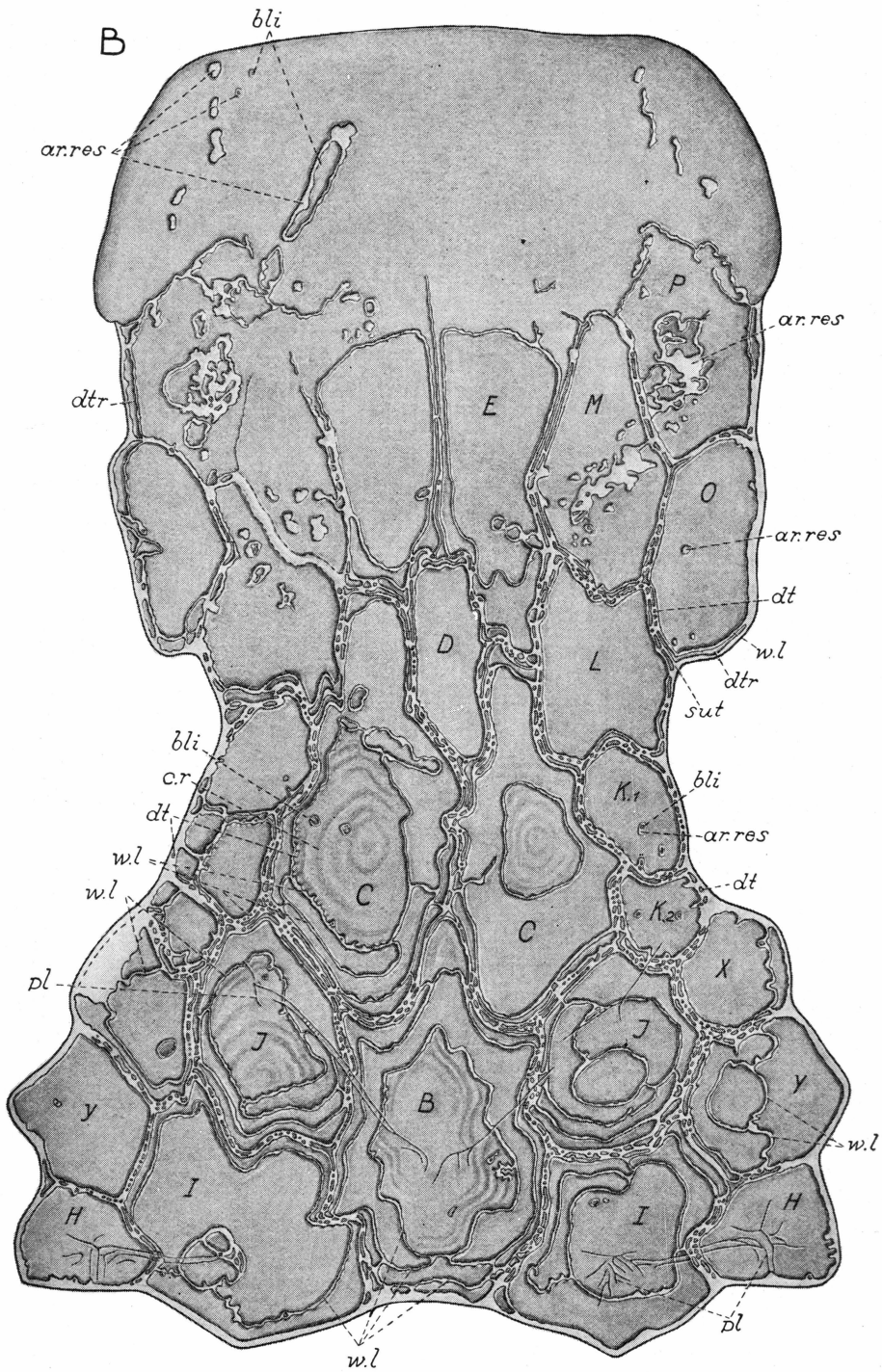

B
bli
ar.res
P
ar.res
dtr
E
M
O
ar.res
dt
D
L
w.l
dtr
sut
bli
c.r
K.1
bli
dt
ar.res
w.l
w.l
C
C
dt
K.2
X
pl
J
J
y
B
y
w.l
I
H
I
H
pl
w.l

Fig. 6 B.

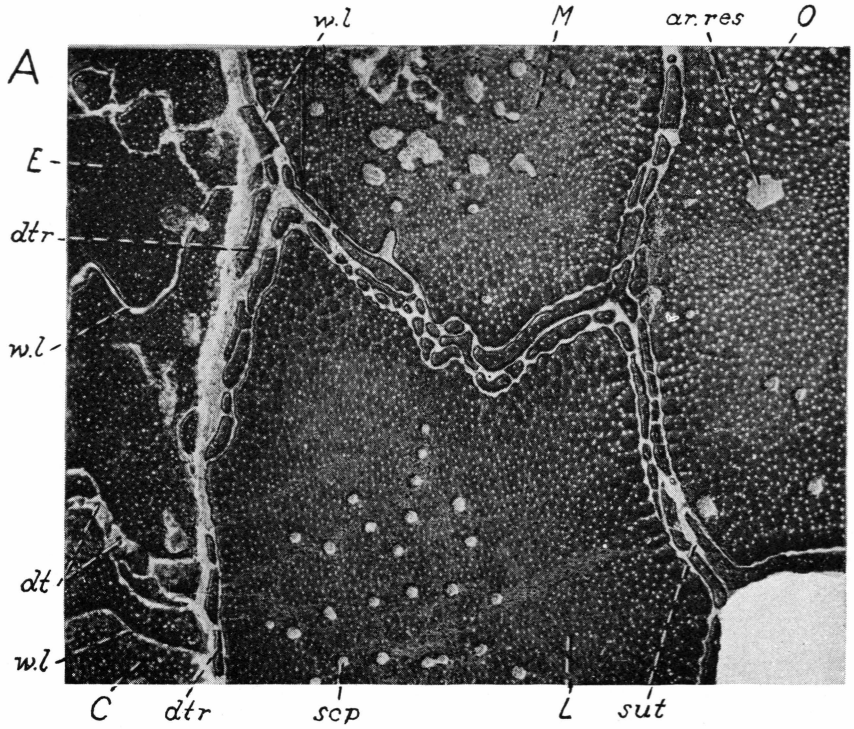


Fig. 7. *Dipterus valenciennesi*. *A*. Part of the cranial roof shown in fig. 6. $^{8}/_{1}$. *B*. Still smaller part of the same cranial roof further magnified. Ca. $^{16}/_{1}$.

C, *E*, *L*, *M*, *O*, dermal bones.

ar. res, rough areas, probably representing areas of resorbtion; *dt*, independent or partly independent dermal teeth; *dtr*, rows of incompletely fused dermal teeth; *f. vc*, openings of vascular canals of bones; *grp. so*, group of small pores, probably corresponding to the groups of small pores in Osteolepids (cf. p. 98) assumed to transmit nerves to cutaneous sensory organs; *scp*, pores of sensory canals; *sut*, sutures; *w. l*, Westoll-lines.

next outside the innermost Westoll-line varies considerably in breadth and also the other zones may be subject to strong variations.

The outermost zone of dentine, which is found along the periphery of the individual dermal bones, that is along the sutures or the free margins, is very narrow in most specimens. This narrow zone (*dtr*, figs. 6, 7, 8 C) may form a continuous or almost continuous band of dentine round each of the bones, but as is evidenced by specimen No. P. 7834 (figs. 6, 7) it may sometimes be subdivided into numerous smaller units. The smallest of these units (*dt*, fig. 7), which are all of about the same size and square, rectangular or polygonal in shape, in great magnification appear as homogenous patches of dentine, without traces of the pores (*f. vc*) which give the external face of the dentine layer its pitted appearance. These small units no doubt represent

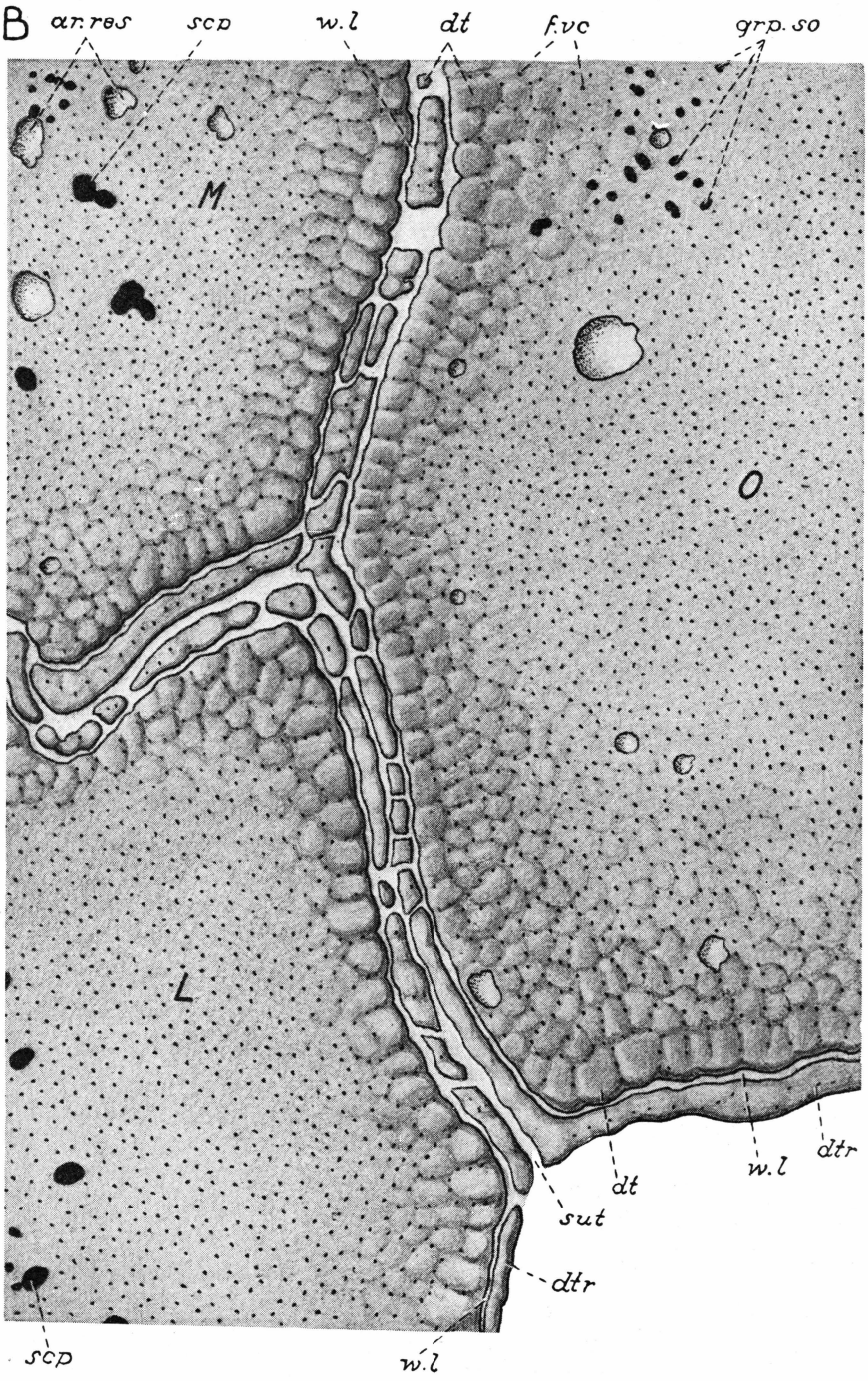


Fig. 7 B.

independent dermal teeth. The larger units (*dtr*) consist of a single or rarely a double row of two or more dermal teeth which have fused more or less completely with each other and form longer or shorter chains. When incompletely fused the individual teeth in the chain are easily recognisable but also in the case of a more complete fusion the boundaries between them are often traceable, being marked by a distinct depression in which one or more superficial pores are often found.

Generally this narrow peripheral zone of dentine (*dtr*, fig. 7) is separated from the zone following inside to it by a distinct concentric Westoll-line (*w. l*)—on the bones shown in fig. 7 B there are only two zones of dentine and one Westoll-line (cf. fig. 6)—but in some places the dermal teeth of the narrow peripheral zone have fused either with the dermal teeth of the corresponding zone of an adjoining bone, forming double rows (e. g. between bones *O* and *M*, fig. 7), or with the adjoining marginal dermal teeth of the zone next inside it (see figs. 6 B, 7 A). In the former case the suture, and in the latter case the Westoll-line is interrupted. As far could be established the dermal teeth of the inner zone in the bones shown in fig. 7 B are of exactly the same height as those in the narrow peripheral zone and accordingly the teeth of these two zones probably belong to one and the same generation of dentine. In this case the Westoll-line thus probably does not separate different generations of dentine (cf. footnote 1, p. 40).

It is of interest that the zone of dentine in specimen No. P. 7834 (figs. 6, 7) which follows inside the narrow peripheral zone most marginally consists of a row of incompletely fused or sometimes almost independent dermal teeth. Also in the part of the dentine layer following next inside this row the dermal teeth have partly retained their independence and are arranged in more or less distinct concentric rows. Three or four such rows in addition to the marginal one are distinguishable in some places (fig. 7). Similar marginal rows of incompletely fused dermal teeth are distinctly shown also in other individuals. It is of special interest that partly independent dermal teeth are often found on bones with more than one Westoll-line along the outer (but never along the inner) margin of each of the various zones of dentine, as is distinctly seen for example on bone *C* from the left side in specimen No. P. 7834 (fig. 6 B).

Very similar marginal rows of partly or wholly independent dermal teeth have been encountered also in Osteolepids, for example along the sutures between the bones of the parietal shield (see JARVIK 1949a). As is quite evident from these conditions, from the shape and structure of the blisters, and other facts mentioned above, the areal growth of each zone or patch (blister) of dentine both in Osteolepids and

in early Dipnoans took place by the successive, marginal apposition of independent dermal teeth the latter thus representing units of growth. The last formed dermal teeth, which at least sometimes were disposed in single concentric rows, apparently soon fused with each other and usually (cf. pp. 47-48) with those earlier formed and were in this way successively incorporated in the continuous layer of dentine, which is known to consist of closely set dermal teeth (Hautzahnparkett, GROSS). Judging from the material available the areal growth of the dentine layer, which could start at one or several centres on each dermal bone, thus proceeded outwards from each of these centres and not, as maintained by WESTOLL and BYSTROW (cf. p. 31), from a peripheral zone inwards towards the central region of the bones.

According to the figures and descriptions given by previous writers (PANDER 1858; pl. 3; WESTOLL 1936; BYSTROW 1942, pp. 281—287, figs. 15—17) the external face of the dentine layer of the dermal bones of the cranial roof in Dipnoans is quite smooth, except for the Westoll-lines (and the pores of the sensory canals, etc.). However, in the *Dipterus*-material available this is only rarely so.

Quite often the dentine layer of the individual dermal bones present concentric markings of another type than the Westoll-lines. These markings (*c. r*, fig. 6), which when Westoll-lines are developed usually occur only on the parts of the bones situated inside the innermost Westoll-line, are generally most distinct on bones *B*, *C* and *J* (fig. 6). The markings, which appear as concentric rings, seem to be caused by faint depressions and elevations in the dentine layer, and it is possible that the dentine layer is somewhat thicker in the elevations than in the depressions. Be this as it may, however, it seems likely that these rings have something to do with the growth of the dentine layer. As will be described below (p. 40, fig. 8 A), similar rings are sometimes developed also on the opercular.

It is of great interest to note that blisters (*bli*) and rough areas (*ar. res*) similar to those found in Osteolepids are developed (figs. 6, 7, 8 C). In fact, these structures are very common in the material available and are found both on the various dermal bones of the cranial roof and on the snout. Small rough areas without blisters are also frequently found. The presence of these structures indicates that the periodical resorbtion and reformation of the dentine layer in Dipnoans at least sometimes took place in the same way as in Osteolepids (cf. pp. 29—30).

The opercular (*Op*) in one of the *Dipterus*-specimens (No. 94 Edinb.) presents interesting conditions as regards the development of the dentine layer (fig. 8 A). In the peripheral parts of this bone the dentine layer

is wanting, the rough external face of the trabecular layer being exposed (*orn*). The preserved part of the dentine layer, except dorsally and posteriorly where it is continuous, is divided by several distinct lines (*w. l*)[1]) into a number of irregular small areas (cf. PANDER 1858; pl. 4:23—26). As far as could be established without microscopical investigations, the dentine in all these areas, and probably also in the continuous part of the dentine layer of the bone as well, is of the same height and thus probably belongs to one and the same generation of dentine. In each of the irregular areas the dentine shows several more or less distinct concentric rings (*c. r*), closely resembling the concentric rings found on some of the dermal bones of the cranial roof (p. 39, fig. 6) and suggestive also of the concentric bands or rings found in the dentine layer in some specimens of Scottish Osteolepids (JARVIK 1948a, p. 33, figs. 10, 11).

The presence of these rings (fig. 8 A) strongly indicates that the dentine layer in each of the areas was laid down and grew independently. In fact, there is reason to believe that a small, blister-like patch of dentine—most probably a single dermal tooth—was originally formed in each area at the centre of the rings and that this patch grew by the deposition of rings of new material along the margins until it filled the whole area and almost met adjoining patches, when the growth apparently ceased. These patches thus probably grew in the same way as the blisters in the Osteolepids presumably did (see pp. 29—30), but contrary to conditions in that group they evidently did not coalesce with the adjoining patches to form a continuous sheet of dentine. The new formation of dentine in this case thus probably started at several places in the central parts of the bone. However, it is impossible to say whether the old dentine layer was completely resorbed before the deposition of these patches, or whether like the blisters in Osteolepids, they were laid down in rough areas of resorbtion in the old dentine layer. It is also difficult to say whether the absence of the dentine on large parts (*orn*) of the external face of the bone, and on the main part of the external face of the subopercular (*Sop*) as well, is due to resorbtion or to post-mortem changes. Nor will I express any opinion as to the nature of the patch of dentine shown on the latter bone.

In some of the scales of the same specimen (fig. 8 B) the dentine

---

[1]) These lines, which probably correspond to the narrow but irregular grooves (areas of resorbtion) round the blisters in Osteolepids (fig. 2) may also be called Westoll-lines. This term in this paper is used in a wide sense and applies to all distinct, narrow grooves—concentric or irregular—in the dentine layer in Dipnoans, which divide that layer into concentric zones or irregular areas (pp. 32—38, figs. 6—10).

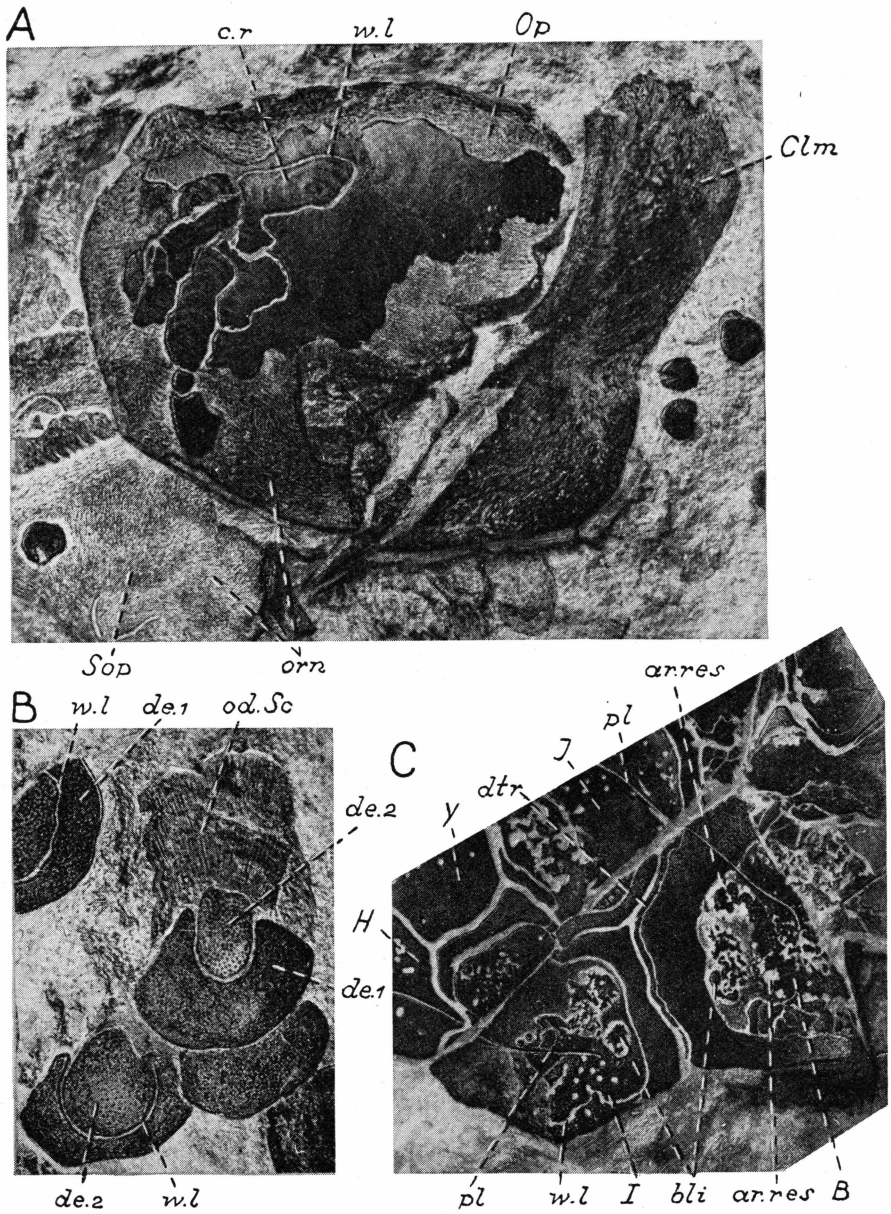


Fig. 8. *Dipterus valenciennesi*. *A*, part of incomplete fish in lateral view, showing mainly the opercular and the cleithrum. Specimen No. 94 Edinb. $^{3}/_{1}$. *B*, some scales of the same individual in external view. $^{5}/_{1}$. *C*, portion of posterior part of cranial roof in external view. Specimen No. 53390 Geol. Surv. $^{3}/_{1}$.

B, dermal bone of cranial roof; *Clm*, cleithrum; *H* (in error for *Y. 2*), *I*, *J*, dermal bones of cranial roof; *Op*, opercular; *Sop*, subopercular; *Y* (in error for *Y. 1*), dermal bone of cranial roof.

ar. res, rough areas, probably formed by resorbtion; *bli*, blister; *c. r*, concentric rings in dentine layer; *de. 1*, peripheral zone of dentine, probably representing old generation of dentine; *de. 2*, central zone of dentine, probably representing new generation of dentine; *dtr*, row of almost completely fused dermal teeth; *od. Sc*, overlapped area of scale; *orn*, ornamented parts of opercular and subopercular; *pl*, pit-line; *w. l*, Westoll-lines.

layer is divided by a U-shaped groove (*w. l*), resembling the Westoll-lines on the cranial roof, into two zones, one peripheral and one central. The dentine layer in the central zone (*de. 2*) is somewhat lighter in colour, and as far as could be established a little higher than the dentine layer in the peripheral zone (*de. 1*). The conditions are thus fairly similar to those found in the Osteolepid opercular shown in fig. 4 A (also fig. 5; cf. figs. 9, 10), and most probably the dentine in the central zone represents a blister, that is, it consists of newly deposited dentine (*de. 2*) surrounded by dentine of an older generation (*de. 1*). If this is correct, the formation of new dentine also in this case started in the central parts and proceeded outwards, not marginally.

In another specimen (No. 93 Edinb.) the gular plates and some other rather large but indeterminable plates with Westoll-lines are found. Two of the latter plates (*Rbr?x*, *Rbr?y*), which may belong to the cheek or, more probably, represent branchiostegal rays, are shown in fig. 9 A. As may be gathered from this figure, only a relatively small part of each of these plates is covered by dentine. The main part of the external face of each of the plates presents a faint ornamentation, which differs clearly from the relatively coarse ornamentation of ridges and tubercles found on other bones of the same individual where the dentine layer is missing (e. g. on the opercular, *Op*). This fact and the general development and position of the two plates renders it likely that the absence of the dentine layer on large parts of the bone is due to these parts having been deeply embedded in the skin (cf. p. 9).

On both the plates figured (*Rbr?x*, *Rbr?y*, fig. 9 A) the dentine layer is divided by distinct circular or U-shaped Westoll-lines into several zones. On the gular plates of the specimen in question the Westoll-lines are in places broad and indistinguishable from the rough

---

Fig. 9. *A*, *Dipterus valenciennesi*. Part of flattened skull in external view, showing some of the dermal bones of the cheek, part of the opercular, and some undetermined plates (branchiostegal rays?) with Westoll-lines. Specimen No. 93 Edinb. $^3/_1$.

B-E, two detached plates of an undetermined form (Dipnoan?) from Kokenhusen, Latvia. *B*, impression of external face of relatively large plate. Specimen No. 4211 Stockh. $^3/_1$. *C*, *D*, small plate in external and internal view. Specimen No. P. 4198 Stockh. $^4/_1$. *E*, diagram of the same plate to show the position of the Westoll-lines of the external face in relation to the rings in the basal layer. The position of the centre of radiation of the plate denoted +. The interrrupted line marks the approximate position of the section shown in fig. 10. $^6/_1$.

Ch. b, dermal bones of cheek; *Op*, opercular; *Rbr?x*, *Rbr?y*, undetermined bones (branchiostegal rays?).

de. 1, peripheral zone of dentine, representing the oldest generation of dentine; *de. 2*, *de. 3*, *de. 4*, younger generations of dentine; *l. b. l*, lamellae of basal (isopedin) layer of bone; *orn*, *orn. 1*, *orn. 2*, areas of bones devoid of dentine; *w. l. 1*, *w. l. 2*, *w. l. 3*, Westoll-lines.

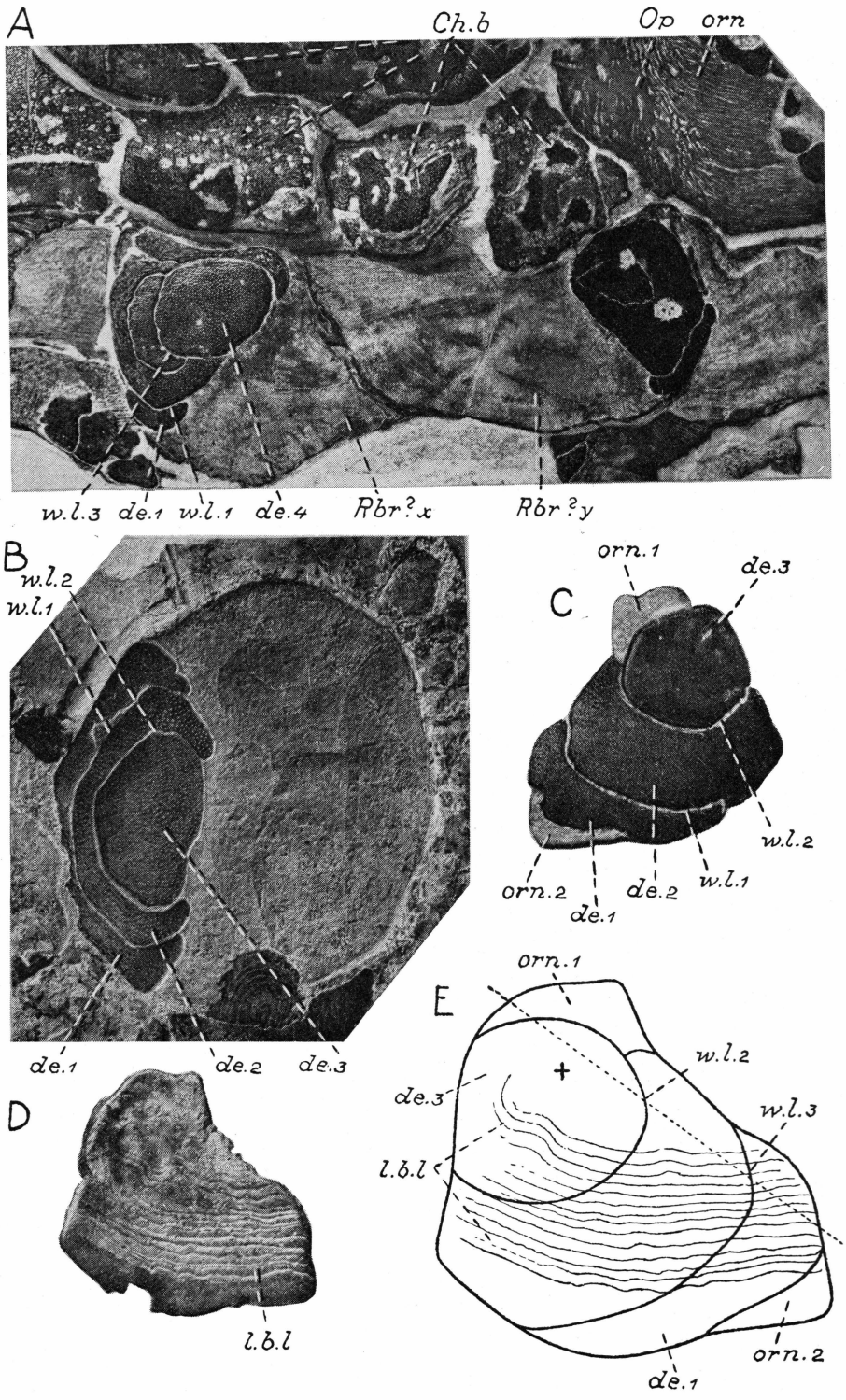

A
Ch.b
Op
orn
w.l.3
de.1
w.l.1
de.4
Rbr?x
Rbr?y
B
w.l.2
w.l.1
de.1
de.2
de.3
C
orn.1
de.3
w.l.2
orn.2
de.2
w.l.1
de.1
D
l.b.l
E
orn.1
w.l.2
de.3
w.l.3
l.b.l
orn.2
de.1

Fig. 9.

areas (*ar. res*) surrounding the blisters in the specimen shown in fig. 4 A and in other Osteolepids (fig. 2). On the plate marked *Rbr?x* in fig. 9 A there are three Westoll-lines (*w. l. 1*, *w. l. 2*, *w. l. 3*) and thus four zones of dentine (*de. 1*, *de. 2*, *de. 3*, *de. 4*). As far as could be established without sections, the dentine layer in each zone rises above and is a little higher than in the zone following next outside it, the dentine in the innermost zone (*de. 4*, fig. 9 A) being the highest and thus probably the youngest. That this is so, is, as we shall now see, strongly supported by the conditions in certain plates from Kokenhusen in Latvia.

Some of these plates from Kokenhusen are very similar to the undetermined plates in *Dipterus* just described and possibly they belong to one of the Dipnoans represented at this locality (cf. PANDER 1858, p. 14; GROSS 1942, p. 394). Two such plates, Nos. P. 4198 and P. 4211 Stockh., both showing three zones of dentine (*de. 1*, *de. 2*, *de. 3*) separated by two Westoll-lines (*w. l. 1*, *w. l. 2*, figs. 9 B, C, E, 10), have been figured. On the lower side of the plates (fig. 9 D; cf. fig. 9 E) there are several concentric and semicircular rings (*l. b. l.*) similar to those found on the lower face of the scales in *Dipterus valenciennesi* (see PANDER 1858, p. 13; pl. 2:8) and many Crossopterygians (p. 110; fig. 32 D, 33 B). These rings, which are most distinct on the marginal parts of the bone farthest from the centre of radiation (+ in fig. 9 E), rise a little above each other towards the periphery, the lower face thus being terraced (fig. 10 A, D; cf. fig. 11). As will be further elucidated below (p. 51), these rings mark the areal growth of the bone plates. It is of considerable interest that there is no correspondance between these rings on the lower face and the Westoll-lines in the dentine layer (see fig. 9 E), and evidently the Westoll-lines have nothing to do with the areal growth of the plates as a whole (see below).

Some sections have been prepared of the smaller of the Kokenhusen plates (No. P. 4198, fig. 9 C—E). The main part of the best of these sections is figured here (fig. 10). The position of this section is marked by an interrupted line in fig. 9 E.

As may be gathered from these sections, the dentine layer in each of the three zones is simple and has been laid down on the rough external face of the trabecular layer, which is exposed in two areas (*orn. 1*, *orn. 2*, figs. 9 C, E, 10 B, C) along the margin of the bone. The dentine layer in the most peripheral zone, *de. 1*, rises—at the outer of the two Westoll-lines (*w. l. 1*)—distinctly above, and is a little higher than, the dentine in the adjoining part of zone *de. 2* (see fig. 10 A), and the dentine in the latter zone at the next Westoll-line (*w. l. 2*) rises above the dentine in the adjoining part of zone *de. 3* (fig. 10 B). However, as is clearly seen in the sections, the dentine layer in zone *de. 3*, the external face of which is convex, is as a whole thicker than in zone *de. 2* and thicker

in the latter zone than in zone *de. 1.* Though the differences in height between the dentine layers of the three zones are quite inconsiderable (cf. p. 31), it is evident that we are concerned with three different generations of dentine, zone *de. 3* representing the youngest and zone *de. 1* the oldest. The youngest generation of dentine is situated mainly in the central parts of the bone, above the centre of radiation (marked + in fig. 9 D), i. e. above that part of the bone which is the oldest—as far as only the deeper parts are considered—whereas the oldest generation of dentine (*de. 1*) mainly covers the part of the bone that is the youngest as proved by the development of the lamellae in the basal layer (cf. p. 51—53 and fig. 11 A). Since the youngest dentine thus covers the oldest part of the bone, it is quite evident that the dentine of this generation cannot have been deposited in connection with the formation and growth of the bone as a whole, but must have been formed independently and later than the underlying parts. In view of the fact that the Westoll-lines and the outermost two zones of dentine (*de. 1*, *de. 2*) do not coincide with the growth rings (*l. b. l*) in the basal layer (see fig. 9 E), it is obvious that at least the main parts of these two zones were also laid down after the formation of the underlying parts of the bone. None of the three generations of dentine actually found can thus represent the first generation of dentine of the bone and evidently that generation, which probably was made up of a very thin layer (cf. p. 28; fig. 4 B), was completely removed before the oldest of the generations of dentine of the bone (*de. 1*) was deposited. In this case, at any rate, a repeated resorbtion and reformation of the dentine layer must obviously have taken place.

No spaces of resorbtion in the pulp cavities of the individual dermal teeth of the dentine layer of the type described by Bystrow (1942) have been observed either along the Westoll-lines or elsewhere; nor have such spaces been found in the other sections described in this paper (figs. 3, 5). However, in the section shown in fig. 3, the part of the old dentine layer (*de. l. 1*) overlain by the blister (*bli*), is pierced by strong canals between the individual dermal teeth, and as already pointed out (p. 25) these canals were obviously formed, or at any rate widened, by resorbtion. Since, in all the sections at my disposal, similar canals (*vc*) are developed where two generations of dentine meet—in fig. 3 along the margin of the blister, in fig. 5 along both margins of the area of resorbtion and in the specimen now under consideration (fig. 10) along each Westoll-line—it is likely that the resorbtion of the old layer of dentine and obviously also the growth of the new one

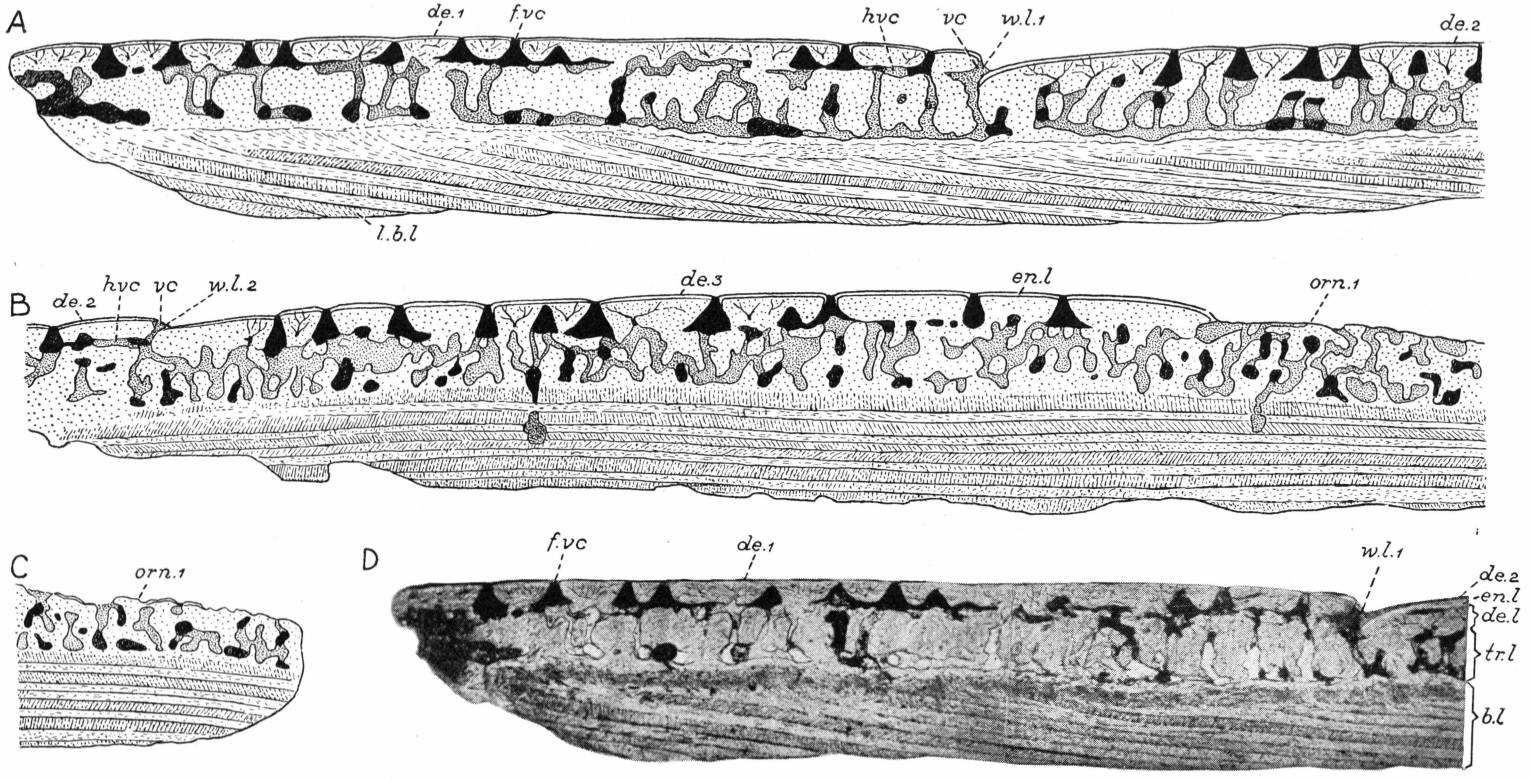


Fig. 10. Section along the interrupted line in fig. 9 E of the undetermined plate from Kokenhusen shown in fig. 9 C-E. Section No. S. 813 Stockh. (specimen No. P. 4198 Stockh.). Ca. $^{67}/_{1}$.

A-C, sketch after microphotograph. A small part of the section between *A* and *B* omitted. *D*, microphotograph, showing the main portion of the part of the section illustrated in *A*. *b. l*, basal (isopedin) layer; *de. l*, dentine layer; *de. 1*, peripheral zone of dentine, representing the oldest generation of dentine; *de. 2*, middle zone of dentine, representing the next oldest generation of dentine; *de. 3*, central zone of dentine, representing the youngest generation of dentine; *en. l*, enamel layer: *f. vc*, opening of vascular canal: *hvc*, horizontal vascular canal; *l. b. l*, lamellae of basal layer; *orn. 1*, ornamented part of bone (cf. fig. 9 C, E); *tr. l*, trabecular layer; *vc*, vascular canals; *w. l. 1*, *w. l. 2*, Westoll-lines.

occurred at these places. In this connection it is perhaps of interest to note that the horizontal vascular canals (*hvc*) in the neighbourhood of the Westoll-lines (fig. 10)—or, as regards the specimen shown in fig. 5, close to the area of resorbtion, which, as is easily understood, is nothing but a broad Westoll-line—are more common below the old than below the new layer of dentine. On the basis of the few sections at my disposal it is impossible to decide whether this condition is fortuitous or whether it implies that also such canals were formed or widened by resorbtion. It is feasible that also such canals were formed and that the old dentine layer in this way became loosened and liable to fall off. This would explain the absence of parts of the dentine layer in many cases (cf. p. 20).

Concluding remarks.

As may be gathered from the descriptions now given, the structure of the dentine layer in Osteolepids and Dipnoans is very intricate, especially in the latter group. Further detailed studies, both macroscopical and microscopical, are necessary to solve definitely all the problems concerning the growth of the dentine layer and the resorbtion and redeposition of that layer. However, in view of the various facts set forth above we may assume that these processes took place somewhat as follows (as regards the Osteolepids see also pp. 29—30)[1]).

The formation of each of the successive dentine layers of the individual dermal bones or scales started at one or several centres. As evidenced by the structure of the very small blisters (see p. 22) a small patch of dentine consisting of a single dermal tooth (or possibly a small group of dermal teeth) was deposited at each such centre of growth.

The areal growth of such a patch of dentine (blister) took place by successive marginal apposition of originally independent dermal teeth (or groups of teeth), which soon fused with each other and with those earlier formed into a continuous dentine layer (cf. p. 38 and fig. 7). The disposition of the new dermal teeth was certainly irregular in many cases and the dentine layer could grow more rapidly in some directions than in others. In some cases, however, the newly formed dermal teeth were arranged in distinct single rows which formed more or less complete rings, concentric with regard to the centre of growth (fig. 7). The teeth in these rings usually fused with each other and

[1]) It is worth while mentioning in this connection that in Tremataspids, in which the histological structure of the exoskeleton resembles that in Osteolepids and early Dipnoans, the dentine layer presents certain lines suggestive of those found in Dipnoans (see Robertson 1938, pl. 2:5, 8; Denison 1947). However, according to Denison it is uncertain whether these lines represent growth-lines. As regards the conditions in primitive *Porolepiformes* see p. 21.

generally also with the marginal dermal teeth of the continuous sheet of dentine following inside the ring and were thus successively incorporated in that sheet. In some cases, however, the new ring of teeth probably retained its independence or fused with rings formed later. In this way the concentric Westoll-lines of the type shown in fig. 7 B (cf. *dtr*, figs. 6, 7 A, 8 C) probably arose. Since such independent concentric rings of dentine as have hitherto been encountered only in the cranial roof of *Dipterus*, occur only along the periphery of the individual dermal bones, it is possible that they were formed in connection with the areal growth of the bone as a whole and cover the newly formed marginal zone of the bone (cf. p. 53 and fig. 11 A). Also the first layer (generation) of dentine of the individual dermal bones or scales, which probably was very thin and did not wholly conceal the ornamentation of the underlying trabecular layer (p. 28, 45, fig. 4 B), probably grew by the apposition of marginal zones formed in connection with the zones of growth in the deeper parts of the bone (cf. p. 53 and fig. 11 A). The areal growth of each new layer of dentine, formed after the resorbtion of a preceding layer, on the other hand, generally took place independently of the areal growth of the deeper parts of the bone, and the centre or centres of growth of the new dentine layer of each of the dermal bones have nothing to do with the centre of growth (centre of radiation) of the deeper parts of the bone (cf. p. 45).

It is difficult to say whether the various layers of dentine increased in thickness in connection with their areal growth. It is feasible, however, that sometimes the newly formed dermal teeth or rings of teeth suddenly became thicker than the preceding ones, which would explain why the dentine if BYSTROW is correct (see p. 31), in certain cases is about double as high outside as inside the Westoll-lines. It deserves to be pointed out in this connection that the indistinct concentric ring (*c. r*) sometimes found in the dentine layer (see pp. 39—40; figs. 7, 8 A) may possibly be due to slight differences in height between the dentine in the various rings.

The growth in thickness of the dentine layer took place either by the deposition of a new layer upon the old one in connection with a partial resorbtion of the latter layer or by a complete resorbtion of the old layer and the formation of a new and thicker layer.

The former mode of growth in thickness was evidently of little importance since the dentine layer both in Osteolepids and Dipnoans generally is simple (26; cf. p. 31). A double layer of dentine has hitherto been found only in the areas in Osteolepids occupied by

blisters of the superficial type (see p. 25; fig. 3). In *Porolepiformes*, on the other hand, two or more layers of dentine above each other are frequently found (p. 26).

Both in Osteolepids and Dipnoans the dentine layer generally increased gradually in thickness by a repeated process of resorbtion and reformation of dentine, each new layer (generation) growing slightly thicker than the preceding one. The absence of the dentine layer in certain cases (cf. p. 20 and figs. 4 A, 8 A, 9 A, *orn*) renders it likely that the whole old dentine layer, or a considerable part of it, was sometimes removed by resorbtion before the deposition of the new layer began, but usually only one or several small areas of resorbtion were formed in the old dentine layer on each of the dermal bones or scales. In each of these areas new material (blisters of the inserted type) was deposited and the processes of resorbtion and redeposition went on simultaneously and at about the same rate on one and the same dermal bone.

As regards the mode of resorbtion and redeposition of the dentine layer there seem to be certain differences between Osteolepids and Dipnoans.

In the Osteolepids these processes usually started at several centres on each of the bones. As described above (pp. 29—30; Jarvik 1948a, fig. 8 A—D), the resorbtion probably began with the formation of dimunitive areas of resorbtion in the old dentine layer, and in each of these areas a small patch of dentine, a blister, belonging to a new and slightly thicker generation of dentine was laid down. The blisters grew by marginal deposition of dermal teeth, as outlined above (p. 47), and all the blisters on each bone, which conceivably belong to one and the same generation of dentine, ultimately fused with each other and formed a continuous layer of new dentine. In this layer the areal growth of the individual blisters is sometimes marked by irregular systems of concentric alternate dark and light rings (see Jarvik 1948a, p. 33, figs. 10, 11). Since the processes of resorbtion and reformation of the dentine layer began simultaneously at several places, these processes could be completed in a relatively short time, which possibly explains why in the Osteolepids—at least as far as is known —there are at most two generations of dentine at the same time on one and the same dermal bone.

In the Dipnoans, on the other hand, three or more generations of dentine are in many cases represented on the individual dermal bones, and another difference as compared with the Osteolepids is that often only one centre of growth is recognisible in each generation of dentine.

Judging from the data presented above (pp. 31—47, figs. 6—10), it seems likely that the resorbtion and growth of the various dentine layers in the Dipnoans often took place in the following way. A single area of resorbtion with a blister belonging to a new and slightly higher generation of dentine (cf. *de. 2*, figs. 9 C, 10) was formed somewhere in the central parts of the old layer of dentine (*de. 1*). This area became enlarged by resorbtion and simultaneously the blister grew in the normal way, so that it nearly filled the area of resorbtion, and it was separated from the surrounding old generation of dentine by a narrow groove-like area of resorbtion, that is a Westoll-line (*w. l. 1*). However, rather soon and long before the old generation of dentine (*de. 1*) was completely destroyed by resorbtion, a new area of resorbtion and a blister belonging to a third and still higher generation of dentine (*de. 3*) was formed somewhere in the blister of the second generation of dentine. In this way there arose three generations of dentine on the same bone, the innermost (*de. 3*) being the youngest (see figs. 9 C, 10), and it is easily understood that further generations of dentine may have been added in the same way.

In view of the fact that both the resorbtion of each of the old layers of dentine and the formation of each of the new layers started at a single centre these processes presumably progressed more slowly than they usually did in the Osteolepids and went on for a relatively long time. It is also to be assumed that in many cases the areal growth of the deeper parts of the bone (cf. pp. 52—53) continued during that same time and that in connection with this process narrow marginal zones of dentine were added, covering the newly formed part of the bone. In this way it would be possible to explain the conditions actually found in the specimen shown in figs. 6 and 7, in which narrow zones of newly deposited dentine are found along the sutures between the various bones (cf. pp. 37—38).

However, as we have seen (p. 39, figs. 6, 7e, C; cf. p. 40 and fig. 8 A), besides narrow, regular Westoll-lines the dermal bones in Dipnoans may show also one or more blisters and irregular areas of resorbtion, closely resembling those found in the Osteolepids. It is to be assumed, therefore, that the comparatively slow mode of resorbtion and reformation of the dentine layer in Dipnoans described above, in this group of fishes was combined with a more rapid one, through which—exactly as in the Osteolepids (see pp. 29—30, 49)—the old dentine layer was completely destroyed by resorbtion in a rather short time (annual season?) and was replaced by a new and thicker layer. Since, in certain specimens, blisters and rough irregular areas of resorbtion are very common on the continuous sheet of dentine covering the snout, where, on the other hand, no traces of concentric Westoll-lines have been found in the material avail-

able, it seems likely that also this continuous layer was rapidly resorbed and formed anew at intervals, which would make the areal growth of the individual dermal bones of the snout possible.

Remarks on the growth of the dermal bones and scales.

In the above account it is mainly the growth of the dentine layer that has been discussed. However, the material available also presents certain data which deserve consideration here, since they seem to be of some significance for the understanding of the growth of the dermal bones as a whole and in this way may shed some new light upon the question of the nature of the dermal bones (cf. JARVIK 1948a, p. 80).

The following facts deserve consideration.

1. As pointed out above the ventral face of the bone plate from Kokenhusen shown in fig. 9 D presents several concentric growth rings, and similar growth rings are developed also on the ventral face of the scales of *Dipterus* (PANDER 1858) and of certain *Porolepiformes* described below (p. 110, figs. 32 D, 33 B). As evidenced from the section of the Kokenhusen plate (fig. 10 A, D), these rings are the inner margins of the lamellae forming the basal (isopedin) layer. These lamellae, which in the parts of the plate showing growth rings on the ventral face, have an oblique position in relation to that face, no doubt registrate the successive growth of the basal layer. This layer thus evidently grew by the successive apposition of concentric new lamellae of isopedin along the margin.

2. The trabecular layer in both Crossopterygians and Dipnoans (see e. g. PANDER 1858; pl. 1:10, 11; JARVIK 1948a, figs. 5 E, F, 6; pls. 37:8, 10, 12, 13) also presents distinct concentric rings, which probably mark the successive areal growth of this layer. This layer thus presumably grew in the same manner as the basal layer. Besides these concentric rings the trabecular layer presents closely set radiating lines, which divide the various rings into minor units.

3. Also the dentine layer grew, as demonstrated above (pp. 47—48, fig. 7 B), by the successive apposition of marginal narrow rings, each ring consisting of a single row of originally independent dermal teeth.

4. In the part of the section of specimen No. P. 4198 Stockh. shown in fig. 10 A, D, about 12 of the oblique isopedin lamellae meet the inner face of the part of the trabecular layer that is covered by the oldest generation of dentine (*de. 1*). On a photograph showing the dorsal face of the sectioned plate (cf. fig. 9 C) in great magnification the dermal teeth of this generation could be counted. Along the section they were found to be approximately 12 in number. Disregarding the fact that

the generation of dentine in question, as pointed out above (p. 45), was formed independently and later than the underlying part of the bone, which probably is of little importance in this connection, there is thus definite agreement between the thickness of the lamellae of the basal layer and the width of the individual teeth of the overlying dentine

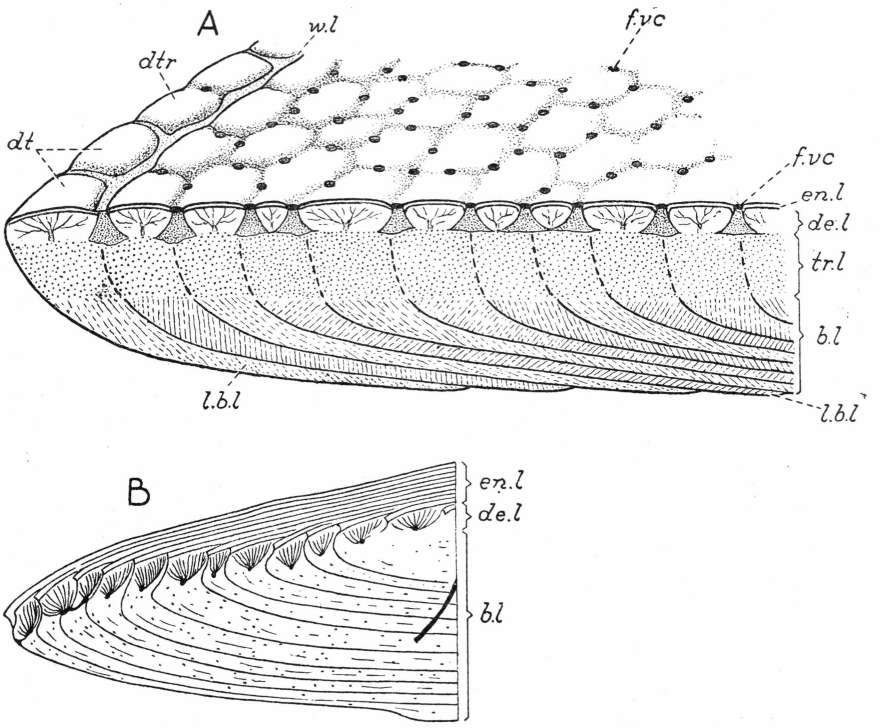


Fig. 11. *A*, diagram illustrating the presumed mode of growth of the scales and dermal bones in Crossopterygians and Dipnoans. Based mainly on the specimens shown in figs. 7 and 10. *B*, *Acrolepis* sp. Vertical section through free edge of scale. From GROSS 1935 (text-fig. 19).

b. l, basal layer; *de. l*, dentine layer; *dt*, dermal teeth, *dtr*, row of incompletely fused dermal teeth; *e. l*, enamel layer; *f. vc*, openings of vascular canals of bone; *l. b. l*, lamellae of basal (isopedin) layer; *tr. l*, trabecular layer; *w. l*, Westoll-line.

layer, and evidently the number of growth rings and the breadth of each ring were approximately the same in the dentine layer as in the basal layer.

Considering the facts summarized in Points 1—4, we are led to the assumption that in the areal growth of the dermal bones and scales in Osteolepids and early Dipnoans narrow concentric zones were successively added along the margins, as shown diagrammatically in fig. 11 A. Each of these presumed zones of

growth, which, as may easily be gathered from fig. 9 D, did not always form a complete ring round the bone or scale, consisted of an isopedin lamella, a laminar portion of the trabecular layer, and a superficial ring of dermal teeth. Provided that this assumption is correct, the dermal bones and scales in Osteolepids and early Dipnoans, and conceivably also in other Crossopterygians and Dipnoans as well, thus grew in fundamentally the same way as in early Actinopterygians (fig. 11 B; see also *Lepidotes*; GROSS 1935, figs. 22, 23; *Palaeoniscus*; ALDINGER 1937, fig. 30; cf. GOODRICH 1907; ALDINGER 1937, p. 372).

As we have seen above, the superficial portion of each presumed zone of growth is composed of a single row of originally independent dermal teeth (*dt*, figs. 7, 11 A), and the portion of the zone of growth belonging to the trabecular layer is also subdivided by the radiating lines mentioned above into a great number of minor units. It is not known whether there is any correspondence in size and number between these units of the trabecular layer and the overlying dermal teeth and as far as I know no corresponding subdivision of the lamellae of the basal layer has been noticed. However, even on the basis of the data available it is tempting to assume that each zone of growth is composed of a great number of small rod-like units of growth, each consisting of a single dermal tooth, an underlying thin portion of the trabecular layer, and a thin pillar of the isopedin lamella, and corresponding to a single or possibly to a group of the small units of growth recently identified by STENSIÖ and ØRVIG (1949) in Elasmobranchs and by them called lepidomoria.

On the presumption that the views as to the growth of the dermal bones and scales tentatively advanced above really are correct, which requires confirmation, the exoskeleton is obviously composed of a greater number of units of growth than there was reason to suppose merely on the basis of embryological data and of the subdivision of the dermal bones actually found in the adult (see JARVIK 1948a, pp. 62—88, 287—292). It may be assumed that these very small units, like the components (primary scales) recognized in my previous paper (JARVIK 1948a), may fuse to make various combinations, and it is possible that many of the small variations in the extent of the dermal bones and scales actually found is due to the said units having fused in different ways. Since these small units apparently were formed continually as long as the growth of the exoskeleton went on it is even possible that new small dermal bones not represented in young individuals, may arise along the sutures in late stages of development (cf. the Wormian dermal bones in Man; DE BEER 1937, pp. 367—368).

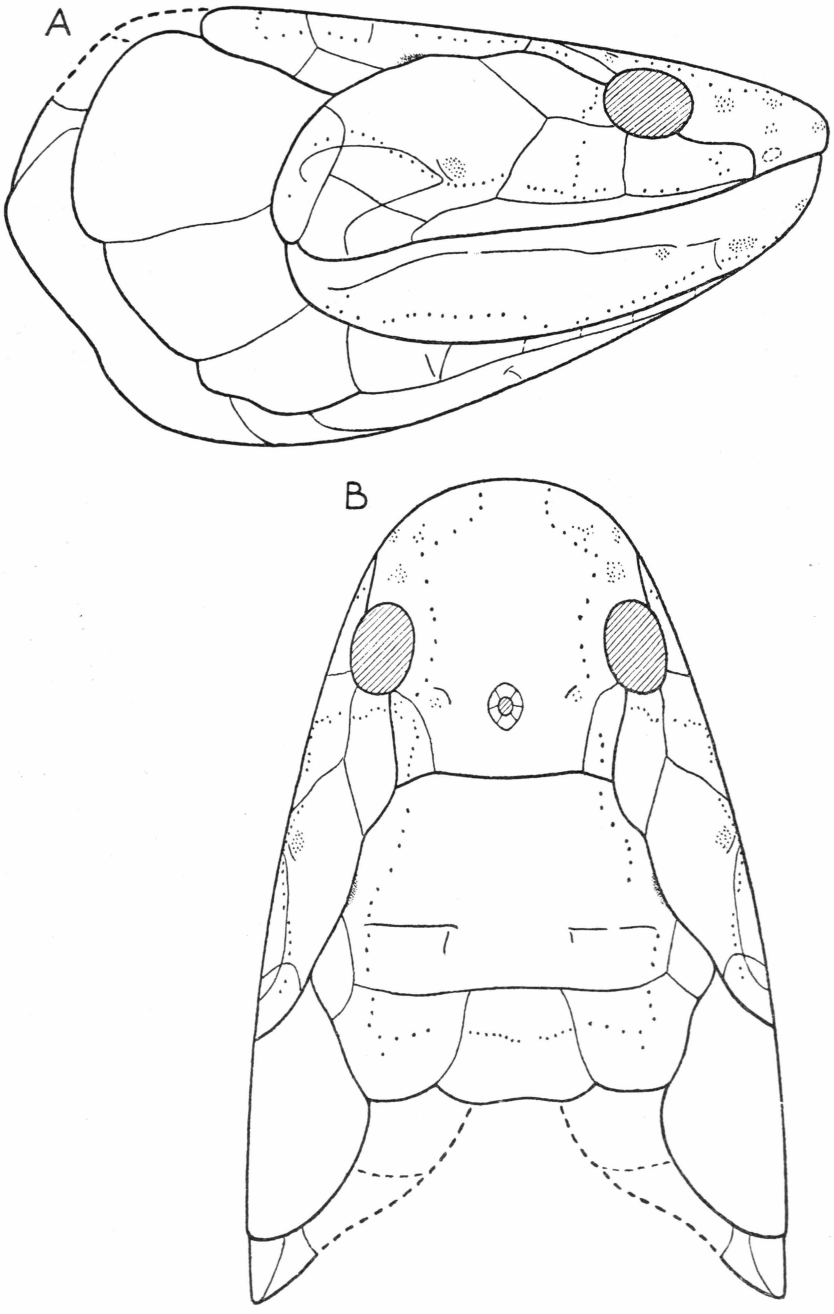
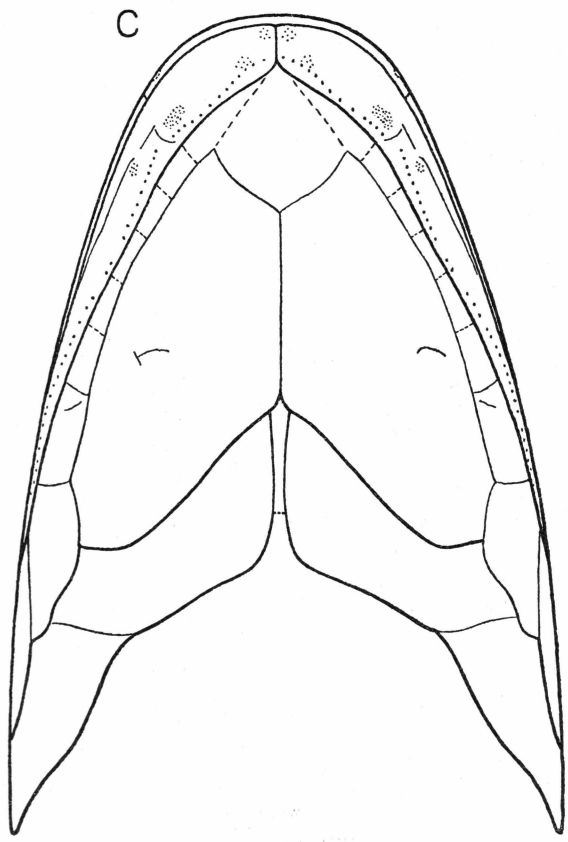


Fig. 12. *Gyroptychius groenlandicus* n. sp. Restoration of the head and exoskeletal shoulder-girdle in, *A*, lateral, *B*, dorsal and, *C*, ventral aspects. Based mainly on the holotype. $^{2}/_{1}$.

For explanations see fig. 29 (also fig. 25).



The head.

The length of the head, from the tip of the snout to the transverse plane through the posterior end of the opercular, is ca. 50 mm. in the type-specimen of *Gyroptychius groenlandicus*, that is about as in the holotype of *G. milleri* (JARVIK 1948a, p. 261); but whereas the head in the latter form is about 3.3 times longer than the parietal shield, the corresponding relation in *G. groenlandicus* is ca. 3.6, that is the parietal shield is relatively short. In both forms the head is fairly short and broad, being only about 1.40 times longer than it is broad (cf. JARVIK 1948a, p. 35).

In the type-specimen the parietal shield measures 14, the fronto-ethmoidal shield 22, and the external cheek plate about 32 mm. in length. The lower jaw may be estimated to have been ca. 41 mm. long. The opercular measures 15 and the principal gular 28 mm. in length. Specimen No. P. 1325 (pl. 3:1; pl. 4), which next to the holotype is the most complete of the specimens available, is only a little larger

than the holotype (col. 1, 2, table 1; col. 7, table 2; col. 1, table 4; col. 3, table 5; col. 1, table 6). In the other specimens, which are generally represented only by detached dermal bones or complex units, these structures are sometimes of about the same size as, or smaller, than the corresponding structures in the holotype (see tables 1—6). In most cases, however, they are relatively large and in some specimens they attain a remarkable size. Thus, in specimen No. P. 1307 the quadrato-jugal is about 1.5 times longer than that in the holotype (see col. 3, table 3), and in No. P. 1382, which shows the fronto-ethmoidal shield, this shield is 36 mm. long, that is ca. 1.65 times longer than that in the holotype (col. 2, table 1). The subopercular in No. P. 1390 is ca. 1.60 and the opercular in No. P. 1379 about 1.70 times longer than in the holotype (see col. 1, 3, table 5). Still larger, proportionately, are the median extrascapular shown in pl. 5:4, which is about 1.85 times longer and about 1.90 times broader than the corresponding bone in the holotype, and the lachrymal (No. P. 1330) shown in pl. 9:6, which is almost 3 times longer than that in the type-specimen (cf. col. 1, table 2). It is difficult to say whether all these relatively large bones and units belong to *G. groenlandicus*.

The cranial roof.

The exoskeletal cranial roof (fig. 13) which is composed of the fronto-ethmoidal shield, the parietal shield, and the extrascapular series of bones, is most completely shown in the type-specimen and in Nos. P. 1301 and P. 1325 (fig. 15 A—C).

The anterior part of the cranial roof covering the snout curves in the way characteristic of *G. milleri* (fig. 14 B, D; JARVIK 1948a, pp. 36—37, 262). Most anteriorly, at the tip of the snout, it is thus bent strongly downwards and a little backwards, whereas in the region above the lachrymo-maxillary notch it curves very little downwards. The snout, accordingly, is very broad and the fenestra exonarina anterior (*fe. exa*) is not visible when the skull is viewed from above. The remaining parts of the cranial roof curve as in Osteolepids in general (JARVIK 1948a, pp. 15—16, fig. 3 B—F). The median depression of the cranial roof and the elevation at the pineal foramen (*m. el*, fig. 14 B; cf. JARVIK 1948a, pp. 13, 36) are in most specimens weakly developed or not discernible.

The ventrally protruding part of the cranial roof situated ventrally and postero-ventrally to the fenestra exonarina anterior in the material available is badly crushed or missing, and accordingly the subnarial corner (*snc*, fig. 13 B) is not well displayed. The lachrymo-maxillary notch (*i. La+Mx*, figs. 12 A, B, 13, 15 A—C, 16; pl. 2:1; pl. 4:1; pl. 5:1; pl. 6:1—5), fairly well shown in several specimens, is angular

and also in other respects suggestive of that in *G. milleri* (fig. 14 B, D). As in that form, the preorbital corner (*proc*, figs. 12 A, B, 13, 15 A—C, 16; pl. 1:1; pl. 2:1; pl. 3; pl. 5:1; pl. 6:1—5; pl. 7; pl. 9:3) is situated on the tip of a process projecting in a postero-ventral or posterior direction and bounding the orbital fenestra antero-ventrally. In No. P. 1381 (pl. 9:3) this process is very large and forms the main part of the ventral margin of the orbital fenestra, and in No. P. 1375 (pl. 7:6), too, it attains a considerable size.

The orbital notch (*i. o*, figs. 12 A, B, 13, 15, 16; pl. 1:1; pl. 2:1; pl. 3; pl. 5:1; pl. 6:1—5; pl. 7; pl. 9:2, 3) is short and deep (cf. figs. 14, 25 A, C). Its length amounts to ca. 0.42—0.48 of the length of the parietal shield and to ca. 0.25—0.30 of the length of the fronto-ethmoidal shield (col. 3, 4, table 1). On an average it is thus a little longer, proportionately, than in *G. milleri*, in which the corresponding ratios range from ca. 0.34 to ca. 0.40 and from ca. 0.18 to ca. 0.29, respectively. As in that form but contrary to conditions in most other Middle Devonian Osteolepids from Scotland (Jarvik 1948a, col. 7, table 1), it is less than twice as long as it is deep, the ratio *l. i. o/dp. i. o* ranging from ca. 1.56 to ca. 1.90 (col. 5, table 1).

The postorbital corner (*ptoc*, figs. 12 A, B, 13, 15, 16; pl. 2:1; pl. 3; pl. 5:1; pl. 6:1—3, 5; pl. 7:2, 6) varies as in other Osteolepids, and may be formed either by the posterior supraorbital or by the dermosphenotic (cf. Jarvik 1948a, p. 40). The postorbital notch (*i. Po*, figs. 12 A, B, 13, 15; pl. 3:1) is long and shallow. It is about 6 times longer than it is deep and its length amounts to about 0.64—0.70 of the length of the parietal shield (col. 6, table 1). It is thus a little longer, proportionately, than in *G. milleri* (*l. i. Po/a* ca. 0.52—0.58) and nearly as long as in *G. agassizi* (*l. i. Po/a* ca. 0.68—0.75). The spiracular notch (*i. spir*, figs. 12 A, B, 13, 15, 17 A—F; pl. 2:1; pl. 3:1; pl. 5:2; pl. 8:1—3, 5; pl. 9:1, 2, 4, 5) is developed as is usual in Osteolepids.

As to its proportions the cranial roof agrees most closely with that in *G. milleri* (figs. 14 B, D; 25 C; table 1).

The ratio *b/a*, giving the length of the fronto-ethmoidal shield as compared with the length of the parietal shield, could be calculated only in three specimens (fig. 15 A—C; col. 7, table 1). In two of these specimens, viz. in the holotype and No. P. 1301, this ratio is ca. 1.51 and ca. 1.53, respectively, whereas in the third specimen, No. P. 1325, the fronto-ethmoidal shield is a little shorter proportionately, being only about 1.41 times longer than the parietal shield. The latter specimen in this respect agrees with the holotype of *G. milleri*.

The preorbital division of the fronto-ethmoidal shield as a whole is somewhat shorter proportionately than the corresponding division in *G. milleri*. Its length (*r*) is thus only 0.76—0.89 of the length

Table 1. *Gyroptychius groenlandicus* n. sp. The range of variation of the length of (col. 3—15) in the various specimens. The corresponding figures for *G. agassizi* and

a, median length of parietal shield; *b*, median length of fronto-ethmoidal shield; *d*, breadth roof at orbital, postorbital, and spiracular notches; *l. i. o*, *l. i. Po*, lenght of orbital and postorbital

For explanations see also

Museum's number	Locality	1	2	3	4	5	6
		$\frac{a}{\text{mm.}}$	$\frac{b}{\text{mm.}}$	$\frac{l.io}{a}$	$\frac{l.io}{b}$	$\frac{l.io}{dp.io}$	$\frac{l.i.Po}{a}$
G. groenlandicus							
P. 1310 (holotype) ...	210–234 m.[1])	14	22	0.48	0.30	1.82	0.68
P. 1301	—	14	22	0.42	0.27	1.56	0.65
P. 1325	—	15	23	0.43	0.29	1.90	0.64
P. 1401	—	15	..	..	..	..	0.70
P. 1302	—	..	22	..	0.27	1.63	..
P. 1327	—	..	25	..	0.28	1.64	..
P. 1303	Kollen	..	20	..	0.30	1.80	..
P. 1304	—	..	22	..	0.30	1.82	..
P. 1371	Circusbjærg	..	25	..	(0.25)	(1.90)	..
P. 1382	Vimmelsk.	..	36	..	0.25	1.74	..
P. 1306	210–234 m.[1])	14	..	..	..	..	..
P. 1340	—	18	..	..	..	..	..
P. 1305	Kollen	15	..	..	..	..	..
P. 1362	—	19	..	..	..	..	..
P. 1391	E. part of Circusbj.	17	..	..	..	..	..
G. milleri.....	..	15–26	21–39	0.34–0.40	0.18–0.29	1.10–1.89	0.52–0.58
G. agassizi.....	..	16–29	24–42	0.32–0.35	0.23–0.24	2.50–2.70	0.68–0.75

[1]) The horizon at 210—234 m. in the NW. part of Hesteskoen, Canning Land.

($s+t$) of the orbital and postorbital divisions together (col. 8, table 1), whereas in *G. milleri* the ratio $r/s+t$ ranges from ca. 0.85 to ca. 1.00. The orbital division, on the other hand, is relatively longer than that in *G. milleri* (cf. col. 3, 4, table 1), whereas the postorbital division is of about the same length in the two species (col. 9). The differences between *G. groenlandicus* and *G. milleri* as regards the relative length of the preorbital and orbital divisions are thus due to the fact that the orbital fenestra is somewhat larger and extends a little farther forwards in the former than in the latter species.

As in *G. milleri* the cranial roof is very broad in the posterior parts of the snout—about as broad as the fronto-ethmoidal shield is long—but relatively narrow at the orbital notches, which are deep and situated close together. The breadth of the cranial roof at the posterior part of the snout in the well-preserved specimens thus ranges from ca. 0.96

the parietal (col. 1) and fronto-ethmoidal (col. 2) shields and of certain proportions *G. milleri* (fig. 14) given for comparison (cf. JARVIK 1948a, tables 1, 9, pp. 42, 248

of cranial roof at preorbital corner; *dp. i. o*, depth of orbital notch; *e, f, g*, breadth of cranial notches; *r, s, t*, length of preorbital, orbital, and postorbital divisions of fronto-ethmoidal shield. JARVIK 1948a, fig. 12.

7	8	9	10	11	12	13	14	15
$\frac{b}{a}$	$\frac{r}{s+t}$	$\frac{t}{r+s}$	$\frac{d}{b}$	$\frac{e}{b}$	$\frac{e}{a}$	$\frac{f}{b}$	$\frac{f}{a}$	$\frac{g}{a}$
1.51	0.86	0.33	1.05	0.56	0.86	0.68	1.04	1.43
1.53	0.83	0.39	0.96	0.54	0.85	0.65	1.00	1.54
1.41	0.83	0.39	1.02	0.57	0.81	0.63	0.90	1.24
..	..	..	..	..	0.85	..	1.00	1.42
..	0.84	0.35	0.96	0.53	..	0.61	..	..
..	0.89	0.33	0.96	0.56	..	0.62	..	..
..	0.80	0.36	0.97	0.56	..	0.69	..	..
..	0.86	0.34	1.02	0.55	..	0.62	..	..
..	0.76	..	0.90	0.55	..	0.61	..	..
..	0.76	0.46	0.98	0.56	..	0.68	..	..
..	..	..	..	..	..	..	0.92	1.31
..	..	..	..	..	..	..	0.91	1.30
..	..	..	..	..	..	..	0.97	1.47
..	..	..	..	..	..	..	1.00	1.36
..	..	..	..	..	..	..	0.96	1.31
1.41–1.43	0.85–1.00	0.33–0.44	0.93–1.08	0.50–0.57	0.78–0.84	0.51–0.58	0.76–0.83	1.10–1.23
1.47–1.50	0.66–0.71	0.50–0.58	0.76–0.81	0.60–0.67	0.91–0.95	0.43–0.50	0.68–0.73	0.98–1.10

to ca. 1.05 (0.93—1.08 in *G. milleri*) of the length of the fronto-ethmoidal shield (col. 10, table 1), and the breadth of the cranial roof at the orbital notches is about 0.53—0.57 of the length of the fronto-ethmoidal shield and about 0.81—0.86 of the length of the parietal shield (col. 11, 12, table 1). In *G. milleri* the corresponding ratios range from ca. 0.50 to ca. 0.57 and from ca. 0.78 to ca. 0.84, respectively. As to the proportions of the anterior part of the fronto-ethmoidal shield, *G. groenlandicus* thus agrees well with *G. milleri*. However, at the posterior end of the fronto-ethmoidal shield, that is at the deepest point of the postorbital notch, this shield is slightly broader than in *G. milleri*, and the parietal shield as a whole is distinctly broader in relation to its length both than in *G. milleri* and in other Scottish Middle Devonian Osteolepids (cf. JARVIK 1948a, col. 15, 16, table 1). The breadth of the cranial roof is thus at the postorbital notch about 0.61—0.69 (0.51—0.58 in *G. milleri*)

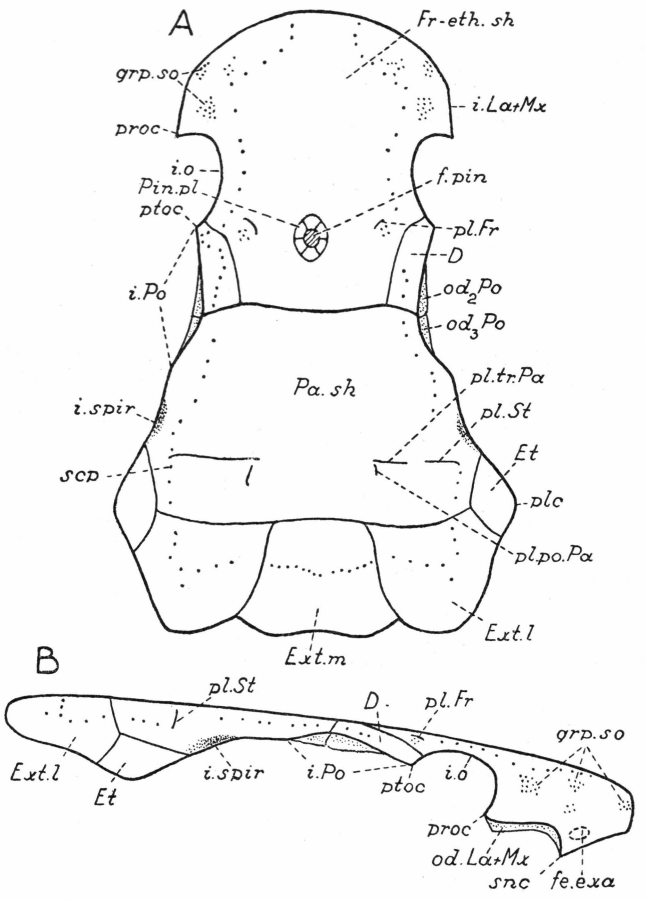


Fig. 13. *Gyroptychius groenlandicus* n. sp. Restorations of the cranial roof in, *A*, lateral and, *B*, dorsal views. $^2/_1$.

Explanations of figs. 13 and 14.

D, dermosphenotic; *Et*, extratemporal; *Ext. l*, *Ext. m*, lateral and median extrascapulars; *Fr-eth. sh*, fronto-ethmoidal shield; *It*, intertemporal; *Pa*, parietal; *Pa. sh*, parietal shield; *Pin. pl*, pineal plates; *St*, supratemporal.

fe. exa, fenestra exonarina anterior; *f. pin*, pineal foramen; *grp. so*, groups of small pores, probably for nerves to groups of cutaneous sensory organs; *i. La + Mx*, lachrymo-maxillary notch; *i. o*, orbital notch; *i. Po*, postorbital notch; *i. spir*, spiracular notch; *m. el*, median elevation; *od. La + Mx*, area of cranial roof overlapped by lachrymal and maxillary; $od_2 Po$, area of fronto-ethmoidal shield (dermosphenotic) overlapped by postorbital; $od_3 Po$, area of parietal shield (intertemporal) overlapped by postorbital; *pl. Ext. l*, pit-line of lateral extrascapular; *pl. Fr*, frontal pit-line; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *plc*, *proc*, *ptoc*, postero-lateral, preorbital, and postorbital corners of cranial roof; *scp*, pores of sensory canals; *snc*, subnarial corner of cranial roof.

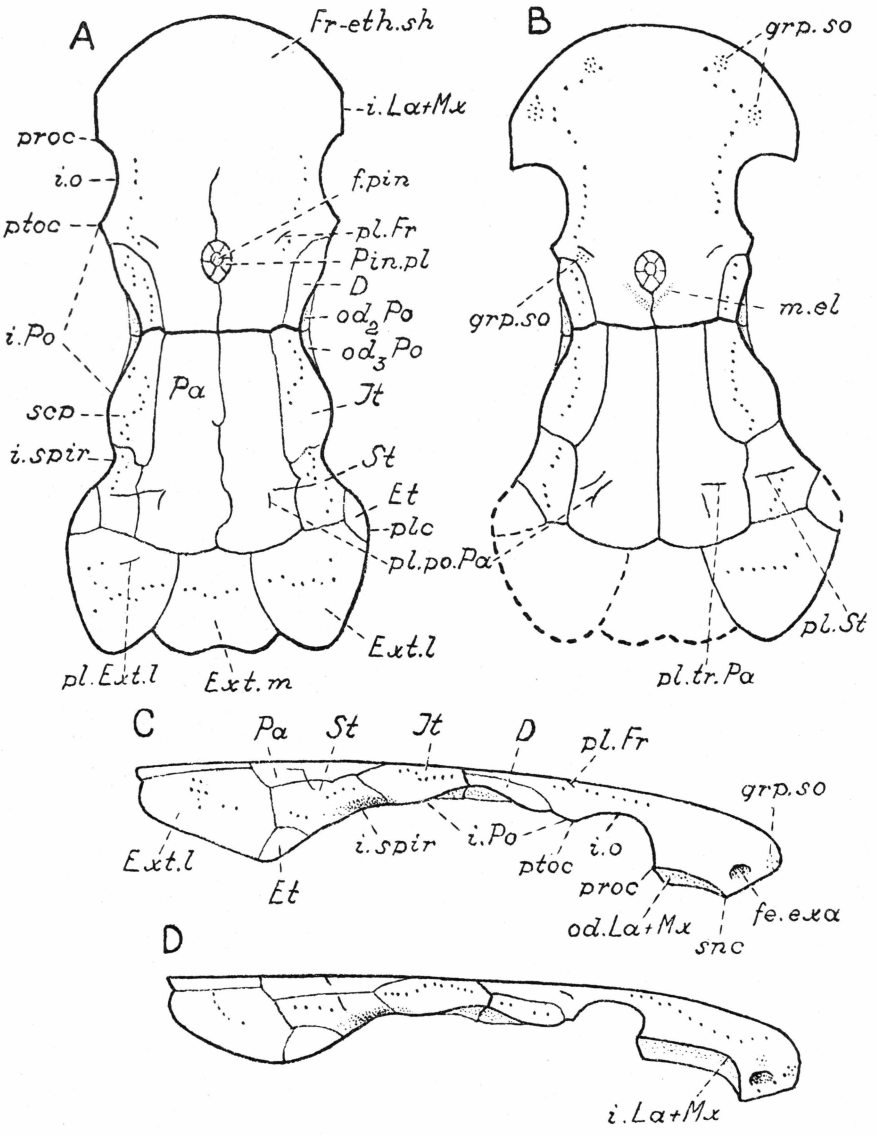


Fig. 14. Restorations of the cranial roof in dorsal and lateral aspects of, *A*, *C*, *Gyroptychius agassizi* (Traill) and, *B*, *D*, *Gyroptychius milleri* Jarvik. The length of the parietal shield ca. 29 mm. (= the length of the parietal shield in the holotype of *G. groenlandicus* magnified 2 times).

of the length of the fronto-etmoidal shield (col. 13, table 1) and about 0.90—1.04 (0.76—0.83 in *G. milleri*) of the length of the parietal shield (col. 14). At the spiracular notch the parietal shield is no less than ca. 1.24 to ca. 1.54 times broader than it is long, whereas in *G. milleri* the corresponding relation varies from ca. 1.10 to ca. 1.23 (col. 15).

The sutures between the dermal bones of the fronto-ethmoidal and parietal shields are as a whole weakly developed or not visible at all on the external faces of these shields (figs. 15—17; pl. 2:1; pl. 3; pl. 5:1, 2; pl. 6; pl. 7:1, 2; pl. 8; cf. JARVIK 1948a, pp. 46—47). As demonstrated above (pp. 30—31), the successive formation of new and thicker layers of dentine in connection with the resorbtion of the old layers probably led to an obliteration of the sutures, and the differences in their development is no reliable taxonomic character. No traces of sutures have been found on the external face of the snout; nor is the suture between the posterior supraorbital and the frontal shown. The suture separating the dermosphenotic from the remaining part of the fronto-ethmoidal shield is partly or wholly visible and this bone is sometimes detached or missing. The posterior part of the median suture between the frontals, the median suture between the parietals, and the sutures separating the supratemporal and intertemporal from each other and from the parietal are more or less distinct or not discernible. The extratemporal is detached or missing in all specimens.

On account of the weak development or absence of sutures the boundaries of the individual dermal bones forming the fronto-ethmoidal and parietal shields are generally imperfectly shown or not shown at all, and very little can be said as to the variations of these bones in number and extent.

The disposition of the dermal bones of the snout is partly shown in one specimen (pl. 7:5), which displays the inner side of the fronto-ethmoidal shield. As far as could be ascertained the dermal bones here, as in other parts of the skull, are disposed as in *Osteolepis macro-*

Fig. 15. *Gyroptychius groenlandicus* n. sp. The cranial roof of four specimens in dorsal aspect, showing variations. In the specimen shown in *D* the enamel and dentine layers are wanting. Key to the museum-numbers on pp. 13, 15. *A*, $^2/_1$; in *B-D* the length of the parietal shield is approximately the same as in *A* (ca. 29 mm.; the true length of the parietal shield is given in col. 1, table 1). The four specimens shown also in pl. 1:1; pl. 2:1; pl. 3:1, 2; pl. 5:1, 2; pl. 9:2.

D, dermosphenotic; *Et*, extratemporal; *Ext. l*, *Ext. m*, lateral and median extrascapulars; *Fr. cp*, paired bone, probably belonging to central frontal series of bones; *Fr-eth. sh*, fronto-ethmoidal shield; *Pa. sh*, parietal shield; *Pin. pl*, pineal plates. *ar. pin*, rough area surrounding pineal foramen; *fe. exa*, fenestra exonarina anterior; *f. pin*, pineal foramen; *grp. so*, groups of pores, probably for nerves to groups of cutaneous sensory organs; *i. Et*, notch for extratemporal; *i. La+Mx*, lachrymo-maxillary notch; *i. o*, orbital notch; *ioc*, infraorbital sensory canal; *i. Po*, postorbital notch; *i. spir*, spiracular notch; *od. La+Mx*, area overlapped by lachrymal and maxillary; *od$_2$Po*, *od$_3$Po*, areas overlapped by postorbital; *pl. Fr*, frontal pit-line; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *poc*, postotic sensory canal; *proc*, preorbital corner of cranial roof; *ptoc*, postorbital corner of cranial roof; *scp*, pores of sensory canals.

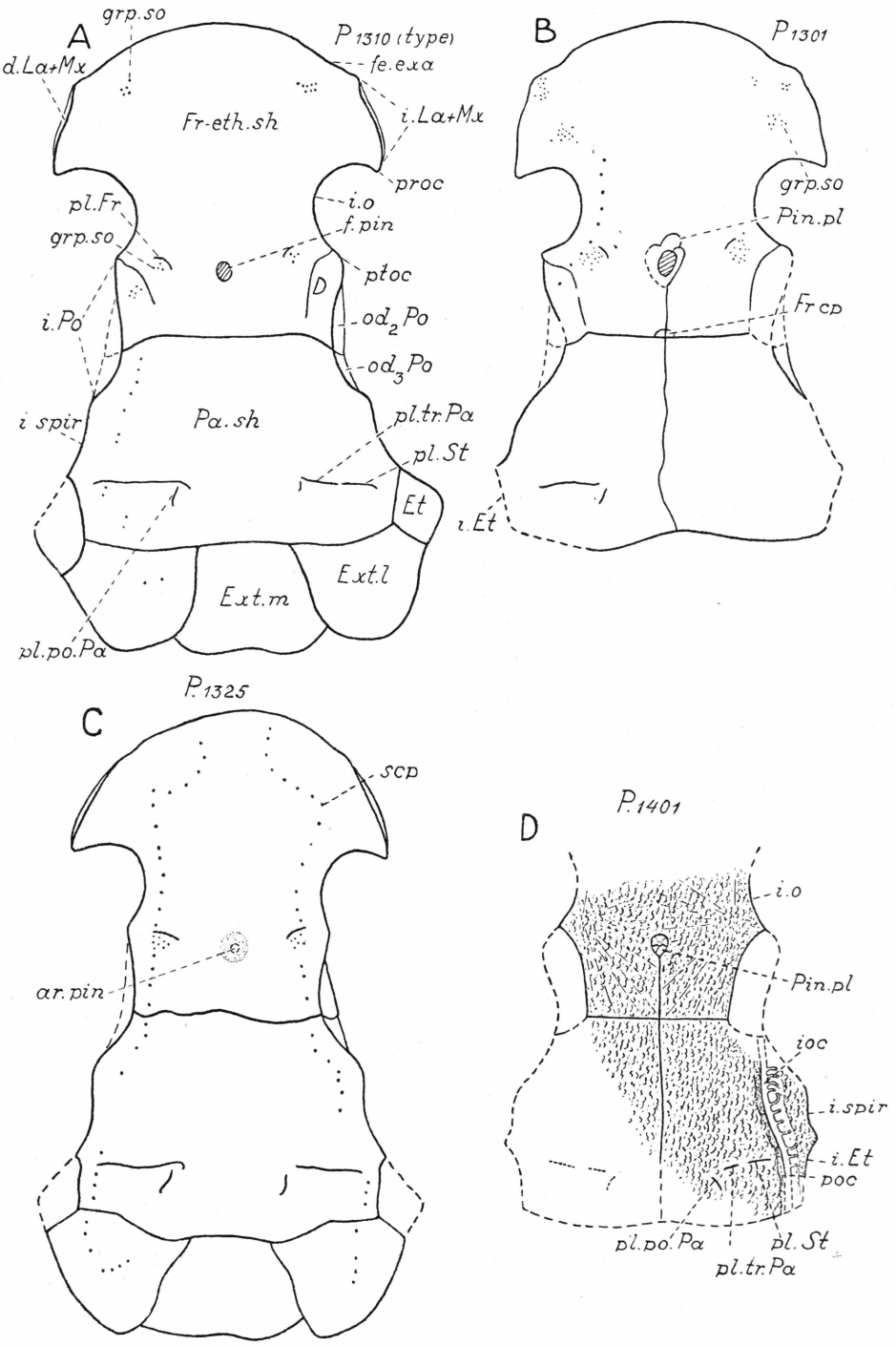

A
grp.so
od.La+Mx
P 1310 (type)
fe.exa
Fr-eth.sh
i.La+Mx
proc
pl.Fr
grp.so
i.o
f.pin
ptoc
D
i.Po
od2 Po
od3 Po
i spir
Pa.sh
pl.tr.Pa
pl.St
Et
Ext.m
Ext.l
pl.po.Pa
B
P 1301
grp.so
Pin.pl
Fr cp
i.Et
C
P 1325
scp
ar.pin
D
P 1401
i.o
Pin.pl
ioc
i.spir
i.Et
poc
pl.po.Pa
pl.St
pl.tr.Pa

Fig. 15.

lepidotus (JARVIK 1948a, figs. 16 A, 37). After leaving the frontal (*Fr*) the supraorbital sensory canal (*soc*) pierces a series of nasals (shown only on the left side) consisting of at least six independent elements (*NRP*, *Na. 3*, *Na. 7*). The foremost one (*NRP*), which is incompletely preserved, is relatively large and is probably a naso-rostral or a naso-rostro-premaxillary. Laterally to the nasal series and in front of the posterior supraorbital (*So. 2*) follows a large bone (*So-Te*) which forms the anterior margin of the orbital fenestra and evidently is a compound supraorbito-tectal. In front of this bone there are one or more anterior tectals (*Te. a*). The lateral rostral, the medial rostral and the premaxillary (alternatively the rostral and premaxillary components of the compound naso-rostro-premaxillary) are not preserved in this specimen.

The fenestra exonarina anterior (*fe. exa*, figs. 12 A, C, 13 B, 15 A—C, 16 A—D, F, 29 A, C; pl. 1:1; pl. 2:1; pl. 3:2, 3; pl. 4:1; pl. 6:3—5; pl. 7:1) is shown in several specimens but is always more or less incomplete. As in *G. milleri* (figs. 14 D, 25 C, D) it lies close in front of the anterior margin of the lachrymo-maxillary notch and rather far ventrally, probably being invisible when the fish was viewed from above. In flattened specimens presented in dorsal view it generally forms a slight notch in the outline of the snout (figs. 15 A—C, 16 A—D, F).

The frontal (*Fr*, pl. 7:5; pl. 9:2) and the posterior supraorbital (*So. 2*, fig. 16 D; pl. 7:3, 5) are developed as usual in Osteolepids. The latter bone may be relatively long and meet the postorbital or may be shorter and excluded from contact with this bone by the dermosphenotic (see figs. 12 A, B, 13, 15, 16). The dermosphenotic (*D*, figs. 12 A, B, 13, 15, 16, 29 A, B; pl. 1:1; pl. 2:1; pl. 3:2, 3; pl. 5:1; pl. 6:1—3, 5, 6; pl. 7:1, 2, 5; pl. 9:3), which as pointed out above may be detached or missing, is long and narrow but is otherwise of varying shape. In some specimens, viz. in those in which the posterior supraorbital is relatively short, it forms the postorbital corner and reaches the orbital fenestra between the posterior supraorbital and the postorbital (see fig. 12 A, B).

The pineal plates (*Pin. pl*, figs. 12 B, 13 A, 15 B, D, 16 A, C, D, 29 B; pl. 3:2; pl. 5:1; pl. 6:1; pl. 7:2; pl. 9:2) are shown in some of the specimens only, whereas in most of the specimens they are either wanting, there being a pineal fenestra, or have fused (most probably superficially) with each other and the frontals. In some specimens they have fused with each other but are separated from the frontals by a more or less distinct suture (pl. 6:1), and in some specimens two or three independent plates are shown. Judging from the shape and position of these plates there have been six plates in all as in other Osteolepids

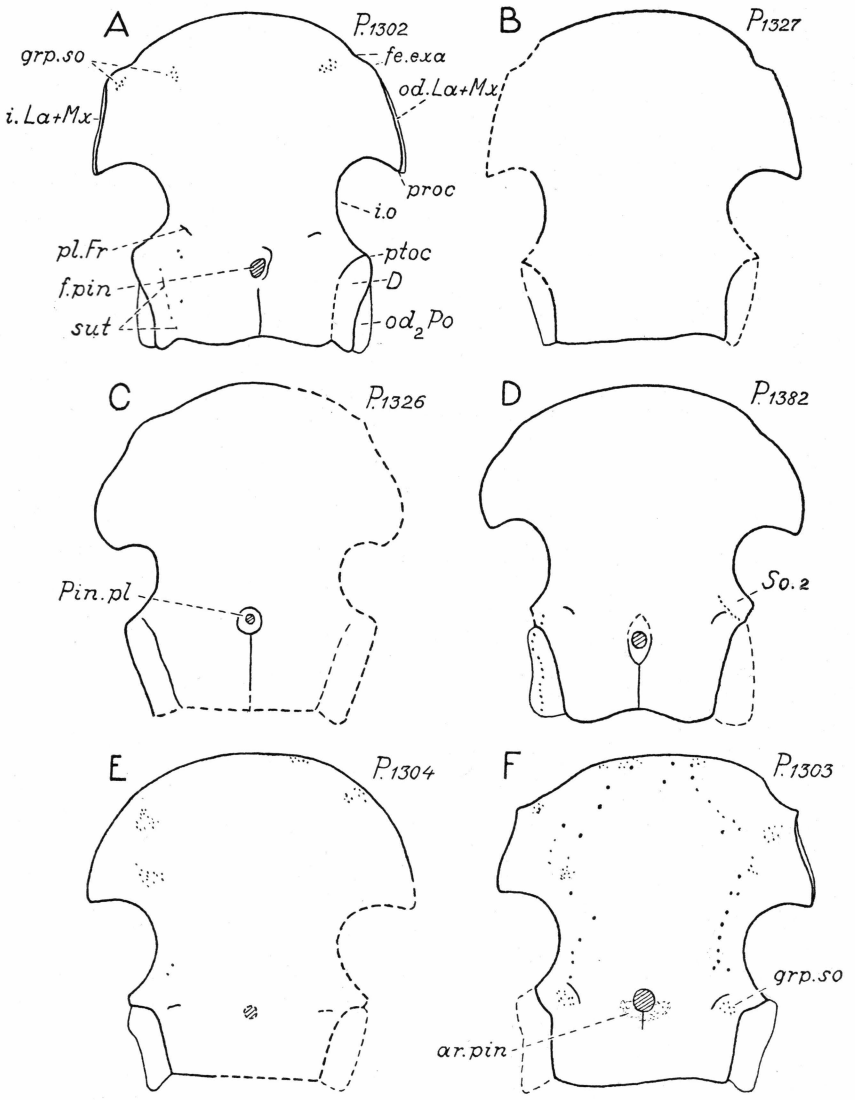


Fig. 16. *Gyroptychius groenlandicus* n. sp. Fronto-ethmoidal shield of six specimens in dorsal aspect, showing variations. The length of each of the shields is approximately the same as in the holotype magnified 2 times (see fig. 15 A). The real length of the shields is given in col. 2, table 1 (see also pl. 3:3; pl. 6; pl. 7:1, 2). The specimen shown in *D* figured by SÄVE-SÖDERBERGH (1933, pl. 14:2). Key to the museum-numbers on pp. 13—15.

D, dermosphenotic; *Pin. pl*, pineal plates; *So. 2*, posterior supraorbital.

ar. pin, rough area surrounding pineal foramen; *fe. exa*, fenestra exonarina anterior; *f. pin*, pineal foramen; *grp. so*, groups of pores, probably for nerves to groups of cutaneous sensory organs; *i. o*, orbital notch; *i. La+ Mx*, lachrymo-maxillary notch; *od. La+ Mx*, area overlapped by lachrymal and maxillary; $od_2 Po$, area of dermosphenotic overlapped by postorbital; *pl. Fr*, frontal pit-line; *proc*, preorbital corner; *ptoc*, postorbital corner; *sut*, traces of suture between dermosphenotic and frontal.

(fig. 14 A, B). In some specimens (figs. 15 C, 16 F; pl. 3:1; pl. 6:5) the pineal foramen is surrounded by a rough area (*ar. pin*) similar to that found in certain specimens of Scottish Osteolepids (JARVIK 1948a, p. 58).

The pineal foramen (*f. pin*, figs. 12 B, 13 B, 15, 16; pl. 1:1; pl. 2:1; pl. 3; pl. 5:1; pl. 6:1, 5; pl. 7:2—4; pl. 9:2) lies, in most of the specimens, as in *G. milleri* (fig. 14 B; JARVIK 1948a, p. 264, figs. 78, 79), that is in the foremost part of the postorbital division of the fronto-ethmoidal shield, postero-medially to the frontal pit-line and posterior to the transverse line running through the postorbital corner, the pineal fenestra extending forwards to or a little in advance of that line. In some specimens (fig. 16 C) it lies a little farther forwards, just medially to the postorbital corner. The ratio *c/a* ranges from ca. 0.31 to ca. 0.38 and the ratio *c/b* from ca. 0.21 to ca. 0.24, that is about as in *G. milleri* (JARVIK 1948a, col. 17, 18, tables 1, 9).

The supratemporal (*St*), intertemporal (*It*), and parietal (*Pa*, figs. 17 A, C—F; pl. 8:1, 3—5; pl. 9:1, 2, 4, 5), which usually have fused superficially (*Pa. sh*, figs. 12 A, B, 13, 15, 17 B, 29 A, B; pl. 1:1; pl. 2:1; pl. 3:1, 2; pl. 5:2; pl. 8:2, 6), are developed as in other Osteolepids, though they are a little broader proportionately. The extratemporal (*Et*), which is detached or missing, leaving a distinct notch (*i. Et*, figs. 15 B—D, 17 A—F; pl. 2:1; pl. 3:1; pl. 5:2; pl. 8:1—3, 5; pl. 9:1, 2, 4, 5) in the posterior part of the lateral margin of the parietal shield, is preserved only on the right side of the holotype (figs. 12 A, B, 13, 15 A, 29 A, B; pl. 1:1; pl. 2:1). It is a quadrangular bone forming the postero-lateral corner (*plc*) of the cranial roof and has a fairly long postero-lateral margin, meeting and overlapping the opercular (cf. p. 78).

The extrascapulars (*Ext. l*, *Ext. m*, figs. 12 A, B, 13, 29 A, B), which are of the normal Osteolepid type, are shown in the holotype (fig. 15 A; pl. 1:1; pl. 2:1) and in No. P. 1325 (fig. 15 C; pl. 3:1), and, besides, detached lateral extrascapulars are represented by specimens Nos. P. 1338 (fig. 17 H; pl. 5:3) and P. 1424. A large detached median extrascapular is shown in No. P. 1339 (fig. 17 G; pl. 5:4).

Subdivisions of the dermal bones of the cranial roof are rarely found in the material available—certainly in part because of the weak development of the sutures—and only the following three cases have been noticed.

Fig. 17. *Gyroptychius groenlandicus* n. sp. *A-F*, six parietal shields in external view, showing variations. In *E*, *F*, the enamel and dentine layers are wanting. *G*, median extrascapular, and *H*, lateral extrascapular in external view. All the sketches are drawn to a scale, assuming the parietal shield to be about 29 mm. in length (= the length of the parietal shield in the holotype magnified 2 times). Key to the specimen-numbers on pp. 13—15.

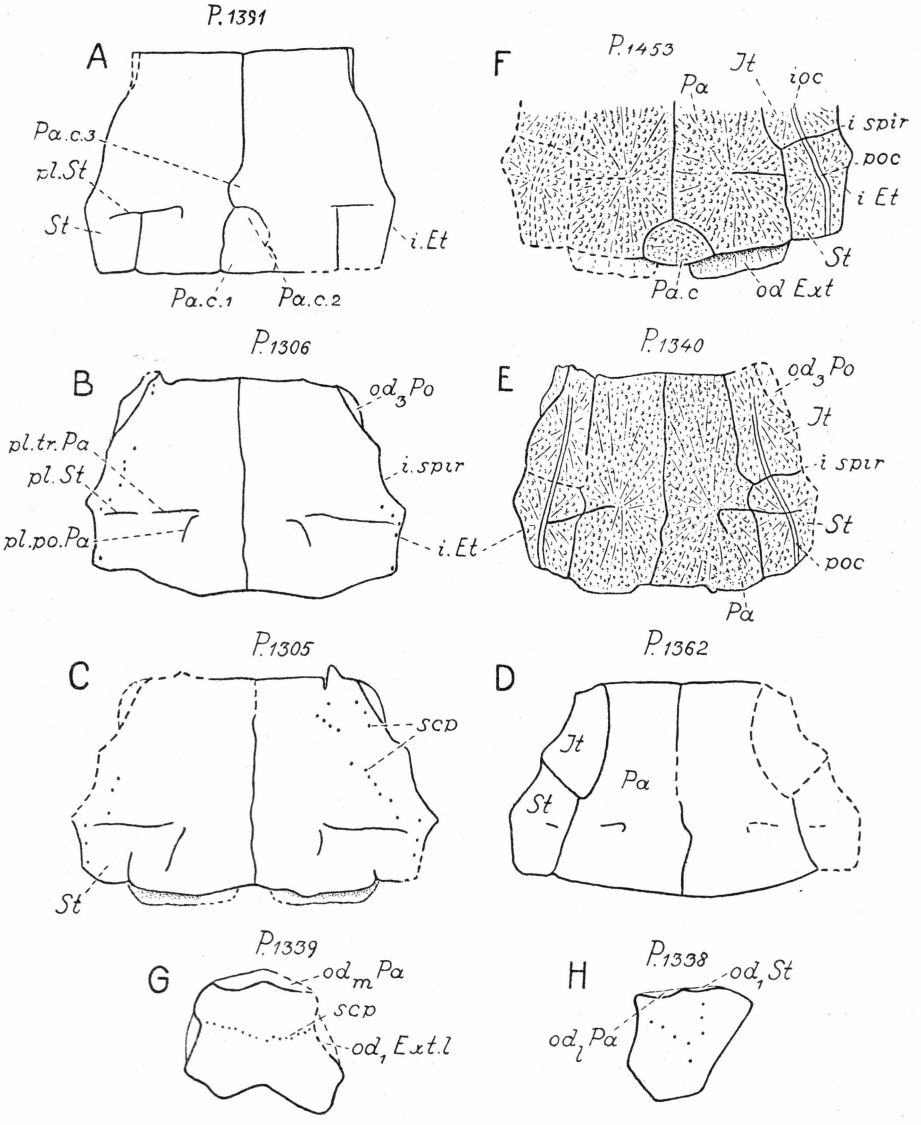


Fig. 17.

It, intertemporal; *Pa*, parietal; *Pa. c*, *Pa. c. 1*, *Pa. c. 2*, *Pa. c. 3*, independent or partly independent elements belonging to posterior unpaired portion of central parietal series of bones; *St*, supratemporal.

i. Et, notch for extratemporal bone; *ioc*, infraorbital sensory canal; *i. spir*, spiracular notch; *od. Ext*, area of parietal shield overlapped by extrascapulars; $od_l Pa$, area of lateral extrascapular overlapped by parietal; $od_m Pa$, area of median extrascapular overlapped by parietal; $od_1 Ext.\,l$, area of median extrascapular overlapped by lateral extrascapular; $od_1 St$, area of lateral extrascapular overlapped by supratemporal; $od_3 Po$, area of intertemporal overlapped by postorbital; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *poc*, postotic sensory canal; *scp*, pores of sensory canals.

In specimen No. P. 1301 (fig. 15 B; pl. 3:2; pl. 5:1) a small paired bone (*Fr. cp*) is found close behind the median suture between the frontals. This bone, which probably occupied a small median notch in the posterior margin of the fronto-ethmoidal shield, evidently represents the posterior element of the paired central frontal series of bones (cf. JARVIK 1948a, p. 66, fig. 17). In one of the ornamented specimens (No. P. 1453, fig. 17 F; pl. 9:5) a relatively large median unpaired bone (*Pa. c*) is found between the posterior ends of the parietals. This bone strongly reminds of an independent bone found in one specimen of *G. agassizi* (JARVIK 1948a, pp. 64, 247, fig. 72 J) and like that bone it represents the posterior element of the posterior unpaired portion of the central parietal series. A similar though somewhat larger and only partly independent bone is found also in No. P. 1391 (fig. 17 A; pl. 8:5). This bone (*Pa. c. 1*, *Pa. c. 2*), which extends further forward than that in No. P. 1453, shows traces of a transverse suture and most probably it consists of two unpaired bones of the central parietal series, which have fused superficially. A third element (*Pa. c. 3*) of the same series of bones is indicated by a strong curve in the suture between the parietals (cf. JARVIK 1948a, pp. 64, 67).

The external cheek plate.

The external cheek plate (figs. 12 A, B, 18, 29 A, B) is most completely shown in the holotype, which is the only specimen showing all its dermal bones (pl. 1; pl. 2:1, 4). The lachrymal, jugal, postorbital, and maxillary are detached or—as regards the left lachrymal and the right jugal—missing, whereas the squamosal, preopercular, and quadratojugal are found in connection with each other, forming a unit. The corresponding unit is shown in several other specimens (fig. 20; pl. 12, 13) and also detached postorbitals and jugals are fairly common in the material available (fig. 19; pl. 10). The lachrymal and maxillary, on the other hand, are rarely found.

The external cheek plate in the holotype is ca. 2.23 times longer than the parietal shield and ca. 2.58 times longer than it is high. It is thus about as long and high as in the holotype of *G. milleri*, in which the corresponding relations may be estimated to have been ca. 2.20 and ca. 2.52, respectively, but shorter and higher than in *G. agassizi* (fig. 25 A, C; JARVIK 1948a, col. 19, 20, tables 1, 9). The length of the posterior unit of the cheek plate formed by the squamosal, postorbital, and quadratojugal—that is the distance from the anterior corner of the squamosal to the posterior margin of the preopercular—is ca. 1.35 times longer than the parietal shield. In *G. milleri* the corresponding relation is only about 1.25 and in *G. agassizi* ca. 1.45.

The lachrymal (*La*, figs. 12 A, B, 18, 19 A, B, 29 A, B; pl. 1:2; pl. 2:1; pl. 9:3, 6) is displayed only in the holotype and in Nos. P. 1330 and P. 1381. In No. P. 1330, which is from the same locality as the holotype, it is of a remarkable size, being no less than 22 mm. long, that is nearly 3 times as long as in the holotype (col. 1, table 2). As in the genus *Gyroptychius* in general, the bone is short and high—the length: height ratio is in the holotype ca. 1.80 and in No. P. 1330 ca. 1.51 (col. 2, table 2)—and higher (in the holotype ca. 1.12 and in No.

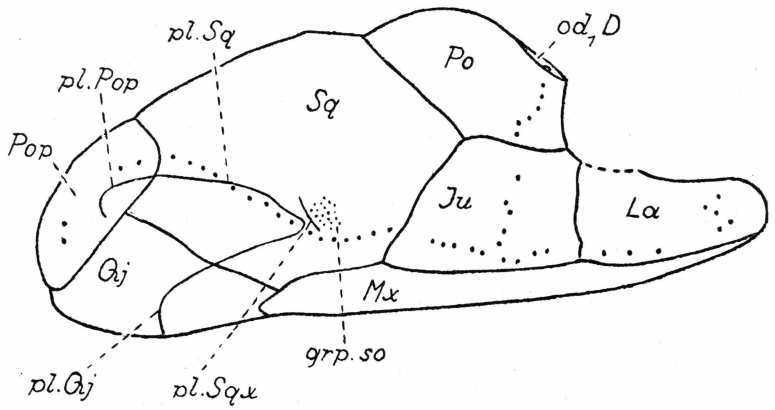


Fig. 18. *Gyroptychius groenlandicus* n. sp. Restoration of the external cheek plate in external view. Based mainly on the holotype. $^3/_1$.

Ju, jugal; *La*, lachrymal; *Mx*, maxillary; *Po*, postorbital; *Pop*, preopercular; *Qj*, quadratojugal; *Sq*, squamosal.

grp. so, group of pores, probably for nerves to group of cutaneous sensory organs; od_1D, area of postorbital overlapped by dermosphenotic; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *pl. Sqx*, additional squamosal pit-line.

P. 1330 ca. 1.25 times; col. 3) posteriorly than at the anterior end of the orbital notch of the bone. As in *G. milleri* (fig. 25 C) a distinct anterior margin is developed. The orbital notch of the bone is short, especially when, as in No. P. 1381 (pl. 9:3), the process bearing the preorbital corner (*proc*) is well developed. It is uncertain whether the bone meets the postorbital, excluding the jugal from the orbital fenestra as it does in *G. agassizi* (fig. 25 A), or whether the jugal has an orbital margin as in *Osteolepis* and *Thursius* (Jarvik 1948a, figs. 37, 53, 58, 62, 65; cf. p. 72). The lachrymal in No. P. 1330 is overlapped by the jugal (the area od_1Ju, fig. 19 B; pl. 9:6).

The jugal (*Ju*, figs. 12 A, B, 18, 19 C—J, 29 A, B; pl. 1:1, 4; pl. 2:1; pl. 3:2; pl. 9:3; pl. 10:1—8; pl. 12:2), which is preserved in several specimens (pp. 13—14), varies somewhat in shape and size (col. 5, table 2). In most of the specimens, including the type-sepcimen, it is

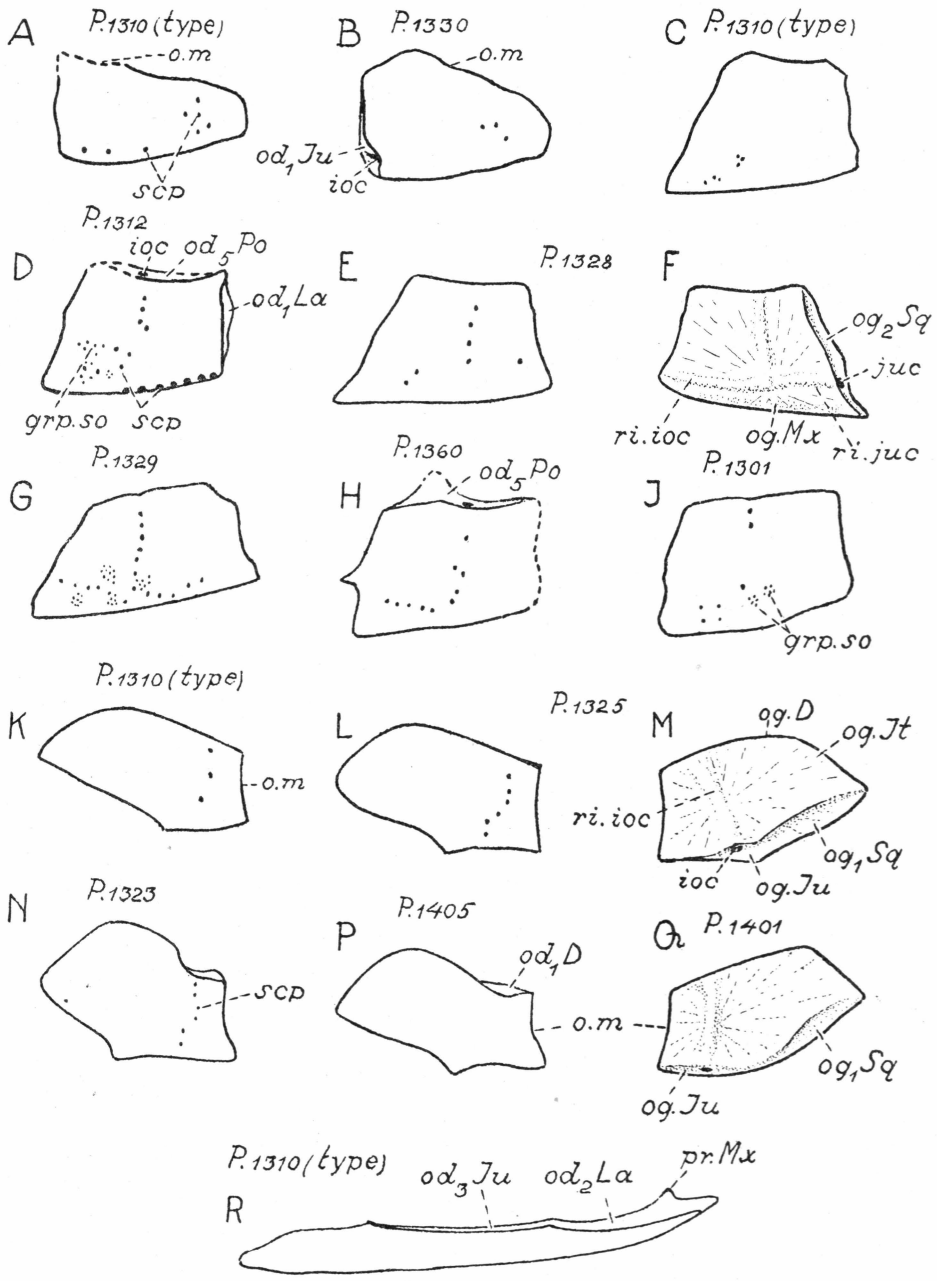


Fig. 19. *Gyroptychius groenlandicus* n. sp. Restorations of the anterior elements of the right external cheek plate in outer and, *F*, *M*, *Q*, inner views. *A*, *B*, lachrymal; *C-J*, jugal; *K-Q*, postorbital; *R*, maxillary. All the sketches are drawn to a scale, assuming the parietal shield to be about 43 mm. in length (= the length of the parietal shield of the holotype magnified 3 times; the real length of the individual

Table 2. *Gyroptychius groenlandicus* n. sp. The range of variation in length and in certain proportions of the lacrymal, jugal, and postorbital in the material available.

a, length of parietal shield; *ht. Ju*, height of jugal; *ht. La*, height of lachrymal; *ht. Po*, height of postorbital; ht_1, height of posterior margin of lachrymal; *l. Ju*, length of jugal; *l. La*, length of lachrymal; *l. Po*, length of postorbital.

Mus. No.	Locality	1	2	3	4	5	6	7	8	9
		lachrymal				jugal		postorbital		
		l. La mm.	$\frac{l.\,La}{ht_1}$	$\frac{ht_1}{ht.\,La}$	$\frac{l.\,La}{a}$	*l. Ju* mm.	$\frac{l.\,Ju}{ht.\,Ju}$	*l. Po* mm.	$\frac{l.\,Po}{ht.\,Po}$	$\frac{l.\,Po}{a}$
P. 1310 ..... (holotype)	210–234 m.[1])	8	1.80	1.12	0.58	9	1.42	10	2.07	0.71
P. 1330	—	22	1.51	1.25	..	..	..	..	..	..
P. 1301	—	..	..	..	..	10	1.43	..	..	..
P. 1312	—	..	..	..	..	13	1.44	..	..	..
P. 1328	—	..	..	..	..	12	1.54	..	..	..
P. 1329	—	..	..	..	..	15	1.88	..	..	..
P. 1360	—	..	..	..	..	16	1.47	..	..	..
P. 1381	202–204 m.[1])	..	..	..	..	15	1.49	..	..	..
P. 1389	Kollen	..	..	..	..	12	1.64	..	..	..
P. 1323	210–234 m.[1])	..	..	..	..	..	..	14	1.65	..
P. 1325	—	..	..	..	..	..	..	11	1.87	0.67
P. 1401	—	..	..	..	..	..	..	13	2.00	0.75
P. 1405	Circusbjærg	..	..	..	..	..	..	13	2.08	..

[1]) 202—204 m. in profile *c* and the horizon at 210—234 m. in the NW. part of Hesteskoen, Canning Land.

relatively short and high, about 1.42—1.54 times longer than it is high (col. 6, table 2). In two specimens, Nos. P. 1389 and P. 1329 (fig. 19 G), it is of a somewhat longer and lower type, being 1.64 and 1.88 times longer than high, respectively, (cf. fig. 25 A, C; Jarvik 1948a, col. 24, tables 1, 9). The postero-dorsal margin, which meets the squamosal,

---

dermal bones is given in col. 1, 5, 7, table 2; col. 7, table 3; see also pl. 1:1, 2—4; pl. 2:1; pl. 3:1; pl. 9:2, 6; pl. 10). Key to the specimen-numbers on pp. 13—15.

grp. so, groups of pores, probably for nerves to groups of cutaneous sensory organs; *ioc*, infraorbital sensory canal; *juc*, jugal sensory canal; od_1D, area of postorbital overlapped by dermosphenotic; od_1Ju, area of lachrymal overlapped by jugal; od_1La, area of jugal overlapped by lachrymal; od_2La, area of maxillary overlapped by lachrymal; od_3Ju, area of maxillary overlapped by jugal; od_5Po, area of jugal overlapped by postorbital; *og. D*, *og. It*, areas of postorbital overlapping dermosphenotic and intertemporal; *og. Ju*, area of postorbital overlapping jugal; *og. Mx*, area of jugal overlapping maxillary; og_1Sq, area of postorbital overlapping squamosal; og_2Sq, area of jugal overlapping squamosal; *o. m*, orbital margin; *pr. Mx*, anterior process of maxillary; *ri. ioc*, *ri. juc*, ridges housing infraorbital and jugal sensory canals; *scp*, pores of sensory canals.

generally consists of two concave portions separated by a convex portion or, as in No. P. 1360 (fig. 19 H), by a pointed process. It could not be established with certainty whether the jugal reaches the orbital fenestra and forms part of the margin of that fenestra. In some specimens the dorsal and anterior margins of the bone meet in a more or less rounded corner (fig. 19 D—F, H, J), and most probably the jugal in these specimens did not extend to the orbital fenestra. In other specimens, e. g. in the holotype, the bone has a short but distinct antero-dorsal margin (fig. 19 C, G; pl. 1:4; pl. 9:3; pl. 10:2, 3). It is possible that this margin formed part of the orbital margin—most probably it did so in the holotype (see figs. 12 A, B, 18) and in No. P. 1381 (pl. 9:3)—but it is also possible that this margin, like the corresponding margin in some specimens of *G. agassizi* (JARVIK 1948a, fig. 73 D, F), met the postorbital and lachrymal (cf. fig. 25 A). Also in No. P. 1330 (fig. 19 B; pl. 9:6) the jugal—judging from the shape of the lachrymal—was excluded from the orbital fenestra. Along the dorsal margin of the bone there is a depressed area (*od*$_5$*Po*) overlapped by the postorbital and in one specimen, No. P. 1312, there is a rather broad area of that kind (*od*$_1$*La*, fig. 19 D) along the anterior margin. This area was no doubt overlapped by the lachrymal, but as we have seen above in No. P. 1330 (fig. 19 B) it is the lachrymal that is overlapped by the jugal. Also in No. P. 1381 (pl. 9:3) the jugal seems to overlap the lachrymal. As is well shown in No. P. 1328 (fig. 19 F; pl. 10:6), the inner face of the bone, in addition to ridges (*ri. ioc*, *ri. juc*) housing the sensory canals, presents two depressed areas, one (*og*$_2$*Sq*) along the posterior margin overlapping the squamosal, and one (*og. Mx*) along the ventral margin overlapping the maxillary.

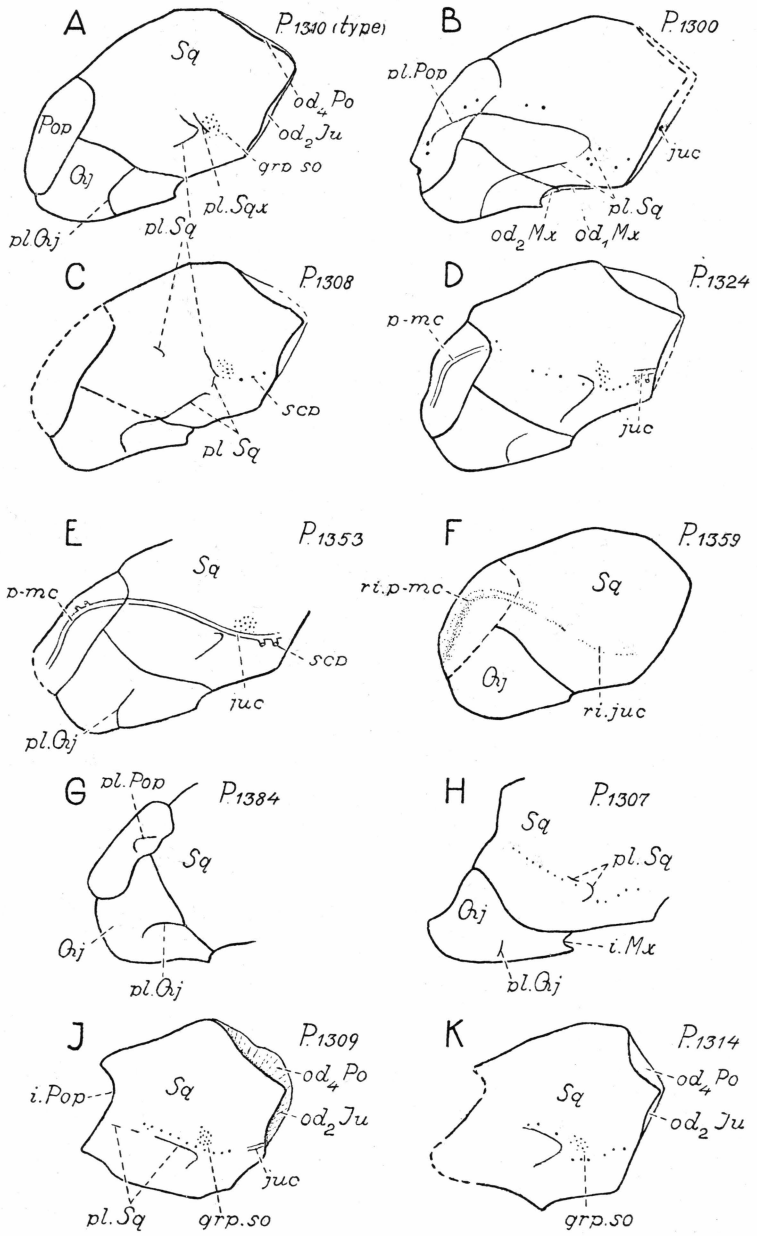
The postorbital (*Po*, figs. 12 A, B, 18, 19 K—Q, 29 A, B; pl. 1:1, 3; pl. 2:1; pl. 3:1; pl. 9:2, 3; pl. 10:9, 10), which is well shown in six specimens, is long and low. In five of the specimens it is about 2.00, and in the sixth specimen (fig. 19 N) ca. 1.65, times longer than it is high (col. 8, table 2) and its length amounts to ca. 0.67—0.75 of the length of the parietal shield (col. 9, table 2). It is thus both longer and

---

Fig. 20. *Gyroptychius groenlandicus* n. sp. Sketches of the posterior part of the right external cheek plate and, *J*, *K*, the squamosal in outer and, *F*, inner aspects, showing variations. All the sketches are drawn to a scale, assuming the parietal shield to be about 29 mm. in length (= the length of the parietal shield in the holotype magnified 2 times; the real length of the individual dermal bones is given in col. 1, 3, 5, table 3; see also pl. 1:1; pl. 2:1; pl. 12:2; pl. 13; pl. 14:1—3). Key to the specimen-numbers on pp. 13—15.

Pop, preopercular; *Qj*, quadratojugal; *Sq*, squamosal.

grp. so, group of pores, probably for nerves to group of cutaneous sensory organs; *i. Mx*, notch for posterior end of maxillary; *i. Pop*, notch for preopercular; *juc*,



jugal sensory canal; $od_1 Mx$, area of squamosal overlapped by maxillary; $od_2 Ju$, area of squamosal overlapped by jugal; $od_2 Mx$, area of quadratojugal overlapped by maxillary; $od_4 Po$, area of squamosal overlapped by postorbital; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *pl. Sqx*, additional squamosal pit-line; *p-mc*, preoperculo-mandibular sensory canal; *ri. juc*, ridge housing jugal sensory canal; *ri. p-mc*, ridge housing preoperculo-mandibular sensory canal; *scp*, pores of sensory canals.

lower than in the holotype of *G. milleri* (fig. 25 C), in which the length: height ratio is ca. 1.60 and the ratio *l. Po:a* ca. 0.56 (JARVIK 1948a, col. 25, 26, tables 1, 9). On the external face of the bone there is anterodorsally a small depressed area (od_1D) overlapped by the frontoethmoidal shield (the dermosphenotic alone or by this bone and the posterior supraorbital). The inner face of the bone presents a ridge (*ri. ioc*) housing the infraorbital sensory canal, two distinct depressed areas (og_1Ju, og_1Sq) overlapping the jugal and the squamosal, and one indistinct area (*og. D*, *og. It*) overlapping the cranial roof (the area od_2Po of the dermosphenotic and the area od_3Po of the intertemporal).

The squamosal (*Sq*, figs. 2, 12 A, B, 18, 20, 29 A, B; pl. 1:1; pl. 2:1; pl. 3:1, 2; pl. 9:2, 3; pls. 11—13; pl. 14:1—4) is most often found in connection with the quadratojugal or with this bone and the preopercular, being separated from these bones by more or less disinct sutures. In three specimens (Nos. P. 1309, fig. 20 J; pl. 14:1; P. 1314, fig. 20 K; pl. 14:2; and P. 1376) the bone occurs isolated. The bone varies somewhat in shape and size. The length in the material available ranges from ca. 11 to ca. 18 mm. and the length:height ratio from ca. 1.29 to ca. 1.46 (col. 1, 2, table 3). The bone is as long as or longer proportionately than in the holotype of *G. milleri* (fig. 25 C), in which the length: height ratio is about 1.31 (JARVIK 1948a, col. 27, tables 1,9). The areas (od_4Po, od_2Ju) overlapped by the postorbital and jugal are generally well developed, whereas the area overlapped by the maxillary (od_1Mx, figs. 2, 20 B; pl. 11) is very narrow or missing. No area overlapped by the parietal shield corresponding to the area in the Scottish Osteolepids (see JARVIK 1948a, p. 86; *od. It*, fig. 21 A) overlapped by the intertemporal has been noticed. The inner face of the bone (fig. 20 F; pl. 13:2) presents a ridge (*ri. juc*) housing the jugal sensory canal and slightly depressed areas overlapping the preopercular and the quadratojugal.

The preopercular (*Pop*, figs. 2, 12 A, B, 18, 20 A, B, D—G, 29 A, B; pl. 1:1; pl. 2:1; pls. 11, 12; pl. 13:1—4, 6) varies considerably in size and shape and may be short and high as in No. P. 1300, in which it is ca. 3.75 times higher than it is long (broad), or relatively low and long as in the holotype and in Nos. P. 1324, P. 1353, and P. 1384, in which the corresponding ratio is about 2.65—3.10 (col. 5, 6, table 3).

The quadratojugal (*Qj*, figs. 2, 12 A, 18, 20 A—H, 29 A; pl. 1:1; pl. 2:1; pl. 9:2; pl. 11; pl. 12:2; pl. 13; pl. 14:3, 4; pl. 18:5), ranging from ca. 9 to ca. 15 mm. in length (col. 3, table 3), is somewhat shorter and higher proportionately than in the other species of the genus. The length: height ratio thus ranges from ca. 1.22 to ca. 1.80 (col. 4), whereas the corresponding ratio in the Scottish species always exceeds 2.00 (see JARVIK 1948a, p. 249, col. 28, tables 1, 9). The anterior

Table 3. *Gyroptychius groenlandicus* n. sp. The range of variation in length and in certain proportions of the squamosal, quadratojugal, preopercular, and maxillary. All specimens originate from the horizon at 210—234 m. in the NW. part of Hesteskoen, Canning Land.

ht. Mx, height of maxillary; *ht. Pop*, height of preopercular; *ht. Qj*, height of quadratojugal; *ht. Sq*, height of squamosal; *l. Mx*, length of maxillary; *l. Pop*, length of preopercular; *l. Qj*, length of quadratojugal; *l. Sq*, length of squamosal.

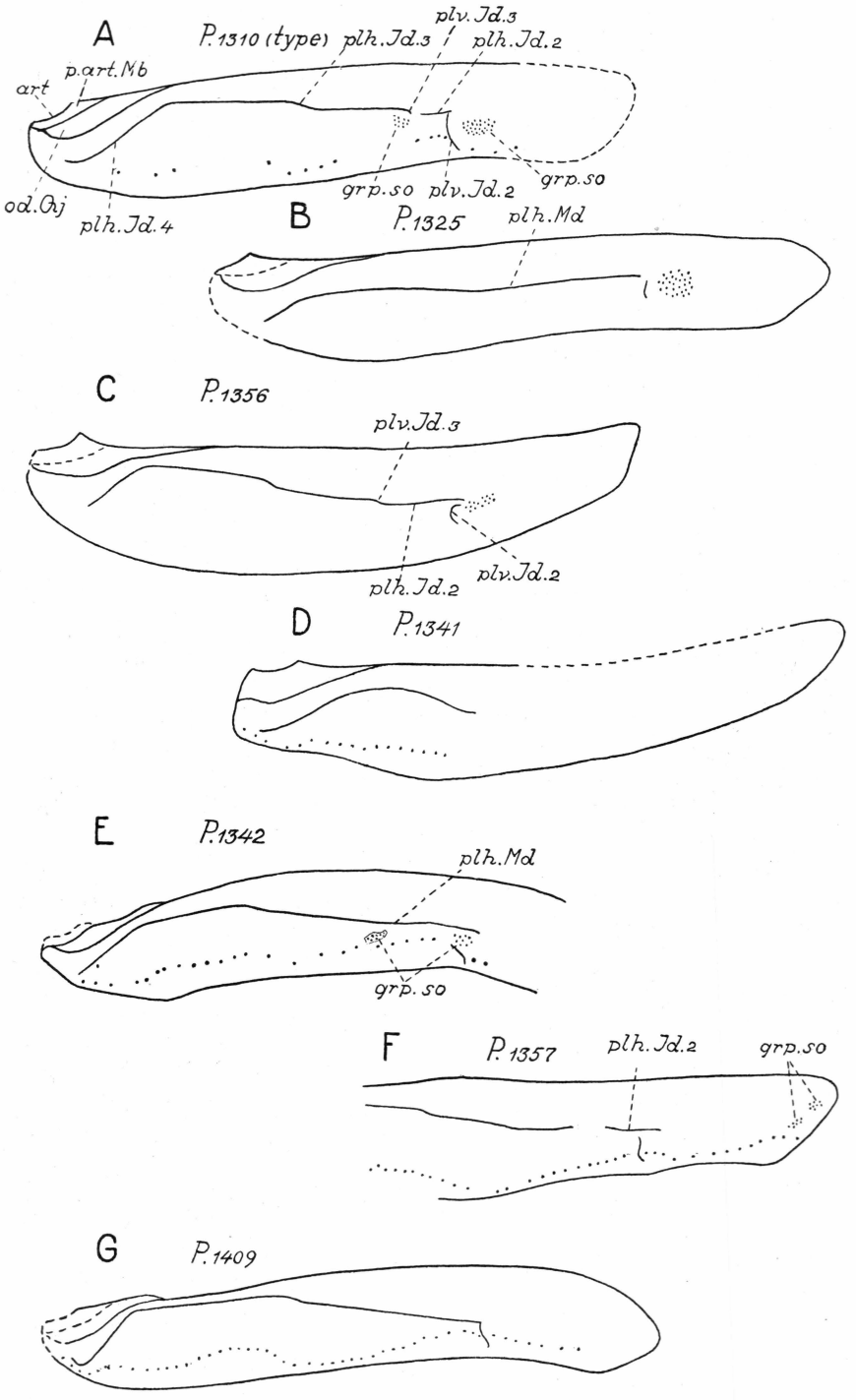
Mus. No.	1	2	3	4	5	6	7	8
	squamosal		quadratojugal		preopercular		maxillary	
	l. Sq mm.	$\frac{l.\,Sq}{ht.\,Sq}$	*l. Qj* mm.	$\frac{l.\,Qj}{ht.\,Qj}$	*ht. Pop* mm.	$\frac{ht.\,Pop}{l.\,Pop}$	*l. Mx* mm.	$\frac{l.\,Mx}{ht.\,Mx}$
P. 1310 (holotype)	15	1.40	10	1.75	8	2.68	21	10.5
P. 1300	15	1.34	9	1.50	10	3.75	..	..
P. 1307	..	..	15	1.56	..	..	..	..
P. 1308	18	1.40	10	1.65	..	..	..	..
P. 1309	17	1.29	..	..	..	..	..	..
P. 1314	18	1.38	..	..	..	..	..	..
P. 1317	..	..	10	1.42	..	..	..	..
P. 1324	18	1.46	12	1.80	12	2.65	..	..
P. 1353	15	..	10	1.50	9	3.10	..	..
P. 1359	11	1.30	..	..	..	..	..	..
P. 1376	11	1.30	..	..	..	..	..	..
P. 1384	..	..	11	1.22	10	2.92	..	..
P. 1401	..	..	12	1.75	..	..	..	..

margin of the bone is often notched (*i. Mx*) to receive the posterior end of the maxillary, as it is also in the Scottish species of the genus, and along this margin a narrow depressed area ($od_2\,Mx$, figs. 2, 20 B; pl. 11) overlapped by the maxillary is sometimes found.

The maxillary (*Mx*, figs. 12 A, 18, 19 R, 29 A; pl. 1:1; pl.2:2—4) is shown only in the holotype and in No. P. 1417. In the holotype the bone is ca. 10.5 times longer than it is high and it is thus of the low type characteristic of the genus (cf. Jarvik 1948a, pp. 92, 249; col. 29, table 9). The anterior process (*pr. Mx*) and the areas (od_2La, od_3Ju) overlapped by the lachrymal and jugal are shown in the holotype. Posteriorly the bone, at least in some specimens (fig. 2), overlaps the squamosal and the quadratojugal (the areas $od_1\,Mx$ and $od_2\,Mx$).

The orbital fenestra (figs. 12 A, B, 29 A, B) is small, as in the Scottish species of the genus—the length amounts to ca. 0.45 of the length of the parietal shield—and is situated far dorsally and rather close to the fenestra of the other side.

No traces of sclerotic plates have been found.


A
P. 1310 (type)
plv. Jd. 3
plh. Jd. 3
plh. Jd. 2
art
p. art. Mb
od. Obj
plh. Jd. 4
grp. so
plv. Jd. 2
grp. so
B
P. 1325
plh. Md
C
P. 1356
plv. Jd. 3
plh. Jd. 2
plv. Jd. 2
D
P. 1341
E
P. 1342
plh. Md
grp. so
F
P. 1357
plh. Jd. 2
grp. so
G
P. 1409

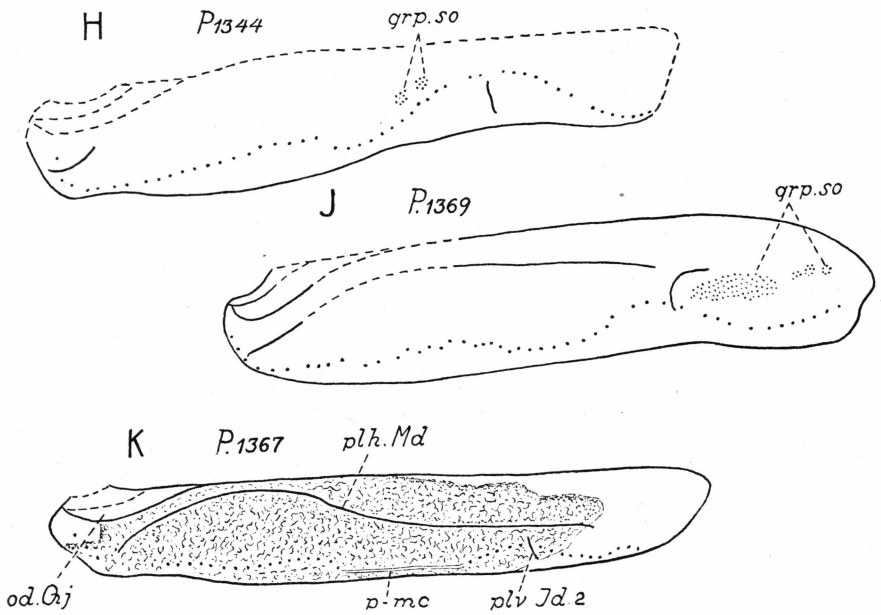


Fig. 21. *Gyroptychius groenlandicus* n. sp. Sketches of the right lower jaw of ten specimens in external view, showing variations. All the sketches are drawn to a scale, assuming the parietal shield to be about 29 mm. in length (cf. fig. 20; the real length of the jaws is given in col. 1, table 4; see also pl. 1:1; pl. 2:2, 3; pl. 3:1; pl. 4; pl. 14:6; pls. 15, 16). Key to the specimen-numbers on pp. 13—15.

art, articular area; *grp. so*, groups of pores, probably for nerves to groups of cutaneous sensory organs; *od. Qj*, area of lower jaw overlapped by quadratojugal; *p. art. Mb*, pars articularis of meckelian bone; *plh. Id. 2*, *plh. Id. 3*, *plh. Id. 4*, horizontal pit-lines of infradentaries 2, 3 and 4; *plh. Md*, horizontal part of mandibular pit-line; *plv. Id. 2*, *plv. Id. 3*, vertical pit-lines of infradentaries 2 and 3; *p-mc*, preoperculo-mandibular sensory canal.

The lower jaw.

The lower jaw of the holotype (*Lj*, figs. 12 A, C, 21 A, 29 A, C; pl. 1:1; pl. 2:2, 3), the anterior part of which is lacking on both sides, may be estimated to have been ca. 40 mm., i. e. it is ca. 2.75 times longer than the parietal shield. In No. P. 1325 (fig. 21 B; pl. 3:1; pl. 4) the lower jaw measures 42 mm. and is ca. 2.61 times longer than the parietal shield (col. 1, 2, table 4). Judging from these two specimens the lower jaw thus seems to be a little longer proportionately than in *G. milleri*, in which the corresponding ratio (*l. Lj/a*) is ca. 2.50 and about as in *G. agassizi* (*l. Lj/a* ca. 2.70—2.82).

The lower jaw is shown also in several other specimens (fig. 21 C—K; pl. 14:5, 6; pls. 15, 16; pl. 19:3). In most specimens the length of the jaw ranges from 42 to 47 mm. In No. 1343 from Kollen it measures

55 mm. (col. 1, table 4). As to shape it agrees well with the jaw in the Scottish Osteolepids (JARVIK 1948a, p. 93, fig. 23) and, as in these forms, no sutures between the dermal bones are to be seen on its external face. The area overlapped by the quadratojugal (*od. Qj*) is often well shown, and dorsally to the posterior part of the latter, the pars articularis of the meckelian bone (*p. art. Mb*) with the articular area of the jaw (*art*) is sometimes displayed. Anteriorly there is a symphysial pit, but it could not be established with certainty whether areas overlapped by symphysial dermal bones (cf. fig. 27 A and JARVIK 1948a, p. 93). are developed. The medial side of the jaw is not displayed in any of the specimens.

Table 4. *Gyroptychius groenlandicus* n. sp. Range of variation in total length and in certain proportions of the lower jaw.

a, length of parietal shield; *k*, distance from vertical pit-line of infradentary 2 to posterior end of jaw (cf. JARVIK 1948a, fig. 12 D); *l. Lj*, length of lower jaw; *m*, distance from vertical pit-line of infradentary 2 to anterior end of jaw.

Mus. No.	Locality	1	2	3
		l. Lj mm.	$\frac{l.\,Lj}{a}$	$\frac{k}{m}$
P. 1310 (holotype)	210–234 m.[1])	(40)	(2.75)	(2.35)
P. 1325	—	42	2.61	2.35
P. 1341	—	46	..	..
P. 1356	—	43	..	2.45
P. 1409	—	47	..	2.44
P. 1343	Kollen	55	..	..
P. 1344	—	43	..	2.35
P. 1369	—	47	..	2.43
P. 1367	Circusbjærg	47	..	2.49
P. 1390	—	43	..	..

[1]) The horizon at 210—234 m. in the NW. part of Hesteskoen, Canning Land.

Opercular and gular bones.

The opercular (*Op*, figs. 12 A, B, 22 A, 29 A, B; pl. 1:1; pl. 2:1) in the holotype, on both sides damaged by crushing and incomplete, is about of the same length as the parietal shield and a little higher than it is long, the length: height ratio being about 0.94 (col. 1, 2, table 5). The depressed area along the dorsal margin of the bone is incompletely divided into two portions, one anterior (*od. Et*) overlapped by the extratemporal and one posterior ($od_2 Ext.\ l$) overlapped by the lateral extrascapular (cf. JARVIK 1948a, p. 95). Anteriorly the

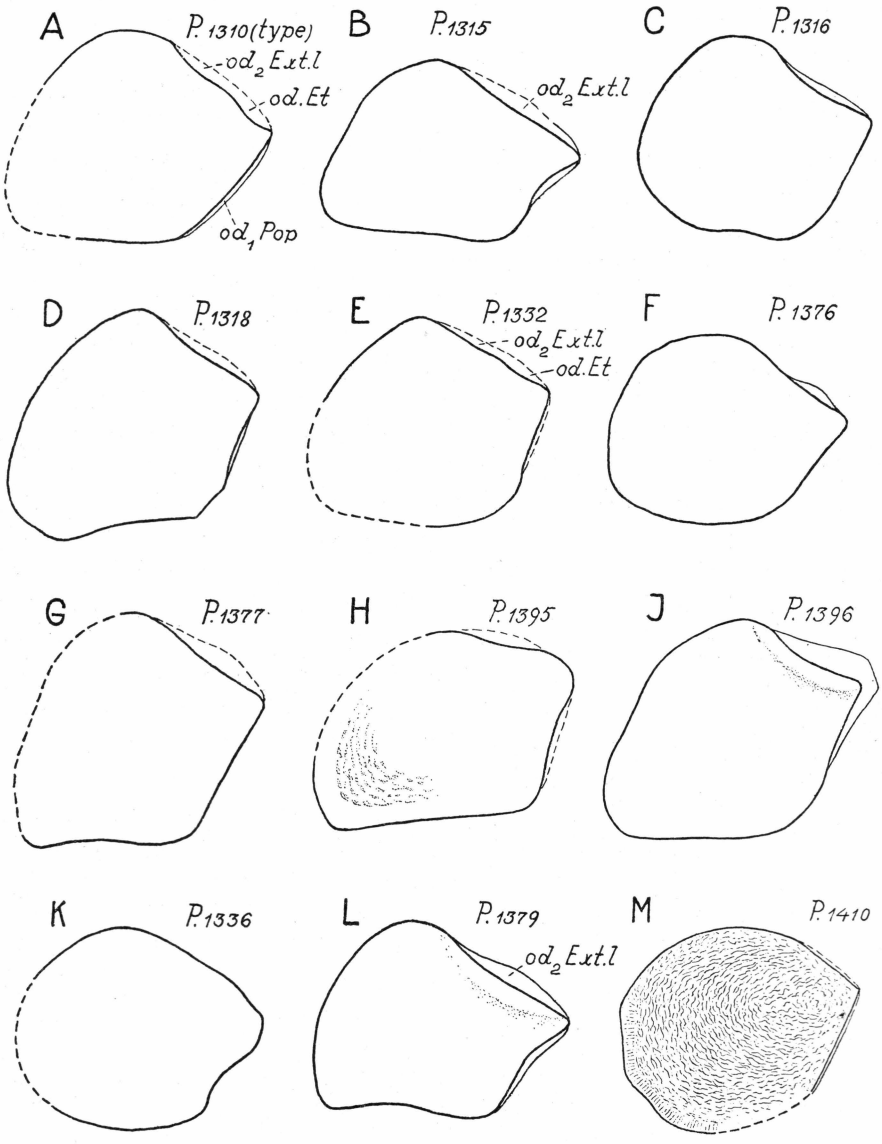


Fig. 22. *Gyroptychius groenlandicus* n. sp. Sketches of the opercular of the right side of twelve specimens from various localities, showing variations. External view. Key to the specimen-numbers on pp. 13—15. *A*, $^2/_1$. In *B-M* the length of the bone is approximately the same as in *A*, which shows the holotype (the real length of the bones is given in col. 1, table 5; cf. also pl. 1:1; pl. 2:1; pl. 17).
od. Et, area overlapped by extratemporal; *od*$_1$*Pop*, area overlapped by preopercular; *od*$_2$*Ext. l*, area overlapped by lateral extrascapular.

bone is as usual overlapped by the external cheek plate (the preopercular; *od*$_1$*Pop*). The dorso-lateral ridge (cf. JARVIK 1948a, p. 16; *ri. dl*, figs. 3 F, 24 A) is indistinct.

The material of Greenland Osteolepids at my disposal includes several detached opercular s (fig. 22 B—M; pl. 17), a few of which are partly or wholly ornamented (fig. 22 H, M; pl. 17:7, 8; cf. pp. 17—19). These detached bones differ more or less from the opercular in the holotype. The length varies from 12 to 24 mm. (14 mm. in the holotype) and the length: height ratio ranges from ca. 0.80 to ca. 1.06 (col. 1, 2, table 5). In most specimens the depressed area along the dorsal margin is undivided and most probably this area (*od*$_2$*Ext. l*) was overlapped only by the lateral extrascapular (thus not by the extratemporal), as is the corresponding area in most specimens of Scottish Osteolepids (JARVIK 1948a, p. 95). The dorso-lateral ridge (*ri. dl*; pl. 1:1; pl. 17:2—4, 6) is well developed in some specimens.

As demonstrated elsewhere (JARVIK 1948a, p. 20) detached operculars of Middle Devonian Osteolepids, like detached subopercular s and detached scales, are generally indeterminable both to genus and species and therefore it is of course impossible to state with certainty that all the detached operculars mentioned above really belong to *G. groenlandicus*. However, since all determinable cranial remains of Osteolepids from East Greenland hitherto known are referable to *G. groenlandicus* and since the range of variation is not greater than in the species of Scottish Osteolepids, it is probable that at least most of them belong to this species.

The subopercular (*Sop*) in the holotype is preserved only on the right side (figs. 12 A, C, 23 A, 29 A, C; pl. 1:5). It is about 12 mm. long, that is somewhat shorter than the opercular and ca. 1.28 times longer than it is high (col. 3, 4, table 5). As in other Osteolepids it is overlapped anteriorly by the lower jaw and the external cheek plate (the area *od*$_2$*Pop*) and dorsally by the opercular (the area *od. Op*). The subopercular in No. P. 1325 (fig. 23 D; pl. 4:1) resembles that in the holotype. The remaining five subopercular s figured (fig. 23 B, C, E—G; pl. 18:1, 2, 5; pl. 19:1, 3) are mutually rather different and differ more or less from that in the holotype (col. 3, 4, table 5), but on account of the fact that the subopercular in the various species of the Scottish Osteolepids is subject to considerable variations (cf. above as regards the opercular), they may at least provisionally be referred to *G. groenlandicus*.

The branchiostegal rays (figs. 12 A, C, 29 A, C; cf. fig. 25) are incompletely shown and cannot be fully described. The holotype only presents the large posterior ray of the left side and the second ray of the right side. The large posterior branchiostegal ray (*Rbr. 1*, fig. 23 H; pl. 1:6; pl. 2:2; col. 1, 2, table 5), which is suggestive of that in the holotype of *G. milleri* (fig. 25 C, D), is about 11 mm. long and ca. 1.52 times longer than it is broad (high). It has a relatively long

antero-dorsal margin overlapped by the lower jaw (the area od_4Lj), and, as in other Osteolepids, the bone is overlapped also by the subopercular (the area *od. Sop*) and by the second ray (the area *od. Rbra*).

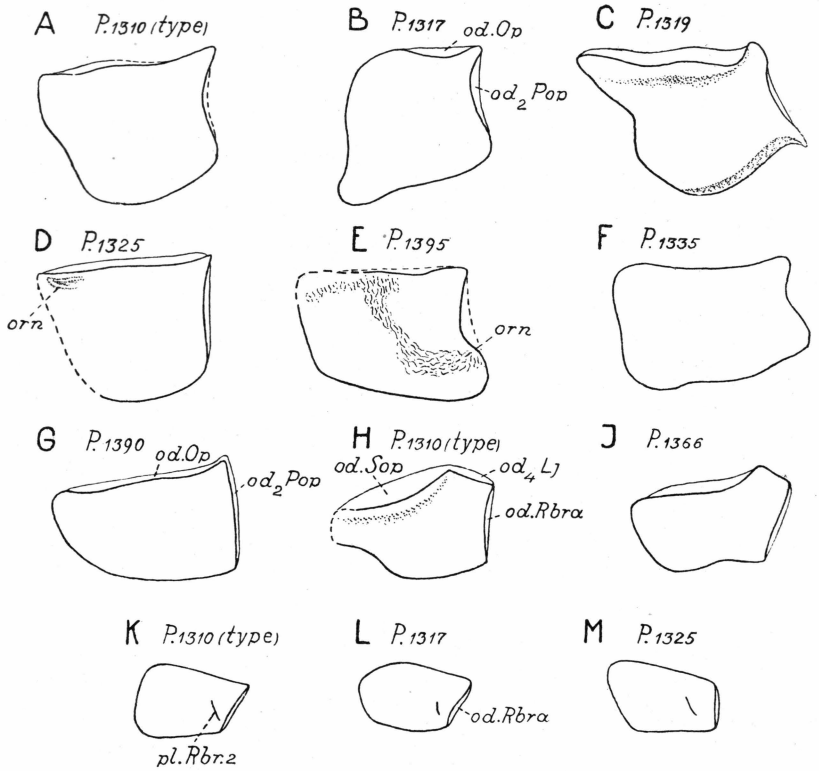
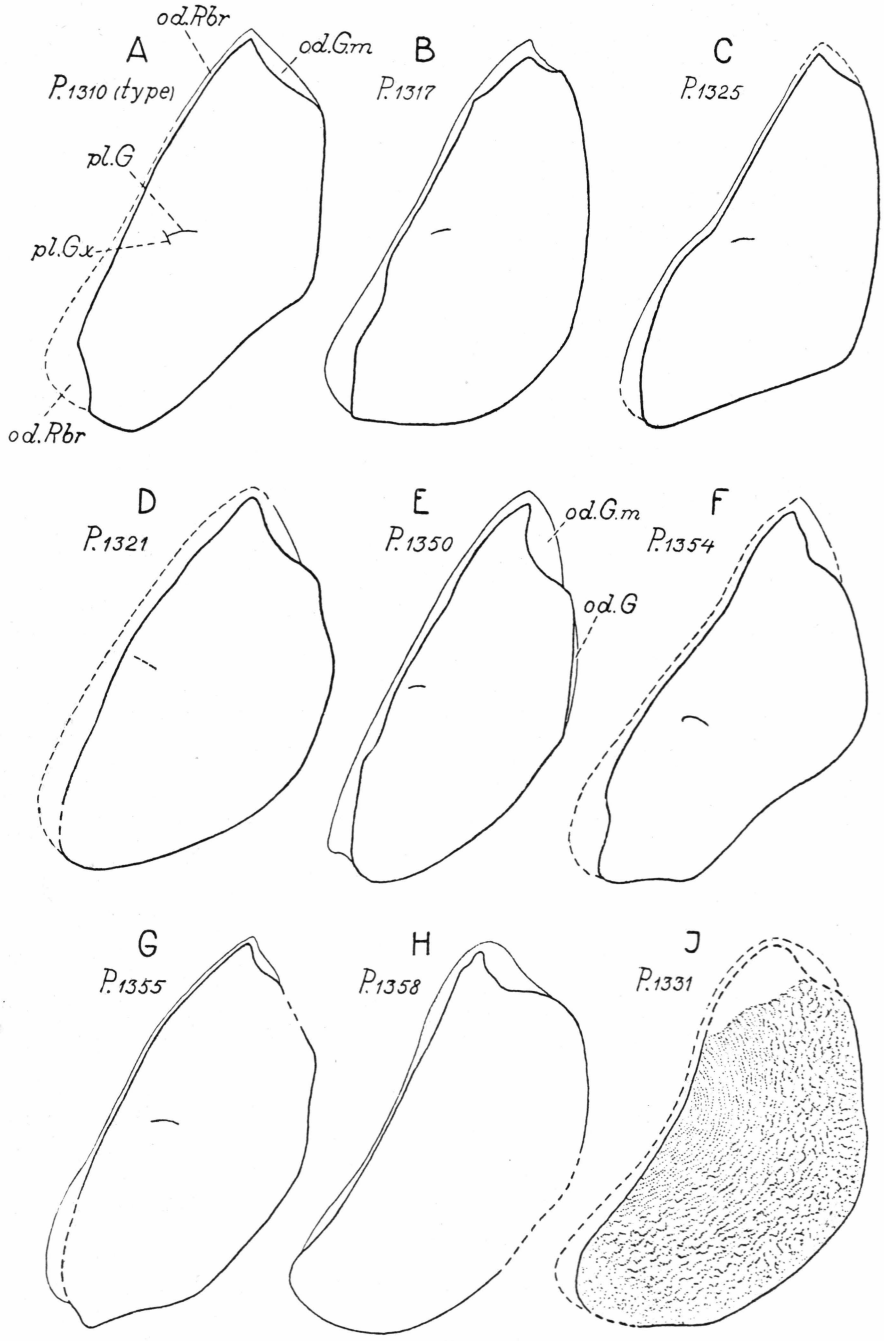


Fig. 23. *Gyroptychius groenlandicus* n. sp. Sketches of, *A-G*, the subopercular, *H*, *J*, the hindmost branchiostegal ray and, *K-M*, the second branchiostegal ray from behind. External view. Key to the specimen-numbers on pp. 13—15. *A*, *H*, *K* (holotype) $^2/_1$; in the other figures the length of the bones is approximately the same as in the corresponding bones in the holotype (the real length of the bones is given in col. 1, 3, table 5; see also pl. 1:5, 6; pl. 2:2; pl. 4:1; pl. 18:1, 2, 5; pl. 19:1—3). *od. Op*, area of subopercular overlapped by opercular; *od. Rbra*, area of branchiostegal ray overlapped by ray following next in front; *od. Sop*, area of hindmost branchiostegal ray overlapped by subopercular; od_2Pop, area of subopercular overlapped by external cheek plate and lower jaw; od_4Lj, area of hindmost branchiostegal ray overlapped by lower jaw; *orn*, ornamentation; *pl. Rbr. 2*, pit-line of second branchiostegal ray.

A detached posterior branchiostegal ray similar to that in the holotype is found in No. P. 1366 (fig. 23 J; pl. 19:2). The second branchiostegal ray (*Rbr. 2*) in the holotype (fig. 23 K; pl. 2:2) measures 7 mm. in length and is about 1.47 times longer than it is broad (high; col. 3, 4,


od.Rbr
od.Grn
A
P.1310 (type)
pl.G
pl.Gx
od.Rbr
B
P.1317
C
P.1325
D
P.1321
E
P.1350
od.G.m
od.G
F
P.1354
G
P.1355
H
P.1358
J
P.1331

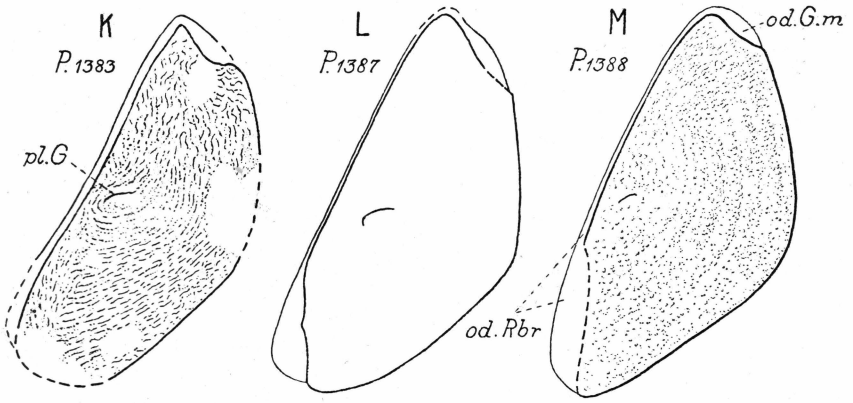


Fig. 24. *Gyroptychius groenlandicus* n. sp. Sketches of the right principal gular of twelve specimens, showing variations. External view. In *J*, *K*, *M*, the enamel and dentine layers are wanting. Key to the specimen-numbers on pp. 13—16. *A* (holotype) $^2/_1$; in the other specimens the length of the plate is approximately the same as in *A* (the real length of the plates is given in col. 1, table 6; cf. also pl. 2:2; pl. 4:1; pl. 18:5; pl. 19:3—6; pl. 20).

od. G, area overlapped by principal gular of other side; *od. G. m*, area overlapped by median gular; *od. Rbr*, area overlapped by branchiostegal rays; *pl. G*, pit-line of principal gular; *pl. Gx*, additional pit-line of principal gular.

table 5). The second ray is displayed also in Nos. P. 1317, P. 1325, and P. 1390 (fig. 23 L, M; pl. 4:1; pl. 18:5; pl. 19:3). In one of these specimens (No. P. 1390) it is a little broader proportionately than in the holotype (length: breadth ratio ca. 1.22), whereas in the two other specimens it is relatively narrow (col. 3, 4, table 5). The third branchiostegal ray (*Rbr. 3*) is preserved in its natural position in No. P. 1390 (pl. 19:3). In front of this ray follows in this specimen a narrow smooth area (*ar. Rbr*) extending forwards between the lower jaw and the principal gular about to the posterior end of the median margin of the lower jaw, which meets the corresponding margin of the other jaw at the symphysis. This area was no doubt occupied by anterior branchiostegal rays and judging from this specimen the branchiostegal rays extend forwards to the symphysis of the jaws (figs. 12 C, 29 C) as they do in *G. milleri* (fig. 25 D). Detached anterior branchiostegal rays, sometimes long and narrow and therefore most probably compound, have found in several specimens (pl. 12:2; pl. 18:3—5).

The principal gular (G) is shown in the holotype (figs. 12 A, C, 24 A, 29 A, C; pl. 2:2) and in Nos. P. 1317, P. 1325, and P. 1390 (fig. 24 B, C; pl. 4:1; pl. 18:5; pl. 19:3), and is in addition represented by several detached plates (fig. 24 D—M; pl. 19:4—6; pl. 20). The length of the bone ranges from ca. 23 to ca. 38 mm. (27 mm. in the holotype;

Table 5. *Gyroptychius groenlandicus* n. sp. Range of variation in length and in the length : height ratio of the opercular, the subopercular, and the first and second branchiostegal rays.

ht, height; *l*, length.

Mus. No,	Locality	1	2	Mus. No.	Locality	3	4
		l mm.	$\frac{l}{ht}$			*l* mm.	$\frac{l}{ht}$
opercular				subopercular			
P. 1310 ... (holotype)	210–234 m.[1])	14	0.94	P. 1310 ... (holotype)	210–234 m.[1])	12	1.28
P. 1315 ...	—	19	1.06	P. 1317 ...	—	11	0.92
P. 1318 ...	—	20	0.86	P. 1319 ...	—	14	1.23
P. 1332 ...	—	19	0.96	P. 1325 ...	—	12	1.29
P. 1376 ...	—	12	1.04	P. 1335 ...	—	15	1.48
P. 1377 ...	—	15	0.82	P. 1395 ...	—	11	1.26
P. 1395 ...	—	12	0.94	P. 1390 ...	Circusbjærg	19	1.52
P. 1410 ...	—	18	0.96	branchiostegal ray 2			
P. 1316 ...	profile *c*[1])	14	1.04				
P. 1335 ...	Vimmelsk.	19	1.06				
P. 1396 ...	Circusbjærg	19	0.80	P. 1310 ... (holotype)	210–234 m.[1])	7	1.47
P. 1379 ...	—	24	0.98	P. 1317 ...	—	9	1.63
branchiostegal ray 1				P. 1325 ...	—	11	1.57
				P. 1390 ...	Circusbjærg	9	1.22
P. 1310 .. (holotype)	210–234 m.[1])	11	1.52				
P. 1366 ..	Circusbjærg	17	1.68				

[1]) The horizon at 210—234 m. and talus in profile *c* in the NW. part of Hesteskoen, Canning Land.

col. 1, table 6) and is in the holotype ca. 1.88 and in No. P. 1325 about 1.84 times longer than the parietal shield (col. 2, table 6). In *G. milleri* (fig. 25 D) the corresponding relation is ca. 1.90. As in other species of *Gyroptychius* (see JARVIK 1948a, col. 31, tables 1, 9), the principal gular is short in comparison with the lower jaw, the ratio *l. G*:*l. Lj* being in the holotype ca. 0.68, in No. P. 1325 ca. 0.72, and in No. P. 1390 ca. 0.74 (col. 3, table 6). The bone is broad in relation to its length—the length : breadth ratio ranges in most of the specimens from ca. 1.93 to ca. 2.14 (col. 4, table 6)—and agrees in this respect with that in *G. milleri* (fig. 25 D; *l. G*:*br. G* ca. 2.16—2.20), but differs clearly from that in *G. agassizi* and other Scottish Middle Devonian Osteolepids (fig. 25 B; JARVIK 1948a, col. 33, table 1). As in other Osteolepids the principal gular is overlapped antero-medially by the median gular (the area *od. G. m*) and laterally by the branchiostegal rays (there area *od. Rbr*).

Table 6. *Gyroptychius groenlandicus* n. sp. Principal gular. Range of variation in length and in certain proportions.

a, length of parietal shield; *br. G*, breadth of principal gular; *l. G*, length of principal gular; *l. Lj*, length of lower jaw; *n*, distance from pit-line of principal gular to anterior end of bone (see JARVIK 1948a, fig. 12 E); *p*, distance from pit-line of principal gular to posterior end of bone.

Mus. No.	Locality	1	2	3	4	5
		l. G mm.	$\frac{l.\,G}{a}$	$\frac{l.\,G}{l.\,Lj}$	$\frac{l.\,G.}{br.\,G}$	$\frac{p}{n}$
P. 1310 ..... (holotype)	210–234 m.[1])	27	1.88	0.68	2.08	1.02
P. 1317	—	35	..	..	2.12	1.10
P. 1321	—	28	..	..	1.93	1.08
P. 1325	—	30	1.84	0.72	2.14	1.06
P. 1331	—	27	..	..	2.04	..
P. 1350	—	38	..	..	2.25	0.87
P. 1354	—	33	..	..	2.06	0.85
P. 1358	—	33	..	..	2.04	..
P. 1383	—	(32)	..	..	(2.20)	(1.10)
P. 1387	—	32	..	..	2.13	0.96
P. 1355	prof. *c*[1])	23	..	..	2.11	1.12
P. 1388	Vimmelsk.	38	..	..	2.06	1.04
P. 1390	Circusbjærg	34	..	0.74	1.98	..

[1]) Horizon at 210—234 m. and talus in profile *c*, NW. part of Hesteskoen, Canning Land.

In two specimens, viz. in No. P. 1350, which shows the left, and in No. P. 1374, which shows the right plate, the principal gular also presents an overlapped area along the medial margin (*od. G*, fig. 24 E; pl. 19:6; pl. 20:2), and obviously these two plates, like the right gular plate in the specimens of *Porolepis* and *Glyptolepis* shown in fig. 27, were overlapped by the gular plate of the other side[1]).

[1]) According to HUBBS & HUBBS (1944, p. 279) the left branchiostegal membrane as a rule overlaps the right one in Ganoids and Teleosts. However, in the specimens of *Porolepis* and *Glyptolepis* shown in fig. 27 and in other specimens of these forms at my disposal the right gular plate overlaps the gular plate of the left side, which must mean that in these forms it is the right branchiostegal membrane that overlaps the left one. As we have seen also in one specimen of *G. groenlandicus* (No. P. 1350), the right gular plate (branchiostegal membrane) overlaps the left one and the same condition is found in some specimens of *Osteolepis macrolepidotus* at my disposal and in several specimens of *Polypterus* (ALLIS 1922; pl. 4:4; POLL 1941/42, figs. 3, 9, 12, 18, 24; JARVIK 1947, fig. 1 C). In one specimen of *G. groenlandicus* (No. P. 1374), in one of the specimens of *Polypterus* figured by POLL (1941/42, fig. 6) and in *Latimeria* (SMITH 1939, p. 61), on the other hand, the left branchiostegal membrane overlaps the right one. In Crossopterygians and Brachiopterygians the overlapping conditions of the branchiostegal membranes thus seem to be less constant than in Teleosts and recent Ganoids.

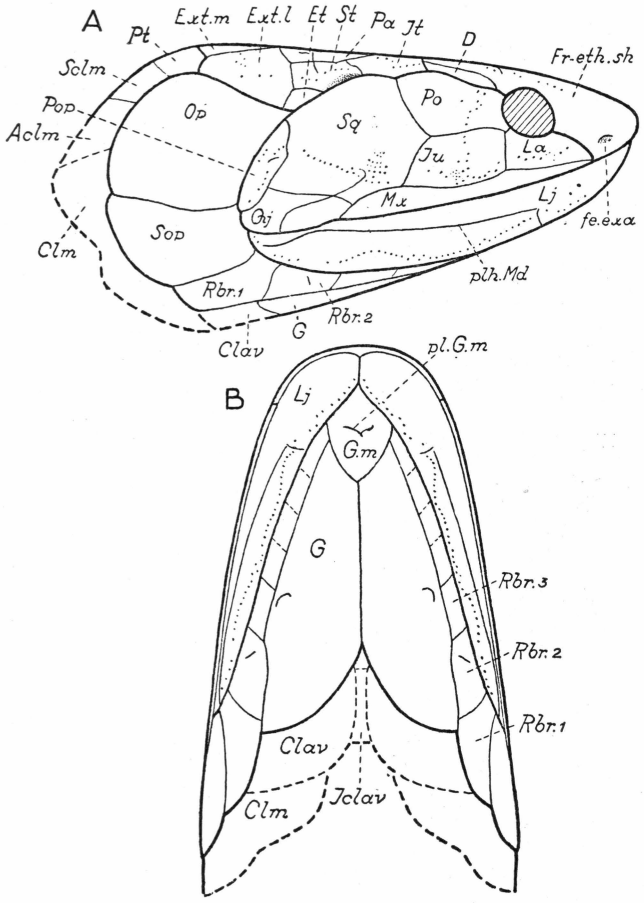
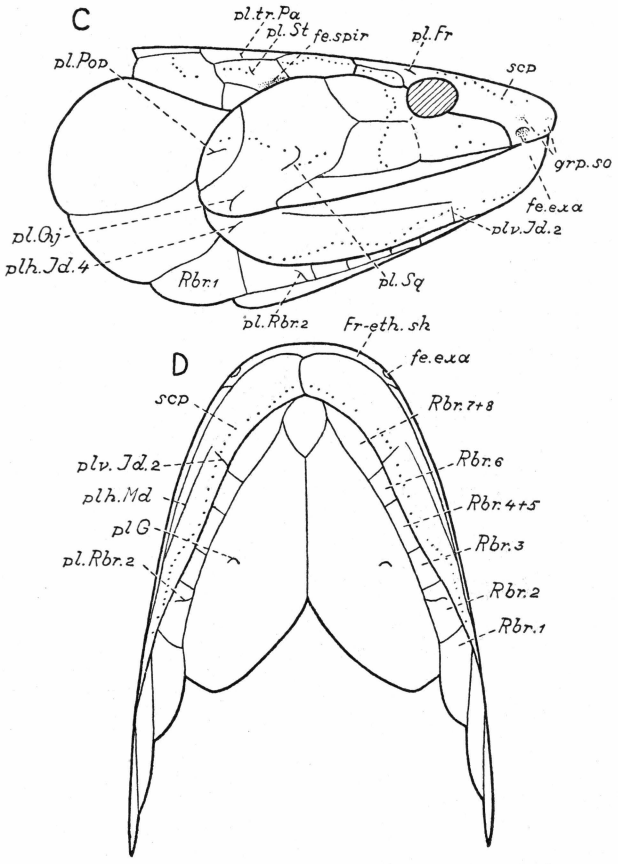


Fig. 25. Restorations of skull and (in *A* och *B* only) exoskeletal shoulder-girdle in lateral and ventral aspects of, *A*, *B*, *Gyroptychius agassizi* (TRAILL) and, *C*, *D*, *Gyroptychius milleri* JARVIK. From JARVIK (1948a, figs. 71 A, C, 77 A, C). All the sketches are drawn to a scale, assuming the parietal shield to be about 29 mm. in length (= the length of the parietal shield in the holotype of *G. groenlandicus* magnified 2 times; cf. figs. 12, 29).

Aclm, anocleithrum; *Clav*, clavicle; *Clm*, cleithrum; *D*, dermosphenotic; *Et*, extratemporal; *Ext. l*, *Ext. m*, lateral and median extra-scapulars; *Fr-eth. sh*, frontoethmoidal shield; *G*, principal gular; *G. m*, median gular; *Iclav*, interclavicle; *It*, intertemporal; *Ju*, jugal; *La*, lachrymal; *Lj*, lower jaw; *Mx*, maxillary; *Op*, oper-

As pointed out above (p. 19), the external face of the principal gular is ornamented in some specimens. These ornamented gulars (fig. 24 J, K, M; pl. 20:3, 5, 6), which are all preserved as more or less complete impressions of the external face, are of the broad type characteristic of *G. groenlandicus* (col. 4, table 6), and also in other respects, e. g. in the development of the overlapped areas and in the position



cular; *Pa*, parietal; *Po*, postorbital; *Pop*, preopercular; *Pt*, posttemporal; *Qj*, quadratojugal; *Rbr. 1*, *Rbr. 2*, *Rbr. 3*, *Rbr. 4+5*, *Rbr. 6*, *Rbr. 7+8*, branchiostegal rays; *Sclm*, supracleithrum; *Sop*, subopercular; *Sq*, squamosal; *St*, supratemporal. *fe. exa*, fenestra exonarina anterior; *fe. spir*, spiracular fenestra; *grp. so*, groups of pores, probably for nerves to groups of cutaneous sensory organs; *pl. Fr*, frontal pit-line; *pl. G*, *pl. G. m*, pit-lines of principal and median gulars; *plh. Id. 4*, horizontal pit-line of infradentary 4; *plh. Md*, horizontal part of mandibular pit-line; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Rbr. 2*, pit-line of second branchiostegal ray; *pl. Sq*, squamosal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *plv. Id. 2*, vertical pit-line of infradentary 2; *scp*, pores of sensory canals.

of the pit-line (col. 5, table 6), they agree well with the principal gular in typical representatives of that form. That they cannot belong to *Tristichopterus* (fig. 26) as assumed by Säve-Söderbergh (1937) is quite obvious since the principal gular in this form, as in the allied form *Eusthenopteron* (Jarvik 1944a, figs. 1 C, 2 D, 9 D, 10 A), is very long and narrow (length: breadth ratio in the figured specimen ca. 3.50).

In this connection it is worth while mentioning that the principal gular in Porolepiform Crossopterygians (fig. 27) may be very suggestive



Fig. 26. *Tristichopterus alatus* EGERTON. Principal gular in inner view. Specimen No. P. 4196 Stockh. From Northsands, Deerness, Orkney. $^{2}/_{1}$.

of that in *G. groenlandicus*. Since Porolepiform Crossopterygians, as evidenced by cranial remains (see p. 100), are represented in the same geological deposits in East Greenland as *G. groenlandicus*, it is of course

---

Fig. 27. *A. Porolepis* sp. Imperfect skull in ventral view. Specimen collected by the English-Norwegian-Swedish Spitzbergen expedition in 1939 (cf. JARVIK 1942, p. 354; FØYN & HEINTZ 1943). From Mt. Vaekter, slope towards Wood Bay, Spitzbergen. $^{3}/_{2}$. *B. Glyptolepis leptopterus* AGASSIZ. Flattened imperfect ventral half of skull with external cheek plate of left side, exoskeletal shoulder-girdle and anterior part of body in outer view. Photograph of gutta-percha cast. Specimen No. P. 1666 Stockholm. From Lethen Bar, Scotland. $^{1}/_{1}$.

Clav, clavicle; *Clm. 1*, *Clm. 2*, *Clm. 3*, parts of cleithrum, probably forming independent bones (see pp. 117—120); *G*, principal gular; *G. m. 1*, *G. m. 2*, median gulars; *Lj*, lower jaw; *Op*, opercular; *Pop*, preopercular; *Qj*, quadratojugal; *Rbr*, branchiostegal rays; *Sop*, subopercular; *Sq 1*, *Sq. 2*, squamosals; *Sy*, symphysial dermal bones (cf. JARVIK 1944a, p. 26; 1948a, p. 23).

od. G, area of principal gular overlapped by principal gular of other side; *od. Rbr*, area of principal gular overlapped by branchiostegal rays; *pl. G*, pit-line of principal gular; *pl. G. m*, pit-line of median gular; *pl. Rbr*, pit-line of branchiostegal ray; *plv. Id. 2*, vertical pit-line of infradentary 2.

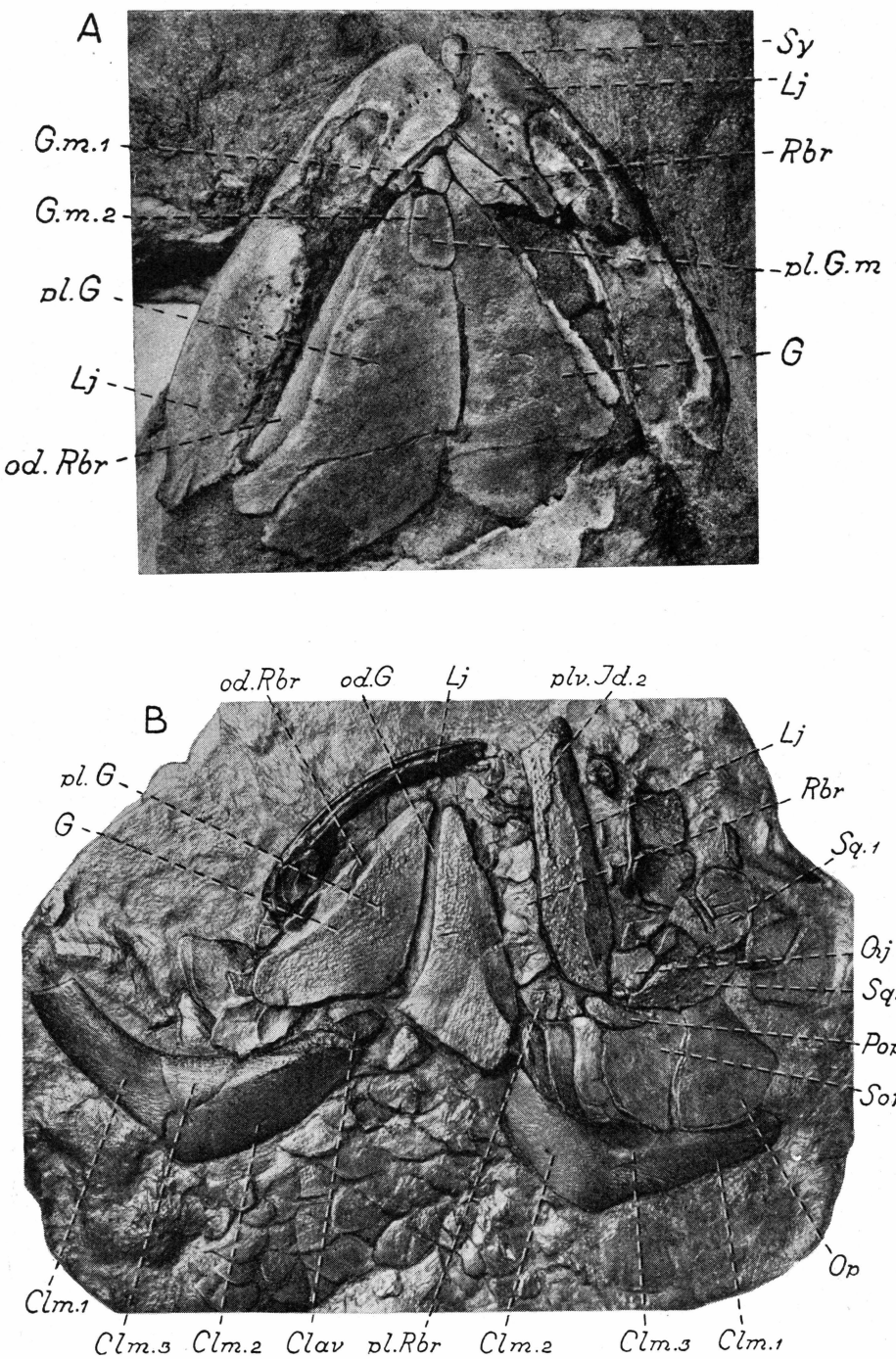

A
Sy
Lj
Rbr
pl.G.m
G
G.m.1
G.m.2
pl.G
Lj
od.Rbr
B
od.Rbr
od.G
Lj
plv.Jd.2
Lj
Rbr
Sq.1
Qj
Sq.2
Pop
Sop
Op
pl.G
G
Clm.1
Clm.3
Clm.2
Clav
pl.Rbr
Clm.2
Clm.3
Clm.1

Fig. 27.

possible that one or more of the ornamented principal gulars may belong to such a form and not to *G. groenlandicus*.

Among the material of *Porolepiformes* at my disposal the principal gular in *G. groenlandicus* most closely resembles that in some specimens of *Porolepis* from Spitzbergen (fig. 27 A). As in *G. groenlandicus*, the principal gular in *Porolepis* is thus broad; in the specimen shown in fig. 27 A it is about 2.00 and in another specimen about 1.80 times longer than it is broad (cf. col. 4, table 6). Antero-medially the plate—exactly as in *G. groenlandicus* and other *Osteolepiformes*—is overlapped by the median gular (in the specimen used for illustration subdivided into two plates, *G. m. 1*, *G. m. 2*) and along the lateral margin there is a depressed area (*od. Rbr*) overlapped by the branchiostegal rays (cf. also footnote 1 on p. 85). Also the pit-line of the principal gular (*pl. G*) in *Porolepis* lies about as in *G. groenlandicus* (figs. 12 C, 24), the ratio *p/n* in the two specimens referred to above being ca. 0.96 and ca. 1.10, respectively, (cf. p. 98 and col. 5, table 6). In *Glyptolepis leptopterus* (fig. 27 B), which is from the Middle Devonian of Scotland and from strata which are probably almost contemporaneous to those yielding *G. groenlandicus* and indeterminable *Porolepiformes* (cf. p. 124), the principal gular differs somewhat from that in *Porolepis*. It is thus a little narrower proportionately (in the figured specimen the length: breadth ratio is ca. 2.50) and the pit-line lies comparatively far forwards (*p/n* ca. 1.28) and medially, and as far as I can find, no area is developed corresponding to that which in the Osteolepids and Porolepids is overlapped by the median gular.

The median gular (*G. m*) is not preserved, but judging from the shape of the notches for this bone in the principal gular (fig. 24) it was short and broad as shown in the restorations (figs. 12 C, 29 C; cf. fig. 25 B, D).

The exoskeletal shoulder-girdle.

The dermal bones of the shoulder-girdle (figs. 12, 28, 29) are poorly preserved in the material available and only the anocleithrum, the cleithrum, and the clavicle have been identified with certainty.

The anocleithrum (*Aclm*, figs. 12 A, B, 28 A, 29 A, B; pl. 1:1; pl. 2:1) is shown only on the left side of the holotype, but it is incompletely preserved. As in other *Osteolepiformes* (JARVIK 1944b; 1948a, pp. 97—98, p. 167), it is strongly overlapped by the supracleithrum (the area *od. Sclm*) and the cleithrum (*od*$_1$*Clm*), but it could not be established whether it is overlapped also by the opercular (cf. JARVIK 1948a, *od*$_3$*Op*, fig. 25 C, G). The anterior process of the bone is not preserved. The non-overlapped part of the bone has a relatively short anterior margin. The

external face of this part of the bone is smooth and shiny posteriorly and ventrally, but ornamented antero-dorsally.

The cleithrum (*Clm*, figs. 12, 28 B, C, 29; pl. 21:1—4) is fairly well shown in two specimens, Nos. P. 1394 from Kollen and No. P. 1403 from the horizon at 210—234 m. in the NW. part of Hesteskoen. The bone, which in these specimens is 23 and 27 mm. high, respectively,

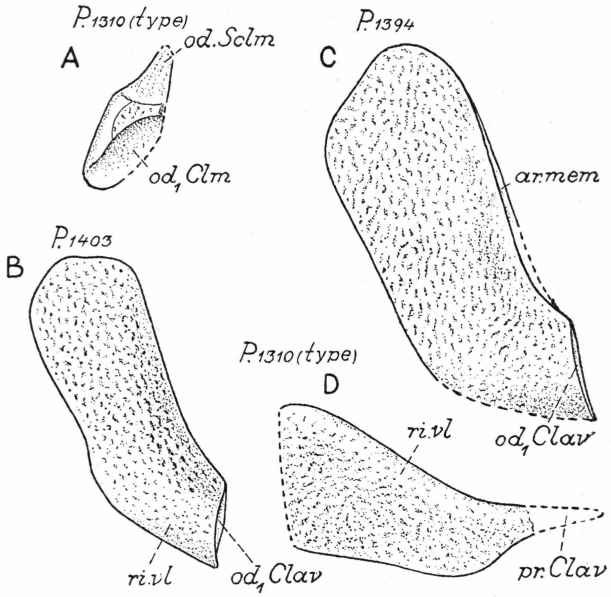


Fig. 28. *Gyroptychius groenlandicus* n. sp. Some bones of the exoskeletal shoulder-girdle in external aspect. *A*, right anocleithrum of holotype (see also pl. 1:1; pl. 2:1); *B*, *C*, right cleithrum of two specimens in lateral view (see also pl. 21:3, 4); *D*, left clavicle of holotype in ventral view (see also pl. 2:2). Key to the specimen-numbers on pp. 13—15. All figures $^3/_1$.

ar. mem, area, probably for attachement of membraneous posterior wall of branchial cavity; *od. Sclm*, area of anocleithrum overlapped by supracleithrum; *od*$_1$*Clav*, area of cleithrum overlapped by clavicle; *od*$_1$*Clm*, area of anocleithrum overlapped by cleithrum; *pr. Clav*, ascending process of clavicle; *ri. vl*, ventro-lateral ridge (cf. JARVIK 1948a, p. 18).

resembles the cleithrum in *Osteolepis* (see JARVIK 1948a, figs. 25 D, G, 46 K, L). In both specimens the external face of the non-overlapped part is wholly ornamented. In a third and much larger but incomplete specimen (the height of the bone may be estimated as having been ca. 60 mm.), also from the horizon at 210—234 m. (pl. 21:1), the external sheet of enamel and dentine (*de. l*) is retained in some places along the posterior margin of the bone. This specimen also presents the inner face of the cleithrum (pl. 21:2) with the areas of attachment for the

endoskeletal shoulder-girdle (*ar*$_1$*Scc*, *ar*$_2$*Scc*, *ar*$_3$*Scc*; cf. JARVIK 1944b, figs. 4 D, 6 C).

The clavicle (*Clav*) is best shown in the holotype, in which the main part of the right plate is presented in ventral aspect (figs. 12 A, C, 28 D, 29 A, C; pl. 2:2). It resembles the clavicle in *Osteolepis macrolepidotus* (JARVIK 1948a, figs. 25 E, G, 37 C, 46 M, N), though, in accordance with the fact that the head as a whole is relatively broad, it is broader than in that form and only the lateral half of its posterior margin meets (and overlaps) the cleithrum. The ascending process (*pr. Clav*) is not exposed. The whole external face of the bone is ornamented as in Nos. P. 1317 (pl. 18:5) and P. 1325 (pl. 4:1), which also show parts of the clavicle.

Squamation and fins.

Scales are very common in the material available and are found in most slabs (pp. 14—15; pl. 1:1; pl. 2:1; pl. 8:4; pl. 13:3—6; pl. 14:2; pl. 15:4; pl. 17:1; pl. 18:3, 5; pl. 22; pl. 23:2—4). In most cases the scales are scattered and only rarely are two or more scales found in their natural connection with each other (pl. 23:4). No extensive continuous parts of the squamation are preserved and since also the fins are poorly preserved, being represented mainly by detached dermal fin-rays, no description can be given of the disposition of the scales and of the shape and position of the fins.

The scales strongly resemble those in the Scottish Osteolepids (JARVIK 1948a, p. 106, fig. 28) and as in the Scottish species they vary strongly in shape and size. The areas overlapped by the adjoining scales (*od*$_1$*Sc*, *od*$_2$*Sc*; pl. 2:1; pl. 8:4; pl. 14:2; pl. 15:4; pl. 18:3; pl. 22; pl. 23:2, 3) are often disclosed and the groove (*gr*) separating each of these areas from the non-overlapped part of the scales is generally very distinct. The ridge (*ri. Sc*; pl. 8:4; pl. 15:4; pl. 22:2, 7, 8) on the inner side of the scales and the depressed areas overlapping adjoining scales (*og*$_1$*Sc*, *og*$_2$*Sc*) are often shown and sometimes the inner face presents small irregular and branching grooves (*gr. nv*; pl. 22:7, 8), probably for small twigs of nerves and vessels.

The size of the scales varies. In the holotype (pl. 1:1; pl. 2:1), which shows a few scales only, the largest of the flank-scales measures ca. 4 mm. in height and ca. 2.3 mm. in length, and the height and length amount to about 0.26 and 0.17, respectively, of the length of the parietal shield. The scales in the holotype are thus small in comparison with the scales in most Scottish Osteolepids and of about the same size, proportionately, as in *G. agassizi* and *G. milleri* (JARVIK 1948a, p. 106; col. 6, 7, table 2). In most other specimens the scales are of about the

same size or a little larger than in the holotype, the height of the largest flank-scales ranging from ca. 3.5 to ca. 6 mm and the length from ca. 2 to ca. 4 mm. One detached scale from the horizon at 210—234 m. in the NW. part of Hesteskoen is of a remarkable size, being ca. 12 mm. high and ca. 9 mm. long (pl. 23:3), and the scales are relatively large also in some other specimens from various localities. It is impossible to say whether these large scales really belong to *G. groenlandicus*.

The external face of the non-overlapped part of the scales is generally smooth and shiny and sometimes one or more blisters (*bli*) are shown (pl. 14:2; JARVIK 1948a, fig. 9 A). In several cases, however, a superficial sheet of varying thickness is lacking, and sometimes, no doubt due to the absence of the enamel and dentine layers, the external face is distinctly ornamented. In some specimens, e. g. in No. P. 1404, only one or a few of the scales are ornamented (pl. 22:2, 3), whereas in other specimens, e. g. in No. P. 1411 (pl. 22:4), the external faces of all the scales and cranial remains bear ornamentation (cf. pp. 17—19).

In one specimen (pl. 23:4) part of the squamation of the tail and remains of the caudal (*cdf*, *cvf*) and the second dorsal (*s. df*) fins are preserved. As is clearly seen, the dorsal lobe of the caudal fin (*cdf*) is high and no doubt the caudal fin is diphycercal as in *G. agassizi* (see JARVIK 1948a, p. 115, figs. 27 F, 76 A).

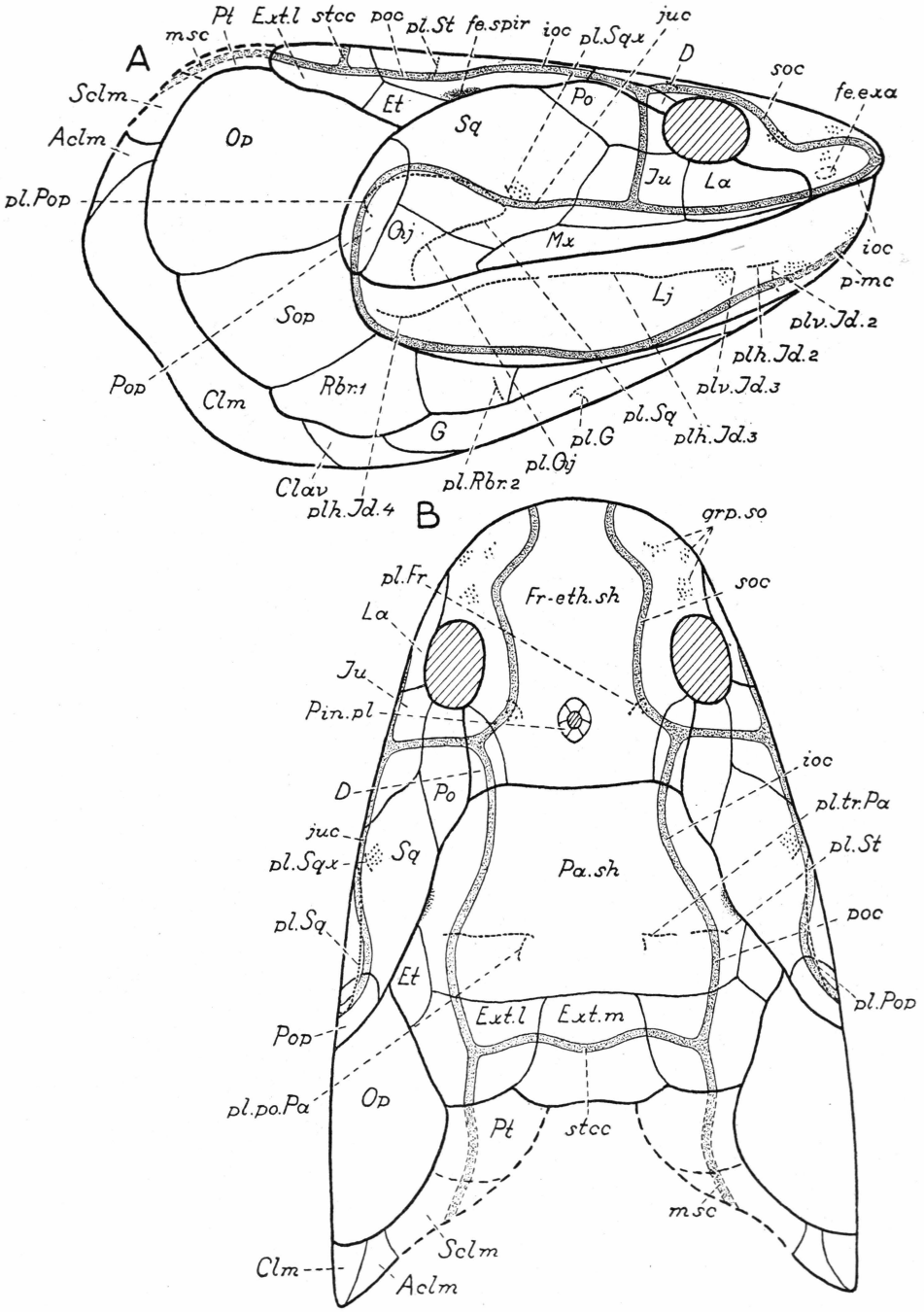
The same specimen (pl. 23:4) also shows a large basal scute (*bs. f*; cf. JARVIK 1948a, p. 110), probably of the anal fin, and in another specimen (pl. 22:5) a detached basal scute is found. Detached dermal fin-rays are preserved in several specimens (pl. 23:4).

Lateral-line system.

Sensory canals.

Parts of the sensory canals of the head are shown in several specimens (*ioc*, *ri. ioc*, etc., figs. 2, 15 D, 17 E, F, 19 B, D, F, H, M, Q, 20 B, D—F, J, 21 K; pl. 2:1, 3; pl. 3:1; pl. 4:1; pl. 5:4; pl. 6:3; pl. 7:3, 5, 6; pl. 9; pl. 10:1, 4, 6; pl. 12:2; pl. 13:2, 4—6; pl. 14:1, 4) and the combined data from these specimens have made possible an almost complete restoration (fig. 29) of the sensory-canal system of the head. As may be gathered from this restoration and other figures showing the sensory canals, these canals run very much as in *Osteolepis macrolepidotus* and other Osteolepids (JARVIK 1948a, pp. 122—126, fig. 32). It could not be ascertained whether an oral sensory canal is developed.

The tubes of the sensory canals of the head (figs. 15 D, 20 D, E; pl. 9:1, 2; pl. 13:4, 6; pl. 14:4) are rarely shown and have been omitted in the restoration (fig. 29). As in other Middle Devonian Osteolepids,


A
Pt
Ext.l
stcc
poc
pl.St
fe.spir
ioc
pl.Sqx
juc
D
soc
fe.ex.a
msc
Sclm
Et
Po
Aclm
Op
Sq
Ju
La
pl.Pop
Obj
Mx
ioc
p-mc
Lj
Sop
plv.Jd.2
plh.Jd.2
Pop
Clm
Rbr.1
plv.Jd.3
pl.Sq
G
pl.G
plh.Jd.3
Clav
plh.Jd.4
pl.Rbr.2
pl.Obj
B
grp.so
pl.Fr
Fr-eth.sh
soc
La
Ju
Pin.pl
ioc
D
Po
pl.tr.Pa
juc
pl.Sqx
Sq
Pa.sh
pl.St
pl.Sq
poc
Et
pl.Pop
Ext.l
Ext.m
Pop
pl.po.Pa
Op
Pt
stcc
msc
Sclm
Clm
Aclm

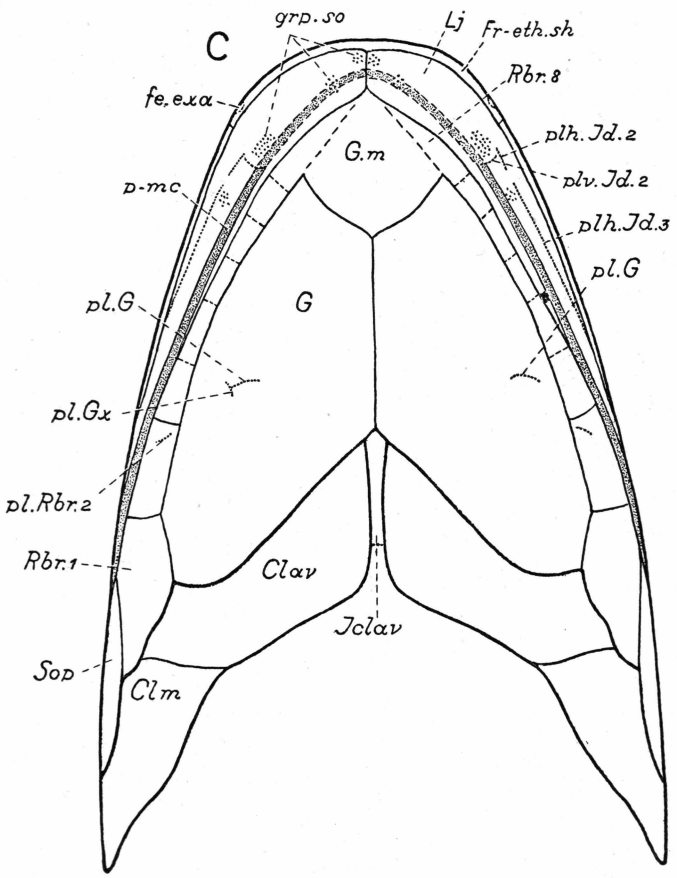


Fig. 29. *Gyroptychius groenlandicus* n. sp. Attempted restoration of the lateral-line system of the head and exoskeletal shoulder-girdle in, *A*, lateral, *B*, dorsal and, *C*, ventral aspect. The tubes and pores of the sensory canals omitted (cf. fig. 12; JARVIK 1948a, fig. 32). Ca. $^2/_1$.

Aclm, anocleithrum; *Clav*, clavicle; *Clm*, cleithrum; *D*, dermosphenotic; *Et*, extratemporal; *Ext. l*, *Ext. m*, lateral and median extrascapulars; *Fr-eth. sh*, frontoethmoidal shield; *G*, principal gular; *G. m*, median gular; *Iclav*, interclavicle; *Ju*, jugal; *La*, lachrymal; *Lj*, lower jaw; *Mx*, maxillary; *Op*, opercular; *Pa. sh*, parietal shield; *Pin. pl*, pineal plates; *Po*, postorbital; *Pop*, preopercular; *Pt*, posttemporal; *Qj*, quadratojugal; *Rbr. 1*, *Rbr. 8*, branchiostegal rays; *Sclm*, supracleithrum; *Sop*, subopercular; *Sq*, squamosal; *St*, supratemporal.

fe. exa, fenestra exonarina anterior; *fe. spir*, spiracular fenestra; *grp. so*, groups of pores, probably for twigs of nerves to groups of cutaneous sensory organs; *ioc*, infraorbital sensory canal; *juc*, jugal sensory canal; *msc*, main sensory canal; *pl. Fr*, frontal pit-line; *pl. G*, pit-line of principal gular; *pl. Gx*, additional pit-line of principal gular; *plh. Id. 2*, *plh. Id. 3*, *plh. Id. 4*, horizontal pit-lines of infradentaries 2, 3, and 4; *pl. Pop*, preopercular pit-line; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Rbr. 2*, pit-line of second branchiostegal ray; *pl. Sq*, squamosal pit-line; *pl. Sqx*, additional squamosal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *plv. Id. 2*, *plv. Id. 3*, vertical pit-lines of infradentaries 2 and 3; *p-mc*, preoperculo-mandibular sensory canal; *poc*, postotic sensory canal; *soc*, supraorbital sensory canal; *stcc*, supratemporal commissural canal.

they are short and unbranching or little branching and as a whole they are given off from the canals in the same directions as in *Osteolepis macrolepidotus*. In two specimens (fig. 15 D; pl. 9:1, 2) the tubes in the intertemporal are laterally directed.

The pores (*scp*, *iocp*, *jucp*, etc., figs. 2, 12, 13, 15 A—C, 16 A, D—F, 17 B, C, G, H, 18, 19 A—E, G—L, N, 20 B—E, H—K, 21 A, D—K, 29; also several of the plates) of the sensory canals of the head are generally arranged in single rows as in other Middle Devonian Osteolepids.

The sensory canals of the exoskeletal shoulder-girdle and of the body and their tubes and pores are too incompletely displayed to be described.

Pit-lines.

The grooves for the pit-lines are generally well shown and in many cases it has been possible to count the nerve-foramina in their bottom (*nf*, fig. 2; pl. 6:6; pl. 11; pl. 12:1). Since each nerve-foramen at least probably transmitted a nerve-twig to a single sensory organ, it is possible to determine the number of sensory organs in the individual pit-lines. The nerve-foramina, which vary in number with the length of the pit-lines, are very closely set and probably the sensory organs were small. In the holotype and in No. P. 1300 (fig. 2) there are thus no less than about 9 nerve-foramina per mm. For comparison it may be mentioned that the pit-lines in adult specimens of *Polypterus bichir* (cf. JARVIK 1947) contain only about 4—5 organs per mm.

The frontal pit-line (*pl. Fr*, figs. 12 A, B, 13, 15 A—C, 16 A, D—F, 29 A, B; pl. 1:1; pl. 2:1; pl. 3; pl. 5:1; pl. 6:1, 2, 5, 6) is short as in *G. milleri* (fig. 14 B, D) and as in that form it usually lies antero-laterally to the pineal foramen and medially to the postorbital corner. In No. P. 1302 (fig. 16 A) it lies relatively far forwards, antero-medially to the postorbital corner. The number of nerve-foramina (sensory organs) is about 18 in the holotype, and in No. P. 1303, in which the pit-line lies partly on a blister (*bli*, pl. 6:5, 6), about 24. The supratemporal pit-line (*pl. St*) and the transverse and posterior oblique parietal pit-lines (*pl. tr. Pa*, *pl. po. Pa*, figs. 12 A, B, 13, 15, 17 A—F, 29 A, B; pl. 1:1; pl. 3:1, 2; pl. 5:2; pl. 8:1—3, 5, 6; pl. 9:2, 4, 5) are developed as usual in Osteolepids (cf. fig. 14). In the holotype the supratemporal pit-line contains ca. 30, the transverse parietal pit-line ca. 24, and the posterior oblique parietal pit-line ca. 17 nerve-foramina. On the extrascapulars no traces of pit-lines have been found.

The squamosal pit-line (*pl. Sq*, figs. 2, 12 A, B, 18, 20, 29 A, B; pl. 1:1; pl. 2:1; pl. 3:2; pls. 11, 12; pl. 13:1, 3—6; pl. 14:1—4) consists, as in other *Osteolepiformes* (fig. 25 A, C; JARVIK 1944a, 1948a, p. 133, of two shanks, dorsal and ventral. In the holotype an extra

squamosal pit-line is developed (*pl. Sqx*, figs. 12 A, B, 18, 20 A, 29 A, B; pl. 1:1; pl. 2:1). The dorsal and ventral shanks of the squamosal pit-line vary in length and may be interrupted at one or more places. The dorsal shank may be continuous with the preopercular pit-line and the ventral one with the quadratojugal pit-line. In No. P. 1300 (figs. 2, 20 B; pl. 11; pl. 12:1; pl. 13:1) both these alternatives are realised, there being a long pit-line extending from the preopercular over the squamosal to the ventral margin of the quadratojugal. This long pit-line is interrupted in four places, in three of those by areas of resorbtion and blisters. In this specimen ca. 80 nerve-foramina are shown in the bottom of the squamosal pit-line, but since the pit-line is interrupted by a fairly long area of resorbtion, in which no nerve-foramina are to be seen, the nerve-foramina certainly are more numerous, probably about 100. In No. P. 1308 (fig. 20 C; pl. 13:5), in which the squamosal pit-line is subdivided into four portions, the most ventral and largest one of these portions, which is continuous with the quadratojugal pit-line, contains ca. 39 nerve-foramina, the next one ca. 6, the third ca. 15, and the fourth, which belongs to the dorsal shank, 7. The latter portion curves ventrally in its anterior part. In the holotype the squamosal pit-line contains ca. 40 and the extra squamosal pit-line ca. 20 nerve-foramina. The preopercular pit-line (*pl. Pop*, figs. 2, 12 A, B, 18, 20 B, G, 29 A, B; pl. 11; pl. 12:2; pl. 13:1) is shown only in No. P. 1384; besides in No. P. 1300. In the former specimen it is remarkable as its posterior part bends ventrally and anteriorly. In No. P. 1300 it contains 20 and in No. P. 1384 about 22 nerve-foramina. The quadratojugal pit-line (*pl. Qj*, figs. 2, 12 A, 18, 20 A—E, G, H, 29 A; pl. 1:1; pl. 2:1; pl. 9:2; pl. 11; pl. 12:2; pl. 13:1, 3—6; pl. 14:3, 4; pl. 18:5) is shown in several specimens. When extending to the ventral margin of the bone, which it does in most of the specimens, it reaches that margin a little in front of the middle of the margin, thus slightly farther forwards than in *G. milleri* (fig. 19 B; JARVIK 1948a, p. 268). The number of nerve-foramina is ca. 36 in the holotype, in No. P. 1300 ca. 38, and in No. P. 1308 ca. 42.

The pit-lines of the lower jaw, which, for descriptive purposes, I have previously (JARVIK 1948a, pp. 126—127, 134) called the horizontal pit-lines of infradentaries 2, 3, and 4 (*plh. Id. 2*, *plh. 3*, *plh. Id. 4*, figs. 12 A, C, 21, 29 A, C; pl. 1:1; pl. 2:2, 3; pl. 3:1; pl. 4; pl. 14:5, 6; pls. 15, 16; pl. 19:3) are, as in other Osteolepids, separate or form a continuous pit-line (*plh. Md*; the horizontal part of the mandibular pit-line, SÄVE-SÖDERBERGH, 1933). In most of the specimens the horizontal pit-line of infradentary 3 curves distinctly ventrally in its middle part, and in the holotype and some other specimens it is curved a little ventrally also at its anterior end. The latter ventrally

curving part (*plv. Id. 3*, figs. 12 A, C, 21 A, C, 29 A, C; pl. 1:1; pl. 2:3; pl. 15:5), which lies in front of a group of pores (*grp. so*) supposed to transmit nerves to special cutaneous sensory organs, is situated somewhat as, and probably corresponds to the pit-line found in one specimen of *Thursius pholidotus* (JARVIK 1948a, p. 127, fig. 68 F) and provisionally called the vertical pit-line of infradentary 3. The horizontal part of the mandibular pit-line, when continuous, contains ca. 300 nerve-foramina. The vertical pit-line of infradentary 2. (*plv. Id. 2*, figs. 12 A, C, 21, 29 A, C; pl. 1:1; pl. 2:2, 3; pl. 4; pl. 15:1, 2, 5—7; pl. 16:1, 3—6), in the holotype containing ca. 20 nerve-foramina, is situated on the anterior third of the jaw, the ratio k/m ranging from ca. 2.35 to ca. 2.49 (col. 3, table 4). In the single specimen of *G. milleri* showing this pit-line the corresponding ratio is about 2.36, and the pit-line is thus similarly situated in these two forms.

The pit-line of the second branchiostegal ray (*pl. Rbr. 2*, figs. 12 A, C, 23 K—M; 29 A, C; pl. 2:2; pl. 4:1; pl. 18:5; pl. 19:3) is developed as usual. The nerve-foramina in the holotype are about 20 and in No. P. 1317 about 13. The pit-line of the principal gular (*pl. G*, figs. 12 A, C, 24, 29 A, C; pl. 2:2; pl. 4:1; pl. 18:5; pl. 19:6; pl. 20:3, 4, 6) is situated as in *G. agassizi* and *G. milleri* (fig. 25 C, D; JARVIK 1948a, col. 25, table 9), about at the middle of the bone, the ratio p/n ranging from ca. 0.85 to ca. 1.12 (col. 5, table 6). The number of nerve-foramina is 22 in the holotype and ca. 14 in No. P. 1317. On the left gular of the holotype (pl. 2:2) an additional pit-line (*pl. Gx*) is found, containing about 10 nerve-foramina. The pit-line of the median gular is not preserved.

Pit-lines of the sensory lines of the body have been noticed on a few scales only (see *pl. ac. sl*, pl. 1:1) and nothing can be said about their disposition.

Cutaneous sensory organs.

Groups of pores (*grp. so*, figs. 2, 12, 13, 15 A—C, 16 A, E, F, 18, 19 D, G, J, 20 A, C—E, J, K, 21 A—C, E, F, H, J, 29; pl. 1:1; pl. 2:1—3; pls. 3, 4; pl. 5:1; pl. 6:2—6; pl. 10:1—3; pl. 11; pl. 13:1, 3, 5, 6; pl. 14:1, 2; pl. 15:1, 2, 5; pl. 16:1, 3) supposed to transmit nerves to groups of cutaneous sensory organs are common in the material available. As a whole these groups of pores are situated as in the Scottish Osteolepids (JARVIK 1948a, fig. 36). There are thus often several such groups on the snout and one on the frontal close behind the frontal pit-line. On the cheek, one group is often found on the squamosal close in front of the bend of the squamosal pit-line, and sometimes there are one or more groups on the jugal. On the anterior part of the lower jaw there

are two groups, sometimes continuous, one near the anterior end and one close in front of the vertical pit-line of infradentary 2. In addition to these two groups, which were found also in the Scottish Osteolepids, there is sometimes a third group, situated close in front of the ventrally curving anterior part (the vertical pit-line of infradentary 3) of the horizontal pit-line of infradentary 3.

Remarks:—The new species of *Gyroptychius*, *G. groenlandicus*, now described, as a whole agrees well with the Scottish species of the genus, and as a matter of fact the foundation of a new species has not made it necessary to make any alterations in the diagnosis of the genus compiled on the basis of the Scottish material (JARVIK 1948a, p. 236).

Gyroptychius groenlandicus n. sp. in most respects closely resembles *G. milleri* JARVIK and like that form it differs distinctly as regards the structure of the head from *G. agassizi* (TRAILL). The following characters common to *G. groenlandicus* and *G. milleri* and distinguishing these two forms from *G. agassizi* may be mentioned:

In both *G. groenlandicus* and *G. milleri* the head is comparatively broad. The snout curves very little downwards in the region above the lacrymo-maxillary notch and is accordingly very broad (generally about as broad as the fronto-ethmoidal shield is long). The preorbital division of the fronto-ethmoidal shield is longer ($r/s+t$ more than 0.75) and the postorbital division shorter ($t/r+s$ generally less than 0.45) than in *G. agassizi* (in this form the ratio $r/s+t$ ranges from ca. 0.66 to 0.71 and $t/r+s$ from ca. 0.50 to ca. 0.58). The orbital notches extend in advance of the preorbital corner and are bounded antero-ventrally by a more or less strong process of the fronto-ethmoidal shield. They are situated far dorsally and close together, the cranial roof being relatively narrow between the notches (the ratio e/a less than 0.90 and e/b less than 0.60). The parietal shield is broad, the ratio f/a being at least 0.75 (f/b more than 0.50) and the ratio g/a more than 1.10. The lachrymo-maxillary notch is angular and the lachrymal has a distinct anterior margin. The principal gular is very broad (the ratio *l. G*/*br. G* generally less than 2.20; in *G. agassizi* this ratio ranges from ca. 2.98 to ca. 3.04).

G. groenlandicus differs from *G. milleri* mainly in the following respects:

The preorbital division of the fronto-ethmoidal shield is relatively short ($r/s+t$ ca. 0.76—0.89; about 0.85—1.00 in *G. milleri*) and the orbital notches are a little longer proportionately, extending a little farther forwards than in *G. milleri*. The postorbital notch and the post-orbital bone are relatively long, the ratio *l. i. Po*/*a* ranging from ca. 0.64—0.70 and the ratio *l. Po*/*a* from ca. 0.67 to ca. 0.75 (in *G. milleri*

the corresponding ratios are both less than 0.60). The parietal shield is relatively short and broad, being about as broad as it is long anteriorly (ratio *f/a* about 0.91—1.04; in *G. milleri* only about 0.76—0.83) and about 1.25—1.54 (in *G. milleri* ca. 1.10—1.23) times broader than it is long at the spiracular notch. The quadratojugal is relatively short and high (*l. Qj/ht. Qj* ca. 1.22—1.80; in *G. milleri* more than 2.00). The quadratojugal pit-line reaches the ventral margin of the quadratojugal a little in front of, but in *G. milleri* about at, the middle of the ventral margin.

As a whole these differences between *G. groenlandicus* and *G. milleri* are rather inconsiderable and evidently these two species are very closely related.

2. Gyroptychius? cf. groenlandicus n. sp.

(Pl. 23:1).

The scales and other cranial remains described above and definitely or with some doubt included in *Gyroptychius groenlandicus* n. sp. all originate from the Series with *Gyroptychius groenlandicus*. In the material at my disposal from the underlying series of strata, the Series with *Asterolepis säve-söderberghi*, Osteolepid remains are rare and only a few detached scales could be identifiied with certainty. These scales (pl. 23:1), which are from the fossiliferous horizon at 304 m. in profile *i* S. of Kap Brown on Wegeners Halvö (cf. p. 8 and SÄVE-SÖDERBERGH 1937, p. 18), where they occur together with teeth of Crossopterygians (see p. 121) and remains of *Asterolepis* sp., *Homostius groenlandicus*?, and *Onchus* sp. (STENSIÖ & SÄVE-SÖDERBERGH 1938, pp. 19, 34, 35), are indistinguishable from the scales of *Gyroptychius groenlandicus* n. sp. (cf. pl. 23:1 and pl. 23:2) and may perhaps belong to this form. However, since the material from the horizon at 304 m. in profile *i* does not include any determinable cranial remains of Osteolepids, and since detached Osteolepid scales are indeterminable both as to genus and species (see p. 13; JARVIK 1948a, p. 106), this cannot be definitely proved. Provisionally the scales in question may be referred to as *Gyroptychius*? cf. *groenlandicus* (cf. RICHTER 1943, pp. 36—39).

B. Porolepiformes.

Material:—Fossil remains with certainty referable to the *Porolepiformes* are rare in the material available (pl. 24) and consist only of a detached, incomplete parietal shield (No. P. 1364) from the horizon at 210—234 m. in the NW. part of Hesteskoen, a detached jugal (No. P. 1435)

from the eastern part of Circusbjærg, and some detached scales. The cranial remains and some of the scales—Nos. P. 1418, P. 1419 from the horizon at 210—234 m., and No. P. 1334 from Kollen—come from the Series with *Gyroptychius groenlandicus*, whereas the remaining scales are from the Series with *Asterolepis säve-söderberghi*. The latter scales, which are poorly preserved and incomplete, originate from the following localities (see fig. 1 and SÄVE-SÖDERBERGH 1937): Kap Brown, the horizon at 304 m. in profile *i* (No. P. 1458); talus below 303 m. in the same profile (No. P. 1459); the edge of the NE. part of Hesteskoen (Nos. P. 1427, P. 1448, P. 1449, P. 1460); the eastern slope of the NE. part of Hesteskoen (No. P. 1447); and from profile *j* in the southern ridge of Hesteskoen (Nos. P. 1454, P. 1455, P. 1456).

As regards a detached cleithrum and certain other remains possibly belonging to the *Porolepiformes* see pp. 88—90, 116, 120.

Remarks on previously described forms.

In my description of the structure of the snout in *Porolepiformes* (JARVIK 1942, p. 241) the known forms were provisionally placed in two families, *Porolepidae* and *Holoptychiidae*.

In the family *Porolepidae* were included forms with rhomboidal scales of the types originally described by KADE (1858) as *Gyroptychius posnaniensis* and *Gyrolepis posnaniensis* and with the external faces of the dermal bones and scales covered with a smooth and shiny sheet of enamel and dentine (cf. GROSS 1935, pp. 39—41). All these forms were provisionally (cf. JARVIK 1942, p. 354, footnote 3) placed in the genus *Porolepis* WOODWARD (WOODWARD 1891b). This genus is known from the Lower Devonian in Rhineland (GROSS 1933, 1936), Spitzbergen (WOODWARD 1891b, JARVIK 1942)[1]), Ural and Taymir (OBRUCHEV 1938, 1939, 1940), and from the Pernau and Luga Beds in the Baltic Middle Devonian (GROSS 1942)[2]).

The family *Holoptychiidae*, characterized by cycloidal scales and ornamented dermal bones and scales, includes three genera, *Laccognathus* GROSS, *Glyptolepis* AG., and *Holoptychius* AG.

The genus *Laccognathus* with the species *L. panderi* (GROSS 1941; 1942, pp. 388—390, 428—429; earlier generally called *Dendrodus biporcatus*; PANDER 1860; GROSS 1930; 1933; 1936) from the upper part

[1]) The age of the deposits in Spitzbergen yielding *Porolepis*, viz. the Wood Bay Series, is uncertain (cf. p. 124, footnote 1; FØYN & HEINTZ 1943).

[2]) According to GROSS (1942, p. 426) the scales described by KADE, which were found in glacial boulders at Meseritz in Silesia, originate from the Luga beds (see table on p. 123), and he included the Baltic *Porolepis* remains (scales only) in *Porolepis posnaniensis* (KADE).

(the Podsnetogor and Oredesch Beds; see table on p. 123) of the Baltic Middle Devonian is well defined. It is characterized inter alia by the structure of the lower jaw and the ornamentation, which consists of pointed dentine-tubercles (see p. 110).

According to WOODWARD (1891a, pp. 331—337) the genus *Glyptolepis* includes two species, *G. leptopterus* (see MILLER 1841, pl. 5:2; AGASSIZ 1844, pl. 20, 21; pl. 21a:1, 2; WOODWARD 1891a; pl. 11:2) and *G. paucidens* from the Scottish Upper Middle Devonian. In addition certain scales and cranial remains from other countries have been referred to this genus. Among these forms only *G. baltica* from the upper part of the Baltic Middle Devonian (GROSS 1930; 1933; 1942, p. 390) should be mentioned here. The genus *Holoptychius*, which comprises several species, is known from the Upper Devonian, inter alia in Scotland (figs. 31 D, 33 D; WOODWARD 1891a; JARVIK 1948a, figs. 33, 34) and East Greenland (see STENSIÖ 1931; JARVIK 1942, p. 379; 1948b). In *Glyptolepis* the scales bear an ornamentation of delicate ridges anteriorly subdivided into tubercles (cf. p. 110). The genus *Holoptychius* only differs from *Glyptolepis* in the coarser and more irregular ornament of its scales (WATSON 1935, p. 163), and by WOODWARD (1891a) *Glyptolepis* was regarded to be a subgenus of *Holoptychius*[1]).

As a whole the morphology of the various *Porolepiformes* is incompletely known and most of the genera and species are insufficiently defined. Whether the Porolepids from Spitzbergen really are referable to a single genus and whether in such a case this genus comprises also the forms from the Rhineland, the Baltic area, etc., remains uncertain. It is also uncertain whether a genus *Glyptolepis* exists and whether the forms included in *Holoptychius* pertain to a single genus. A revision of the taxonomy of the *Porolepiformes* is thus highly necessary and until such a revision has been done it is difficult or impossible to refer new material to either of the known genera and species. Under these circumstances it seems unwise to attempt generic and specific determinations of the poor remains of *Porolepiformes* from East Greenland to be described below. Since, as we shall see, it is even impossible to say whether the parietal shield and the jugal belong to the family *Porolepidae* or to *Holoptychiidae*, I have avoided to place the Greenland Porolepiform remains in any of these families, and they will be described provisionally as *Porolepiformes*: *Incertae familiae* (cf. RICHTER 1943, p. 36).

---

[1]) According to GROSS (1930, pp. 25—27), the genus *Glyptolepis* differs clearly from *Holotychius* in the histological structure of the scales (as regards the minute structure of the teeth see BYSTROW 1939). However, GROSS based this statement on investigations of detached scales from the Baltic Devonian, and it remains to be proved that the true *Glyptolepis* and *Holoptychius* from Scotland differ from each other in the corresponding respects.

The Greenland Porolepiform remains, as pointed out above, consist only of a parietal shield, a jugal, and some scales (as regards a detached cleithrum see pp. 116—120). In order to facilitate the subsequent descriptions the corresponding structures in the previously known genera will be briefly considered, mainly on the basis of material at my disposal[1]).

The parietal shield is rather similar in the four Porolepiform genera (figs. 30, 31). It is generally composed of three paired bones, the parieto-intertemporal (*Pa-It*), the supratemporal (*St*), and the extratemporal (*Et*). In one specimen of *Holoptychius flemingi* (Jarvik 1948a, figs. 33 B, 34) the supratemporal has been found to be subdivided into two bones, anterior and posterior.

The lateral margin of the parietal shield (figs. 30, 31) presents two notches, one anteriorly, the prespiracular notch (*i. Prsp*) for the prespiracular plate (see Jarvik 1948a, p. 130, footnote 1; this notch corresponds to the posterior part of the postorbital notch in *Osteolepiformes*, *i. Po*, fig. 13; cf. Jarvik 1948a, pp. 87—88), and one in the middle part of the margin, the spiracular notch (*i. spir*). As in the Osteolepids, the extratemporal is often wanting, leaving a third notch, the extratemporal notch (*i. Et*), in the lateral margin of the remaining part of the parietal shield.

In the development of the prespiracular and extratemporal notches and the prespiracular and extratemporal bones and in the position of the spiracular notch there are certain differences between various forms.

In some specimens of *Porolepis* from Spitzbergen (figs. 30 B, 31 A) the extratemporal notch (*i. Et*) is indistinct. The extratemporal bone (*Et*) is long and narrow and extends so far forwards as to meet the prespiracular plate (*Prsp*). The spiracular notch (*i. spir*) is developed in the lateral margin of the extratemporal. The prespiracular plate (*Prsp*), too, is long and narrow. The prespiracular notch extends far backwards and is bounded posteriorly (fig. 31 A, right side) or posteromedially (fig. 30 B; fig. 31 A, left side; one and the same specimen may be different in this respect on the two sides) by the supratemporal,

[1]) This material consists of *Porolepis* spp. from Spitzbergen, collected mainly during the English-Norwegian-Swedish expedition to Spitzbergen in 1939 (see Jarvik 1942, p. 354; Føyn & Heintz 1943), *Holoptychius* sp. from East Greenland (see Jarvik 1942, p. 379; 1948b), and some specimens of *Glyptolepis leptopterus* and *Holoptychius flemingi* from the Middle and Upper Devonian, respectively, in Scotland. The Scottish specimens of *Holoptychius* belong to the Sedgwick Geological Museum, Cambridge (Nos. A. 6027—A. 6034, from Dura Den), and the *Glyptolepis*-specimens to the Geol. Surv., London (Nos. 53364, Tynet Burn, and 53406, Lethen Bar) and the Paleozoological Dpt. of the Swedish Museum of Natural History (Nos. P. 1666, see fig. 27 B, and P. 4120, Lethen Bar).

which bone, like the parieto-intertemporal, is overlapped by the prespiracular plate.

In the specimen of *Porolepis* shown in fig. 30 A, on the other hand, the extratemporal, judging from the shape of the extratemporal notch, is shorter, relatively, and does not meet the prespiracular plate. The spiracular notch is situated in front of the extratemporal bone and is developed in the anterior part of the lateral margin of the supratemporal. The prespiracular notch is developed much as shown on the right side in fig. 31 A and is bounded posteriorly by the supratemporal, as it sometimes is also in the specimens mentioned above.

In *Laccognathus panderi* (fig. 31 B), *Glyptolepis leptopterus* (fig. 31 C), and in *Holoptychius flemingi* (fig. 31 D; JARVIK 1948a, figs. 33, 34) the extratemporal notch, the extratemporal bone, and the spiracular notch as a whole are developed as in the *Porolepis*-specimen shown in fig. 30 A. However, the prespiracular plate is distinctly shorter and the prespiracular notch is, at least mainly, bounded posteriorly by a laterally projecting part of the parieto-intertemporal. As pointed out elsewhere (JARVIK 1948a, p. 130, footnote 1; fig. 33 B), the prespiracular plate in *Holoptychius*, contrary to conditions in *Porolepis* and *Glyptolepis*, is pierced by a sensory canal, provisionally called the prespiracular sensory canal (*prspc*, fig. 31 D).

The infraorbital (*ioc*) and postotic (*poc*) sensory canals, as far as known, have a similar course in the various forms (fig. 31). In *Laccognathus* (fig. 31 B) the postotic canal runs, according to GROSS, most posteriorly in the suture between the supratemporal and the extratemporal. The tubes of the sensory canals are strongly developed and are frequently branching (fig. 31 C). The numerous pores in *Holoptychius* are found on the whole non-overlapped part of the external face of the parietal shield, whereas in *Porolepis* (fig. 30), in which the tubes are

---

Fig. 30. *Porolepis* spp. Two parietal shields from Spitzbergen in dorsal aspect. Extratemporal wanting. *A*, specimen No. 446; collected by the English-Norwegian-Swedish Spitzbergen expedition in 1939 (cf. JARVIK 1942, p. 354, footnote 2). From the valley N. of Mt. Garborg, Ekman Bay. Photographed in alcohol. $^5/_4$. *B*, specimen No. II 985, belonging to the Palaeontological Museum, Oslo. $^3/_2$.

Ot-oc, otico-occipital; *Pa-It*, parieto-intertemporal; *St*, supratemporal.

i. Et, notch for extratemporal bone; *ioc*, infraorbital sensory canal; *i. Prsp*, notch for prespiracular plate; *i. spir*, spiracular notch; *od. Et*, area of supratemporal overlapped by extratemporal; *od. Ext. l*, area of parieto-intertemporal overlapped by lateral extrascapular; *od. Ext. m*, area of parieto-intertemporal overlapped by median extrascapular; $od_1 Prsp$, area of parieto-intertemporal overlapped by prespiracular plate; $od_2 Prsp$, area of supratemporal overlapped by prespiracular plate; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line.

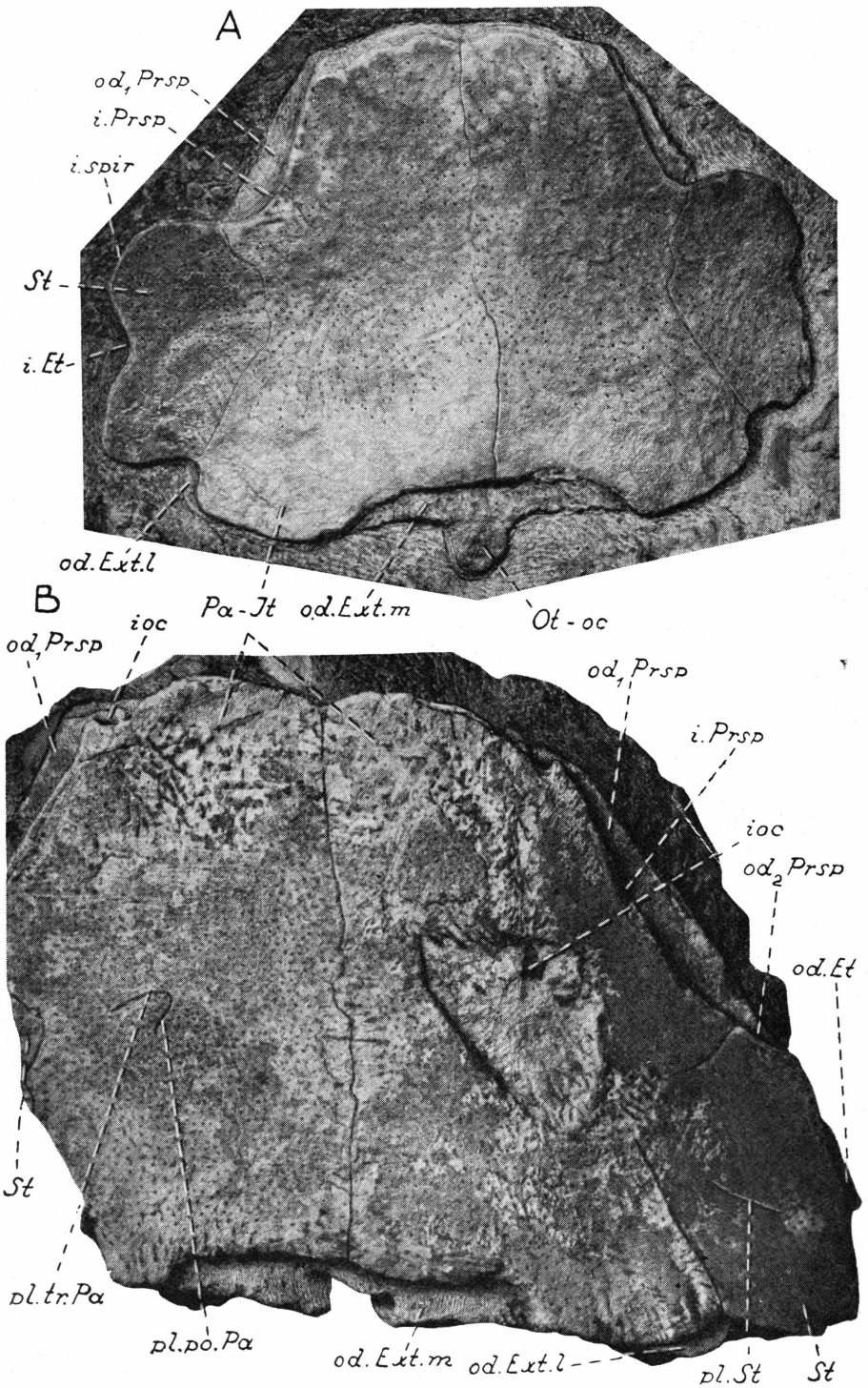

A
od1 Prsp
i.Prsp
i.spir
St
i.Et
od.Ext.l
Pa-Jt
od.Ext.m
Ot-oc
B
od1 Prsp
ioc
od1 Prsp
i.Prsp
ioc
od2 Prsp
od.Et
St
pl.tr.Pa
pl.po.Pa
od.Ext.m
od.Ext.l
pl.St
St

Fig. 30.

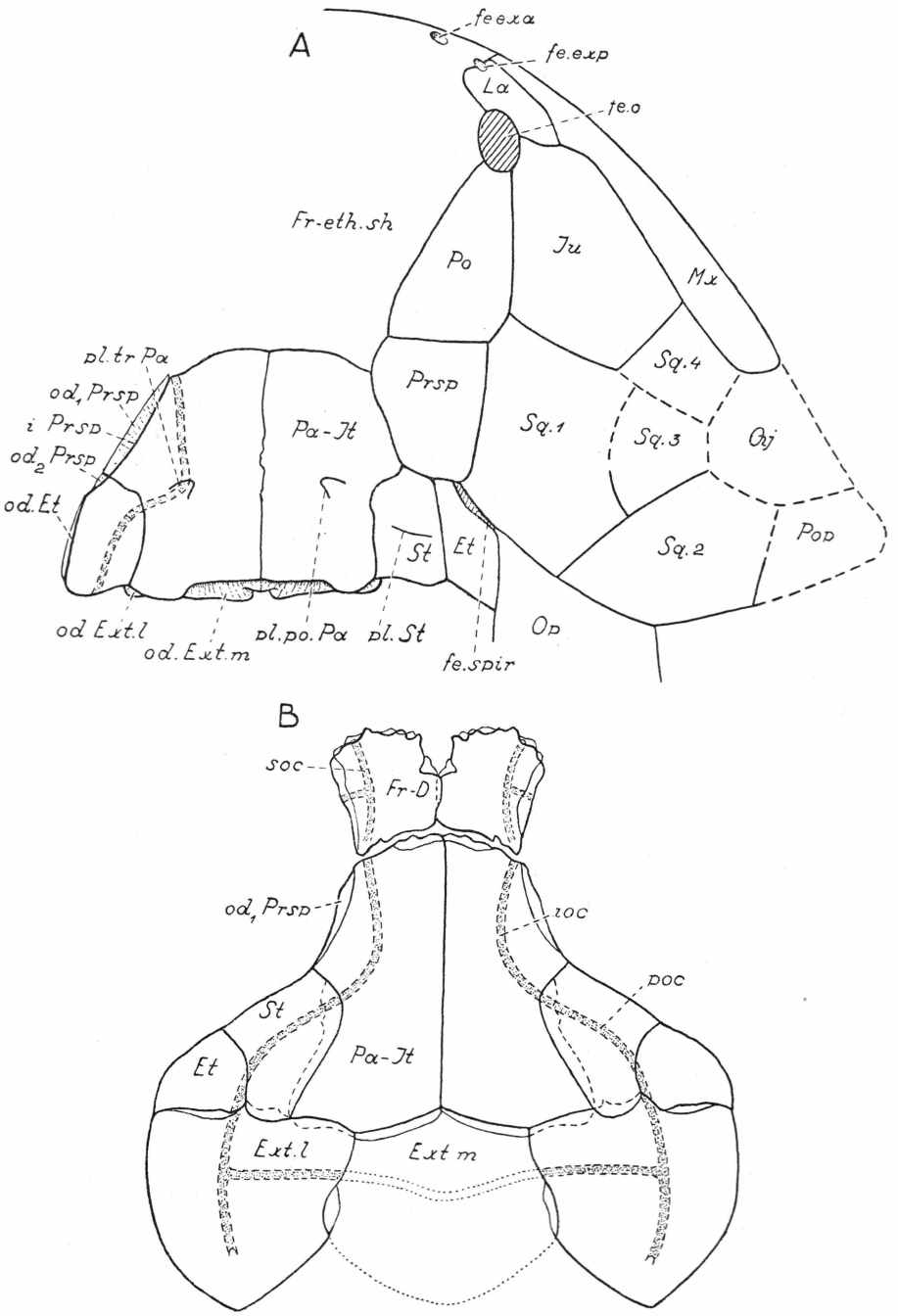
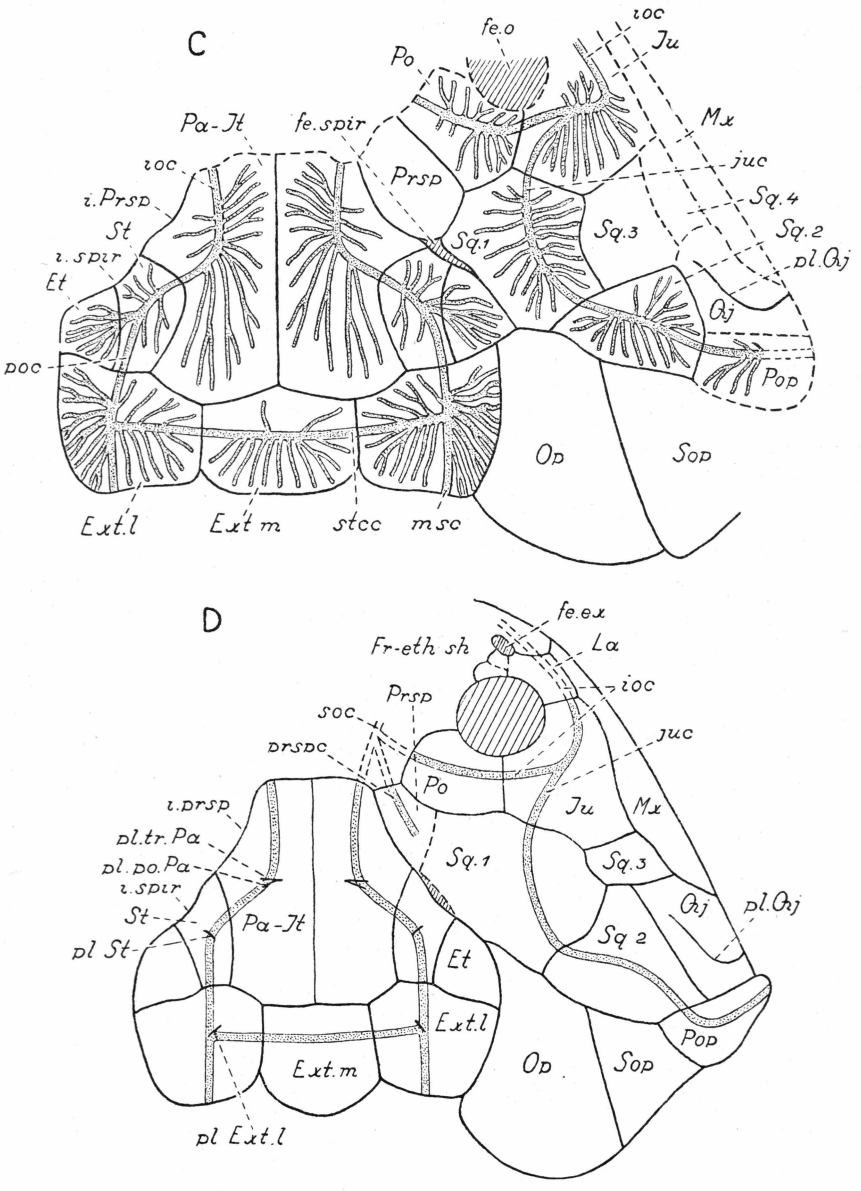


Fig. 31. Sketches of parts of the cranial roof and (in *A*, *C* and *D*) the right external cheek plate in *A*, *Porolepis* sp., *B*, *Laccognathus panderi*, *C*, *Glyptolepis leptopterus* and, *D*, *Holoptychius flemingi*. The dermal bones spread out into one plane. *A*, based on the specimen shown in fig. 30 B and two other specimens from Spitzbergen (No. 117, E.-N.-S. exp. From Mt. Sigurd, Wood Bay. No. 252, E.-N.-S. exp. From Mt. Scott Keltie, Wood Bay). *B*, from GROSS (1936, fig. 5). *C*, based mainly on specimen No. 53364 Geol. Surv. From Lethen Bar, Scotland. *D*, based on specimens Nos. A. 6027—A. 6034 Sedgw. Mus. From Dura Den, Scotland.



Et, extratemporal; *Ext. l*, *Ext. m*, lateral and median extrascapulars; *Fr-D*, fronto-dermosphenotic; *Fr-eth. sh*, fronto-ethmoidal shield; *Ju*, jugal; *La*, lachrymal; *Mx*, maxillary; *Op*, opercular; *Po*, postorbital; *Pop*, preopercular; *Prsp*, prespiracular plate; *Qj*, quadratojugal; *Sop*, subopercular; *Sq. 1*, *Sq. 2*, *Sq. 3*, *Sq. 4*, squamosals. *fe. ex*, fenestra exonarina communis (see JARVIK 1942); *fe. exa*, fenestra exonarina anterior; *fe. exp*, fenestra exonarina posterior; *fe. o*, orbital fenestra; *fe. spir*, spiracular fenestra; *juc*, jugal sensory canal; *msc*, main sensory canal; *pl. Ext. l*, pit-line of lateral extrascapular; *pl. Qj*, quadratojugal pit-line; *poc*, postotic sensory canal; *prspc*, prespiracular sensory canal; *soc*, supraorbital sensory canal; *stcc* supratemporal commissural sensory canal. — For further explanations see fig. 30.

shorter, no pores are found on the posterior and the most anterior parts of the external face of the parieto-intertemporal.

The supratemporal pit-line (*pl. St*, figs. 30 B, 31 A, D) lies somewhat as in Osteolepids (fig. 29), whereas, in connection with the fusion of the parietal and intertemporal into a compound parieto-intertemporal, the transverse parietal pit-line (*pl. tr. Pa*) and the posterior oblique parietal pit-line (*pl. po. Pa*) were displaced considerably anteriorly and laterally (cf. JARVIK 1948a, p. 119).

The jugal (*Ju*, fig. 31 A) in *Porolepis* (like the postorbital) is relatively long and low, being ca. 1.60 times longer than it is high. In *Glyptolepis leptopterus* and *Holoptychius flemingi* (fig. 31 C, D), which both have short and high postorbitals (*Po*), the jugal is relatively shorter and higher, being ca. 1.25 as long as it is high. The orbital notch of the bone is small in *Porolepis*, in which the orbital fenestra (*fe. o*) is very small (and situated far forwards), and relatively large in *Glyptolepis* and *Holoptychius*. The infraorbital (*ioc*) and jugal (*juc*) sensory canals meet at a very acute angle in a manner characteristic of the *Porolepiformes* (cf. fig. 29 A; JARVIK 1948a, pp. 119—120).

The thick, more or less rhomboidal or rounded scales in *Porolepis* (fig. 32 A, B; KADE 1858, figs. 6—10; WOODWARD 1891b, p. 9; pl. 2:6—10) usually bear a characteristic ornamentation but are otherwise much as in the Osteolepids (p. 92, pl. 22; pl. 23:1—4; JARVIK 1948a, p. 106, figs. 5—7, 9 A, 28; pl. 37). The ornamentation consists of conspicuous, more or less longitudinal and generally unbranching ridges, sometimes very short and confined to a narrow zone along the overlapped areas of the scales (fig. 32 A; *Gyrolepis posnaniensis*, according to KADE) and sometimes longer and stretching over a considerable part of the external face of the scale (fig. 32 B; *Gyroptychius posnaniensis* according to KADE). In certain cases the ridges most anteriorly, close to the overlapped areas, are subdivided into small tubercles (fig. 32 B). When the ornamentation is wanting, as is sometimes the case (e. g. in Nos. S. II. 1 and S. II. 7, Pal. Mus. Oslo), the scales in *Porolepis* are, macroscopically, not easily distinguishable from Osteolepid scales. Also the histological structure of the scales seems to be similar in the two groups (see GROSS 1935, pp. 39—43; cf. JARVIK 1948a, p. 10, footnote 1)[1]).

[1]) According to GROSS (1935, p. 40) one of the few differences between the scales in *Porolepis* and *Osteolepis* recorded by him is that the enamel layer in *Osteolepis* is confined to the external face of the dentine layer, whereas in *Porolepis* it covers also the walls of the canals ascending through that layer. However, since the latter condition is found also in the sections of Osteolepids presented in this paper (figs. 3, 5; cf. also fig. 10), there is obviously no difference between *Porolepiformes* and *Osteolepiformes* in this respect.

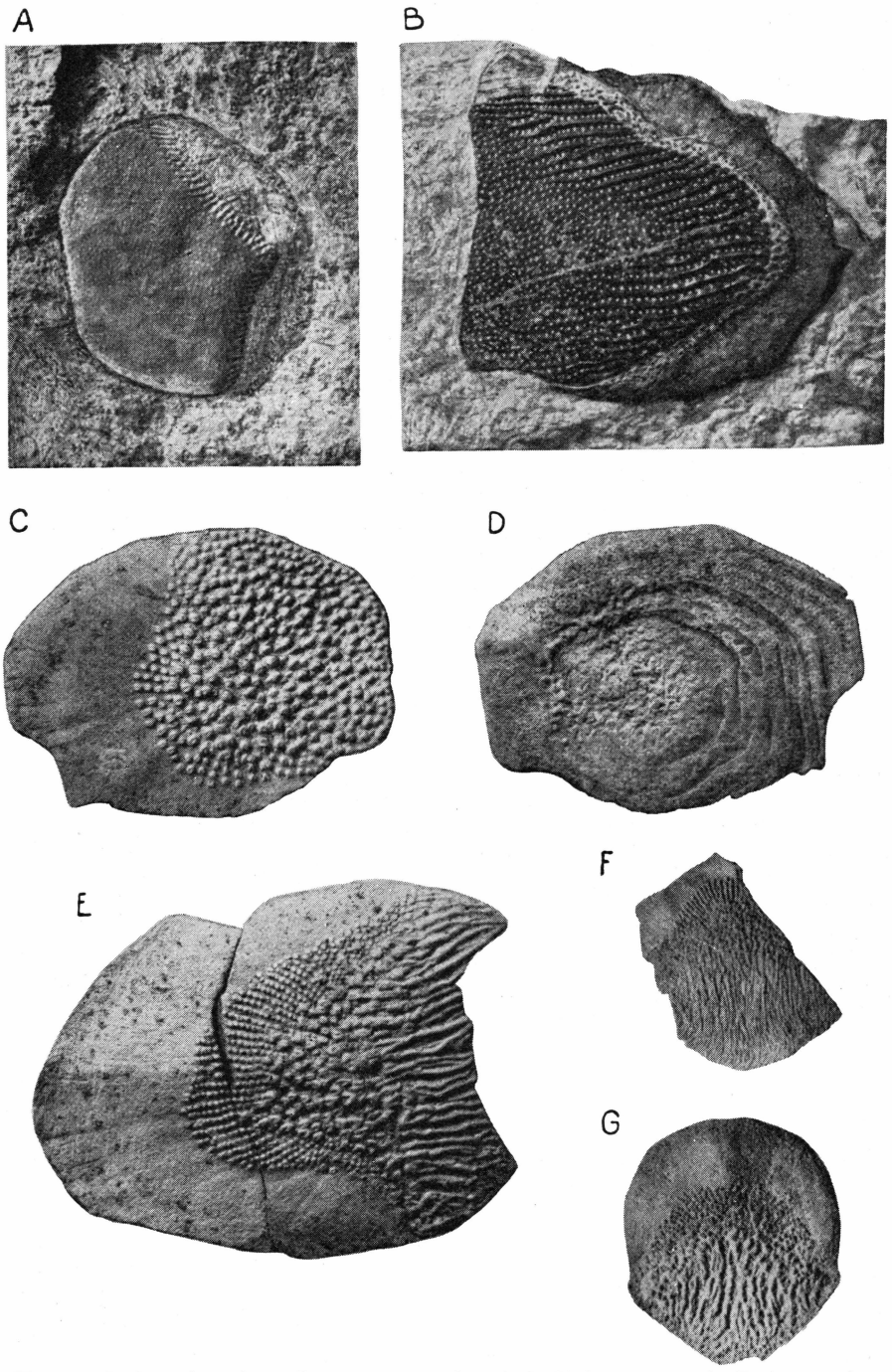


Fig. 32. Scales of various *Porolepiformes* in, *A-C*, *E-G*, outer and, *D*, inner views. *A*, *B*, *Porolepis* spp. from Spitzbergen. *A*, specimen E.-N.-S. No. 160. From Mt. Errol White, West Fjord, Wijde Bay. $^3/_1$. *B*, specimen E.-N.-S. No. 279. From Vaerdalen, Wood Bay. $^3/_1$. *C*, *D*, *Laccognathus panderi* Gross. Specimen No. P. 3111 Stockh. From Ehrmann b. Ligat, Latvia. $^3/_2$. *E-G*, *Glyptolepis baltica* Gross. *E*, specimen No. P. 3115 Stockh. From Ehrmann b. Ligat, Latvia. $^3/_2$. *F*, *G*, after Gross (1933; pl. 6:20, 24).

The scales in the Holoptychiids are, as is well known, of the cycloidal type (see e. g. WOODWARD 1891a; GROSS 1930; 1933). They are thinner than in the Porolepids and more or less rounded. The non-overlapped part, however, which is always ornamented, is generally somewhat rhomboidal in shape as in the Porolepids, but it is less distinctly bounded and therefore less conspicuous than in those forms. The ridge found on the ventral face of the scales in Porolepids, which strongly resembles that in Osteolepids (p. 92; JARVIK 1948a, p. 106; *ri. Sc*, fig. 28), has no distinct equivalent in Holoptychiids. The ventral face of the scale is generally somewhat concave and terraced, rising outwards along more or less conspicuous concentric lines (figs. 32 D, 33 B). The annular zones between these lines no doubt represent the inner margins of the isopedin lamellae, which certainly have an oblique position similar to that in the section shown in fig. 10 (cf. p. 51; fig. 11 A).

The ornamentation of the non-overlapped part of the scales consists in *Glyptolepis* (figs. 32 E—G, 33 A, C; cf. pl. 24:3; GROSS 1930; pl. 3:12; 1933, pl. 6:9, 11, 20, 21, 24) and *Holoptychius* (fig. 33 D; see also MURCHISON 1868; pl. 2 bis: 1—3; AGASSIZ 1844; pl. 22, 23; pl. 24:2—10; WOODWARD 1891a; pl. 11:1; 1900; LERICHE 1931; pls. 7, 8; STENSIÖ 1931; pl. 34:1—6; pl. 35:1—9, 11, 12; HEINTZ 1932; pl. 6:2, 3, 5) of irregular branching ridges, often subdivided most anteriorly into small tubercles. As pointed out above (p. 102), the ornamentation is said to be coarser in *Holoptychius* than in *Glyptolepis* (WATSON 1935, p. 163, cf. WOODWARD 1891a, pp. 327, 332), but whether this d fference is a reliable generic character remains very uncertain. In *Holoptychius flemingi* (fig. 33 D), at any rate, the ornamentation of many of the scales is rather delicate and suggestive of that in *Glyptolepis leptopterus* (fig. 33 A, C) and *G. baltica* (fig. 32 E—G). In *Laccognathus* (fig. 32 C; GROSS 1930; pl. 3:13; 1933; pl. 6:25) the ornamentation consists of isolated tubercles, arranged in more or less distinct concentric rings, and besides, in rows converging towards the centre of the scale, where the largest tubercles are found. The tubercles, which are intermingled with very small ones, consist of blunt striated denticles, sometimes with the apex directed backward and resembling those found in *Latimeria* (ROUX 1942).

As pointed out above (p. 108), the scales in early *Porolepiformes* (Porolepids) and early *Osteolepiformes* (Osteolepids) may be very similar both as to the general appearance and the minute structure, and they are not always easily distinguishable from each other. The advanced representatives of these two groups, viz. the forms included in the families *Holoptychiidae* (figs. 32 C—G, 33 A—D) and *Rhizodontidae* (fig. 33 E), respectively, are characterized by cycloidal scales, and similar scales are found also in *Coelacanthiformes* (fig. 33 F; MOY-THOMAS

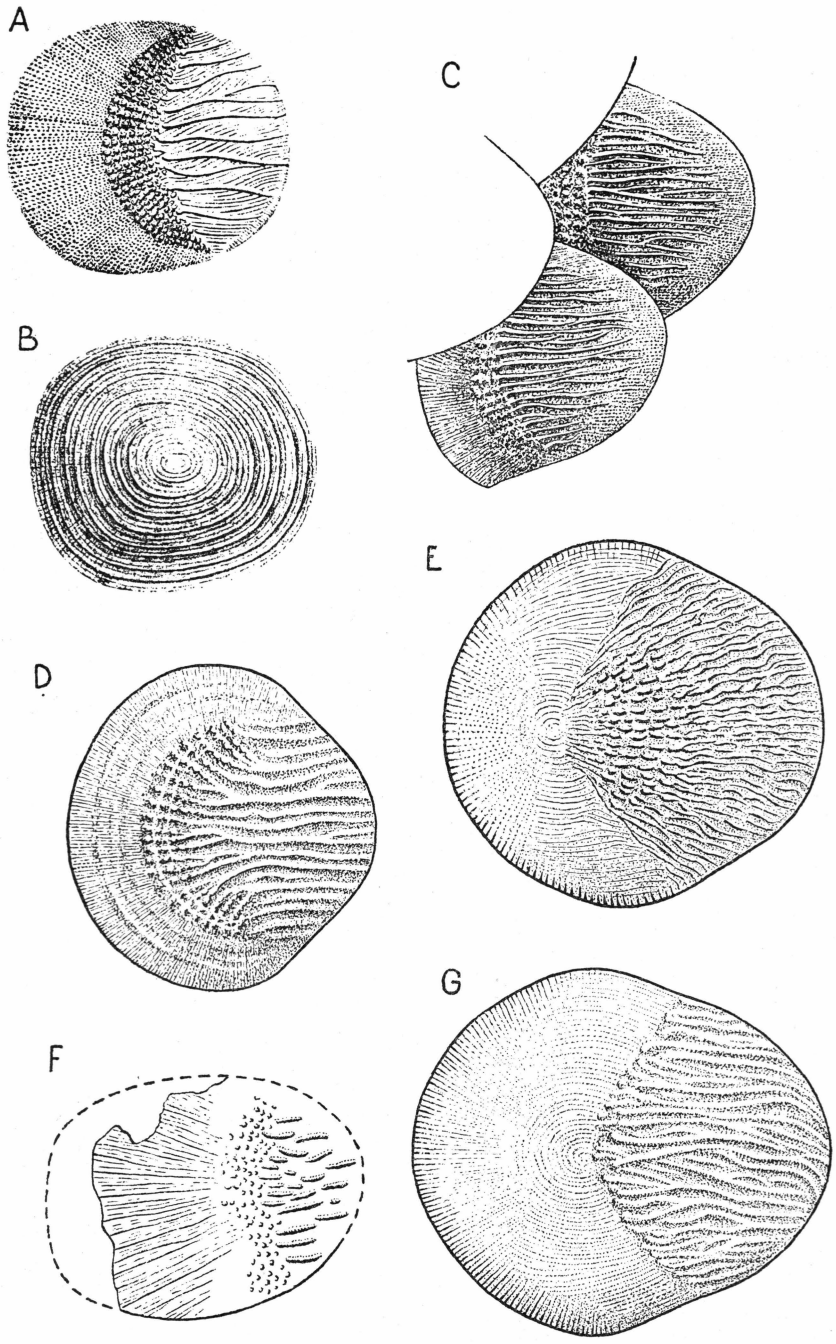


Fig. 33. Restorations of cycloidal scales of various forms in external and (*B*) internal aspects. *A-C*, *Glyptolepis leptopterus*. *A*, *B*, from PANDER (1860; pl. 7:7a, 7b); *C*, from McCOY (1855; pl. 20:6a). *D*, *Holoptychius flemingi*. After specimen No. A. 6027 Sedgw. Mus. *E*, *Eusthenopteron foordi*. After specimen No. P. 2609 Stockh. *F*, *Diplocercides? jaekeli*. From STENSIÖ (1937, fig. 21). *G*, *Scaumenacia curta*. After specimen No. P. 765 Stockh.

1935a; pl. 7:8—10; 1935b, figs. 6, 8, 11; 1937, fig. 14; pl. 1:B; MOY-THOMAS & WESTOLL 1935, fig. 12; STENSIÖ 1937, figs. 21, 23; pl. 6; pl. 7:2, 3; pl. 10:4) and in *Dipnoi* (e. g. *Scaumenacia*, fig. 33 G). The cycloidal scales in advanced *Porolepiformes* and *Osteolepiformes* no doubt developed independently from the dentine-covered rhomboidal scales in the early representatives of these groups, and certainly also the cycloidal scales in *Dipnoi*, and probably in *Coelacanthiformes* as well, have undergone a similar phyletic development. Possibly each group comprises more than one evolutionary series. Since the structure of the cycloidal scales in the four groups mentioned above at least in most respects seems to be very similar—in fact it is still unknown whether there are any reliable distinctive characters between the scales in the four said groups—it must be assumed that the structural changes of the scales in phylogeny were somewhat similar in the various evolutionary series. It is possible that some of the differences actually found between the scales in forms belonging to different groups, for example between the scales in *Holoptychius* (fig. 33 D) and *Eusthenopteron* (fig. 33 E; cf. BRYANT 1919, pp. 5—6; GROSS 1935, pp. 38—39; BYSTROW 1939, p. 314), may be due to the fact that the phyletic evolution did not take place in exactly the same manner, but it is also possible that the differences are due to the scales in question not representing corresponding stages in the evolutionary series. As is thus evident, sufficient data for a correct determination of cycloidal scales are still lacking, and when such scales are found detached it is at present hardly possible to decide with any degree of certainty to which of the four said groups they belong.

Description.

Porolepiformes: Incertae familiae.

Specimen No. P. 1364.

(Fig. 34 A; pl. 24:1).

This specimen consists of a detached imperfect parietal shield from the horizon at 210—234 m. in the NW. part of Hesteskoen.

The parietal shield is incomplete on the right side and the extratemporals of both sides are lacking. It measures about 20 mm. in length, and the breadth most anteriorly amounts to ca. 0.80 and at the spiracular notch to ca. 1.50 of the length of the shield.

The dorsal face of the shield, which is somewhat damaged by weathering, in the present imperfect state of preservation exhibits a coarse ornamentation of low and indistinct ridges and tubercles. The tubes of the sensory canals have a very superficial position and are

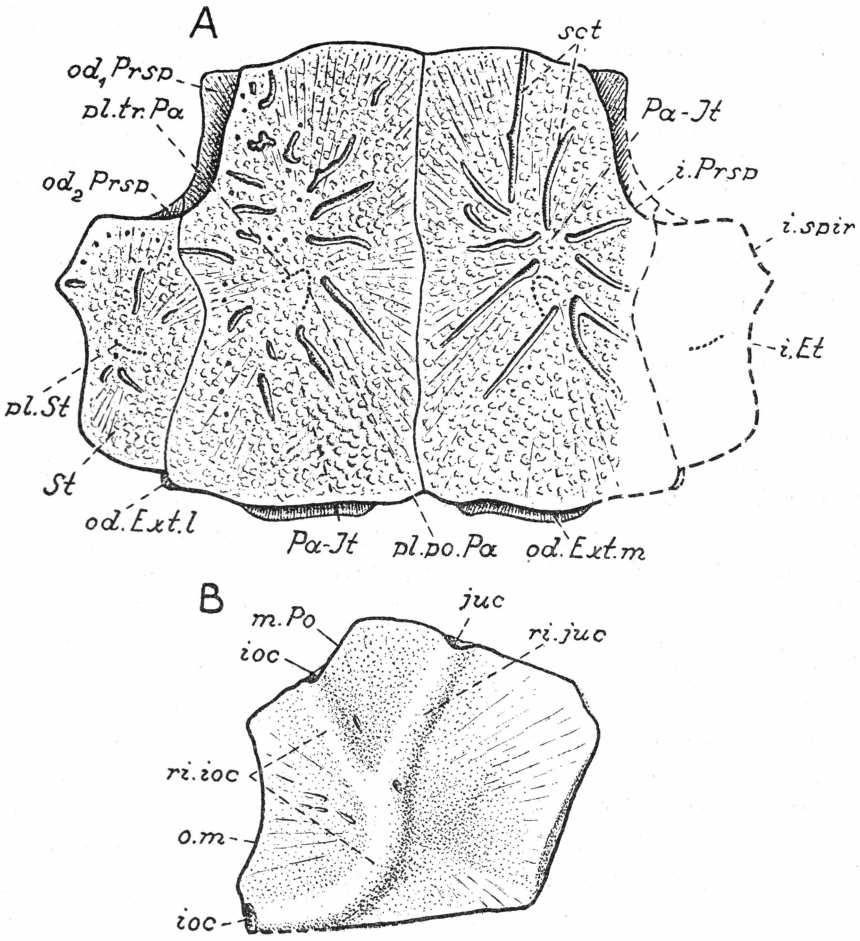


Fig. 34. Undetermined *Porolepiformes*. *A*, restoration of parietal shield in external view. Extratemporal omitted. After the specimen shown in pl. 24:1. $^3/_1$. *B*, jugal in inner view. After the specimen shown in pl. 24:2. $^3/_1$.

Pa-It, parieto-intertemporal; *St*, supratemporal.

i. Et, extratemporal notch; *ioc*, infraorbital sensory canal; *i. Prsp*, prespiracular notch; *i. spir*, spiracular notch; *juc*, jugal sensory canal; *m. Po*, margin meeting postorbital; $od_1 Prsp$, $od_2 Prsp$, areas of parieto-intertemporal and supratemporal overlapped by prespiracular plate; *od. Ext. l*, *od. Ext. m*, areas of parieto-intertemporal overlapped by lateral and median extrascapulars; *o. m*, orbital margin; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *ri. ioc*, *ri. juc*, ridges housing infraorbital and jugal sensory canals; *sct*, tubes of sensory canals.

partly represented by open grooves (*sct*, fig. 34 A; pl. 24:1). It is possible, therefore, that the dermal bones of the shield were originally covered by a layer of enamel and dentine, which, as in the ornamented specimens of *Gyroptychius groenlandicus* (see pp. 17—19, fig. 17 E, F; pl. 9:1, 2, 4, 5),

has been lost secondarily. Whether this really is so I would not venture to decide, but as a matter of fact the parietal shield under consideration, as we now shall see, resembles in a most striking manner one of the parietal shields of *Porolepis* from Spitzbergen figured above (fig. 30 A), and it is therefore possible that it may belong to a Porolepid rather than to a Holoptychiid.

As in this specimen of *Porolepis* (fig. 30 A), the parieto-intertemporal (*Pa-It*, fig. 34 A; pl. 24:1) extends farther backwards than the supratemporal (*St*) and behind that bone exhibits a distinct lateral margin along which there is a depressed area (*od. Ext. l*) overlapped by the lateral extrascapular. In both forms the lateral margin of the supratemporal posteriorly presents a distinct extratemporal notch (*i. Et*) and anteriorly a likewise distinct spiracular notch (*i. spir*). The extratemporal bone evidently did not meet the prespiracular plate, ending anteriorly behind the spiracular fenestra (cf. fig. 31). The prespiracular notch (*i. Prsp*) is deep and is bounded medially by the parieto-intertemporal and posteriorly mainly by the supratemporal, which bone has a distinct anterior margin meeting the prespiracular plate. The latter plate overlaps the parieto-intertemporal (the area $od_1 Prsp$) and (in No. P. 1364 only) the supratemporal (the area $od_2 Prsp$; cf., however, fig. 30 B). The posterior margin presents a median notch, in which the posterior part of the otico-occipital (*Ot-oc*) is shown, and laterally to this notch a paired depressed area (*od. Ext. m*) is found overlapped by the extrascapulars (cf. *Eusthenopteron*, JARVIK 1944a, figs. 3 A, 4, 7 C).

As in other *Porolepiformes* (fig. 31), the infraorbital sensory canal (*ioc*; pl. 24:1) enters the parieto-intertemporal close medially to the antero-lateral corner of this bone, thence running backwards and medially towards the centre of radiation of the bone. At this place it turns sharply laterally and is continued by the postotic sensory canal (cf. *poc*, fig. 31), which pierces the supratemporal. The tubes of the infraorbital canal, which as pointed out above are partly represented by superficial grooves (*sct*), are long, as in other *Porolepiformes*, and converge towards the centre of radiation of the parieto-intertemporal. However, no tubes are found in the posterior and antero-medial parts of the parieto-intertemporal and also in this respect the specimen now under consideration agrees with the parietal shield of *Porolepis* shown in fig. 30 A. The supratemporal pit-line (*pl. St*) and the parietal pit-lines (*pl. po. Pa*, *pl. tr. Pa*) are situated as usual.

Specimen No. P. 1435.

(Fig. 34 B; pl. 24:2).

This specimen, which originates from the Series with *Gyroptychius groenlandicus* in the eastern part of Circusbjærg, Wegeners Halvö, shows

the inner side of a typical Porolepiform jugal and the external side of an indeterminable ornamented bone. The latter bone, which possibly represents a clavicle, is incomplete and will not be further considered.

The jugal is about 18 mm. long and about 14 mm. high, and it is about 1.30 times longer than it is high. It is thus about as long in relation to its height as in *Glyptolepis leptopterus* and *Holoptychius flemingi* (p. 108, fig. 31 C, D) but shorter than in the available specimens of *Porolepis* showing this bone (fig. 31 A). Also in other respects it resembles the jugal in *Glyptolepis* and *Holoptychius*. The orbital notch (*o. m*) is long and the margin (*m. Po*) meeting the postorbital is rather short, indicating that the postorbital has been of the short and high type characteristic of these two genera. The external face of the bone, which is only partly exposed, shows an ornamentation similar to that of the parietal shield described above. The infraorbital and jugal sensory canals, which cause distinct ridges on the inner face of the bone (*ri. ioc*, *ri. juc*), meet at a very acute angle as in other *Porolepiformes* (see fig. 31 C, D).

Specimen No. P. 1334.

(Pl. 24:3).

Specimen No. P. 1334 consists of an impression of the external face of a scale, which, as mentioned above (p. 101), originates from Kollen.

The scale, which is rounded in shape and rather large, measures ca. 21 mm. in length and ca. 23 mm. in height. The overlapped portions are large and not distinctly bounded from the somewhat rhomboidal ornamented non-overlapped portion. In the central parts of the scale the ornamentation consists of relatively coarse irregular ridges and tubercles. Towards the overlapped parts of the bone these ridges and tubercles are continued by distinct radiate rows of small tubercles, and towards the free margins of the scale by delicate branching ridges. In the narrow spaces between the ridges minute wrinkles and pits are found.

As already pointed out by Säve-Söderbergh (1937, p. 16), this scale strongly resembles the scales of the type called *Glyptolepis baltica* by Gross (fig. 32 E—G; Gross 1930; pl. 3:12; 1933; pl. 6:9, 20, 21, 24), which originate from the uppermost part (the Oredesch and Podsnetogor Beds; see table on p. 123) of the Middle Devonian in the Baltic area.

The detached scales (Nos. P. 4118, P. 4119) from the horizon at 210—234 m. and those (Nos. P. 1427, P. 1447—P. 1449, P. 1454, P. 1456, P. 1458—P. 1460) from the Series with *Asterolepis säve-söderberghi* mentioned above (p. 101) are generally imperfectly preserved but seem to be of a similar type. The inner face is terraced in the usual manner (see p. 110 and fig. 32 D).

Remarks:—It is impossible to decide whether the detached Porolepiform remains now described belong to one and the same genus and species. As we have seen, the parietal shield most closely resembles that shield in an undetermined Porolepid from Spitzbergen, whereas the jugal and the scales are of the type found in *Glyptolepis* and *Holoptychius* (as regards the scales cf. p. 112).

C. Undetermined Crossopterygians.

As pointed out above (p. 7), the material from the Middle Devonian of East Greenland now under consideration includes numerous more or less fragmentary bones, many of which certainly belong to Crossopterygians. Among these bones only two detached cleithra, Nos. P. 1402 and P. 1461, will be described here. In addition, some detached teeth (Nos. P. 1412, P. 1413, and P. 1457) will be briefly considered.

Cleithra.

Specimen No. P. 1402.

(Fig. 35 A; pl. 21:5).

This specimen, which is from the N. slope of the eastern part of Circusbjærg, Wegeners Halvö, is mainly preserved as an impression of the inner face of the cleithrum of the right side.

The bone measures ca. 45 mm. in height. It is remarkably low and broad (cf. figs. 28 B, C, 35 B). The breadth at the dorsal end of the ventral triangular portion of the bone is ca. 20 mm., and the bone is thus at this place ca. 2.35 times higher than it is long. The dorsal and ventral portions of the bone are separated from each other by a distinct, dorsally concave line (*sut*, fig. 35 A; pl. 21:5). The inner face of the cleithrum is situated at a somewhat higher level ventrally to this line than dorsally to it. This condition and the configuration of the inner face nearest ventrally to the line strongly indicate that this line represents a suture and that the cleithrum thus consists of two independent bones, dorsal and ventral (*Clm. 1*, *Clm. 2*), the ventral element of which (the portion marked *og. Clm. 1* in pl. 21:5) overlaps the dorsal one.

This supposition is strongly supported by the conditions in certain specimens of various *Porolepiformes* at my disposal.

In the specimen of *Holoptychius* sp. from East Greenland shown in fig. 36 two such clearly independent cleithral elements (*Clm. 1*, *Clm. 2*) are actually found. This specimen, which was collected in the upper part of the *Remigolepis* Series (Upper Upper Devonian; see JARVIK 1948b;

1949 b) on the southern side of Celsius Bjærg during Dr. LAUGE KOCH's expedition to East Greenland in 1947, presents the two cleithral bones and the clavicle (*Clav*) in both external and internal views. The suture (*sut*) separating the dorsal and ventral cleithral elements is well shown both on the outer and the inner face of the shoulder-girdle. The suture on the outer side (fig. 36 B) is situated almost exactly as the line in No. P. 1402 (*sut*, fig. 35 A; pl. 21:5), which is regarded as a suture, and as that line it is concave dorsally. As a whole it lies further dorsally

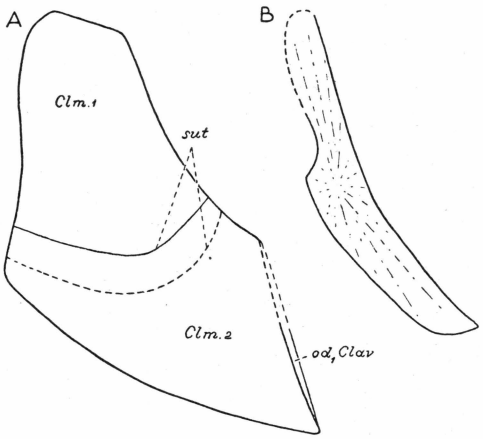


Fig. 35. Sketches of two undetermined Crossopterygian cleithra in external view. *A*. Specimen No. P. 1402. Same specimen as in pl. 21:5. $^3/_1$. *B*. Specimen No. P. 1461. From the NE. part of Hesteskoen, Canning Land. $^3/_1$.

Clm. 1, *Clm. 2*, dorsal and ventral cleithral bones.

$od_1 Clav$, area overlapped by clavicle; *sut*, suture between the dorsal and ventral cleithral bones (the course of the suture on the inner face marked with an interrupted line).

than the suture on the inner face (fig. 36 A), and the dorsal cleithral bone is clearly overlapped by the ventral one. The dorsal bone is thickened at its ventral margin and articulates antero-ventrally with the strong ascending process (*pr. Clav*) of the clavicle. Dorsally to the thickened ventral margin a large portion of the preserved part of the inner face is rough and conceivably the endoskeletal shoulder-girdle was attached to the dorsal cleithral bone. The inner face of the ventral cleithral bone is smooth and the antero-ventro-medial margin of this bone is inserted in a groove bounded by two lamellae ($l_e Clav$, $l_i Clav$; fig. 36; see also fig. 37) in the posterior margin of the clavicle in a manner characteristic of the *Porolepiformes* (JARVIK 1944b, p. 19, fig. 9 A, C, D).

Also in *Glyptolepis leptopterus* (figs. 27 B, 37) the cleithrum may sometimes be subdivided in a similar way. In three specimens of this form (Nos. P. 1663, P. 1664, P. 1666 Stockh.) represented by gutta-

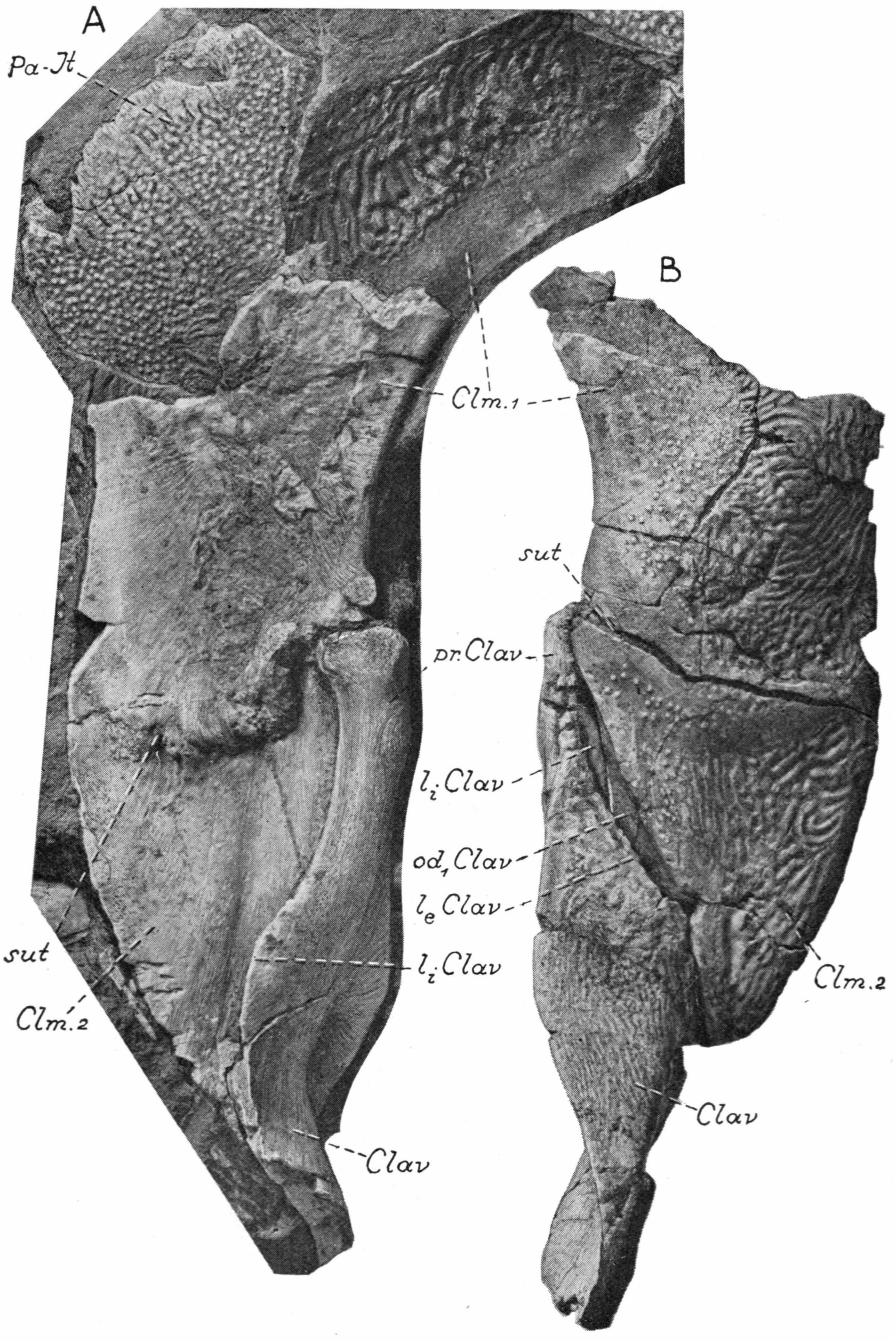


Fig. 36. *Holoptychius* sp. Part of the exoskeletal shoulder-girdle of left side in, *A*, inner and, *B*, outer aspects, showing independent dorsal and ventral cleithral bones and clavicle. In *A* the parietal shield is partly displayed. Specimen No. 782, belonging to the University of Copenhagen (collected during the Danish expedition to East

percha casts a distinct suture with about the same position and course as in the specimen of *Holoptychius* just described is found on the external face of the cleithrum, and in a fourth specimen (No. 53406 Geol. Surv.), which shows part of the exoskeletal shoulder-girdle in inner view, the

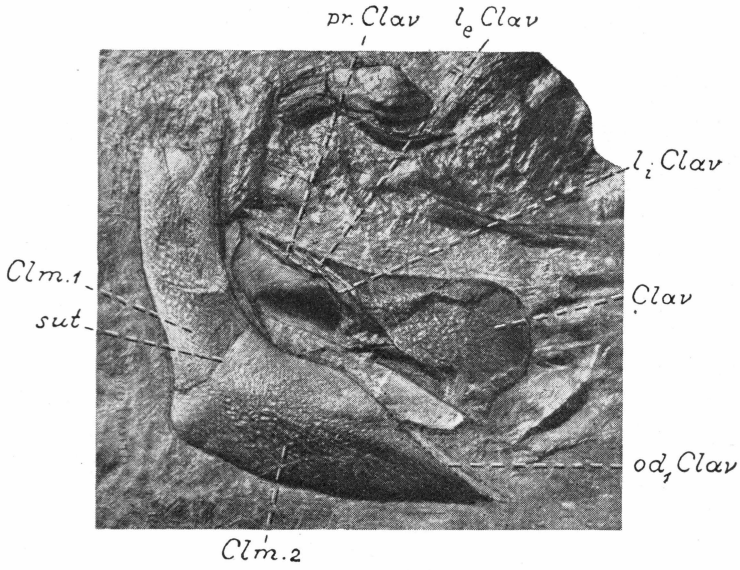


Fig. 37. *Glyptolepis leptopterus*. Cleithrum and clavicle of right side in external view. Photograph of gutta-percha cast. Specimen No. P. 1664 Stockh. From Tynet Burn, Scotland. $^3/_2$.

Clav, clavicle; *Clm. 1*, *Clm. 2*, dorsal and ventral cleithral bones.

l_e *Clav*, l_i *Clav*, external and internal laminae at posterior margin of clavicle; od_1*Clav*, area of cleithrum overlapped by external lamina of clavicle; *pr. Clav*, ascending process of clavicle; *sut*, suture between dorsal and ventral cleithral bones.

radiation of the two cleithral bones and the suture between them are seen. In two of the specimens represented by gutta-percha casts there are indications of an additional suture separating the triangular antero-dorsal portion (*Clm. 3*, fig. 27 B) of the ventral cleithral bone, and it is thus possible that the cleithrum in these two specimens is subdivided

---

Greenland in 1947 under the leadership of Dr. Lauge Koch). From the upper part of the *Remigolepis* Series (Upper Upper Devonian; cf. Jarvik 1948b; 1949 b) in Celsius Bjærg (S. side, middle part; horizon at 795 m.), Ymers Ö. $^5/_4$.

Clav, clavicle; *Clm. 1*, *Clm. 2*, dorsal and ventral cleithral bones; *Pa-It*, parieto-intertemporal.

l_e*Clav*, l_i*Clav*, external and internal lamellae at posterior margin of clavicle clasping ventral part of anterior margin of cleithrum; od_1*Clav*, area of cleithrum overlapped by external lamella of clavicle; *pr. Clav*, ascending process of clavicle; *sut*, suture between dorsal and ventral cleithral bones.

into three independent bones (*Clm. 1*, *Clm. 2*, *Clm. 3*, fig. 27 B). In some specimens of *Porolepis* from Spitzbergen at my disposal the cleithrum also seems to be subdivided into dorsal and ventral bones.

Besides in specimen No. P. 1402, a subdivision of the cleithrum into dorsal and ventral bones has hitherto been encountered among Crossopterygians only in the *Porolepiformes*, and one would be inclined to assume, therefore, that this feature is characteristic of this group and that No. P. 1402 belongs to a Porolepiform Crossopterygian. However, according to views advanced in a previous paper (JARVIK 1944b, p. 26, footnote 1), independent dorsal and ventral cleithral bones seem to occur also in Arthrodires, being represented there by the anterior lateral plate and the anterior ventro-lateral plate, respectively. It would thus appear that the subdivision of the cleithrum sometimes found in the *Porolepiformes*[1]) implies a recapitulation of primitive conditions and that the cleithrum in the common ancestors of Arthrodires and Crossopterygians was represented by at least two elements (cf. below). Under these circumstances it is conceivable that a corresponding subdivision of the cleithrum may occur also in *Osteolepiforms*, and consequently specimen No. P. 1402 cannot be placed definitely in the *Porolepiformes* only because the cleithrum is subdivided.

In this connection it is worth while mentioning that a postero-ventral portion of the cleithrum (the extracleithrum) is sometimes independent in *Coelacanthiformes* (see MOY-THOMAS and WESTOLL 1935, p. 454; JARVIK 1944b, p. 22). The cleithrum in Crossopterygians may thus be represented by at least three or four independent bones, and as already assumed elsewhere (JARVIK 1948a, p. 85, footnote 1; cf. pp. 76—85, 287—292) this bone like the clavicle and the dermal bones of the skull, evidently is a highly complex structure (cf. pp. 51—53, 66—68).

Specimen No. P. 1461.

(Fig. 35 B).

This specimen, which is from the Series with *Asterolepis säve-söderberghi* in the NE. part of Hesteskoen, Canning Land, consists of an imperfect cleithrum. The bone measures ca. 90 mm. in height and is about 6 times longer than it is high. It is thus of a much higher and narrower type than that in No. P. 1402, and higher and narrower also than in *Gyroptychius groenlandicus* (fig. 28 B, C; pl. 21:1—4).

---

[1]) In several specimens of various *Porolepiformes* at my disposal, inter alia in the specimens of *Holoptychius flemingi* (JARVIK 1944b, fig. 8 E; 1948a, figs. 33, 34; cf. also GROSS 1936, figs. 8 A, B, D, E, F, 9 C, D, F, G; pl. 8:1—3; NILSSON 1939, fig. 5 A) the cleithrum shows no signs of being subdivided and evidently a compound cleithrum corresponding to that in *Osteolepiformes* is often developed.

Detached teeth.

Specimen Nos. P. 1412, P. 1413, and P. 1457.

(Pl. 23:5—7).

These specimens, which are all from the horizon at 304 m. in profile *i* S. of Kap Brown, Wegeners Halvö (Series with *Asterolepis säve-söderberghi*), comprise numerous detached teeth, three of which have been figured here. One of these teeth (pl. 23:7) measuring about 7 mm. in length, is slightly bent, round in section, and striated at the base only, whereas the other two (pl. 23:5, 6), which are 11 and 6 mm. long respectively, are fairly straight, have a relatively stronger striation and are provided with cutting edges. The remaining teeth contained in the same slabs as these three specimens are of the same types as those figured or different. Thus some of the teeth are blunt and relatively short and thick, whereas others are remarkably long and slender and pointed. Some teeth attain a considerable size, the largest one, which is incomplete, being at least 25 mm. long.

Detached teeth are also represented in the other material from the same locality and are found also in material from other localities, especially from those in the Series with *Asterolepis säve-söderberghi.* In the material from the horizon at 210—234 m. in the NW. part of Hesteskoen, which has yielded most of the specimens described in this paper, no detached teeth have been observed.

IV. STRATIGRAPHICAL REMARKS

According to the descriptions of the Placoderms by STENSIÖ (STENSIÖ & SÄVE-SÖDERBERGH 1938) and the descriptions of the Crossopterygians given above, the fauna of the three vertebrate-bearing series of the Middle Devonian of Canning Land and Wegeners Halvö distinguished by SÄVE-SÖDERBERGH (1937) comprises the following forms:

Series with *Gyroptychius* ("*Canningius*") *groenlandicus*.
Gyroptychius groenlandicus n. sp.,
Porolepiformes indet.
Series with *Asterolepis säve-söderberghi*.
Asterolepis säve-söderberghi STENSIÖ,
Asterolepis sp.,
Homostius kochi STENSIÖ,
Homostius kochi? STENSIÖ,
Onchus sp.,
Gyroptychius? cf. *groenlandicus* n. sp.,
Porolepiformes indet.
Heterostius Series.
Heterostius groenlandicus STENSIÖ,
Homostius kochi STENSIÖ.

On the basis of the Placoderms and the Osteolepiform Crossopterygians, provisionally determined by him as *Canningius groenlandicus* n. g., n. sp. and *?Tristichopterus* sp., SÄVE-SÖDERBERGH (1937; see also STENSIÖ & SÄVE-SÖDERBERGH 1938) parallellized the three vertebrate-bearing series of strata with the Upper Middle Devonian sequence in the Baltic Devonian field and in Scotland as shown in the table on p. 123 (cf. JARVIK 1937, pp. 120—121; WESTOLL 1937, pp. 36—40; table 1; pl. 4).

As demonstrated above, the Osteolepid provisionally placed in the genus *Canningius* belongs to the genus *Gyroptychius* (see JARVIK 1948a) and has been described as *G. groenlandicus* n. sp. This form is in most of its characters indistinguishable from, and no doubt very closely allied to, *G. milleri* JARVIK from the Thurso Flagstone Group

<table>
<tr><th>Baltic States</th><th colspan="2">Scotland</th><th>East Greenland
(esp. Canning L.).</th></tr>
<tr><td>Dm_5 (Podsnetogor Beds):
Asterolepis radiata</td><td colspan="2">Nairn Beds:
Aster. maxima</td><td rowspan="3"></td></tr>
<tr><td rowspan="3">Dm_4 (Oredesch Beds):
Aster. ornata</td><td colspan="2">Eday Sandstone, John o'Groats Sandstone Group, Brindister Beds:
Microbrachius, Tristichopterus, Pentlandia, Aster. thule</td><td>Series w. Canningius groenlandicus.
?Tristichopterus sp.</td></tr>
<tr><td colspan="2">S. with Coccosteus fletti</td><td rowspan="3">Series w. Asterolepis säve-söderberghi, Homostius, Crossopterygii</td></tr>
<tr><td rowspan="2">Rousay Beds, Thurso Flagstone Group</td><td>S. w. Aster. orcadensis</td></tr>
<tr><td>Dm_3 (Luga Beds):
Heterostius, Homostius</td><td>S. w. Thursius pholidotus, Gyroptychius milleri, Coccosteus minor, Homostius</td><td>Heterostius Series; also w. Homostius</td></tr>
<tr><td>D_{1-2} (Pernau and Narowa Beds):
Pterichthyodes.</td><td colspan="2">Stromness Beds (Sandwick Fish-Bed), Achanarras, Moray Firth Area:
Pterichthyodes, Homostius</td><td></td></tr>
</table>

Table 7. Correlations according to SÄVE-SÖDERBERGH (cf. pp. 124—125; JARVIK 1949 a, table 5). From SÄVE-SÖDERBERGH (1937); with some additions.

and Rousay Beds in Scotland (pp. 99—100). The ornamented specimens from East Greenland referred to ?*Tristichopterus* sp. do not belong to this genus. At least most of them are specimens of *Gyroptychius groenlandicus* in which the external dentine and enamel layers are wanting (pp. 17, 19, 87).

The great similarities between *G. groenlandicus* and *G. milleri* of course do not necessarily mean that the deposits from which these two forms originate, viz. the Thurso Flagstone Group and Rousay Beds in Scotland and the Series with *Gyroptychius groenlandicus* in East Greenland, are contemporaneous. However, the Greenland species of *Homostius* and *Heterostius*, which still are imperfectly known, differ clearly from the representatives of these genera in other areas (STENSIÖ & SÄVE-SÖDERBERGH 1938) and the similarities between *Asterolepis säve-söderberghi* and *Asterolepis orcadensis* demonstrated by STENSIÖ (STENSIÖ and SÄVE-SÖDERBERGH 1938, p. 18; cf. SÄVE-SÖDERBERGH 1937, p. 35) are rather inconsiderable compared with those found to exist between *G. groenlandicus* and *G. milleri*. Under these circum-

stances the great similarity between the last-mentioned two forms becomes the most important landmark that we possess at present for a correlation of the Greenland Middle Devonian deposits with those in Scotland. We are therefore justified in concluding that the Middle Devonian deposits from East Greenland are a little older than assumed by SÄVE-SÖDERBERGH (see the table 7 on p. 123) and that the Series with *Gyroptychius groenlandicus* is at least approximately contemporaneous with the deposits in Scotland (the Thurso Flagstone Group and the Rousay Beds) yielding *Gyroptychius milleri*. Whether the Series with *Asterolepis säve-söderberghi* in East Greenland corresponds to the lower part of the Rousay Beds or to the Stromness Beds in Scotland I would not venture to decide. As regards the *Heterostius* Series see below.

As far as I can find neither the *Porolepiformes* nor the *Placodermi* listed above (p. 122) contradict this conclusion as regards the age of the series with *Gyroptychius groenlandicus*.

Among the poor remains of *Porolepiformes* from East Greenland the parietal shield described above resembles that shield in an undetermined Porolepid (*Porolepis* sp.) from Spitzbergen. This latter shield originates from the upper part of the middle division (the Lykta division) of the Wood Bay Series in Mt. Garborg, Ekman Bay (see FØYN & HEINTZ 1943, pp. 39—40), and thus comes from deposits which generally are regarded to be Lower Devonian in age[1]). However, if the parietal shield from East Greenland really belongs to the genus *Porolepis*, which is still very uncertain, this will have no influence on the correlation suggested above since this genus, as recently demonstrated by GROSS (1942, p. 426), in the Baltic States occurs in the lower part (Pernau and Luga Beds) of the Upper Middle Devonian (cf. footnote 1 and p. 101). The Porolepiform jugal and scales from East Greenland resemble the corresponding structures in *Glyptolepis* and *Holoptychius*. Of these genera the genus *Glyptolepis* (cf. p. 102) in Scotland is represented both in the Stromness and the Rousay Beds, and in the Baltic area the genus, according to the determinations by GROSS (1942, p. 390), occurs in all the strata listed in the table on p. 123.

[1]) As recently stressed by FØYN & HEINTZ (1943) the age of the Wood Bay Series is uncertain. The upper part of the Lykta division contains, according to the preliminary determinations of the fossils carried out by HEINTZ (see FØYN & HEINTZ 1943, pp. 19, 47), in addition to the Porolepids, inter alia also *Actinolepis*, *Homostius*, and uncertain remains of *Heterostius*. The latter three genera are charcteristic of the lower part (the Pernau, Narowa and Luga Beds, see table on p. 123) of the Baltic Upper Middle Devonian and, as recently maintained by GROSS (1942, p. 426; cf. footnote 2 on p. 101), the genus *Porolepis*, which previously has been regarded as exclusively Lower Devonian in age, occurs in the Pernau and Luga Beds, being represented there by the type species, viz. *Porolepis posnaniensis* (KADE).

As regards the Placoderms it should be pointed out that the genus *Asterolepis* and probably also the genera *Homostius* and *Heterostius* have a wider stratigraphical range than known in 1937, when Säve-Söderbergh made his correlations (cf. footnote 1 on p. 124; Nilsson 1941). The genus *Asterolepis* is thus now known from the Luga and Narowa Beds in the Baltic area and is possibly represented also in the Pernau Beds (Gross 1940; 1942, pp. 371, 377, 390). The genus *Homostius* occurs according to Gross (1942, pp. 376, 390) in the Pernau Beds and according to the same writer (op. cit. pp. 377, 390) the genus *Heterostius* is probably represented in the Narowa Beds. Since the genera *Heterostius* and *Homostius* thus seem to be represented in the Pernau and Narowa Beds and since the genus *Homostius* occurs in the Stromness Beds (*Heterostius* is unknown in Scotland) there is nothing to prevent that the Series with *Heterostius* (and *Homostius*) in East Greenland is broadly contemporaneous with these strata (cf. Jarvik 1949 a).

V. SUMMARY

1. A new species of *Gyroptychius*, *G. groenlandicus*, from the Middle Devonian in East Greenland has been described (pp. 11—26, 54—100, figs. 2, 3, 12, 13—24, 28, 29). This species comprises certain specimens in which the enamel and dentine layers of the bones are secondarily wanting (pp. 16—19, figs. 17 E, F, 24 J, K, M).

2. This new species agrees in most respects with *Gyroptychius milleri* JARVIK from the Scottish Middle Devonian and is certainly more closely related to that species than to *G. agassizi* (TRAILL). The differences between *G. milleri* (figs. 14 B, D, 25 C, D) and *G. groenlandicus* and between these two forms and *G. agassizi* (figs. 14 A, C, 25 A, B) are summarized on pp. 99—100.

3. Besides *Gyroptychius groenlandicus* n. sp. and certain scales provisionally described as *Gyroptychius*? cf. *groenlandicus* n. sp. (p. 100), the Middle Devonian Crossopterygian fauna of Canning Land and Wegeners Halvö includes *Porolepiformes* indeterminable as to family, genus, and species, and Crossopterygians indeterminable as to group (pp. 116—121).

4. In connection with the description of the *Porolepiformes* (pp. 110—116, fig. 34; pl. 24) some new data on the structure of the cranial roof and external cheek plate in *Porolepiformes* in general have been given (pp. 103—108, figs. 30, 31). In addition, the gular plates in *Porolepis* sp. (p. 90, fig. 27 A), *Glyptolepis leptopterus* (p. 90, fig. 27 B), and *Tristichopterus alatus* (p. 87, fig. 26) have been briefly considered.

5. The cleithrum in Crossopterygians may sometimes be subdivided into two independent bones, dorsal and ventral (pp. 116—120, figs. 27 B, 35 A, 36, 37).

6. The dentine-covered scales in early *Osteolepiformes* (Osteolepids), early *Porolepiformes* (Porolepids), and early *Dipnoi* (*Dipterus*), as far as known, have an almost identical histological structure (pp. 21, 31, 108, 111). The scales in Osteolepids and Porolepids may agree also as regards the external appearance (pp. 108, 111). The cycloidal scales in advanced

Osteolepiformes (Rhizodontids, fig. 35 E) and advanced *Porolepiformes* (Holoptychiids, figs. 32 C—G, 33 A—D) no doubt developed independently from the rhomboidal, dentine-covered scales in the early representatives of these two groups, and probably the cycloidal scales in *Coelacanthiformes* (fig. 33 F) and advanced *Dipnoi* (fig. 33 G) have undergone a similar phyletic development. Whether the phyletic changes of the scales took place in fundamentally the same manner in the various groups or whether there are any distinct differences is still unknown, and scales of *Osteolepiformes*, *Porolepiformes*, *Coelacanthiformes*, and *Dipnoi* are at present in many cases indeterminable even as to group, when found detached (pp. 110—112).

7. On the basis of the material of *Gyroptychius groenlandicus* and of a number of specimens of *Dipterus valenciennesi* and some detached dermal bones of Osteolepids and (?) Dipnoans from Kokenhusen in Latvia the blisters, areas of resorbtion, Westoll-lines, and other structures in the dentine layer have been described and the growth and the periodical resorbtion and reformation of that layer have been discussed (pp. 19—51, figs. 2—10, 11 A). The conditions have been found to be rather intricate, especially in the Dipnoans, and further investigations, both macroscopical and microscopical, are necessary before all the problems pertaining to these questions can be definitely solved. The material available provides evidence for the following conclusions (Points Nos. 8—14).

8. The dentine layer (Hautzahnparkett, Gross), which consists of closely set dermal teeth, is generally simple in Osteolepids and early Dipnoans (pp. 26, 31, 48, figs. 3, 5, 10). In certain specimens of *Gyroptychius groenlandicus* it was found to be overlain by patches of younger dentine and trabecular tissue (blisters of the superficial type; pp. 21—22, fig. 3), which is of much interest since two or more layers of dermal teeth, the one above the other, are frequently found in the *Porolepiformes* (pp. 24—26).

9. The dermal teeth of the dentine layer represent units of growth (p. 39). A single dermal tooth, or possibly a small group of such teeth, was laid down at each centre of growth (p. 47; cf. Point No. 14).

10. The areal growth of the dentine layer, which on each of the dermal bones or scales could start at one or more centres, both in Osteolepids and in early Dipnoans occurred by the successive deposition of new dermal teeth along the margins of the first formed patch of dentine. The newly formed dermal teeth, which were irregularly disposed or arranged in more or less distinct annular rows (figs. 7, 11 A), usually fused with each other and with the previously formed dermal teeth and were in this way gradually incorporated in the continuous dentine

layer. Sometimes, partly or wholly independent dermal teeth or rings of teeth are found along the outer margins of the various areas of dentine (pp. 36—30, 48, figs. 7, 11 A), and sometimes the peripheral dermal teeth of one bone fused with the dermal teeth of an adjoining bone, which led to a partial or complete obliteration of the suture (pp. 30—31, 38).

11. The growth in thickness of the dentine layer generally (cf. p. 48) took place by repeated resorbtion and reformation of dentine (pp. 48—49). The first formed dentine layer, representing the first generation of dentine, was very thin, probably not wholly concealing the underlying ornamented external face of the trabecular layer (pp. 28, 45, 48, fig. 4 B). It was soon resorbed and replaced by a new and slightly thicker layer, representing the second generation of dentine, and this latter layer was resorbed and replaced by a still thicker layer belonging to the third generation of dentine, and so on. The dermal teeth in each generation of dentine seem to be about equal in height (p. 38, figs. 3, 5, 10). Though not directly evidenced by the material available, it is feasible, however, that in Dipnoans, in which the resorbtion and reformation of the dentine layer sometimes proceeded relatively slowly (cf. Point No. 13), the new dermal teeth in certain cases suddenly grew higher than the teeth of the same generation previously formed (p. 48).

12. The growth of the various generations (layers) of dentine of each of the dermal bones or scales, the first generation and possibly also the most peripheral portions of the later formed generations excepted (p. 48), took place independently of the growth of the deeper parts, and the centre or centres of growth of each of the various, successively formed dentine layers have no definite relations to the growth centre (centre of radiation) of the underlying part of the bone or scale (pp. 44—45, 48).

13. As regards the mode of resorbtion and reformation of the dentine layer there are certain differences between Osteolepids and early Dipnoans (pp. 49—51).

In the Osteolepids (pp. 29—30, 49, figs. 2—5; JARVIK 1948a, figs. 8 A—D, 9) these processes, which generally started at several centres, took place rapidly, and at most two generations of dentine are seen at the same time on one and the same dermal bone or scale. Each new generation of dentine was formed by the fusion of patches of dentine (blisters of the inserted type) deposited in irregular areas of resorbtion in the old layer of dentine.

In Dipnoans (pp. 49—51, figs. 6—10) the conditions are more complicated. In many cases (figs. 9, 10) the processes of resorbtion and reformation of the dentine layer probably started each time at one centre only on each of the dermal bones and scales and went

on at a slow rate for a relatively long period of time. This often resulted in the formation of three or more generations of dentine side by side on one and the same dermal bone or scale. The various generations of dentine are separated from each other by narrow, often concentric groove-like areas of resorbtion (Westoll-lines; pp. 32—33, footnote 1 on p. 40). Sometimes, however, as is evidenced by the presence of numerous irregular areas of resorbtion and blisters similar to those found in the Osteolepids, the processes of resorbtion and reformation of the dentine layer took place more rapidly and conceivably in the same manner as in the Osteolepids. The Westoll-lines do not always separate different generations of dentine (p. 38, figs. 7 B, 8 A) and also other complications occur (see e. g. the comments on the opercular shown in fig. 8 A, p. 40).

14. The growth of the dermal bones and scales in Dipnoans and Crossopterygians has been discussed (pp. 51—53, fig. 11 A). The opinion has been tentatively advanced that the dermal bones (like the dentine layer; cf. Points Nos. 9, 10) grew by the successive deposition of very small units of growth along the margins. These presumed units of growth, which may correspond to the small units of growth, the lepidomoria, recently identified by Stensiö and Ørvig (1949) in Elasmobranchs, consist of a dermal tooth and the underlying thin portions of the trabecular and basal (isopedin) layers. The units of growth may probably fuse in various ways, which would make it possible to explain even small variations in the size and shape of the individual dermal bones and scales (p. 53). There seem to be no fundamental differences as regards the growth of the dermal bones and scales between Crossopterygians and Dipnoans, on the one hand, and early Actinopterygians (fig. 11 B), on the other (p. 53).

15. The Series with *Gyroptychius groenlandicus*, the uppermost of the three vertebrate-bearing Middle Devonian series in Canning Land and Wegeners Halvö (pp. 122—125), is probably approximately contemporaneous with the Thurso Flagstone Group and the Rousay Beds in Scotland, which contain *G. milleri*. The *Heterostius* Series in East Greenland probably corresponds to the Stromness Beds in Scotland and to the Narowa and Pernau Beds in the Baltic Devonian field (p. 125).

VI. BIBLIOGRAPHY

Agassiz, L. 1844. Poissons fossiles du Vieux Grès Rouge. Neuchatel.

Aldinger, H. 1937. Permische Ganoidfische aus Ostgrönland. København, Medd. om Grønland, Bd. 102.

Allis, E. P. 1922. The Cranial Anatomy of *Polypterus*, with Special Reference to *Polypterus bichir*. Journ. Anat., vol. 56.

Bryant, W. L. 1919. On the Structure of *Eusthenopteron*. Bull. Buffalo Soc. Nat. Sci., vol. 13.

Bütler, H. 1948. Notes on the Geological Map of Canning Land (East Greenland). Medd. om Grønland, Bd. 133.

Bystrow, A. P. 1939. Zahnstruktur der Crossopterygier. Acta Zoologica, Stockholm, bd. 20.

— 1942. Deckknochen und Zähne der *Osteolepis* und *Dipterus*. Acta Zoologica, Stockholm, bd. 23.

de Beer, G. R. 1937. The Development of the Vertebrate Skull. Clarendon Press, Oxford.

Denison, R. H. 1947. The Exoskeleton of *Trematapis*. Amer. Journ. Sci., vol. 245.

Forster-Cooper, C. 1937. The Middle Devonian Fish Fauna of Achanarras. Edinburgh, Roy. Soc. Trans., vol. 59.

Føyn, S. & Heintz, A. 1943. The Downtonian and Devonian Vertebrates of Spitsbergen. VIII. The English-Norwegian-Swedish Expedition 1939. Geological Results. Oslo, Skrifter om Svalbard og Ishavet, Nr. 85.

Goodrich, E. S. 1907. On the Scales of Fish, Living and Extinct, and their Importance in Classification. London, Zool. Soc. Proc.

Graham-Smith, W. & Westoll, T. S. 1937. On a New Long-Headed Dipnoan Fish from the Upper Devonian of Scaumenac Bay, P. Q., Canada. Edinburgh, Roy. Soc. Trans., vol. 59.

Gross, W. 1930. Die Fische des Mittleren Old Red Süd-Livlands. Geol. u. Pal. Abh., N. F., Bd. 18.

— 1933. Die Fische des baltischen Devons. Palaeontographica, Bd. 79, Abt. A.

— 1935. Histologische Studien am Aussenskelett fossiler Agnathen und Fische. Palaeontographica, Bd. 83, Abt. A.

— 1936. Beiträge zur Osteologie baltischer und rheinischer Devon-Crossopterygier. Palaeont. Zeitschr., Bd. 18.

— 1940. Acanthodier und Placodermen aus den *Heterostius*-Schichten Estlands und Lettlands. Annales Soc. Reb. Nat. Invest. Univ. Tartuensis, Const. 46.

— 1941. Über den Unterkiefer einiger devonischer Crossopterygier. Abh. Preussisch. Akad. Wissensch.

— 1942. Die Fischfaunen des baltischen Devons und ihre biostratigraphische Bedeutung. Korrespondenzblatt d. Naturforscher-Vereins zu Riga, Bd. 64.

Heintz, A. 1932. Beitrag zur Kenntnis der Devonischen Fischfauna Ost-Grönlands. Oslo, Skrifter om Svalbard og Ishavet, Nr. 42.

Hubbs, C. & Hubbs, L. 1944. Bilateral Assymetry and Bilateral Variation in Fishes. Mich. Acad. Sci., Papers, vol. 30.

JARVIK, E. 1937. On the Species of *Eusthenopteron* found in Russia and the Baltic States. Uppsala, Geol. Inst. Bull., vol. 27.
— 1942. On the Structure of the Snout of Crossopterygians and Lower Gnathostomes in General. Uppsala, Zool. bidrag fr. Uppsala, bd. 21.
— 1944a. On the Dermal Bones, Sensory Canals and Pit-lines of the Skull in *Eusthenopteron foordi* WHITEAVES, with some Remarks on *E. säve-söderberghi* JARVIK. Stockholm, K. Vet. Akad. Handl., ser. 3, bd. 21.
— 1944b. On the Exoskeletal Shoulder-girdle of Teleostomian Fishes, with special reference to *Eusthenopteron foordi* WHITEAVES. Stockholm, K. Vet. Akad. Handl., ser. 3, bd. 21.
— 1947. Notes on the Pit-lines and Dermal Bones of the Head in *Polypterus*. Uppsala, Zool. bidrag fr. Uppsala, bd. 25.
— 1948a. On the Morphology and Taxonomy of the Middle Devonian Osteolepid Fishes of Scotland. Stockholm, K. Vet. Akad. Handl., ser. 3, bd. 25.
— 1948b. Note on the Upper Devonian Vertebrate Fauna of East Greenland and on the Age of the Ichthyostegid Stegocephalians. Stockholm, K. Vet. Akad., Arkiv f. Zoologi.
— 1949a. On the Middle Devonian Crossopterygians from the Hornelen Field in Western Norway. Bergen, Univ. Årbok (In press).
— 1949b. Note on Middle Devonian Crossopterygians from the Eastern Part of Gauss Halvö, East Greenland. With an Appendix: An Attempt at a Correlation of the Upper Old Red Sandstone of East Greenland with the Marine Sequence. Medd. om Grönland, Bd. 149, Nr. 6.
KADE, G. 1858. Über die devonischen Fischreste eines Diluvialblockes. Programm d. Königlichen Realschule zu Meseritz.
KIAER, J. 1918. Fiskerester fra den devoniske sandsten paa Norges vestkyst. Bergens Mus. Aarbok.
LERICHE, M. 1931. Les Poissons Famenniens de la Belgique. Mém. Classe d. Sci. Acad. roy. Belgique, ser. 2, t. 10.
MCCOY, F. 1855. Systematic description of the British Palaeozoic Fossils. In SEDGWICK, A. & MCCOY, F.: The British Palaeozoic Rocks and Fossils. London.
MILLER, H. 1841. The Old Red Sandstone. 1st Ed. Edinburgh.
— 1849. Footprints of the Creator. 1st Ed. Edinburgh.
MOY-THOMAS, M. A. 1935a. A Synopsis of the Coelacanth Fishes of the Yorkshire Coal Measures. Ann. and Mag. Nat. Hist., ser. 10, vol. 15.
— 1935b. The Coelacanth Fishes from Madagascar. Geol. Mag., vol. 72.
— 1937. The Carboniferous Coelacanth Fishes of Great Britain and Ireland. London, Zool. Soc. Proc., ser. B.
MOY-THOMAS, M. A. & WESTOLL, T. S. 1935. On the Permian Coelacanth, *Coelacanthus granulatus* Ag. Geol. Mag., vol. 72.
MURCHISON, R. I. 1868. Siluria. Fourth Ed. London.
NILSSON, T. 1939. Cleithrum und Humerus der Stegocephalen und Rezenten Amphibien. Lunds Univ. Årsskrift, bd. 35.
— 1941. The Downtonian and Devonian Vertebrates of Spitsbergen. VII. Order *Antiarchi*. Oslo, Skrifter om Svalbard og Ishavet, Nr. 82.
NOE-NYGAARD, A. 1934. Stratigraphical Outlines of the Area round Fleming Inlet (East Greenland). Medd. om Grønland, Bd. 103.
OBRUCHEV, D. 1937. Vertebrata aus dem Obersilur und Devon des Urals. Materials of the Centr. Geol. and Prospect. Inst., Gen. ser., fasc. 2.
— 1939. Discovery of a Lower Devonian Fish Fauna in the USSR. C. R. (Doklady) Acad. Sci. URSS., vol. 22.

OBRUCHEV, D. 1940. Devonian Fishes of Siberia and Central Asia. C. R. (Doklady) Acad. Sci. URSS., vol. 27.

PANDER, C. H. 1858. Über die Ctenodipterinen des devonischen Systems. St. Petersburg.

— 1860. Über die Saurodipterinen, Dendrodonton, Glyptolepiden und Cheirolepiden des devonischen Systems. St. Petersburg.

POLL, M. 1941—1942. Contribution à l'étude systématique des *Polypteridae* (Pisces). Rev. Zool. Bot. Afr., vol. 35.

RICHTER, R. 1943. Einführung in die Zoologische Nomenclatur. Frankfurt am Main.

ROBERTSON, G. M. 1938. The *Tremataspidae*. Parts I and II. Amer. Journ. Sci., vol. 35.

ROMER, A. S. 1945. Vertebrate Paleontology. 2nd Ed. Univ. of Chicago Press, Chicago.

ROUX, G. H. 1942. The Microscopic Anatomy of the *Latimeria* Scale. S. Afr. J. Med. Sci., vol. 7.

SÄVE-SÖDERBERGH, G. 1933. The Dermal Bones of the Head and the Lateral Line System in *Osteolepis macrolepidotus* Ag. With Remarks on the Terminology of the Lateral Line System and on the Dermal Bones of Certain other Crossopterygians. Uppsala, Reg. Soc. Sci. Ups. Nov. Acta, ser. 4, vol. 9.

— 1937. On the Palaeozoic Stratigraphy of Canning Land, Wegener Peninsula, and Depot Island (East Greenland). Medd. om Grønland, Bd. 96.

SMITH, J. L. B. 1939. A Living Coelacanthid Fish from South Africa. Cape Town, Roy. Soc. South Afr. Trans., vol. 28.

STENSIÖ, E. 1931. Upper Devonian Vertebrates from East Greenland. Medd. om Grønland, Bd. 86.

— 1937. On the Devonian Coelacanthids of Germany with Special Reference to the Dermal Skeleton. Stockholm, K. Vet. Akad. Handl., ser. 3, bd. 16.

— 1939. Über die Fische des Devons von Ostgrönland. Mitt. Naturf. Ges. Schaffhausen (Schweiz), Bd. 16.

STENSIÖ, E. & ØRVIG, T. 1949. On the Scales of Elasmobranchs. (Manuscript).

STENSIÖ, E. & SÄVE-SÖDERBERGH, G. 1938. Middle Devonian Vertebrates from Canning Land and Wegener Peninsula (East Greenland). I. *Placodermi, Ichthydorulithes*. Medd. om Grønland, Bd. 96.

TRAQUAIR, R. H. 1875. On the Structure and Affinities of *Tristichopterus alatus* EGERTON. Edinburgh, Roy. Soc., Trans., vol. 27.

WATSON, D. M. S. 1935. Fossil Fishes of the Orcadian Old Red Sandstone. In WILSON, G. V. The Geology of the Orkneys. Edinburgh, Geol. Surv., Scotland, Mem.

WESTOLL, T. S. 1936. On the Structures of the Dermal Ethmoid Shield of *Osteolepis*. Geol. Mag., vol. 73.

— 1937. The Old Red Sandstone Fishes of the North of Scotland, Particularly of Orkney and Shetland. Geologists' Assoc. Proc., vol. 48.

WOODWARD, A. S. 1891a. Catalogue of the Fossil Fishes in the British Museum (Nat. Hist.). Part II. London.

— 1891b. The Devonian Fish-Fauna of Spitzbergen. Ann. and Mag. of Nat. Hist., ser. 6, vol. 8.

— 1900. Notes on Some Upper Devonian Fish-Remains. Stockholm, K. Vet. Akad. Handl., bd. 26.

Færdig fra trykkeriet den 25. januar 1950.

PLATES

The specimens shown in the plates belong to the University of Copenhagen. All specimens except the one shown in pl. 6:1 were collected by Professor G. Säve-Söderbergh of Uppsala and his assistants during Dr. Lauge Koch's expeditions to East Greenland in 1934 and 1936. If not otherwise stated the fossils have been photographed in a dry condition. All photographs have been retouched.

Plate 1.

Gyroptychius groenlandicus n. sp.

Holotype. Specimen No. P. 1310. Canning Land, NW. part of Hesteskoen, 210—234 m. Same specimen as in pl. 2. All figures $^{2}/_{1}$.

Fig. 1. Flattened, imperfect and dislocated skull in dorsal view. Photographed in alcohol.

Fig. 2. Imperfect lachrymal of right side in external view.

Fig. 3. Postorbital of right side in external view.

Fig. 4. Left jugal in external view.

Fig. 5. Right subopercular in external view.

Fig. 6. Posterior branchiostegal ray of left side in external view.

Aclm, anocleithrum; *Et*, extratemporal; *Ext. l*, *Ext. m*, lateral and median extrascapulars; *D*, dermosphenotic; *Fr-eth. sh*, fronto-ethmoidal shield; *Ju*, jugal; *Lj*, lower jaw; *Mx*, maxillary; *Op*, opercular; *Pa. sh*, parietal shield; *Po*, postorbital; *Pop*, preopercular, *Qj*, quadratojugal; *Sq*, squamosal.

bli, blisters; *fe. exa*, fenestra exonarina anterior; *f. pin*, pineal foramen; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *ioc*, infraorbital sensory canal; *iocp*, pores of ditto; *od. La* + *Mx*, area of fronto-ethmoidal shield overlapped by lachrymal and maxillary; *od. Op*, area of subopercular overlapped by opercular; *od. Rbra*, area of hindmost branchiostegal ray overlapped by second ray; *od. Sop*, area of hindmost branchiostegal ray overlapped by subopercular; $od_1 Clm$, area of anocleithrum overlapped by cleithrum; $od_2 La$, area of maxillary overlapped by lachrymal; $od_2 Po$, area of dermosphenotic overlapped by postorbital; $od_4 Lj$, area of hindmost branchiostegal ray overlapped by lower jaw; *o. m*, orbital margin of postorbital; *pl. ac. sl*, pit-line of accessory sensory line of body; *pl. Fr*, frontal pit-line; *plh. Id. 2*, horizontal pit-line of infradentary 2; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *pl. Sqx*, additional squamosal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *plv. Id. 2*, vertical pit-line of infradentary 2; *plv. Id. 3*, vertical pit-line of infradentary 3; *proc*, preorbital corner of cranial roof; *ri. dl*, dorsolateral ridge of opercular.

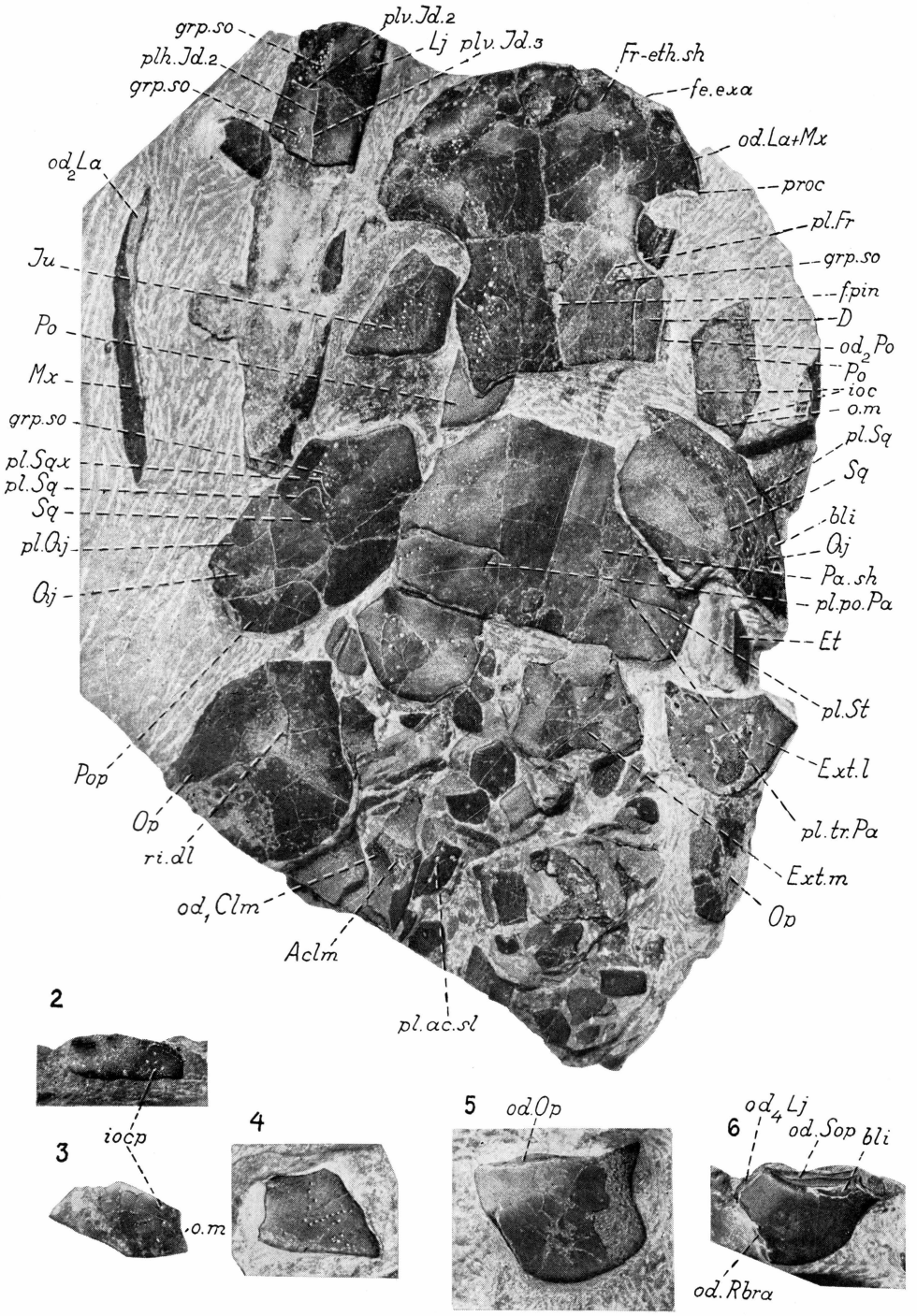

grp.so
plv.Jd.2
plh.Jd.2
Lj
plv.Jd.3
Fr-eth.sh
grp.so
fe.exa
od.La+Mx
od2La
proc
pl.Fr
Ju
grp.so
fpin
Po
D
od2Po
Mx
Po
ioc
grp.so
o.m
pl.Sq
pl.Sqx
Sq
pl.Sq
bli
Sq
pl.Qj
Qj
Qj
Pα.sh
pl.po.Pα
Et
pl.St
Pop
Ext.l
Op
pl.tr.Pα
ri.dl
Ext.m
od1Clm
Op
Aclm
pl.ac.sl
2
iocp
3
o.m
4
5
od.Op
6
od4Lj
od.Sop
bli
od.Rbrα

Plate 2.

Gyroptychius groenlandicus n. sp.

Holotype. Same specimen as in pl. 1. All figures $^{2}/_{1}$.

Fig. 1. Part of the skull shown in pl. 1:1, further prepared.

Fig. 2. Part of the same specimen in ventral view.

Fig. 3. Imperfect lower jaw and maxillary of right side in external view.

Fig. 4. Left maxillary in external view.

Clav, clavicle; *D*, dermosphenotic; *Et*, extratemporal; *Ext. l*, lateral extrascapular; *Fr-eth. sh*, fronto-ethmoidal shield; *G*, principal gular plate; *Ju*, jugal; *La*, lachrymal; *Lj*, lower jaw; *Mx*, maxillary; *Op*, opercular; *Pa. sh*, parietal shield; *Po*, postorbital; *Pop*, preopercular; *Qj*, quadratojugal; *Rbr. 1*, hindmost (first) branchiostegal ray; *Rbr. 2*, second branchiostegal ray.

bli, blisters; *fe. exa*, fenestra exonarina anterior; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. Et*, notch in parietal shield for extratemporal bone; *i. La+Mx*, notch in fronto-ethmoidal shield for lachrymal and maxillary; *i. o*, orbital notch; *ioc*, infraorbital sensory canal; *i. spir*, spiracular notch; *od. G. m*, area of principal gular overlapped by median gular; *od. Qj*, area of lower jaw overlapped by quadratojugal; *od. Rbr*, area of principal gular overlapped by branchiostegal rays; *od. Sclm*, area of anocleithrum overlapped by supracleithrum; $od_1 Sc$, area of scale overlapped by adjoining scale; $od_1 Clm$, area of anocleithrum overlapped by cleithrum; $od_2 Ju$, area of squamosal overlapped by jugal; $od_2 La$, area of maxillary overlapped by lachrymal; $od_2 Po$, area of dermosphenotic overlapped by postorbital; $od_2 Sc$, area of scale overlapped by adjoining scale; $od_3 Ju$, area of maxillary overlapped by jugal; $od_3 Po$, area of parietal shield overlapped by postorbital; *pl. Fr*, frontal pit-line; *pl. G*, pit-line of principal gular; *pl. Gx*, additional pit-line of ditto; *plh. Id. 2*, *plh. Id. 3*, *plh. Id. 4*, horizontal pit-lines of infradentaries 2, 3, and 4; *pl. Qj*, quadratojugal pit-line; *pl. Rbr. 2*, pit-line of second branchiostegal ray; *pl. Sq*, squamosal pit-line; *pl. Sqx*, additional squamosal pit-line; *plv. Id. 2*, *plv. Id. 3*, vertical pit-lines of infradentaries 2 and 3; *p-mc*, preoperculo-mandibular sensory canal; *pr. Mx*, anterior process of maxillary; *proc*, preorbital corner of cranial roof; *ptoc*, postorbital corner of cranial roof.

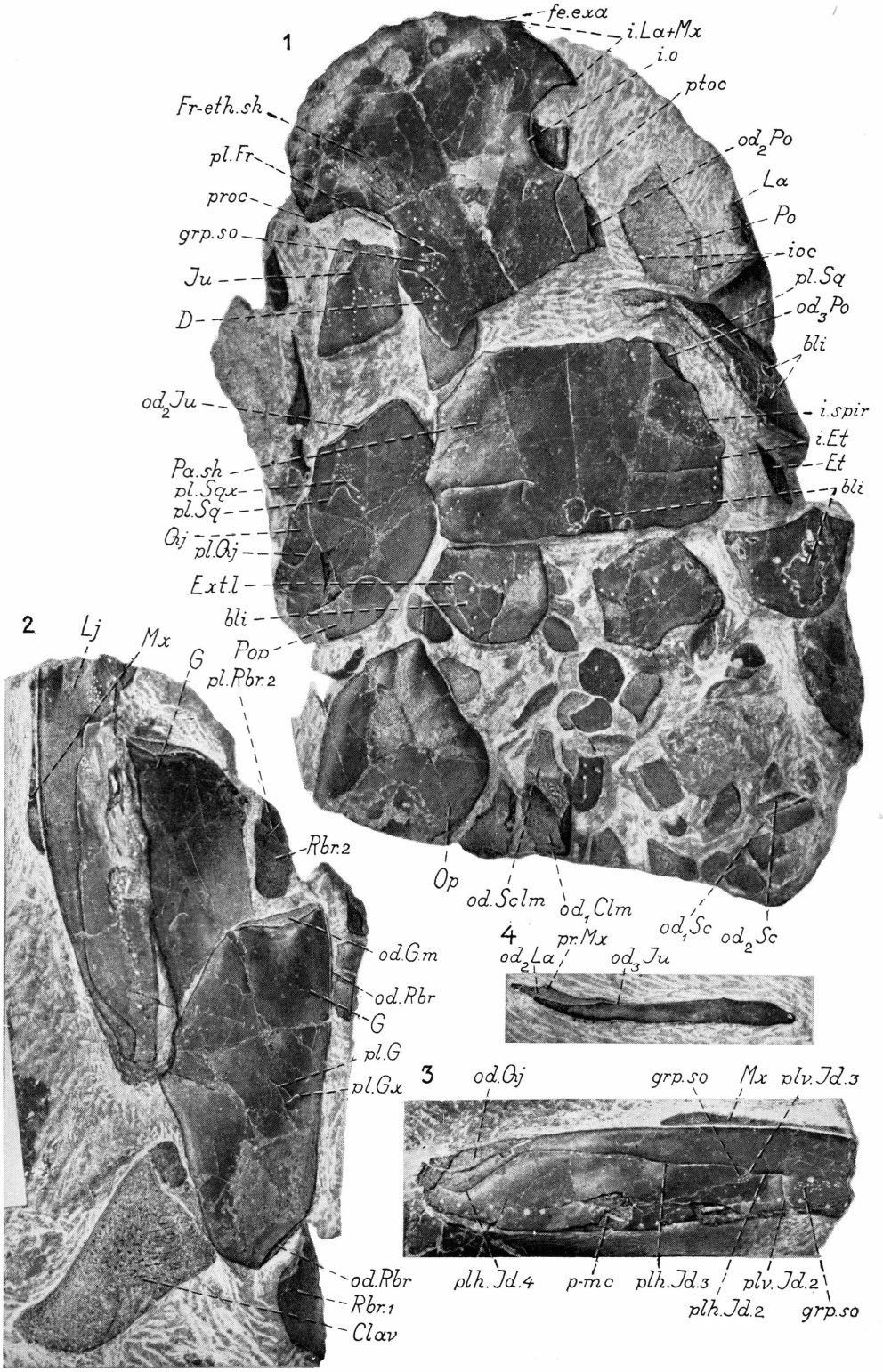

1
fe.exα
i.Lα+Mx
i.o
ptoc
Fr-eth.sh
pl.Fr
od2Po
proc
Lα
grp.so
Po
Ju
ioc
D
pl.Sq
od3Po
bli
od2Ju
i.spir
i.Et
Et
Pα.sh
pl.Sqx
pl.Sq
Oj
pl.Oj
Ext.l
bli
Pop
2
Lj
Mx
G
pl.Rbr.2
Rbr.2
Op
od.Sclm
od1Clm
od1Sc
od2Sc
od.G.m
od.Rbr
G
pl.G
pl.G.x
od.Rbr
Rbr.1
Clαv
4
pr.Mx
od2Lα
od3Ju
3
od.Oj
grp.so
Mx
plv.Jd.3
plh.Jd.4
p-mc
plh.Jd.3
plv.Jd.2
plh.Jd.2
grp.so

Plate 3.

Gyroptychius groenlandicus n. sp.

Fig. 1. Flattened, imperfect skull in dorsal view. Specimen No. P. 1325. Canning Land, NW. part of Hesteskoen, 210—234 m. Same specimen as in pl. 4. $^2/_1$.

Fig. 2. Imperfect, dislocated skull in dorsal view. Specimen No. P. 1301. Canning Land, NW. part of Hesteskoen, 210—234 m. Same specimen as in pl. 5:1, 2. $^2/_1$.

Fig. 3. Fronto-ethmoidal shield in dorsal view. Specimen No. P. 1302. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

D, dermosphenotic; *Ext. l*, *Ext. m*, lateral and median extrascapulars; *Fr. cp*, independent paired bone, probably belonging to central frontal series of bones; *Fr-eth. sh*, fronto-ethmoidal shield; *Ju*, jugal; *Lj*, lower jaw; *Pa. sh*, parietal shield; *Pin. pl*, pineal plates; *Po*, postorbital; *Sq*, squamosal.

ar. pin, rough area surrounding pineal foramen; *ar. res*, rough area, probably representing area of resorbtion; *bli*, blisters; *fe. exa*, fenestra exonarina anterior; *f. pin*, pineal foramen; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. Et*, notch for extratemporal bone; *i. o*, orbital notch; *ioc*, infraorbital sensory canal; *i. Po*, postorbital notch; *i. spir*, spiracular notch; *od. La+Mx*, area of fronto-ethmoidal shield overlapped by lachrymal and maxillary; *od. Qj*, area of lower jaw overlapped by quadratojugal; $od_2 Po$, $od_3 Po$, areas of cranial roof overlapped by postorbital; $og_1 Sq$, area of postorbital overlapping squamosal; *pl. Fr*, frontal pit-line; *plh. Id. 4*, horizontal pit-line of infradentary 4; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. Sq*, squamosal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *proc*, *ptoc*, preorbital and postorbital corners of cranial roof.

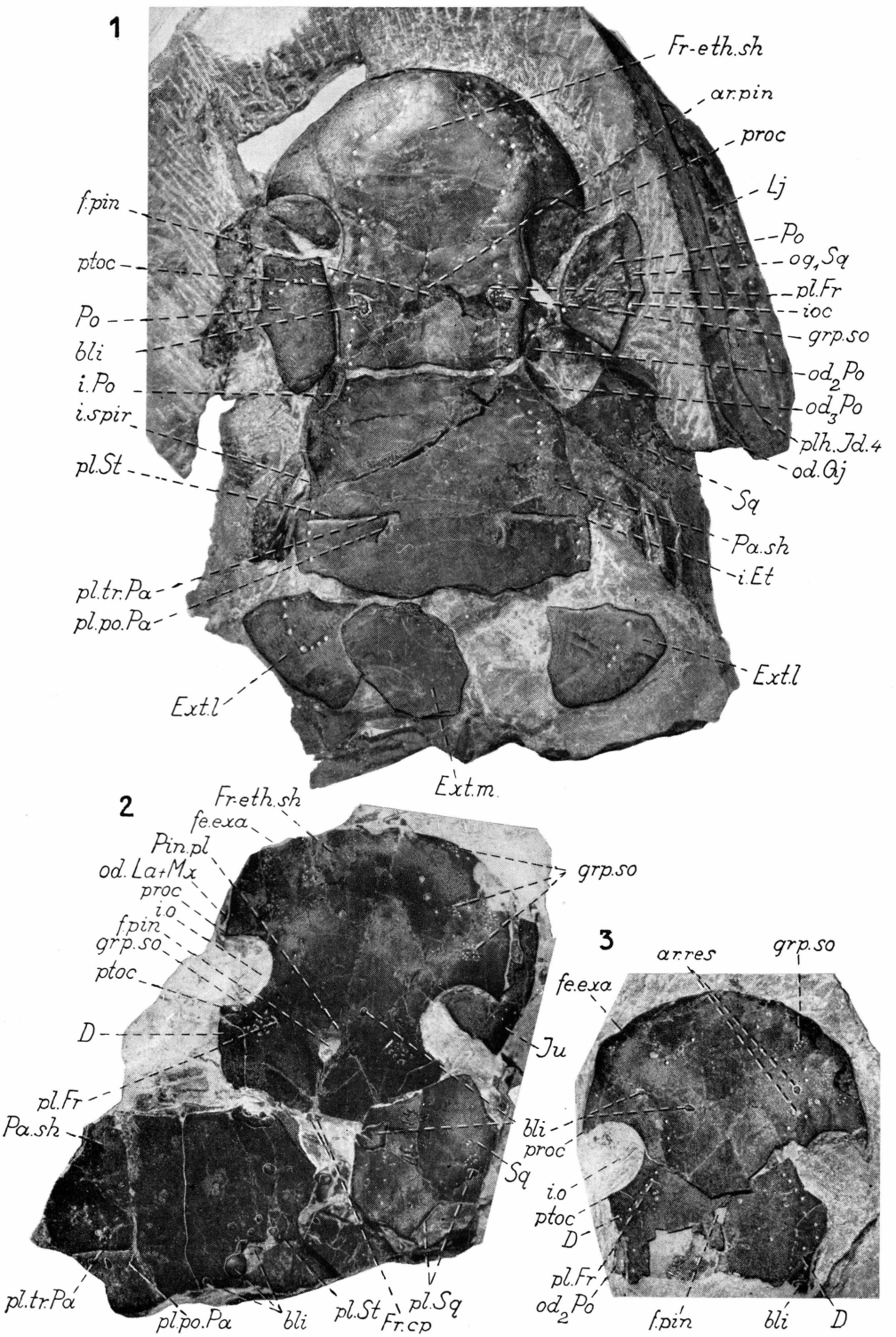

1
Fr-eth.sh
ar.pin
proc
Lj
f.pin
Po
ptoc
og, Sq
pl.Fr
Po
ioc
grp.so
bli
od2 Po
i.Po
od3 Po
i.spir
plh.Jd.4
pl.St
od.Qj
Sq
Pa.sh
i.Et
pl.tr.Pa
pl.po.Pa
Ext.l
Ext.l
Ext.m
2
Fr-eth.sh
fe.exa
Pin.pl
od. Lat/Mx
grp.so
proc
i.o
f.pin
grp.so
ptoc
D
Ju
pl.Fr
Pa.sh
Sq
pl.tr.Pa
pl.po.Pa
bli
pl.St
Fr.cp
pl.Sq
3
ar.res
grp.so
fe.exa
bli
proc
i.o
ptoc
D
pl.Fr
od2 Po
f.pin
bli
D

Plate 4.

Gyroptychius groenlandicus n. sp.

Specimen No. P. 1325. Canning Land, NW. part of Hesteskoen, 210—234 m. Same specimen as in pl. 3:1. $^{2}/_{1}$.

Fig. 1. Skull in ventral aspect.

Fig. 2. Imperfect lower jaw of right side. External view.

Clav, clavicle; *Fr-eth. sh*, fronto-ethmoidal shield; *G*, principal gular; *Lj*, lower jaw; *Rbr*, branchiostegal rays; *Rbr. 2*, second branchiostegal ray; *Sop*, subopercular.

fe. exa, fenestra exonarina anterior; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. La+Mx*, lachrymo-maxillary notch; *od. Op*, area of subopercular overlapped by opercular; *od. Qj*, area of lower jaw overlapped by quadratojugal; *pl. G*, pit-line of principal gular; *plh. Md*, horizontal part of mandibular pit-line; *pl. Rbr. 2*, pit-line of second branchiostegal ray; *plv. Id. 2*, vertical pit-line of infradentary 2; *p-mc*, preoperculo-mandibular sensory canal.

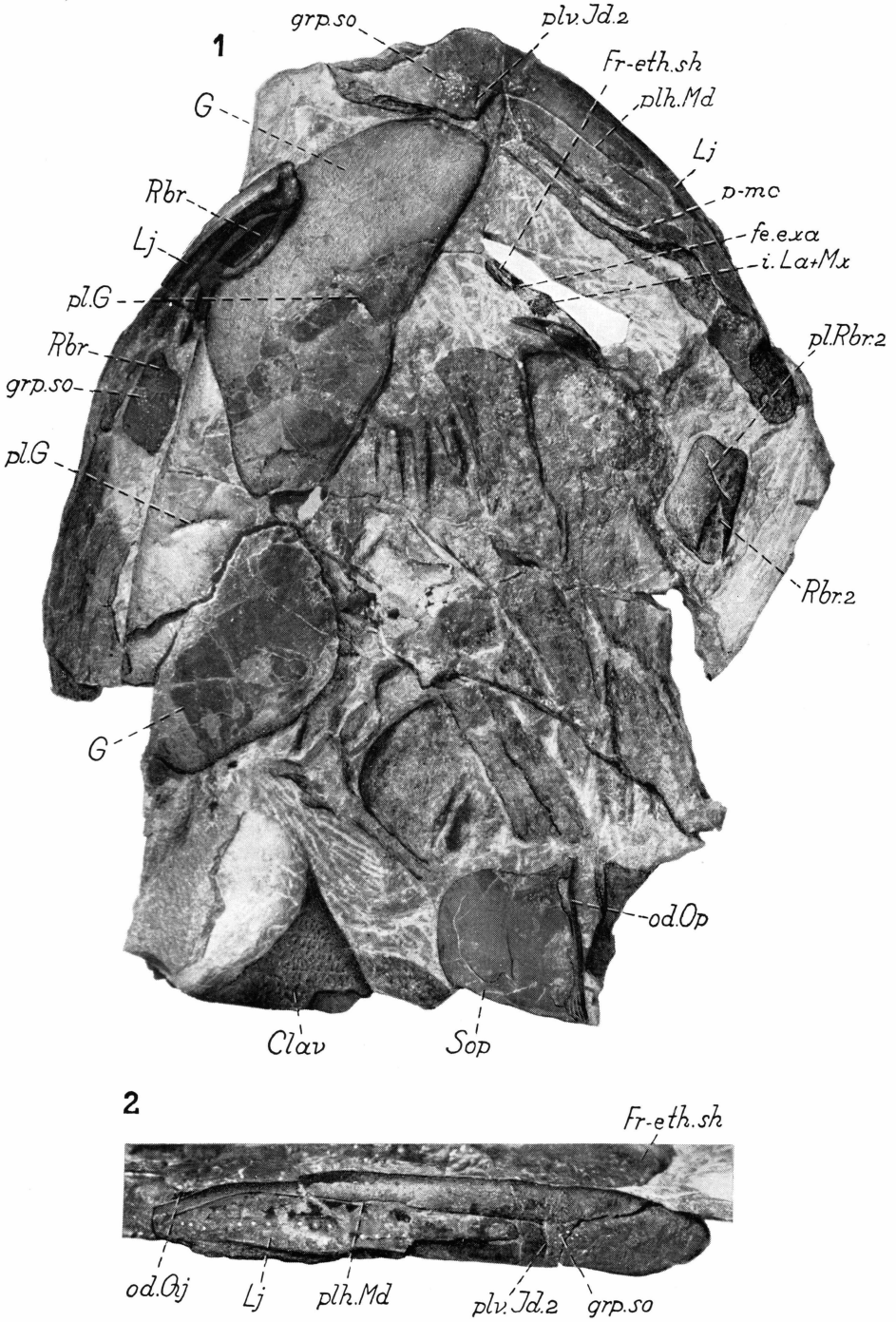

1
grp.so
plv.Jd.2
Fr-eth.sh
plh.Md
G
Lj
Rbr
p-mc
Lj
fe.exα
i.Lα+Mx
pl.G
pl.Rbr.2
Rbr
grp.so
pl.G
Rbr.2
G
od.Op
Clav
Sop
2
Fr-eth.sh
od.Oj
Lj
plh.Md
plv.Jd.2
grp.so

Plate 5.

Gyroptychius groenlandicus n. sp.

Fig. 1. Fronto-ethmoidal shield in dorsal view. Specimen No. P. 1302. Same specimen as in fig. 2 and in pl. 3:2. $^3/_1$.

Fig. 2. Imperfect parietal shield in dorsal aspect. Same specimen as in fig. 1. $^3/_1$.

Fig. 3. Right lateral extrascapular in external view. Specimen No. P. 1338. Canning Land, NW. part of Hesteskoen, 210—234 m. $^3/_1$.

Fig. 4. Deficient median extrascapular of large individual in external view. Specimen No. P. 1339. Canning Land, Kollen. $^3/_1$.

D, dermosphenotic; *Fr. cp*, paired bone, probably belonging to central frontal series of bones; *Pin. pl*, pineal plates.

bli, blisters; *f. pin*, pineal foramen; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. Et*, notch for extratemporal bone; *i. La+Mx*, lachrymo-maxillary notch; *i. spir*, spiracular notch; *od. La+Mx*, area of fronto-ethmoidal shield overlapped by lachrymal and maxillary; $od_l Pa$, area of lateral extrascapular overlapped by parietal; $od_m Pa$, area of median extrascapular overlapped by parietal; $od_1 Ext.\ l$, area of median extrascapular overlapped by lateral extrascapular; $od_1 St$, area of lateral extrascapular overlapped by supratemporal; $od_2 Po$, area of fronto-ethmoidal shield (dermosphenotic) overlapped by postorbital; $od_3 Po$, area of parietal shield (intertemporal) overlapped by postorbital; *orn*, ornamentation; *pl. Fr*, frontal pit-line; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *proc*, *ptoc*, preorbital and postorbital corners of cranial roof; *stcc*, supratemporal commissural sensory canal; *stccp*, pores of ditto.

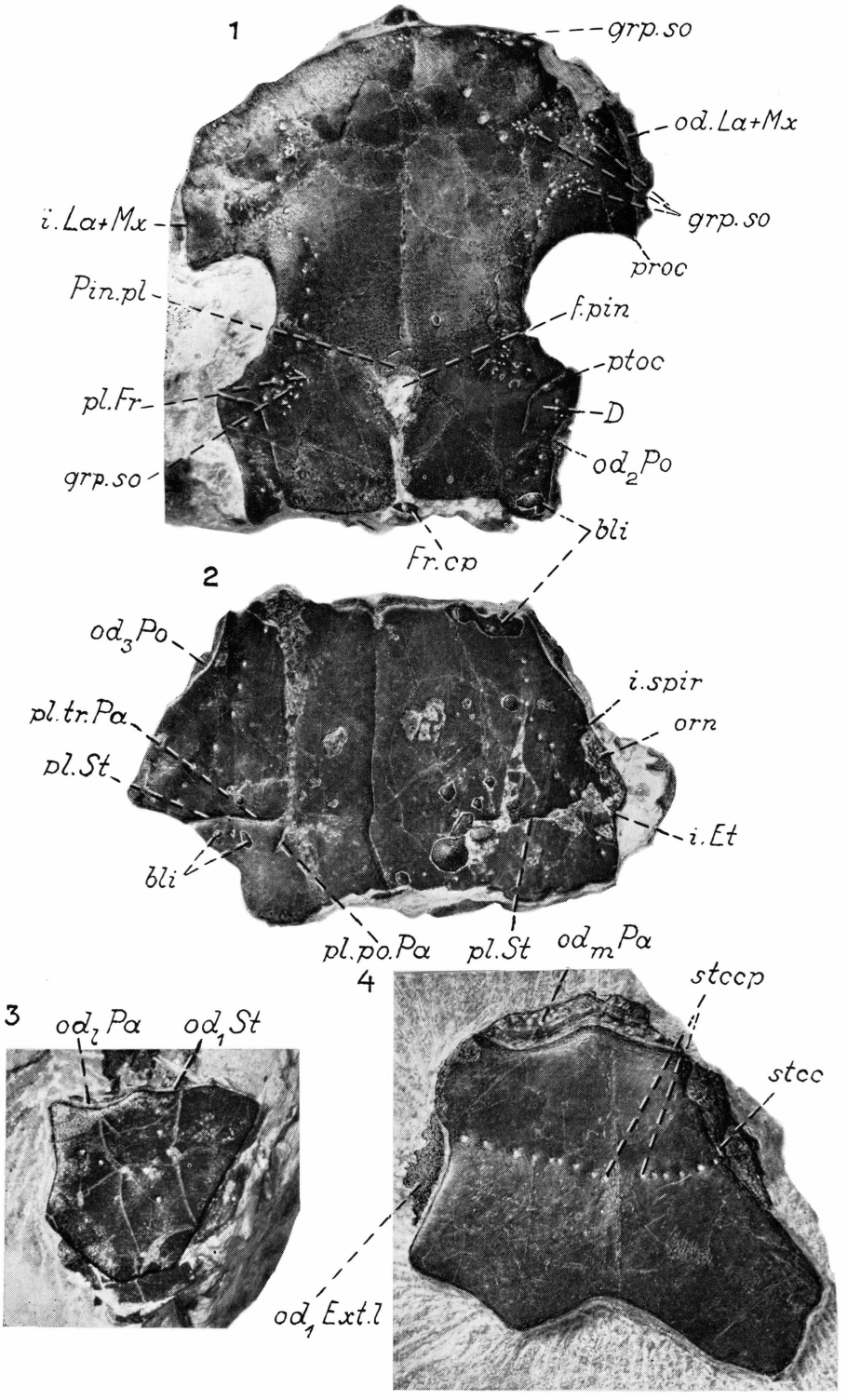

1
grp.so
od.La+Mx
i.La+Mx
grp.so
proc
Pin.pl
f.pin
ptoc
pl.Fr
D
od2Po
grp.so
bli
Fr.cp
2
od3Po
i.spir
pl.tr.Pa
orn
pl.St
i.Et
bli
pl.po.Pa
pl.St
odmPa
3
od2Pa
od1St
4
stccp
stcc
od1Ext.l

Plate 6.

Gyroptychius groenlandicus n. sp.

Fig. 1. Fronto-ethmoidal shield in dorsal view. Specimen No. P. 1382. Wegeners Halvö, Vimmelskaftet. Specimen collected by Professor A. NOE-NYGAARD during Dr. LAUGE KOCH's expedition to East Greenland in 1931—1932. Figured by SÄVE-SÖDERBERGH (1933; pl. 14:2). $^2/_1$.

Fig. 2. Imperfect fronto-ethmoidal shield in dorsal view. Specimen No. P. 1304. Canning Land, Kollen. $^2/_1$.

Fig. 3. Same specimen as in fig. 2. Main part of supraorbital canal disclosed. $^2/_1$.

Fig. 4. Anterior part of same specimen as in figs. 2 and 3 in lateral view. $^4/_1$.

Fig. 5. Nearly perfect fronto-ethmoidal shield in dorsal view. Specimen No. P. 1303. Canning Land, Kollen. $^2/_1$.

Fig. 6. Small part of ditto enlarged, showing inter alia the right frontal pit-line. Ca. $^{23}/_1$.

D, dermosphenotic; *Pin. pl*, pineal plates.

ar. pin, rough area surrounding pineal foramen; *ar. res*, rough areas, probably representing areas of resorbtion; *bli*, blisters; *fe. exa*, fenestra exonarina anterior; *f. pin*, pineal foramen; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. La+Mx*, lachrymo-maxillary notch; *i. o*, orbital notch; *ioc*, infraorbital sensory canal; *nf*, foramina for nerves to sensory organs of frontal pit-line; *od. La+Mx*, area overlapped by lachrymal and maxillary; *pl. Fr*, frontal pit-line; *pmxt*, teeth of premaxillary; *proc*, *ptoc*, preorbital and post-orbital corners of cranial roof; *soc*, supraorbital sensory canal.

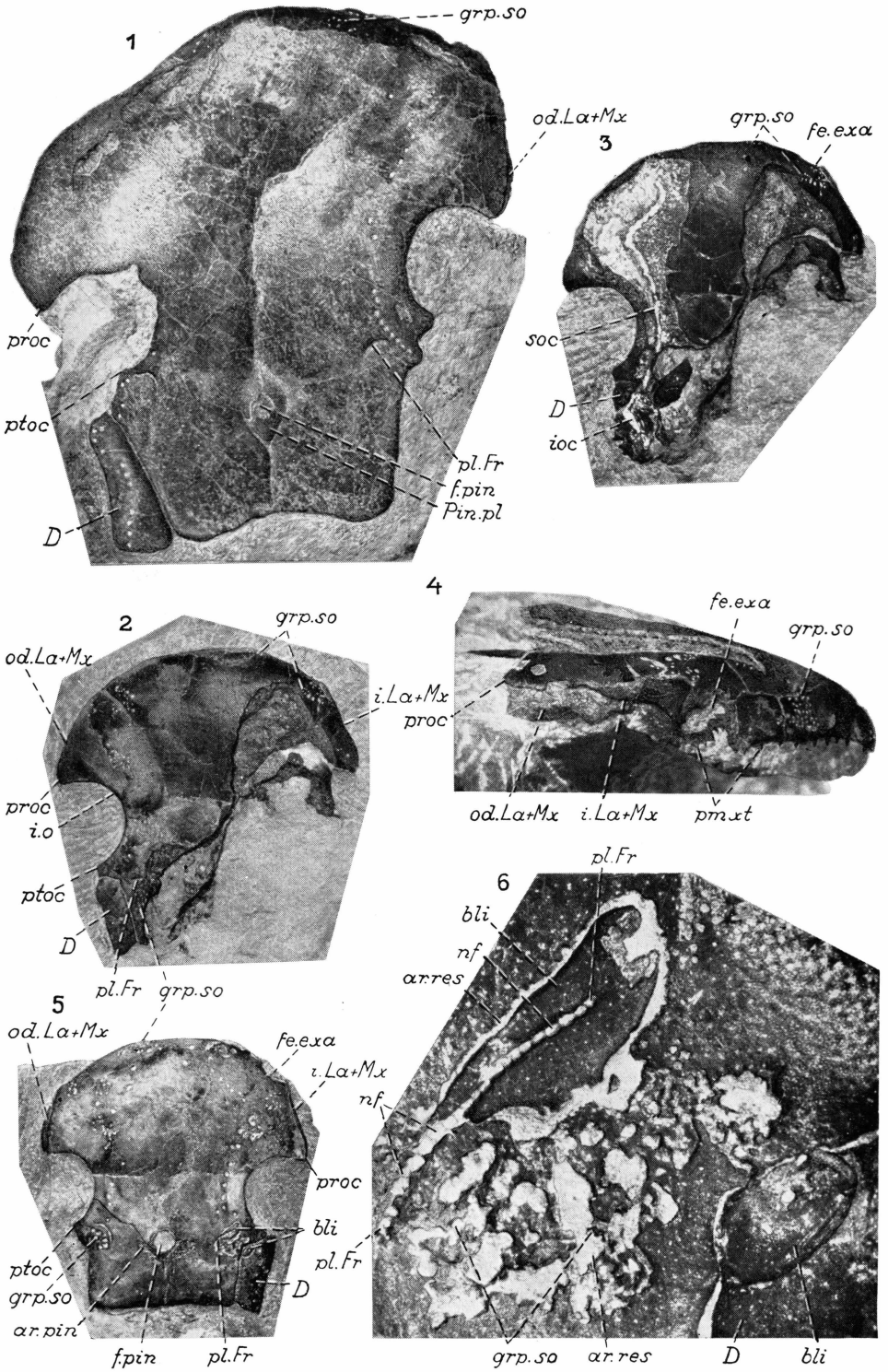

1
grp.so
od.La+Mx
proc
ptoc
pl.Fr
f.pin
Pin.pl
D
3
grp.so
fe.exa
soc
D
ioc
2
grp.so
od.La+Mx
i.La+Mx
proc
i.o
ptoc
D
pl.Fr
grp.so
4
fe.exa
grp.so
i.La+Mx
proc
od.La+Mx
i.La+Mx
pmxt
5
od.La+Mx
fe.exa
i.La+Mx
proc
bli
ptoc
grp.so
D
ar.pin
f.pin
pl.Fr
6
pl.Fr
bli
nf
ar.res
nf
pl.Fr
grp.so
ar.res
D
bli

Plate 7.

Gyroptychius groenlandicus n. sp.

Imperfect fronto-ethmoidal shields of five specimens. All figures $^{2}/_{1}$.

Fig. 1. Impression of external face. Specimen No. P. 1327. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 2. Impression of external face. Specimen No. P. 1326. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 3. Inner side. Specimen No. P. 1371. Wegeners Halvö, Circusbjærg. Photographed in alcohol.

Fig. 4. Impression of ditto.

Fig. 5. Inner side, showing several of the dermal bones of the snout and radiation. Specimen No. P. 1380. Wegeners Halvö, Circusbjærg. Photographed in alcohol.

Fig. 6. Inner side. Sensory canals partly disclosed by preparation. Specimen No. P. 1375. Wegeners Halvö, ridge S. of Kap Brown. Photographed in alcohol.

D, dermosphenotic; *Fr*, frontal; *Na. 3*, *Na. 7*, nasal 3 and 7; *NRP*, naso-rostro-premaxillary; *Pin. pl*, pineal plates; *Ptr*, postrostral; *So-Te*, supraorbito-tectal; *So. 2*, posterior supraorbital; *Te. a*, anterior tectal.

fe. exa, fenestra exonarina anterior; *f. pin*, pineal foramen; *i. o*, orbital notch; *ioc*, infraorbital sensory canal; *proc*, *ptoc*, preorbital and postorbital corners; *soc*, supraorbital sensory canal.

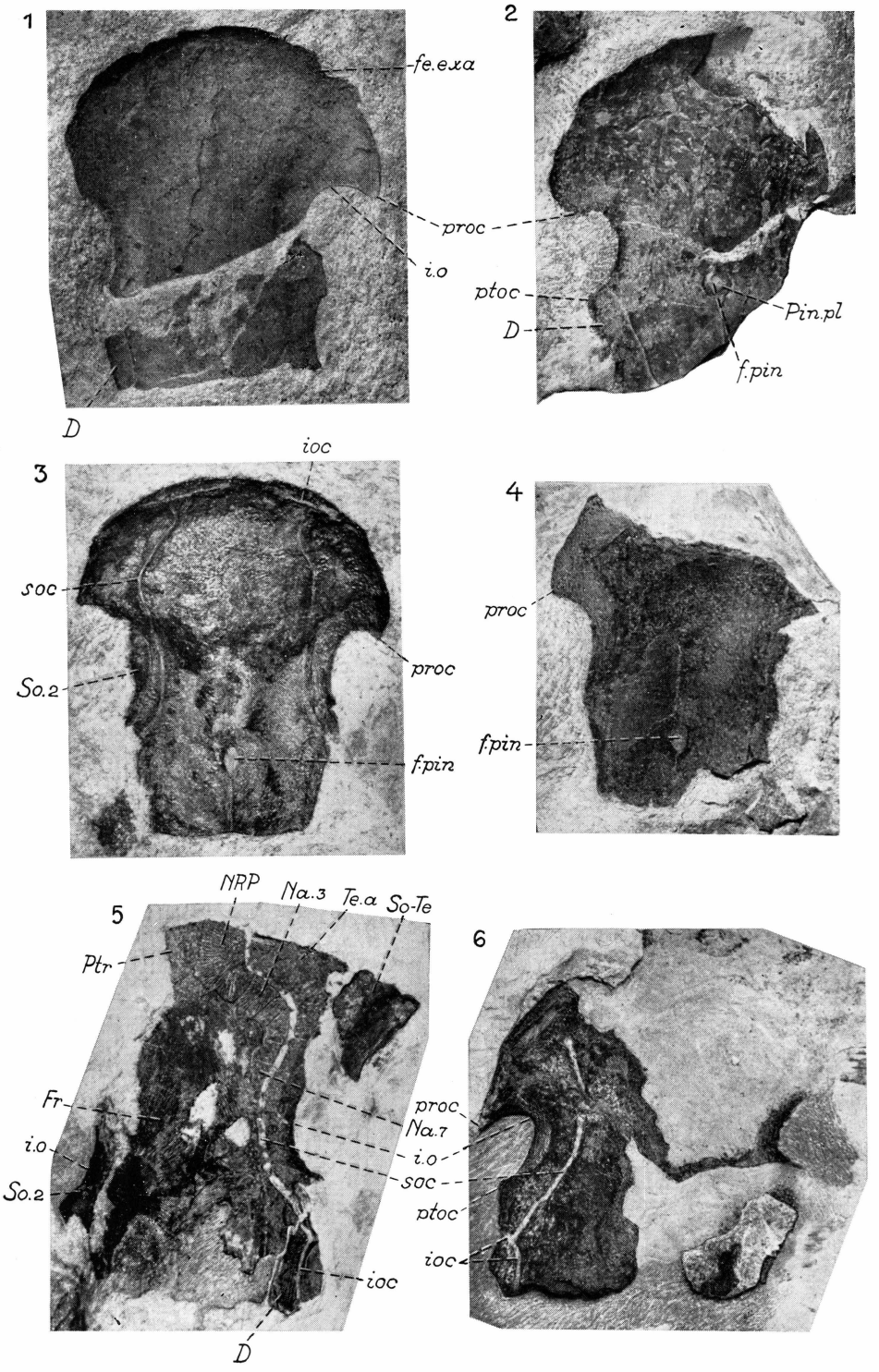

1
fe.exa
proc
i.o
D
2
ptoc
D
Pin.pl
f.pin
3
ioc
soc
So.2
proc
f.pin
4
proc
f.pin
5
NRP
Na.3
Te.a
So-Te
Ptr
Fr
i.o
So.2
ioc
D
6
proc
Na.7
i.o
soc
ptoc
ioc

Plate 8.

Gyroptychius groenlandicus n. sp.

More or less imperfect parietal shields of six specimens in external view. All figures $^{2}/_{1}$.

Fig. 1. Specimen No. P. 1305. Canning Land, Kollen.

Fig. 2. Specimen No. P. 1306. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 3. Specimen No. P. 1362. Canning Land, Kollen.

Fig. 4. Specimen No. P. 1352. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 5. Specimen No. P. 1391. Wegeners Halvö, eastern part of Circusbjærg.

Fig. 6. Specimen No. P. 1386. Canning Land, NW. part of Hesteskoen, 210—234 m. Section through part of this specimen shown in text-fig. 3.

It, intertemporal; *Pa*, parietal; *Pa. c. 1*, *Pa. c. 2*, *Pa. c. 3*, partly independent bones belonging to posterior unpaired portion of central parietal series of bones; *St*, supratemporal.

ar. res, rough areas, probably formed by resorbtion of dentine and enamel layers; *bli*, blisters; *i. Et*, notch for extratemporal bone; *i. spir*, spiracular notch; $od_2 Sc$, area of scale overlapped by adjoining scale; $od_3 Po$, area of intertemporal overlapped by postorbital; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *ri. Sc*, ridge of inner face of scale.

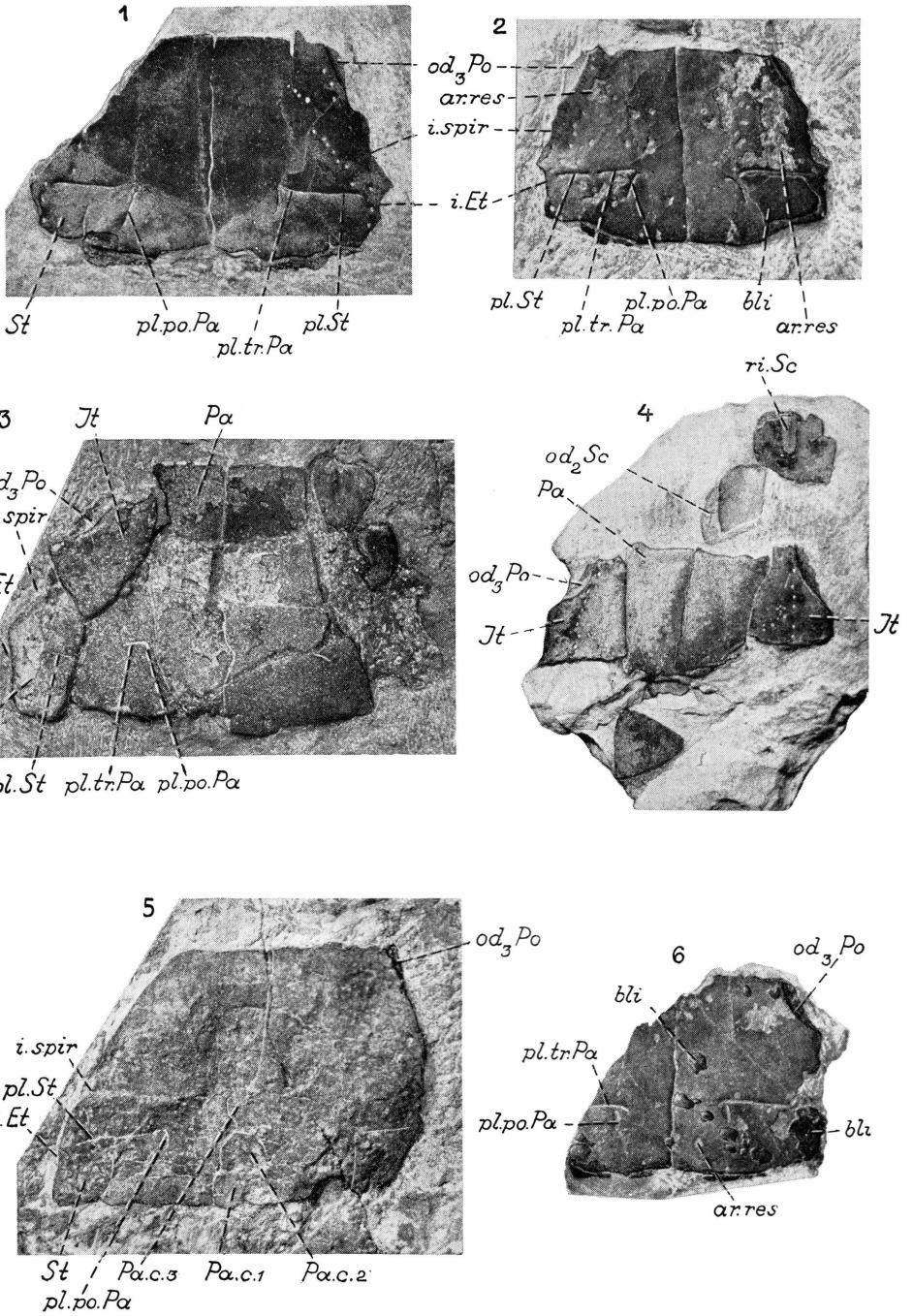

1
St
pl.po.Pα
pl.tr.Pα
pl.St
2
od3Po
ar.res
i.spir
i.Et
pl.St
pl.tr.Pα
pl.po.Pα
bli
ar.res
3
Jt
Pα
od3Po
i.spir
i.Et
St
pl.St
pl.tr.Pα
pl.po.Pα
4
ri.Sc
od2Sc
Pα
od3Po
Jt
Jt
5
od3Po
i.spir
pl.St
i.Et
St
pl.po.Pα
Pα.c.3
Pα.c.1
Pα.c.2
6
od3Po
bli
pl.tr.Pα
pl.po.Pα
bli
ar.res

Plate 9.

Gyroptychius groenlandicus n. sp.

Fig. 1. Much deficient parietal shield in dorsal view. Enamel and dentine layers wanting, disclosing the ornamented external face of the trabecular layer. Specimen No. P. 1347. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 2. Imperfect skull in dorsal aspect. Postorbitals and right opercular presented in inner view. Enamel and dentine layers wanting. Specimen No. P. 1401. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 3. Part of fronto-ethmoidal shield and external cheek plate in inner view. Specimen No. P. 1381. Canning Land, NW. part of Hesteskoen, profile *c*, 202—204 m. $^2/_1$.

Fig. 4. Parietal shield in dorsal view. Enamel and dentine layers wanting. Specimen No. P. 1340. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 5. Imperfect posterior part of parietal shield in external view. Enamel and dentine layers wanting. Specimen No. P. 1453. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 6. Detached plate, probably representing the left lachrymal of a large individual. External view. Specimen No. P. 1330. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

It remains uncertain whether the specimens shown in figs. 3 and 6 belong to *G. groenlandicus*.

D, dermosphenotic; *Fr*, frontal; *Fr-eth. sh*, fronto-ethmoidal shield; *It*, intertemporal; *Ju*, jugal; *La*, lachrymal; *Op*, opercular; *Pa*, parietal; *Pa. c*, independent bone belonging to unpaired posterior portion of central parietal series of bones; *Pin. pl*, pineal plates; *Po*, postorbital; *Qj*, quadratojugal; *Sq*, squamosal; *St*, supratemporal.

fe. o, orbital fenestra; *i. Et*, notch for extratemporal bone; *i. o*, orbital notch; *ioc*, infraorbital sensory canal; *iocp*, pores of ditto; *i. spir*, spiracular notch; *juc*, jugal sensory canal; $od_1 Ju$, area of lachrymal overlapped by jugal; $od_3 Po$, area of intertemporal overlapped by postorbital; *o. m*, orbital margin; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. Qj*, quadratojugal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *poc*, postotic sensory canal; *proc*, preorbital corner of cranial roof; *ri. ioc*, ridge housing infraorbital sensory canal; *soc*, supraorbital sensory canal.

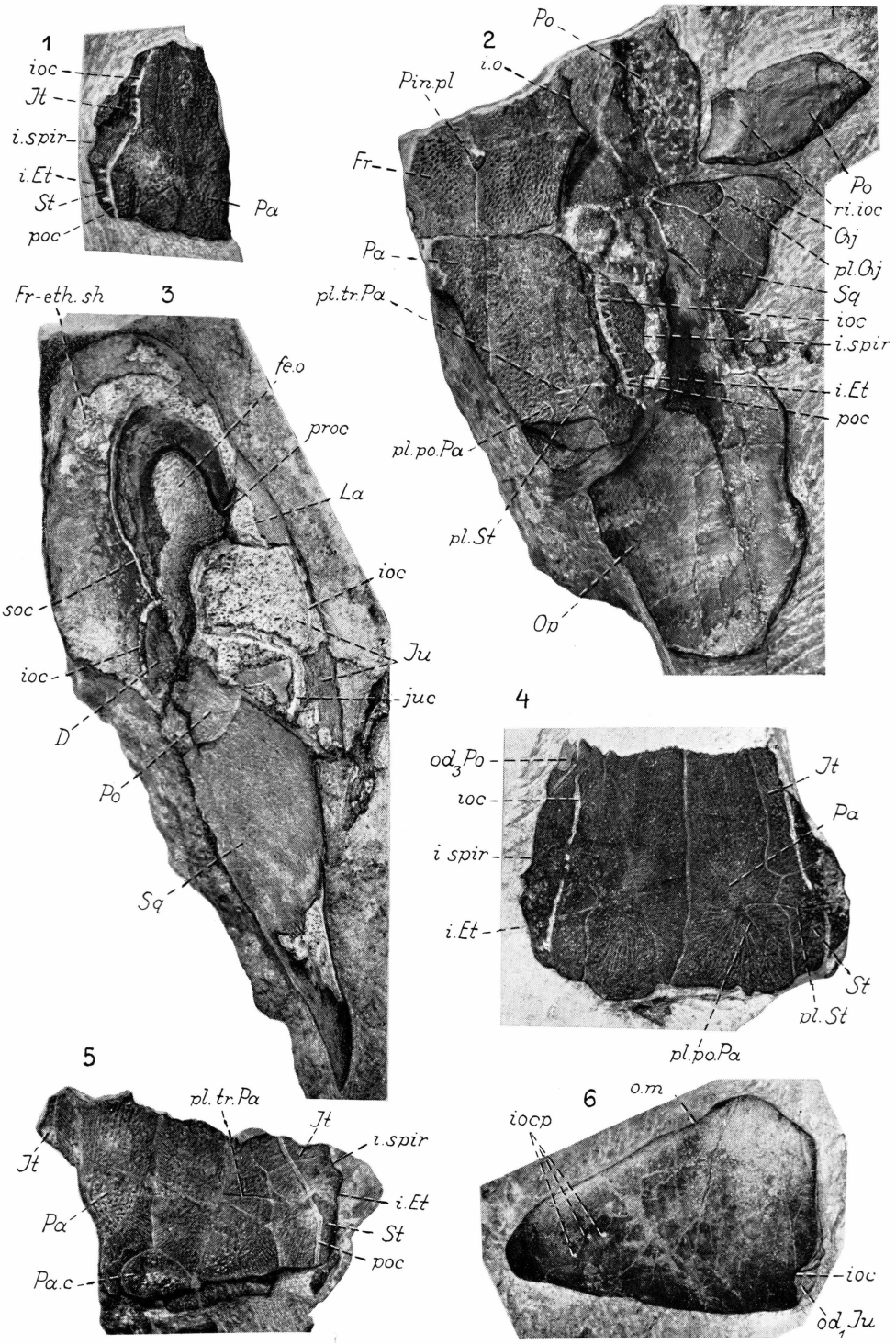

1
ioc
Jt
i.spir
i.Et
St
poc
Pa
2
i.o
Pin.pl
Fr
Pa
pl.tr.Pa
pl.po.Pa
pl.St
Op
Po
ri.ioc
Obj
pl.Obj
Sq
ioc
i.spir
i.Et
poc
3
Fr-eth.sh
fe.o
proc
La
ioc
soc
ioc
D
Po
Sq
Ju
juc
4
od3 Po
ioc
i spir
i.Et
Jt
Pa
St
pl.St
pl.po.Pa
5
pl.tr.Pa
Jt
Jt
Pa
Pa.c
i.spir
i.Et
St
poc
6
o.m
iocp
ioc
od1 Ju

Plate 10.

Gyroptychius groenlandicus n. sp.

All figures $^{3}/_{1}$.

Fig. 1. Right jugal in external view. Specimen No. P. 1301. Canning Land, NW. part of Hesteskoen, 210—234 m. Same specimen as in pl. 3:2 and pl. 5:1, 2.

Fig. 2. Left jugal in external view. Specimen No. P. 1389. Canning Land, Kollen.

Fig. 3. Right jugal in external view. Specimen No. P. 1329. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 4. Imperfect, right jugal in lateral view. Specimen No. P. 1360. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 5. Left jugal in external view. Specimen No. P. 1328. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 6. Same bone as in fig. 5. Inner view.

Fig. 7. Right jugal in external view. Specimen No. P. 1312. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 8. Imperfect, right jugal in external view. Specimen No. P. 1313. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 9. Left postorbital in external view. Specimen No. P. 1323. Canning Land, NW. part of Hesteskoen, 210—234 m.

Fig. 10. Strongly weathered left postorbital in external view. Specimen No. P. 1405. Wegeners Halvö, Circusbjærg.

ar. res, rough area, probably representing area of resorbtion; *bli*, blisters; *grp. so*, group of small pores, probably for nerves to group of cutaneous sensory organs; *ioc*, infraorbital sensory canal; *iocp*, pores of ditto; *juc*, jugal sensory canal; *jucp*, pores of ditto; od_1D, area of postorbital overlapped by dermosphenotic; od_1La, area of jugal overlapped by lachrymal; od_1Po, area of jugal overlapped by postorbital; *og. Mx*, area of jugal overlapping maxillary; *og. Sq*, area jugal overlapping squamosal; *o. m*, orbital margin of postorbital.

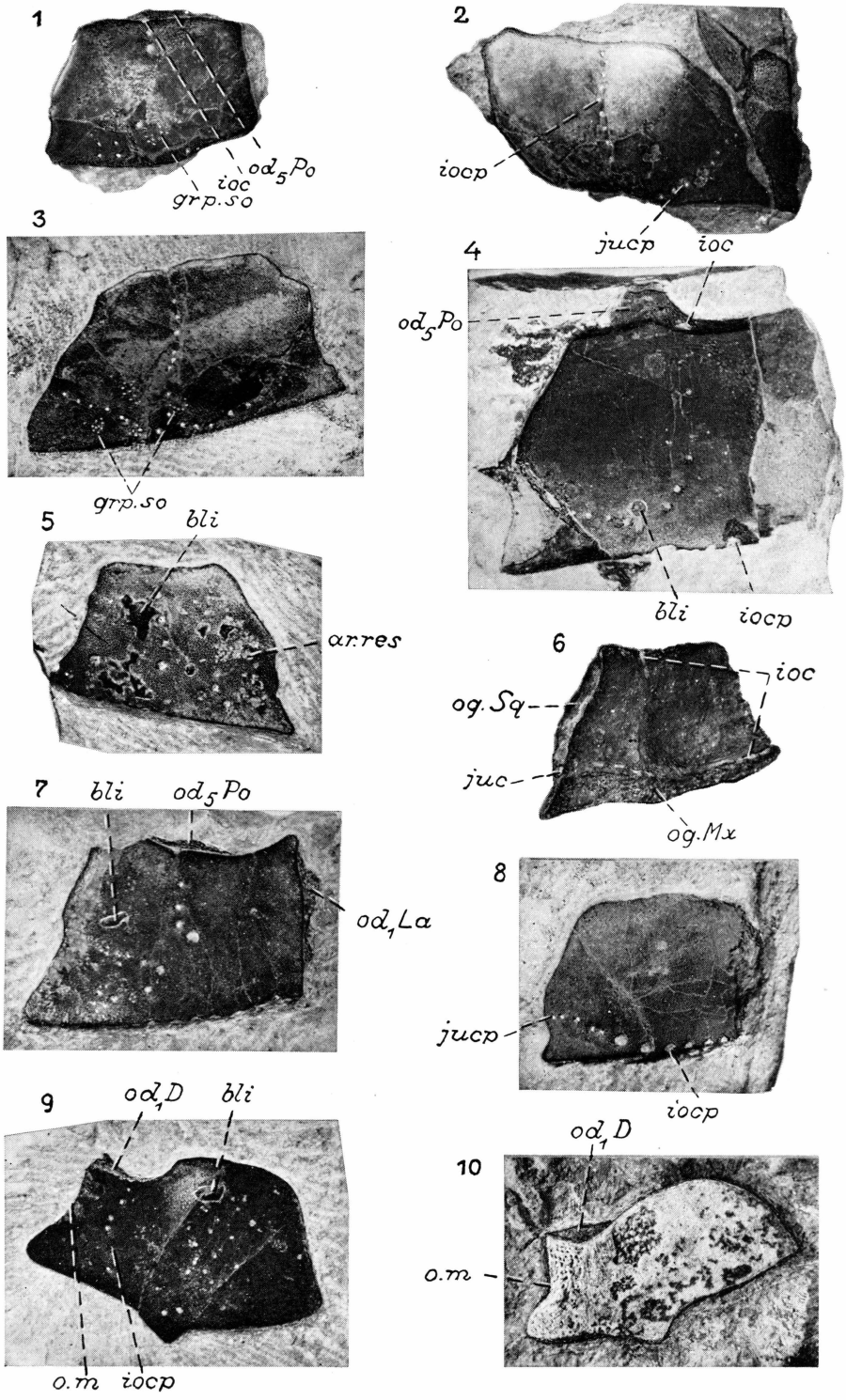

1
od5Po
ioc
grp.so
2
iocp
jucp
ioc
3
grp.so
4
od5Po
bli
iocp
5
bli
arres
6
ioc
og.Sq
juc
og.Mx
7
bli
od5Po
od1La
8
jucp
iocp
9
od1D
bli
o.m
iocp
10
od1D
o.m

Plate 11.

Gyroptychius groenlandicus n. sp.

Part of the external cheek plate reproduced in pl. 13:1 (also text-fig. 2 and pl. 12:1), showing inter alia blisters and areas of resorbtion. External view. Specimen No. P. 1300. Canning Land, NW. part of Hesteskoen, 210—234 m. $^{14}/_{1}$.

Pop, preopercular; *Qj*, quadratojugal; *Sq*, squamosal.

ar. res, rough area, probably representing area of resorbtion; *bli*, blisters; *f. vc*, external openings of canals of trabecular layer; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. Mx*, notch for posterior end of maxillary; *jucp*, pores of jugal sensory canal; *nf*, foramina for nerves to sensory organs of pit-lines; $od_1 Mx$, area of squamosal overlapped by maxillary; $od_2 Mx$, area of quadratojugal overlapped by maxillary; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *p-mcp*, pores of preoperculo-mandibular sensory canal.

p.mcp
bli
pl.Pop
Pop
Qj
pl.Qj
nf
i.Mx
od2Mx
od1Mx
pl.Sq
bli
arres
bli
Sq
arres
grso
jucp
fvc

Plate 12.

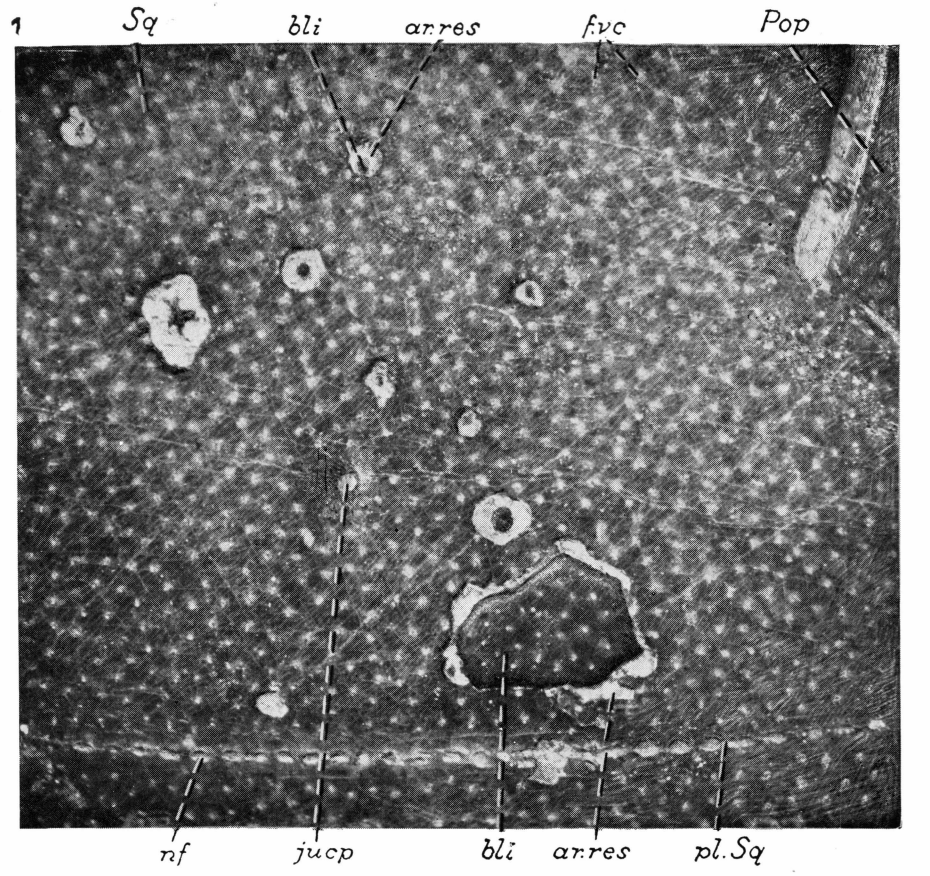
Gyroptychius groenlandicus n. sp.

Fig. 1. Small part of the external cheek plate shown in pl. 11 and pl. 13:1. External view. $^{35}/_{1}$.

Fig. 2. Imperfect, posterior part of external cheek plate, imperfect jugal, and branchiostegal ray in external view. Specimen No. P. 1384. Canning Land, NW. part of Hesteskoen, 210—234 m. The jugal figured by JARVIK (1948a, fig. 9 B). $^{3}/_{1}$.

Ju, jugal; *Pop*, preopercular; *Qj*, quadratojugal; *Rbr*, branchiostegal ray; *Sq*, squamosal.

ar. res, rough areas, probably representing areas of resorbtion; *bli*, blisters; *f. vc*, external openings of canals of trabecular layer; *gr. juc*, groove housing ridge on inner face of squamosal caused by jugal sensory canal; *i. Mx*, notch for posterior end of maxillary; *juc*, jugal sensory canal; *jucp*, pores of ditto; *nf*, foramina for nerves to sensory organs of pit-line; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line.


1
Sq
bli
ar.res
f.vc
Pop
nf
juc.p
bli
ar.res
pl.Sq

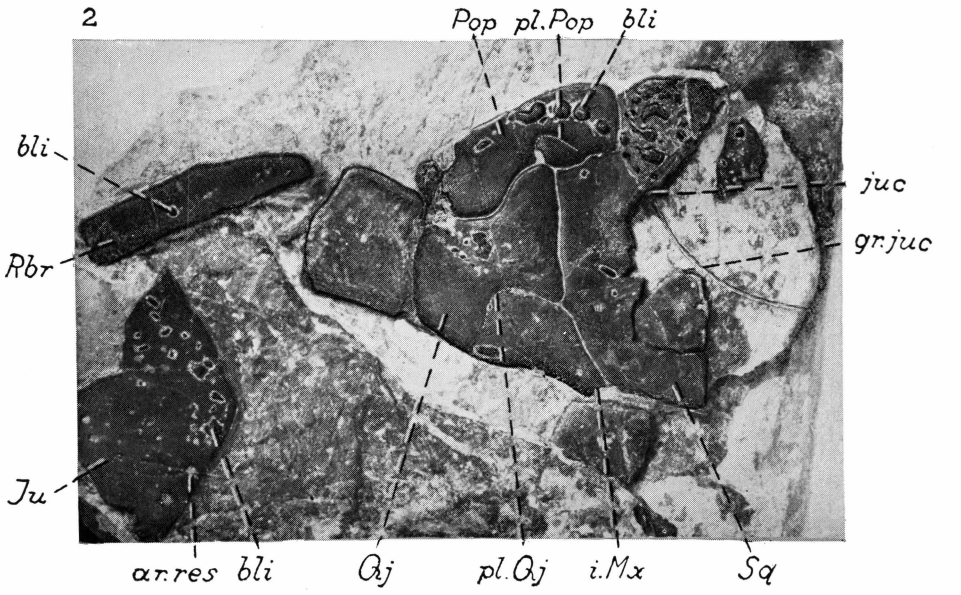

2
Pop
pl.Pop
bli
bli
juc
gr.juc
Rbr
Ju
ar.res
bli
Qj
pl.Qj
i.Mx
Sq

Plate 13.

Gyroptychius groenlandicus n. sp.

Posterior part of external cheek plate of six specimens in outer and, fig. 2, inner views. Canning Land, NW. part of Hesteskoen, 210—234 m. All figures $^{3}/_{1}$.

Fig. 1. Specimen No. P. 1300. Parts of this plate shown in pl. 11 and pl. 12:1.
Fig. 2. Specimen No. P. 1359.
Fig. 3. Specimen No. P. 1353.
Fig. 4. Same specimen as in fig. 3. Sensory canals disclosed by preparation.
Fig. 5. Specimen No. P. 1308.
Fig. 6. Specimen No. P. 1324.

Pop, preopercular; *Qj*, quadratojugal; *Sq*, squamosal.

ar. res, rough area, probably representing area of resorbtion; *bli*, blisters; *grp. so*, group of small pores, probably for nerves to group of cutaneous sensory organs; *i. Mx*, notch for posterior end of maxillary; *juc*, jugal sensory canal; od_2Ju, area of squamosal overlapped by jugal; od_2Mx, area of quadratojugal overlapped by maxillary; od_4Po, area of squamosal overlapped by postorbital; *orn*, ornamentation; *pl. Pop*, preopercular pit-line; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *p-mc*, preoperculo-mandibular sensory canal; *ri. juc*, ridge housing jugal sensory canal; *ri. p-mc*, ridge housing preoperculo-mandibular sensory canal.

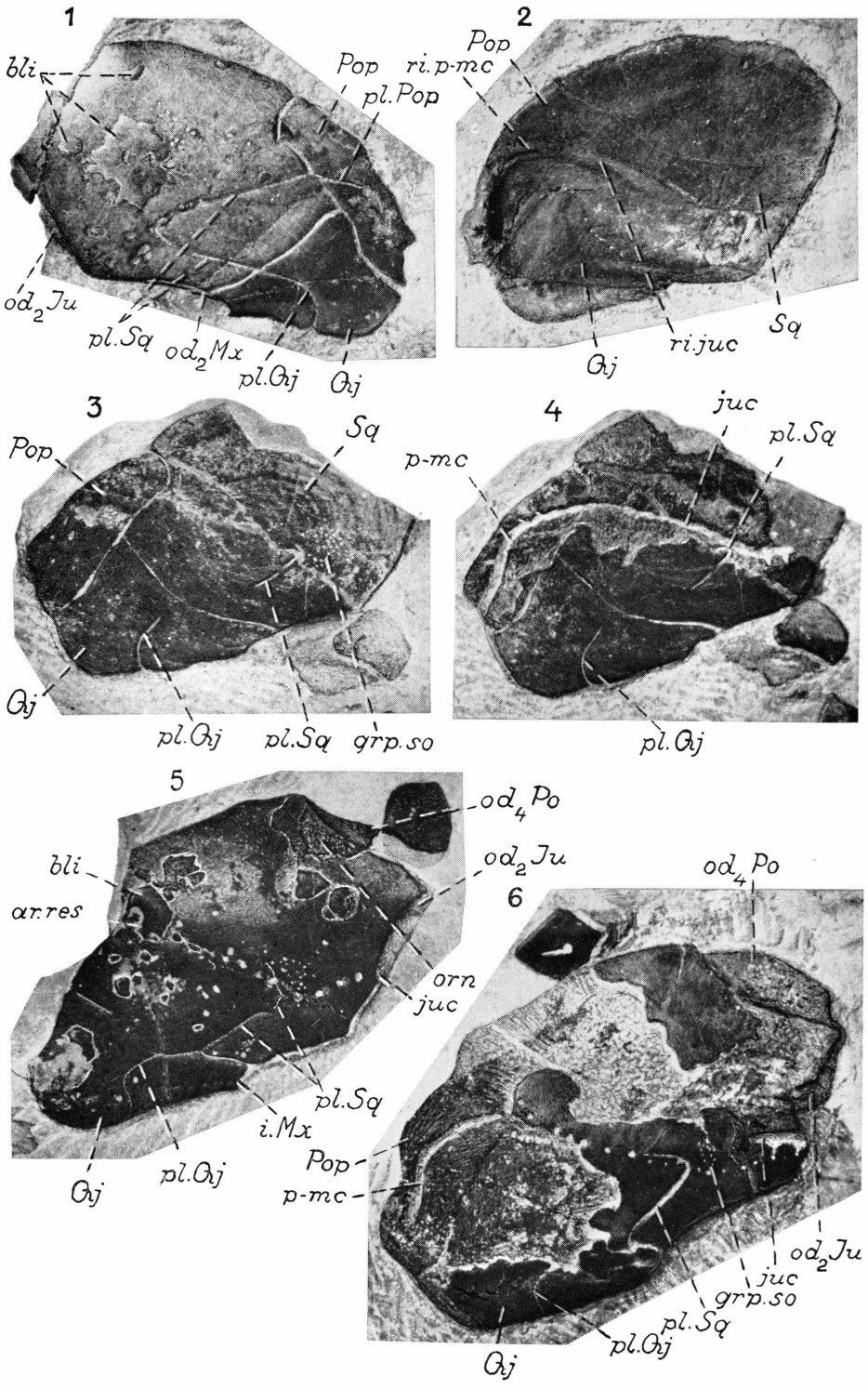

1
bli
Pop
pl.Pop
od2Ju
pl.Sq
od2Mx
pl.Qj
Qj
2
Pop
ri.p-mc
ri.juc
Sq
Qj
3
Pop
Sq
Qj
pl.Qj
pl.Sq
grp.so
4
juc
pl.Sq
p-mc
pl.Qj
5
od4Po
od2Ju
bli
arr.res
orn
juc
pl.Sq
i.Mx
Qj
pl.Qj
6
od4Po
Pop
p-mc
od2Ju
juc
grp.so
pl.Sq
pl.Qj
Qj

Plate 14.

Gyroptychius groenlandicus n. sp.

Fig. 1. Detached squamosal in external view. Specimen No. P. 1309. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 2. Squamosal and some scales in external view. Specimen No. P. 1314. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 3. Quadratojugal and part of squamosal in external view. Specimen No. P. 1307. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

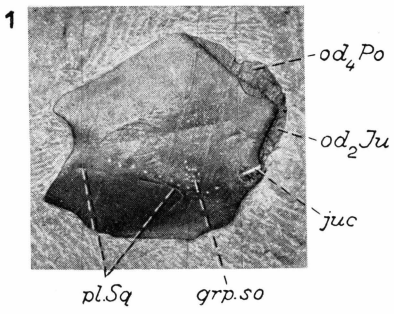
Fig. 4. Deficient, strongly weathered quadratojugal and squamosal in inner view. Specimen No. P. 1322. Canning Land, NW. part of Hesteskoen, profile *c*, talus. $^2/_1$.

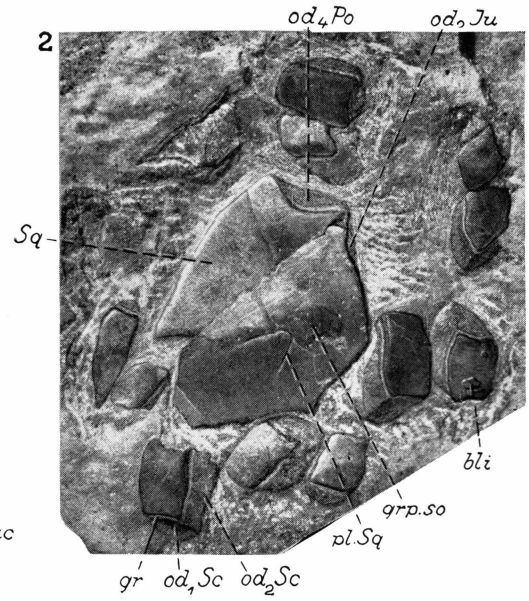
Fig. 5. Posterior part of right lower jaw in lateral aspect. Specimen No. P. 1349. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

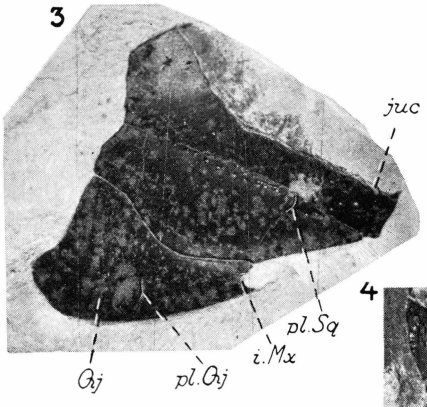
Fig. 6. Imperfect, left lower jaw in lateral view. Specimen No. P. 1341. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

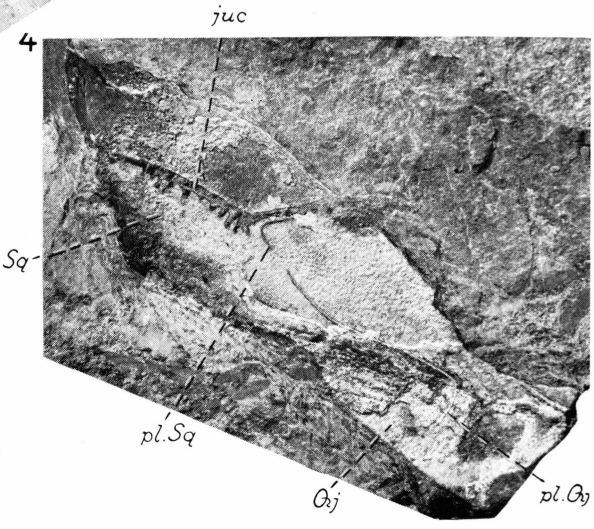
Qj, quadratojugal; *Sq*, squamosal.

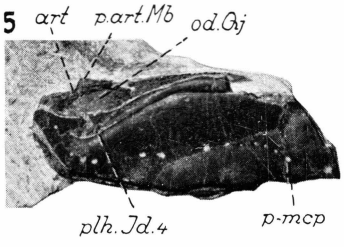
art, articular area of lower jaw; *bli*, blister; *gr*, groove separating overlapped and non-overlapped portions of scale; *grp. so*, group of pores, probably for nerves to group of cutaneous sensory organs; *i. Mx*, notch for posterior end of maxillary; *juc*, jugal sensory canal; *od. Qj*, area of lower jaw overlapped by quadratojugal; $od_1 Sc$, area of scale overlapped by adjoining scale; $od_2 Ju$, area of squamosal overlapped by jugal; $od_2 Sc$, area of scale overlapped by adjoining scale; $od_4 Po$, area of squamosal overlapped by postorbital; *p. art. Mb*, pars articularis of meckelian bone; *plh. Id. 3*, horizontal pit-line of infradentary 3; *plh. Id. 4*, horizontal pit-line of infradentary 4; *pl. Qj*, quadratojugal pit-line; *pl. Sq*, squamosal pit-line; *p-mcp*, pores of preoperculo-mandibular sensory canal.


1
od4Po
od2Ju
juc
pl.Sq
grp.so


2
od4Po
od2Ju
Sq
bli
grp.so
pl.Sq
gr
od1Sc
od2Sc


3
juc
pl.Sq
i.Mx
Oj
pl.Oj


4
juc
Sq
pl.Sq
Oj
pl.Oj


5
art
p.art.Mb
od.Oj
plh.Jd.4
p-mcp

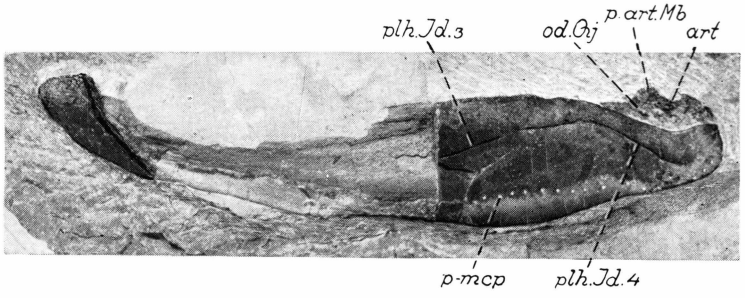

6
plh.Jd.3
od.Oj
p.art.Mb
art
p-mcp
plh.Jd.4

Plate 15.

Gyroptychius groenlandicus n. sp.

Lower jaw, more or less complete, of six specimens in external view, Canning Land, NW. part of Hesteskoen, 210—234 m. All figures $^2/_1$.

Fig. 1. No. P. 1342.
Fig. 2. No. P. 1357.
Fig. 3. No. P. 1385.
Fig. 4. No. P. 1372.
Fig. 5. No. P. 1356.
Fig. 6. No. P. 1409.
Fig. 7. Same specimen as in fig. 6. Impression of external face.

ar. res, rough area, probably formed by resorbtion; *art*, articular area of lower jaw; *bli*, blister; *gr*, groove separating overlapped and non-overlapped portion of scale; *grp. so*, groups of pores, probably for nerves to groups of cutaneous sensory organs; *od. Qj*, area overlapped by quadratojugal; $od_2 Sc$, area of scale overlapped by adjoining scale; *p. art. Mb*, pars articularis of meckelian bone; *plh. Id. 2*, *plh. Id. 3*, *plh. Id. 4*, horizontal pit-lines of infradentaries 2, 3, and 4; *plh. Md*, horizontal part of mandibular pit-line; *plv. Id. 2*, *plv. Id. 3*, vertical pit-lines of infradentaries 2 and 3; *p. mcp*, pores of preoperculo-mandibular sensory canal; *ri. Sc*, ridge of inner side of scale.

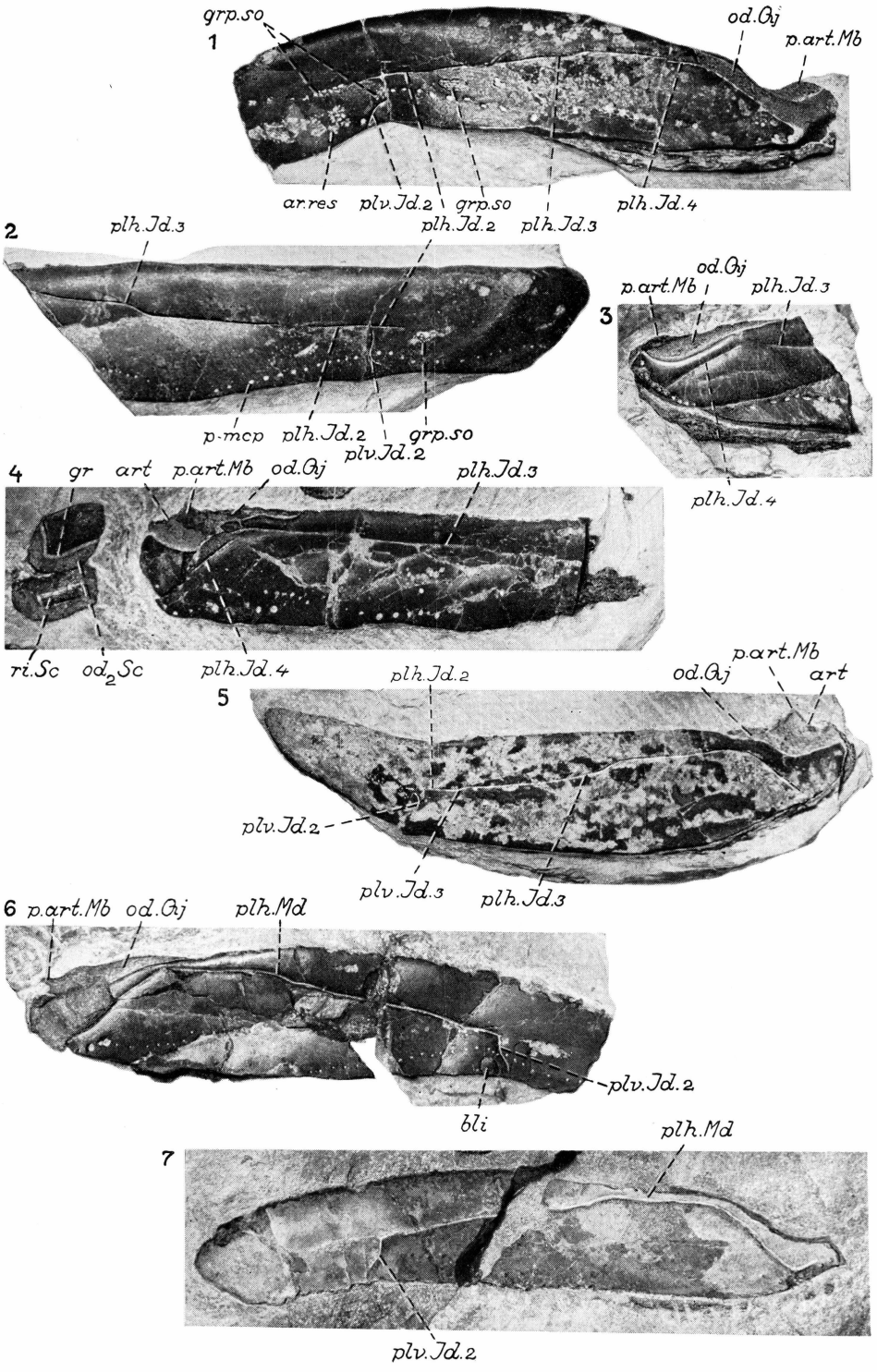

1
grp.so
od.Oj
p.art.Mb
ar.res
plv.Jd.2
grp.so
plh.Jd.4
2
plh.Jd.3
plh.Jd.2
plh.Jd.3
p-mcp
plh.Jd.2
grp.so
plv.Jd.2
3
od.Oj
p.art.Mb
plh.Jd.3
plh.Jd.4
4
gr
art
p.art.Mb
od.Oj
plh.Jd.3
ri.Sc
od2Sc
plh.Jd.4
5
plh.Jd.2
p.art.Mb
od.Oj
art
plv.Jd.2
plv.Jd.3
plh.Jd.3
6
p.art.Mb
od.Oj
plh.Md
plv.Jd.2
bli
7
plh.Md
plv.Jd.2

Plate 16.

Gyroptychius groenlandicus n. sp.

Lower jaw of six specimens. External side. All figures $^{2}/_{1}$.

Fig. 1. Specimen No. P. 1369. Canning Land, Kollen.

Fig. 2. Specimen No. P. 1343. Canning Land, Kollen.

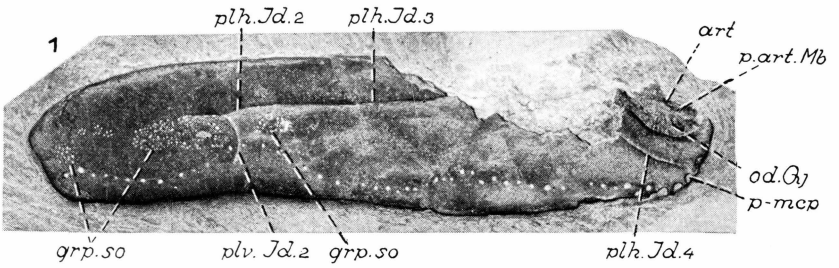
Fig. 3. Specimen No. P. 1344. Canning Land, Kollen.

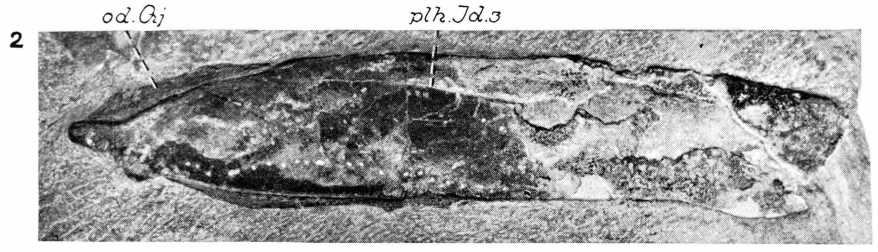
Fig. 4. Specimen No. P. 1367. Wegeners Halvö, eastern part of Circusbjærg. Enamel and dentine layers mainly wanting.

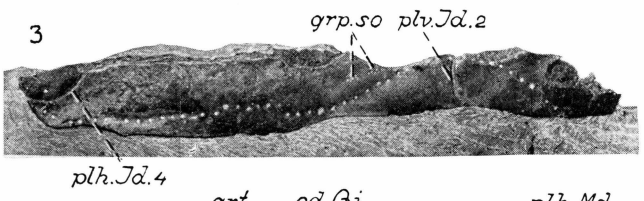
Fig. 5. Specimen No. P. 1368. Wegeners Halvö, eastern part of Circusbjærg.

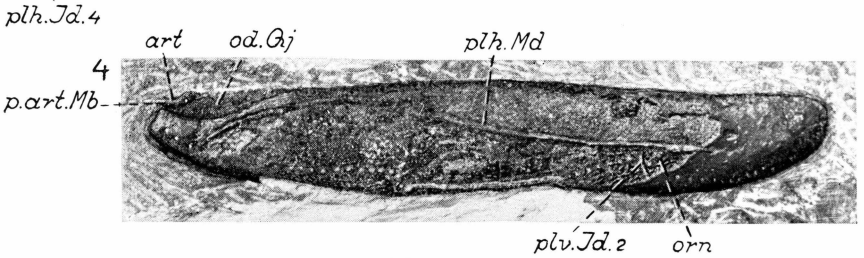
Fig. 6. Specimen No. P. 1337. Wegeners Halvö, Vimmelskaftet. Impression of external face.

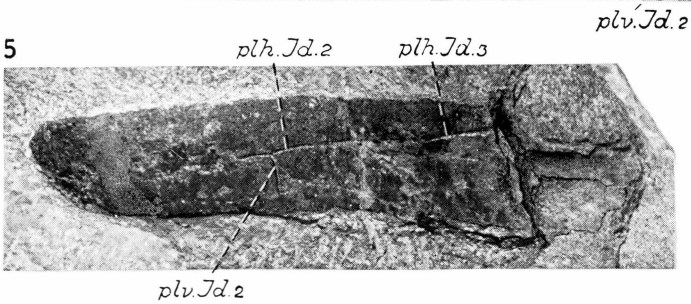
art, articular area of lower jaw; *grp. so*, groups of pores, probably for nerves to groups of cutaneous sensory organs; *od. Qj*, area overlapped by quadratojugal; *orn*, ornamentation; *p. art. Mb*, pars articularis of meckelian bone; *plh. Id. 2*, *plh. Id. 3*, *plh. Id. 4*, horizontal pit-lines of infradentaries 2, 3, and 4; *plh. Md*, horizontal part of mandibular pit-line; *plv. Id. 2*, vertical pit-line of infradentary 2; *p-mcp*, pores of preoperculo-mandibular sensory canal.


1
plh.Jd.2
plh.Jd.3
art
p.art.Mb
od.Gj
p-mcp
grp.so
plv.Jd.2
grp.so
plh.Jd.4


2
od.Gj
plh.Jd.3


3
grp.so
plv.Jd.2
plh.Jd.4


4
art
od.Gj
plh.Md
p.art.Mb
plv.Jd.2
orn


5
plh.Jd.2
plh.Jd.3
plv.Jd.2

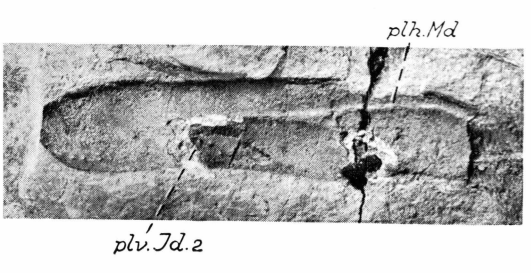

6
plh.Md
plv.Jd.2

Plate 17.

Gyroptychius groenlandicus n. sp.

Opercular of nine specimens. All figures $^{2}/_{1}$.

Fig. 1. Specimen No. P. 1318. Canning Land, NW. part of Hesteskoen, 210—234 m. Preserved mainly as impression of inner face.

Fig. 2. Specimen No. P. 1379. Canning Land or Wegeners Halvö. External view.

Fig. 3. Specimen No. P. 1396. Wegeners Halvö, Circusbjærg. Impression of external face.

Fig. 4. Specimen No. P. 1315. Canning Land, NW. part of Hesteskoen, 210—234 m. Impression of external face.

Fig. 5. Specimen No. P. 1332. Canning Land, NW. part of Hesteskoen, 210—234 m. Preserved mainly as impression of inner face.

Fig. 6. Specimen No. P. 1316. Canning Land, NW. part of Hesteskoen, profile *c*, talus. External side.

Fig. 7. Specimen No. P. 1395. Canning Land, NW. part of Hesteskoen, 210—234 m. Impression of external face. Same specimen as in pl. 18:2.

Fig. 8. Specimen No. P. 1410. Canning Land, NW. part of Hesteskoen, 210—234 m. Impression of external face.

Fig. 9. Specimen No. P. 1336. Wegeners Halvö, Vimmelskaftet. Impression of external face.

od. Et, area overlapped by extratemporal; $od_1 Pop$, area overlapped by preopercular; $od_1 Sc$, area of scale overlapped by adjoining scale; $od_2 Ext.\ l$, area overlapped by lateral extrascapular; *ri. dl*, dorso-lateral ridge.

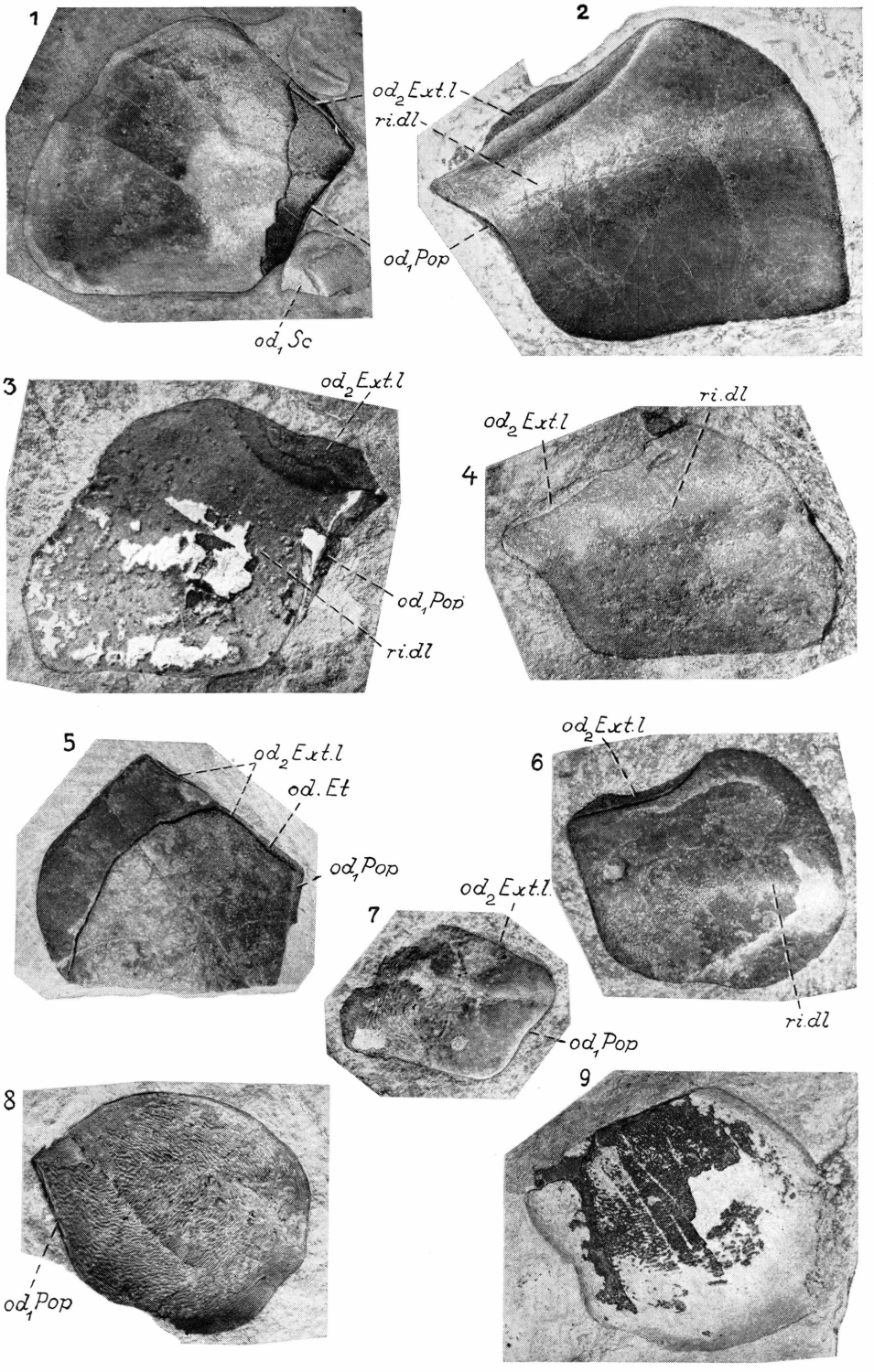

1
od2 Ext.l
ri.dl
od1 Pop
od1 Sc
2
3
od2 Ext.l
od1 Pop
ri.dl
4
od2 Ext.l
ri.dl
5
od2 Ext.l
od. Et
od1 Pop
6
od2 Ext.l
ri.dl
7
od2 Ext.l
od1 Pop
8
od1 Pop
9

Plate 18.

Gyroptychius groenlandicus n. sp.

Fig. 1. Subopercular in external view. Specimen No. P. 1319. Canning Land, NW. part of Hesteskoen, 210—234 m. $^3/_1$.

Fig. 2. Subopercular. Impression of external face. Specimen No. P. 1395. Same specimen as in pl. 17:7. $^3/_1$.

Fig. 3. Branchiostegal ray and scale in external view. Specimen No. P. 1346. Canning Land, Kollen. $^3/_1$.

Fig. 4. Branchiostegal ray in external view. Specimen No. P. 1348. Canning Land, NW. part of Hesteskoen, 210—234 m. $^3/_1$.

Fig. 5. Parts of lower half of skull and exoskeletal shoulder-girdle in ventral view. Specimen No. P. 1317. Canning Land, NW. part of Hesteskoen, 210—234 m. $^3/_1$.

Clav, clavicle; *G*, principal gular; *Qj*, quadratojugal; *Rbr*, branchiostegal rays; *Rbr. 2*, second branchiostegal ray; *Sop*, subopercular.

ar. res, rough area, probably representing area of resorbtion; *bli*, blisters; *od. G. m*, area of principal gular overlapped by median gular; *od. Lj*, area of subopercular overlapped by lower jaw; *od. Op*, area of subopercular overlapped by opercular; *od. Rbr*, area of principal gular overlapped by branchiostegal rays; *od. Rbra*, area of second branchiostegal ray overlapped by third ray; *od. Sq*, area of quadratojugal overlapped by squamosal; $od_1 Sc$, area of scale overlapped by adjoining scale; $od_2 Pop$, area of subopercular overlapped by preopercular; *pl. G*, pit-line of principal gular; *pl. Qj*, quadratojugal pit-line; *pl. Rbr. 2*, pit-line of second branchiostegal ray.

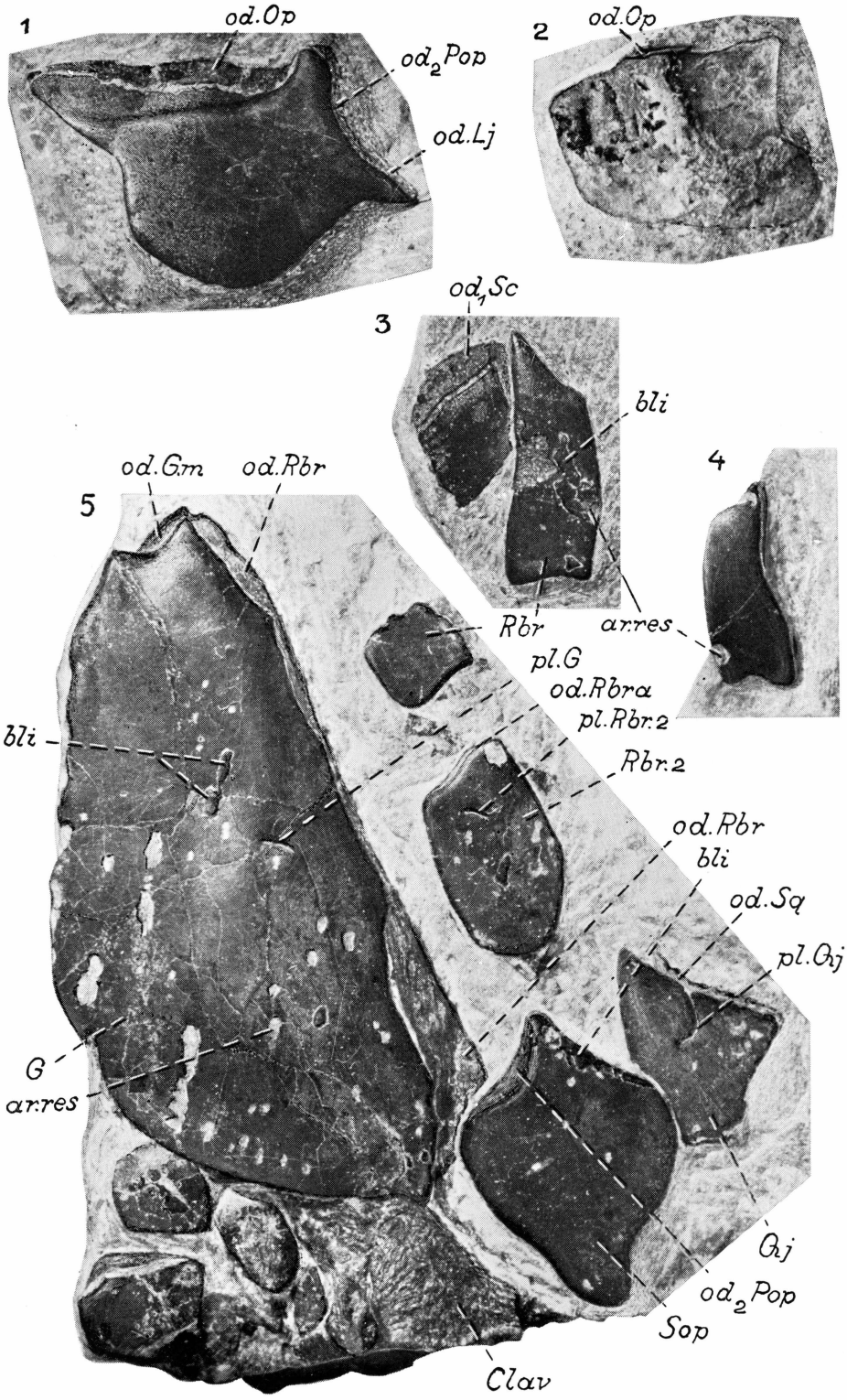

1
od.Op
od2Pop
od.Lj
2
od.Op
3
od1Sc
bli
4
5
od.Gm
od.Rbr
Rbr
arres
pl.G
od.Rbra
pl.Rbr.2
Rbr.2
bli
od.Rbr
bli
od.Sq
pl.Qj
G
arres
Qj
od2Pop
Sop
Clav

Plate 19.

Gyroptychius groenlandicus n. sp.

Fig. 1. Subopercular. Impression of external face. Specimen No. P. 1335. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 2. Hindmost branchiostegal ray in external view. Specimen No. P. 1366. Wegeners Halvö, eastern part of Circusbjærg. $^2/_1$.

Fig. 3. Imperfect, strongly weathered skull in ventral view. Specimen No. P. 1390. Wegeners Halvö, Circusbjærg. $^2/_1$.

Fig. 4. Weathered, nearly perfect right principal gular in external view. Specimen No. P. 1358. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 5. Almost complete principal gular of left side in external view. Specimen No. P. 1321. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 6. Weathered, nearly complete principal gular of left side in external view. Specimen No. P. 1350. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

G, principal gular; *Lj*, lower jaw; *Rbr. 2*, *Rbr. 3*, second and third branchiostegal rays; *Sop*, subopercular.

ar. Rbr, area, probably occupied by anterior branchiostegal rays; *ar. res*, rough area, probably representing area of resorbtion; *bli*, blister; *od. G*, area of left principal gular overlapped by that of right side; *od. G. m*, area of principal gular overlapped by median gular; *od. Op*, area of subopercular overlapped by opercular; *od. Rbr*, area of principal gular overlapped by branchiostegal rays; *od. Rbra*, area of hindmost branchiostegal ray overlapped by second ray; *od. Sop*, area of hindmost branchiostegal ray overlapped by subopercular; *pl. G*, pit-line of principal gular; *plh. Id. 3*, *plh. Id. 4*, horizontal pit-lines of infradentaries 3 and 4; *pl. Rbr. 2*, pit-line of second branchiostegal ray.

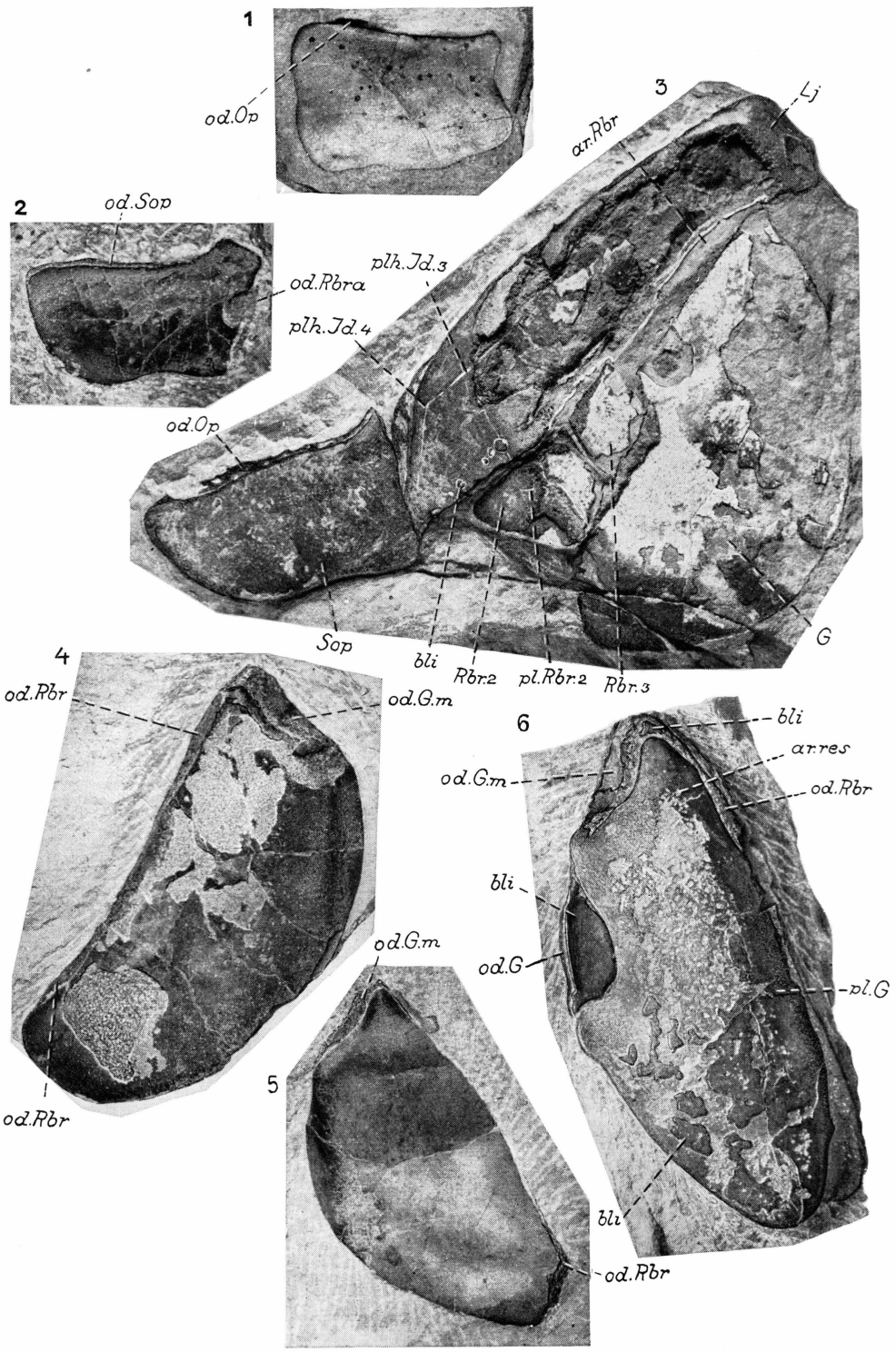

1
od.Op
2
od.Sop
od.Rbr α
3
ar.Rbr
Lj
plh.Jd.3
plh.Jd.4
od.Op
Sop
bli
Rbr.2
pl.Rbr.2
Rbr.3
G
4
od.Rbr
od.G.m
od.Rbr
5
od.G.m
6
bli
ar.res
od.G.m
od.Rbr
bli
od.G
pl.G
bli
od.Rbr

Plate 20.

Gyroptychius groenlandicus n. sp.

Principal gular plate of six specimens. $^2/_1$.

Fig. 1. Specimen No. P. 1355. Canning Land, NW. part of Hesteskoen, profile *c*. Imperfect plate in external view.

Fig. 2. Specimen No. P. 1374. Canning Land, NW. part of Hesteskoen, 210—234 m. Imperfect plate in external view.

Fig. 3. Specimen No. P. 1388. Wegeners Halvö, Vimmelskaftet. Almost perfect impression of external face.

Fig. 4. Specimen No. P. 1354. Canning Land, NW. part of Hesteskoen, 210—234 m. Impression of external face.

Fig. 5. Specimen No. P. 1331. Canning Land, NW. part of Hesteskoen, 210—234 m. Imperfect impression of external side.

Fig. 6. Specimen No. P. 1383. Canning Land, NW. part of Hesteskoen, 210—234 m. Imperfect impression of external face.

It is uncertain whether the plates shown in figs. 3, 5 and 6 really belong to *G. groenlandicus* (cf. pp. 86—90).

Rbr, branchiostegal ray.

ar. res, rough area, probably representing area of resorbtion; *bli*, blister; *od. G*, area overlapped by corresponding plate of other side; *od. G. m*, area overlapped by median gular; *od. Rbr*, area overlapped by branchiostegal rays; *pl. G*, pit-line of principal gular.

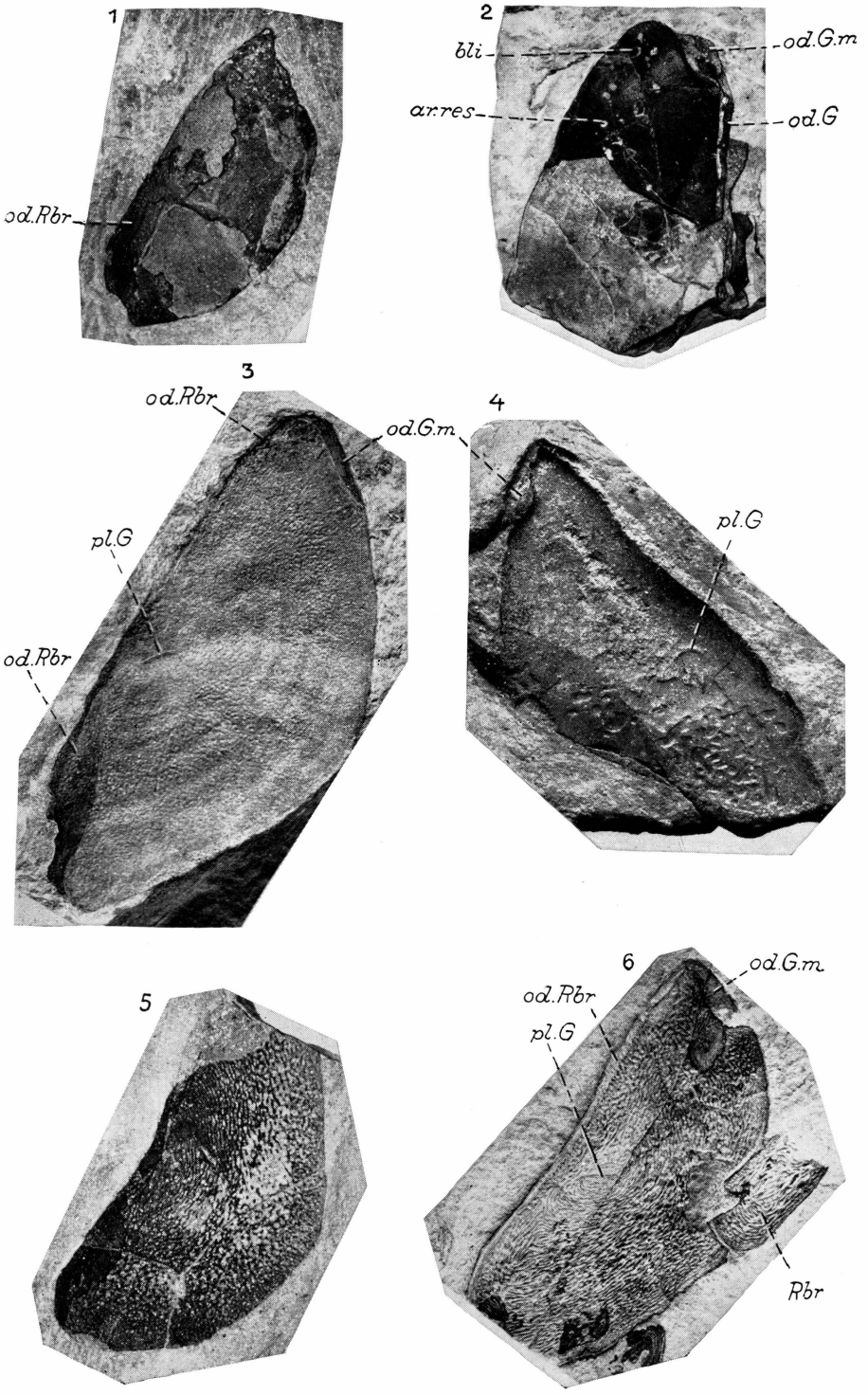

1
od.Rbr
2
bli
od.G.m
arres
od.G
3
od.Rbr
od.G.m
pl.G
od.Rbr
4
pl.G
5
6
od.G.m
od.Rbr
pl.G
Rbr

Plate 21.

Figs. 1, 2. *Gyroptychius groenlandicus* n. sp. Incomplete ventral part of cleithrum of large individual in external and internal views. Specimen No. P. 1399. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 3. *Gyroptychius groenlandicus* n. sp. Imperfect left cleithrum in external view. Specimen No. P. 1403. Canning Land, NW. part of Hesteskoen, 210—234 m. $^2/_1$.

Fig. 4. *Gyroptychius groenlandicus* n. sp. Almost complete impression of external face of right cleithrum. Specimen No. P. 1394. Canning Land, Kollen. $^2/_1$.

Fig. 5. Indeterminable Crossopterygian (*Porolepiformes*?). Left cleithrum. Impression of inner face. Specimen No. P. 1402. Wegeners Halvö, eastern part of Circusbjærg. $^2/_1$.

Clm. 1, *Clm. 2*, dorsal and ventral independent cleithral bones.

ar. mem, area, probably for attachment of membranaceous posterior wall of branchial cavity; $ar_1 Scc$, $ar_2 Scc$, $ar_3 Scc$, areas for attachment of endoskeletal shoulder-girdle (cf. JARVIK 1944b, p. 15, figs. 4 D, 6 C); *de. l*, vestiges of enamel and dentine layers; $od_1 Clav$, area of cleithrum overlapped by clavicle; *og. Clm. 1*, portion of ventral cleithral bone overlapping dorsal cleithral bone; $ri_p Clm$, ridge on inner face of cleithrum; *sut*, suture separating dorsal and ventral cleithral bones.

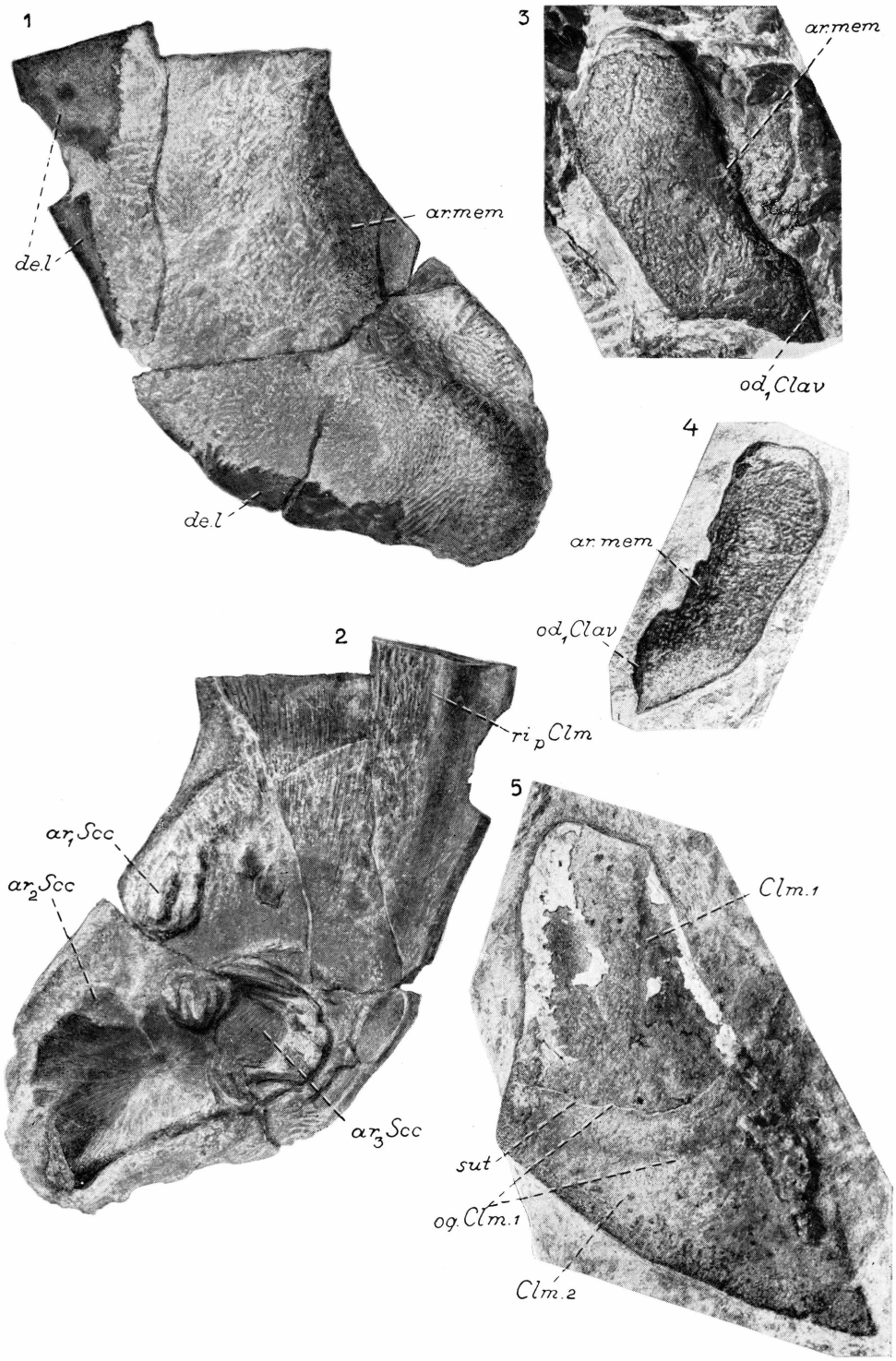

1
de.l
ar.mem
de.l
3
ar.mem
od.1 Clav
4
ar.mem
od.1 Clav
2
ri.p Clm
ar.1 Scc
ar.2 Scc
ar.3 Scc
5
Clm.1
sut
og. Clm.1
Clm.2

Plate 22.

Gyroptychius groenlandicus n. sp.

Fig. 1. Flank-scale in external view. Specimen No. P. 1406. Canning Land, Kollen. $^{6}/_{1}$.

Fig. 2. Several scales in external and internal views. Specimen No. P. 1404. Canning Land, NW. part of Hesteskoen, 210—234 m. $^{8}/_{3}$.

Fig. 3. The ornamented scale shown in fig. 2 enlarged. $^{6}/_{1}$.

Fig. 4. Similar ornamented scale of wholly ornamented individual. External view. Specimen No. P. 1411. Canning Land, NW. part of Hesteskoen, 210—234 m. $^{6}/_{1}$.

Fig. 5. Basal scute of fin. External view. Same specimen as in fig. 1. $^{6}/_{1}$.

Fig. 6. Scale of dorsal median scale row. Dorsal view. Specimen No. P. 1407. Canning Land, NW. part of Hesteskoen, 210—234 m. $^{6}/_{1}$.

Fig. 7. Scale in inner view. Specimen No. P. 1408. Canning Land, Kollen. $^{6}/_{1}$.

Figs. 8, 9. Scale of same specimen as in fig. 7 in internal and external views. $^{6}/_{1}$.

gr, groove separating overlapped and non-overlapped portions of scales; *gr. nv*, grooves for nerves and vessels; *od. Sc*, $od_1 Sc$, $od_2 Sc$, areas overlapped by adjoining scales; $og_1 Sc$, $og_2 Sc$, areas overlapping adjoining scales; *orn. Sc*, ornamented scale; *ri. Sc*, ridge on inner face of scales.

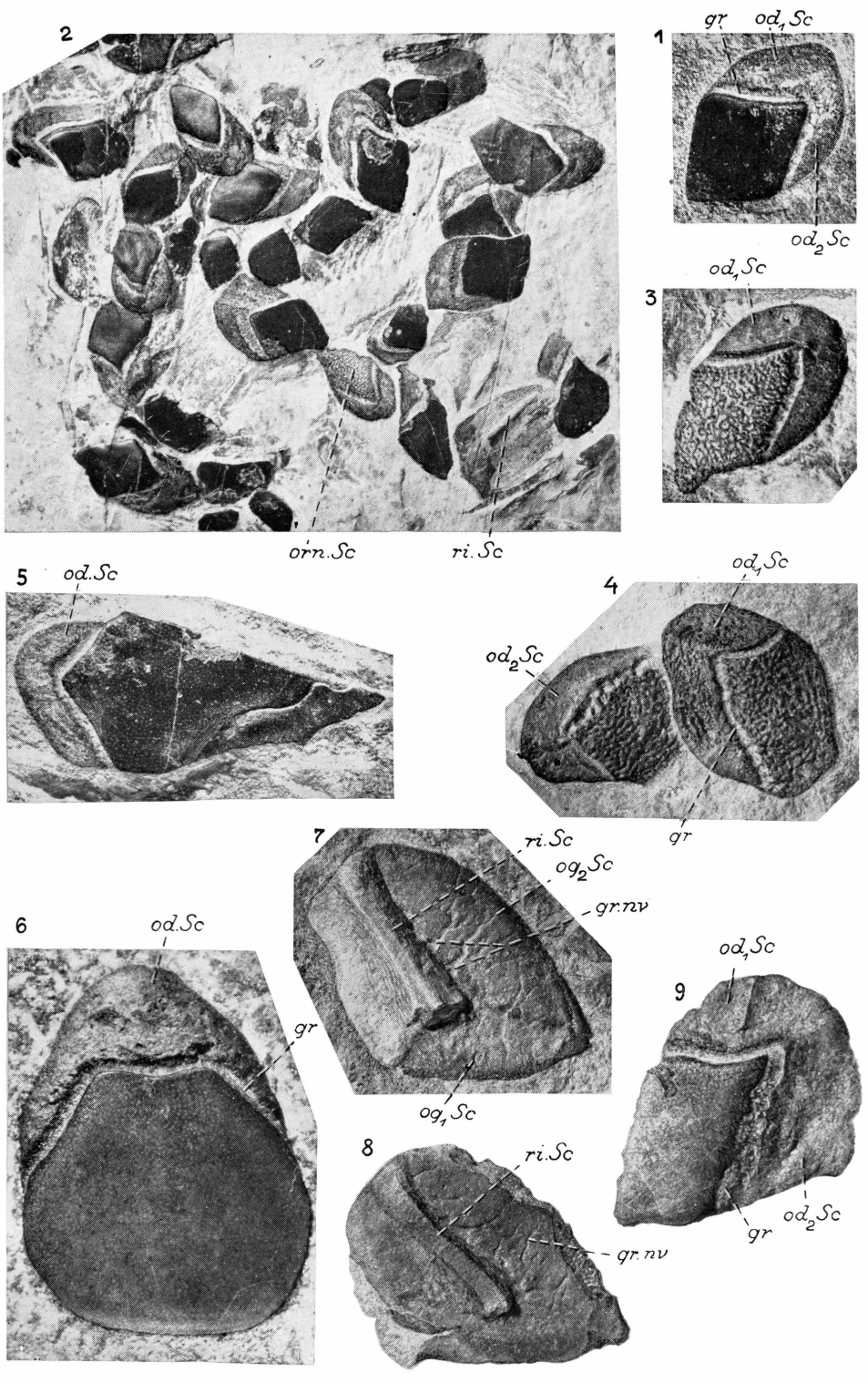

2
orn.Sc
ri.Sc
1
gr
od1Sc
od2Sc
3
od1Sc
5
od.Sc
4
od1Sc
od2Sc
gr
7
ri.Sc
og2Sc
gr.nv
og1Sc
6
od.Sc
gr
8
ri.Sc
gr.nv
9
od1Sc
gr
od2Sc

Plate 23.

Fig. 1. *Gyroptychius*? cf. *groenlandicus* n. sp. Scale in external view. Specimen No. P. 1412. Wegeners Halvö, ridge S. of Kap Brown, 304 m. (Series with *Asterolepis säve-söderberghi*). $^{6}/_{1}$.

Fig. 2. *Gyroptychius groenlandicus* n. sp. Similar scale in external view. Specimen No. P. 1408. Canning Land, Kollen. Same specimen as in pl. 22:7—9. $^{6}/_{1}$.

Fig. 3. *Gyroptychius groenlandicus* n. sp. Large scale in external view. Specimen No. P. 1320. Canning Land, NW. part of Hesteskoen, 210—234 m. $^{2}/_{1}$.

Fig. 4. *Gyroptychius groenlandicus* n. sp. Imperfect posterior part of body. Specimen No. P. 1400. Canning Land, NW. part of Hesteskoen, 210—234 m. Photographed in alcohol. $^{2}/_{1}$.

Figs. 5, 6, and 7. Undetermined Crossopterygians. Detached teeth. Specimen Nos. P. 1457, P. 1413, P. 1412. Wegeners Halvö, ridge S. of Kap Brown, 304 m. (Series with *Asterolepis säve-söderberghi*). $^{6}/_{1}$.

bs. f, basal scute of fin; *cdf*, dorsal lobe of caudal fin; *cvf*, ventral lobe of caudal fin; *gr*, groove separating overlapped and non-overlapped portions of scale; od_1Sc, od_2Sc, overlapped areas of scales; *s. df*, second dorsal fin.

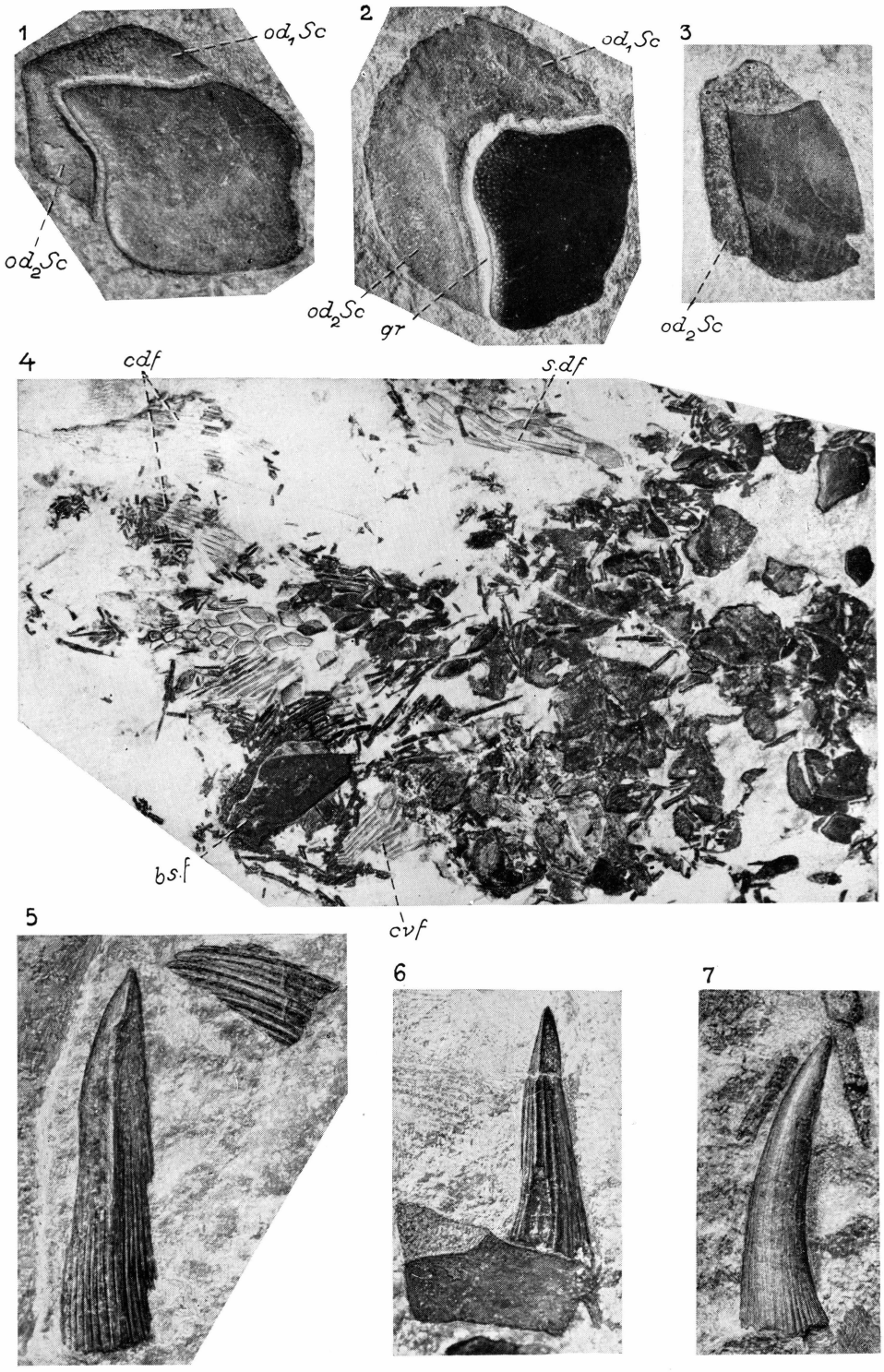

1
od1 Sc
od2 Sc
2
od1 Sc
od2 Sc
gr
3
od2 Sc
4
cdf
s.df
bsf
cvf
5
6
7

Plate 24.

Undertermined *Porolepiformes*.

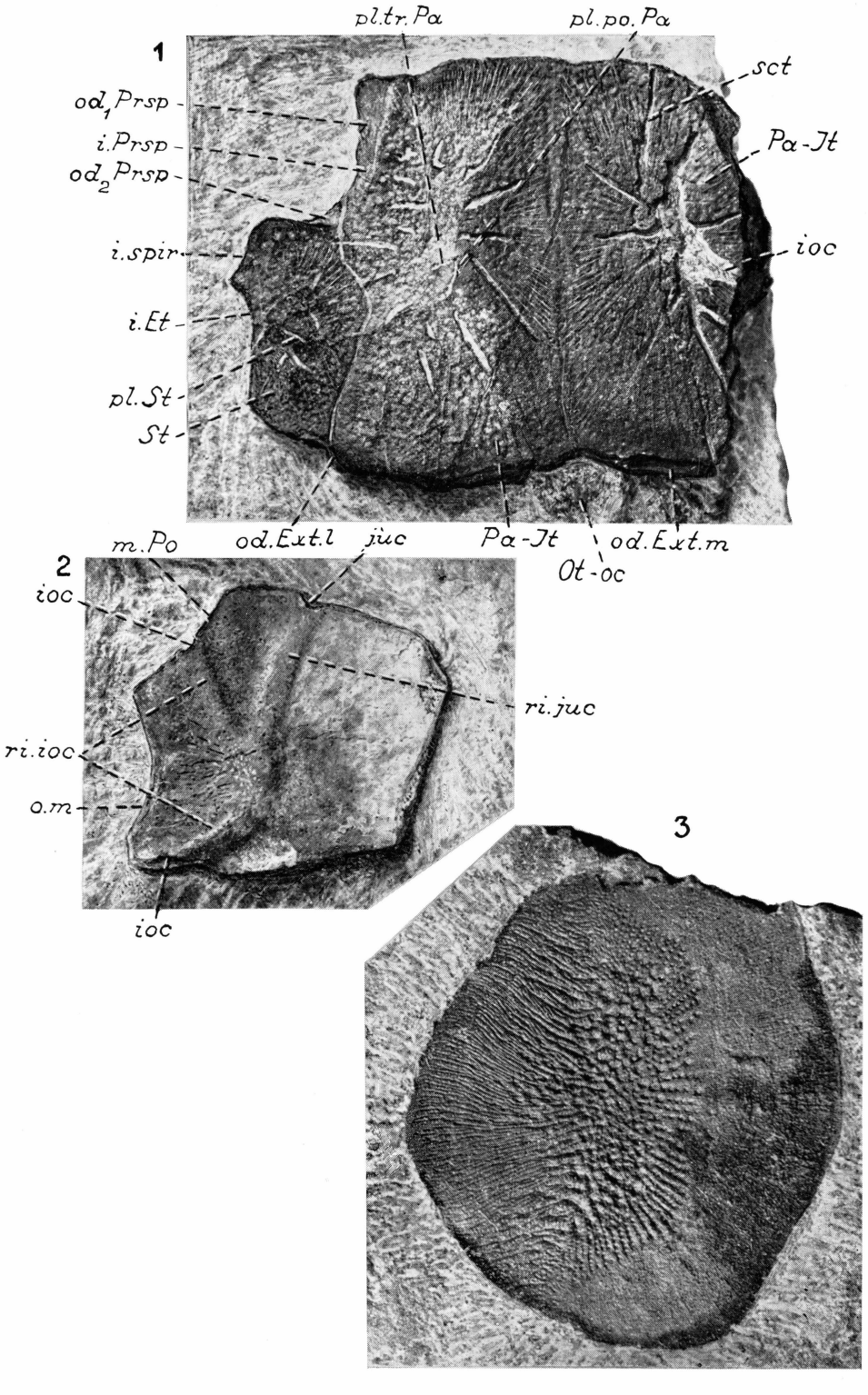
Fig. 1. Imperfect parietal shield in dorsal view. Specimen No. P. 1364. Canning Land, NW. part of Hesteskoen, 210—234 m. $^3/_1$.

Fig. 2. Jugal in inner view. Specimen No. P. 1435. Wegeners Halvö, Circusbjærg. $^3/_1$.

Fig. 3. Scale. Impression of external face. Specimen No. P. 1334. Canning Land, Kollen. $^3/_1$.

Ot-oc, otico-occipital; *Pa-It*, parieto-intertemporal; *St*, supratemporal.

i. Et, extratemporal notch; *ioc*, infraorbital sensory canal; *i. Prsp*, prespiracular notch; *i. spir*, spiracular notch; *juc*, jugal sensory canal; *m. Po*, margin of jugal meeting postorbital; *od. Ext. l*, area of parieto-intertemporal overlapped by lateral extrascapular; *od. Ext. m*, area of parieto-intertemporal overlapped by median extrascapular; $od_1 Prsp$, area of parieto-intertemporal overlapped by prespiracular plate; $od_2 Prsp$, area of supratemporal overlapped by prespiracular plate; *o. m*, orbital margin of jugal; *pl. po. Pa*, posterior oblique parietal pit-line; *pl. St*, supratemporal pit-line; *pl. tr. Pa*, transverse parietal pit-line; *ri. ioc*, ridge housing infraorbital sensory canal; *ri. juc*, ridge housing jugal sensory canal; *sct*, tubes of sensory canals.


1
pl.tr.Pα
pl.po.Pα
sct
od1Prsp
i.Prsp
od2Prsp
Pα-Jt
ioc
i.spir
i.Et
pl.St
St
od.Ext.l
juc
Pα-Jt
od.Ext.m
Ot-oc
2
m.Po
ioc
ri.juc
ri.ioc
o.m
ioc
3