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ON THE INTERRELATIONSHIP AND
THE ZOOGEOGRAPHY OF NORTHERN
SPECIES OF *YOLDIA* MÖLLER, S. STR.
(*MOLLUSCA*, FAM. *LEDIDAE*)

WITH A NEW SUBSPECIES

BY

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WITH 2 FIGURES IN THE TEXT AND 2 PLATES

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I. INTRODUCTION

The systematics of the North Atlantic species belonging to the genus *Yoldia* erected by MÖLLER 1842, *sensu stricto*, has long been highly disputed. While examining the bivalves of East Greenland, the author was confronted with this systematical problem. Therefore, a closer study of the shells of *Yoldia hyperborea* (LOV.) TORELL, *Y. limatula* (SAY), *Y. sapotilla* (GOULD), and *Y. myalis* (COUTHOUY) was undertaken and the results hereof are presented in the present paper. As the species mentioned above have often been confused, and some features of their shells have hitherto apparently been overlooked, a re-description with figures of them all was considered desirable, and it is my hope that this re-description will facilitate the identification of the species. As far as possible, shells from various localities were measured in order to ascertain their variation in shape. Finally, an attempt was made to give the distribution of the species in space and time, as this may throw further light on their interrelationship.

How desirable a definitive elucidation of the problem is, will appear from the following survey of the views held by previous authors:

"*Yoldia hyperborea* LOVÉN", as described by TORELL on the basis of specimens from Spitzbergen, is considered by him to be specifically distinct from "*Yoldia limatula* (SAY)", to which species he refers some specimens from Iceland as well as "*Yoldia arctica*" taken by M. SARS at the coast of the Finmark. Furthermore, TORELL is inclined to regard "*Nucula sapotilla*" from New England merely as a "shrunk" form of "*Yoldia hyperborea*" (TORELL 1859, pp. 150—152). — GOULD distinguishes between "*Yoldia limatula*", "*Yoldia sapotilla*" (according to him possibly only a shortened variety of the former), and "*Yoldia myalis*". In an addition, "*Nucula hyperborea*" from Spitzbergen is indicated as "doubtless identical" with "*Yoldia myalis*" (GOULD 1870, pp. 154—155, and 159—161). — MÖRCH (1875, p. 132) records both "*Yoldia limatula* SAY", and "*Yoldia hyperborea* LOVÉN" from West Greenland. — G. O. SARS (1878, p. 40) applies the name "*Yoldia limatula* SAY", with the synonym "*Y. arctica* MÖLLER, non GRAY", to his specimens from the Finmark-Lofoten—regarding these as identical with *Y. limatula* (SAY)—

but distinguishes between "*Y. myalis* COUTH.", "*Y. sapotilla* STIMPS.", and "*Y. hyperborea* LOV.". — LECHE (1878, p. 22, and 1883, p. 444) doubts whether "*Yoldia hyperborea*" and "*Y. myalis*" are identical, but considers the latter most certainly a variety of the former, and calls attention to the variability of "*Y. hyperborea* LOV.". — VERRILL regards "*Yoldia sapotilla*", "*Y. myalis*", and "*Y. limatula*" as distinct species, but seems to think that the latter forms a unity with the *Yoldia* from Spitzbergen, just as he unites "*Y. sapotilla*" with the *Yoldia* recorded by MÖRCH from West Greenland (VERRILL & SMITH 1874, p. 395). In a later work, however, he separates "*Yoldia hyperborea* TORELL", "*Y. limatula*", and "*Y. myalis*" and mentions "*Yoldia limatula* G. O. SARS (non SAY)" as synonymous with "*Y. hyperborea* TORELL" (VERRILL 1884, p. 226). — According to COLLIN (1887, p. 9), it is very difficult to keep "*Y. limatula*" of G. O. SARS, "*Y. hyperborea* LOV.", "*Y. arctica* MÖLL.", "*Y. myalis* COUTH.", and "*Nucula sapotilla* GOULD" separate. — POSSELT regards "*Yoldia hyperborea* (LOVÉN) TORELL", "*Y. limatula* 'SAY', SARS", and "*Y. sapotilla* GOULD" as forms belonging to one and the same species, with which "*Y. myalis* COUTH." has nothing to do; he also regards "*Y. limatula* SAY" and "*Y. limatula* SARS" as specifically different (POSSELT & JENSEN 1898, pp. 31—32). — BRÖGGER (1900—01, p. 35) supposes that "*Y. hyperborea*", "SARS'S *Y. limatula*", and "SAY'S *Y. limatula*" from Iceland are varieties of the same species. — WHITEAVES (1901, pp. 125—126) distinguishes between "*Yoldia limatula* (SAY)", "*Y. sapotilla* (GOULD)"—"possibly an abbreviated variety of the former"—and "*Y. myalis* (COUTHOUY)". — After a comparison of "*Yoldia hyperborea* LOVÉN" with "*Y. limatula* SAY", "*Y. sapotilla* GOULD", and typical specimens of the "*Y. limatula* of SARS", FRIELE and GRIEG (1901, pp. 13—14) are of opinion that all these forms should be regarded as varieties of the main form *Y. hyperborea*. As to the systematical position of "*Y. myalis* COUTHOUY", they are inclined to agree with POSSELT. — HÄGG (1904, p. 10), in a footnote to "*Y. hyperborea* (LOVÉN) TORELL" from Spitzbergen, suggests that "*Y. sapotilla* GOULD", "*Y. myalis* COUTHOUY", "*Y. limatula* SAY", and "*Y. limatula* SARS" are possibly forms of *Y. hyperborea* only. — ODHNER (1910, p. 18) records both "*Yoldia limatula* SAY" and "*Yoldia hyperborea* TORELL" from Iceland. — DAUTZENBERG and FISCHER (1912, pp. 402—403) consider the *Yoldia* of SARS as different from "*Y. limatula* SAY", proposing the specific name of "*Yoldia norvegica*" instead of "*Y. limatula* SARS". — ØYEN discusses the fossil forms of *Y. hyperborea* found in the Trondhejm area in connection with the recent northern species of *Yoldia*, and regards them all as an "almost unbreakable chain of connected forms, a connection which is still more strengthened by the continuity of the fossil forms" (1915, pp. 405—407, translated from the Norwegian). — E. S.

MORSE (1919, pp. 148—150) distinguishes "*Yoldia sapotilla* (GOULD)" from "*Y. limatula* (SAY)", and points out some distinctive features in the soft parts of these two species. — In his list of molluscs, JOHNSON (1934, p. 17) enumerates "*Y. limatula* SAY", "*Y. myalis* COUTHOUY", "*Y. sapotilla* GOULD", and "*Y. cascoensis* MIGHELS and ADAMS". — F. J. MADSEN (1949, p. 20), after mentioning some opinions expressed in previous works, is "inclined to regard the East Atlantic *Yoldia* as specifically identical with the West Atlantic *Yoldia limatula*, and TORELL's *hyperborea* as merely an obtuse form. Consequently, I have recorded all the Icelandic *Yoldia* under the name of *limatula*". — THORSON (1951b, p. 62) finally includes the records of "*Yoldia sapotilla*" among those of "*Y. hyperborea* (LOVÉN) TORELL".

It is a particular pleasure to the author to record his gratitude to Dr. G. THORSON and Dr. H. LEMCHE for their valuable criticism, and their advice in systematical matters. Special thanks are also due to Mr. POUL H. WINTHER and Mr. A. ØYE for their preparation of the drawings and the photographs. My thanks are likewise due to Miss E. GLEERUP, who has corrected and revised the English manuscript.

II. MATERIAL

The present work is based upon the material found in the Zoological Museum, Copenhagen, comprising a large number of *Yoldia hyperborea* from West and East Greenland, Iceland, Spitzbergen, a few specimens from the Murman Coast and the Kara Sea, several specimens of *Y. sapotilla*, *Y. limatula*, and a few specimen of *Y. myalis* from the east coast of North America. Furthermore, the Zoological Museums in Bergen and Oslo have kindly lent us a valuable part of their material of *Yoldia*. Finally, a comparison with a few fossil forms of *Yoldia* was included in the study.

III. MEASUREMENTS USED

The measurements are illustrated in the following drawing.

The length "L", height "H", and breadth "B" of the shells were measured by means of sliding calipers with a vernier scale. The depth of the pallial sinus "S" was measured by means of a pair of dividers. All these measurements are given in millimetres. — "H/L", "B/L",

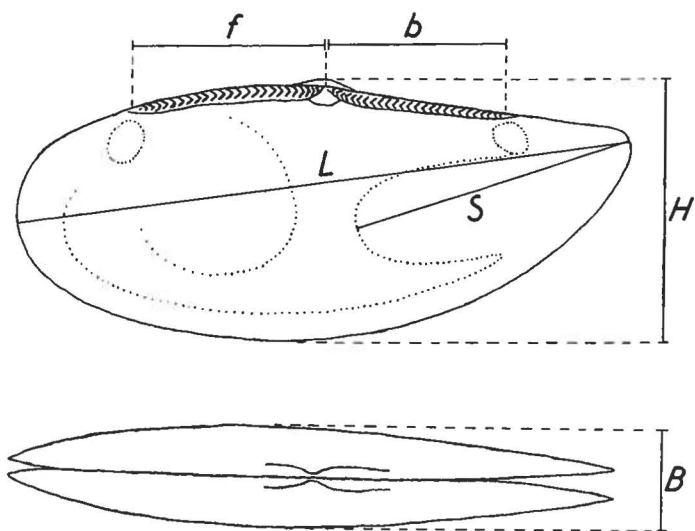


Figure showing the measurements used. For further explanation, see the text.

and "S/L" are the calculated ratios of the height and breadth of the shell, and the depth of sinus to the length, respectively. The letter "f" indicates the number of hinge-teeth in front of, and "b" those behind, the umbo, and "f/b" the calculated ratio of these two figures. If not particularly noted, "f", "b", and "S" always refer to right valves. — A list of all the measurements and counts on which the present paper is based is kept at the Zoological Museum, Copenhagen, Denmark.

IV. DESCRIPTIONS

Yoldia hyperborea (LOVÉN) TORELL.

Synonyms: (*Nucula hyperborea* LOVÉN, mscr.);
Yoldia arctica M. Sars 1851, Mörch 1857, (non GRAY);
Nucula sapotilla REEVE 1855, (non GOULD);
Yoldia limatula G. O. Sars 1878, COLLIN 1887, (non SAY);
Yoldia norvegica DAUTZENBERG & FISCHER 1912.

Subspecies *hyperborea*.

(Cf. pl. 1, fig. 1, and pl. 2, figs. 3 and 4).

Figures: *Yoldia hyperborea*, in: TORELL 1859, pl. 2, figs. 6a—b; LECHE 1883, pl. 33, figs. 16—17; ODHNER 1910, pl. 1, fig. 23; DAUTZENBERG & FISCHER 1912, pl. 11, figs. 3—6.

Diagnosis: TORELL 1859, pp. 149—150.

Type locality: Spitzbergen.

Description: Shell rather thin and somewhat fragile, very much compressed, oblong-ovate, gaping at both ends. Anterior part highest and in adult specimens longer than the sub-triangular posterior part. Antero-dorsal and anterior margins forming a smooth semi-elliptical curve. Beneath the anterior end a distinct sinuation in the margin, almost always another sinuation beneath the posterior end, connected with the umbo by a wave-like swell. Ventral margin behind the umbo compressed, sloping, almost rectilinear or slightly S-curved, to the tip, the latter not pointed but rounded. Umbones small, protruding only a little above the hinge, in adult specimens always behind the middle. The periostracum olivegreen-brownish, glazingly varnished, with darker and lighter concentric zones, these often visible on the inner side. Shells of young specimens light yellow-greenish, and somewhat iridescent. Rather fine concentric lines at irregular intervals on the surface. Resilifer concave, deep, nearly equilateral-triangular, its basal limit often with a concave flexure in the middle. Anterior series of hinge-teeth slightly curved, posterior series almost straight. Hinge-teeth at increasing intervals towards the ends, very small nearest the resilifer, at first increasing, then decreasing, in length, the tips of the teeth forming a regular arch.

Ratio of number of teeth in front of/behind the umbo about 1.3. Interior of shell bluish-white with yellowish-white concentric zones, glossy, with minute radiating lines or striae. The pallial sinus deep, with a more or less distinct angle nearest the umbo. A rather distinct line or band—which marks the limit of the genital mass and the digestive gland—extends in a wide and often irregular curve from the scar of the anterior adductor nearly to the resilifer. Scars of the adductor muscles comparatively small.—The height one-half, or a little more than half of the length; breadth about one-fourth of the length; the latter may exceed 40 mm.

Measurements: 35 shells from Spitzbergen, i. e. 13 from Whaler's Point, 15 from Storfjord, and 7 from Bellsound, were measured. The measurements and ratios of these are compiled in table 1. — The number of measured shells are always given in brackets after the mean values.

Table 1.

L	H/L	B/L	S/L	f/b
16.1—21.0	0.52—0.55	0.25—0.25	0.43—0.48	1.250—1.368
mean:	0.53 (8)	0.25 (2)	0.46 (7)	1.319 (7)
21.5—29.0	0.49—0.54	0.22—0.28	0.42—0.46	1.261—1.400
mean:	0.52 (19)	0.25 (11)	0.43 (14)	1.315 (12)
29.1—35.0	0.48—0.54	0.25—0.25	0.43—0.46	1.259—1.348
mean:	0.51 (8)	0.25 (2)	0.45 (5)	1.309 (7)

In table 2 the measurements and ratios of 32 shells from W. Greenland (Bredefjord 10, "Nordvestgrønland" 1, Narssaq 1, Igaliko 3, "Vestgrønland" 6, and N. Strømfjord 11), and in table 3 the measurements of 29 shells from E. Greenland (Amdrup's Havn 2, Tassiussaq 1, fjord behind Kûngmiut 1, Lindenows Fjord 22, and Nanûserq Fj. 3) are compiled.

Table 2.

L	H/L	B/L	S/L	f/b
9.1—12.5	0.57—0.57	—	—	1.313—1.364
mean:	0.57 (2)	0.24 (1)	—	1.333 (2)
17.3—20.9	0.51—0.53	—	0.47—0.48	1.316—1.389
mean:	0.52 (5)	0.24 (1)	0.47 (4)	1.345 (5)
22.5—28.1	0.49—0.53	0.24—0.26	0.45—0.47	1.238—1.368
mean:	0.50 (9)	0.25 (3)	0.46 (9)	1.298 (9)
29.1—38.7	0.50—0.53	0.27—0.27	0.42—0.47	1.250—1.360
mean:	0.51 (11)	0.27 (5)	0.45 (11)	1.304 (11)
40.3—43.8	0.49—0.52	—	0.44—0.46	1.259—1.333
mean:	0.50 (5)	0.27 (1)	0.45 (5)	1.298 (4)

Table 3.

L	H/L	B/L	S/L	f/b
4.8 (1)	0.63	0.23	—	—
11.4—14.2	0.52—0.57	0.24—0.27	—	1.267—1.333
mean:	0.55 (3)	0.25 (3)	—	1.289 (3)
15.5—19.2	0.51—0.53	0.23—0.25	0.44—0.45	1.294—1.353
mean:	0.52 (4)	0.24 (3)	0.44 (3)	1.323 (4)
21.8—28.5	0.50—0.54	0.24—0.25	0.44—0.49	1.286—1.381
mean:	0.51 (10)	0.25 (5)	0.46 (8)	1.321 (9)
29.3—36.5	0.49—0.53	0.24—0.26	0.44—0.46	1.308—1.333
mean:	0.50 (7)	0.25 (3)	0.45 (4)	1.320 (2)
44.7 (1)	0.51	—	0.41	1.321

Finally, 10 shells from the Kara Sea, and 5 from the Murman Coast were measured and are tabulated below—table 4.

Table 4.

L	H/L	B/L	S/L	f/b
20.2 (1)	0.50	0.23	0.49*	1.333
21.9—28.5	0.47—0.52	0.22—0.24	0.42—0.48*	1.250—1.320
mean:	0.50 (7)	0.23 (4)	0.45 (6)	1.302 (5)
29.1—39.5	0.46*—0.50	0.23—0.25	0.41—0.52*	1.308—1.375
mean:	0.49 (6)	0.24 (4)	0.46 (6)	1.354 (4)
40.5 (1)	0.49	ca. 0.22	—	—

* Shells from the Murman Coast.

The total number of hinge-teeth in valves of about the same length shows a rather great variability, thus e. g. 48 teeth were found in a valve 29.2 mm long from Whaler's Point, and 61 in a valve 29.4 mm long from Bellsound. The ratios f/b, however, differ much less in these two cases, being 1.286 and 1.368, respectively. In general, the ratio f/b is far more suitable for a distinction of the species of *Yoldia* than the total number of hinge-teeth¹). — As no evident dependence

¹) In older specimens of *Y. hyperborea* an erosion—often with a partial reorganisation—of the umbo and the hinge-teeth nearest it may occur. In such cases the ratio f/b may exceed the range of variation given in the tables, e. g. 1.130 was found in a valve 31.8 mm long from W. Greenland. Other abnormalities, too, may influence the ratio f/b. Thus, a valve of the ssp. *limatuloides* from W. Iceland had the ratio f/b = 1.444, due to a deformation of its posterior part. All valves which proved to be abnormal in these respects were not considered in the statistical calculations of the ratio f/b.

of the ratio f/b on the length can be shown in a diagram, the mean values and the mean errors of the ratio f/b have been calculated, viz.

- 1.314 $\pm$ 0.004, in 26 valves from Spitzbergen;
- 1.310 $\pm$ 0.004, in 31 valves from West Greenland;
- 1.317 $\pm$ 0.004, in 19 valves from East Greenland.

Tables 1, 2, and 3 show that the shells from Spitzbergen, and W. and E. Greenland agree fairly well as regards the means and variations of the ratios H/L , B/L , and f/b . It will be noticed that the height generally amounts to more than 50 per cent of the length, and that the ratio H/L decreases somewhat with an increase of length. The depth of the pallial sinus amounts to 41—48 per cent of the length, being often proportionally deeper in smaller valves.

The shells from the Kara Sea and the Murman Coast show a somewhat greater variability for the ratios H/L , and S/L (cf. tab. 4), and the ratios H/L and B/L are often a little smaller than those found in *Y. hyperborea* from Spitzbergen, W. and E. Greenland. The summarised mean value and the mean error of the ratio f/b in 10 valves from the Kara Sea and the Murman Coast were calculated to be 1.326 ± 0.007 .

The largest specimens of ssp. *hyperborea* at hand measured: $L \times H$, and $f \times b$ (right valve): 44.7×22.9 mm, 37×28 hinge-teeth, Tasiussaq, E. Greenland; 43.8×22.0 mm, 35×28 hinge-teeth, (umbo eroded), N.W. Greenland.

Subspecies *limatuloides*, n. ssp.

("Yoldia limatula SAY" sensu G. O. Sars, non SAY).

(Cf. pl. 1, fig. 2, and pl. 2, figs. 1 and 2).

Figures: *Yoldia limatula* (non SAY), in: TORELL 1859, pl. 2, figs. 5a—b; Sars 1878, pl. 4, figs. 12a—b; ODHNER 1910, pl. 1, fig. 24.

Type locality: Fossfjord (Arnarfjord), N.W. Iceland.

Type: Zool. Museum, Copenhagen.

Description: The subspecies *limatuloides* differs from the typical *Y. hyperborea* in the following characters: Shell more elongated, in adult specimens the length amounting to more than twice the height. Posterior part more acuminate and the tip somewhat pointed. Hinge-margin behind the umbo more sharply compressed, and the pallial sinus as a rule deeper than in the subspecies *hyperborea*. — Measurements of type specimen: Length 36 mm, height 15.6 mm, breadth 6.9 mm, depth of pallial sinus of right valve 18.2 mm, of left valve 18.0 mm; right valve 38 hinge-teeth in front of, 29 behind the umbo; left valve 37 and 28 teeth, respectively.

Thus, *ssp. limatuloides* superficially resembles the N. American *Y. limatula*, which explains that these two different species have often been confused. The antero- and postero-ventral sinuations, however, are always distinct in *ssp. limatuloides*, whereas such sinuations are lacking *Y. limatula* (cf. pl. 1, figs. 2 and 3). Nor is the compression of the posterior hinge area of the former limited in such a way as is the case in the latter. Furthermore, the lines and scars on the inner side of the valves of *ssp. limatuloides* show quite the same development as in *ssp. hyperborea*, and finally the ratios f/b of the last two forms are also of the same magnitude. It is therefore beyond any doubt that *ssp. limatuloides* belongs to *Y. hyperborea*, not to *Y. limatula*.

Measurements: The measurements of 27 specimens from the type locality (Fossfjord, N.W. Iceland) are compiled in table 5, and the measurements of 30 spec. from E. Iceland (Reydarfj. 15, and Seydisfj. 15) in table 4. Table 7 gives the measurements of 33 spec. from the Finmark-Lofoten (Buksnæs fj. 7, Ramfj. 10, Regnæs (Salten) 1, Kåfjord (Lyngen) 4, and the Finmark 11).

Table 5.

L	H/L	B/L	S/L	f/b
20.0—29.4	0.43—0.48	0.19—0.24	0.49—0.52	1.304—1.375
mean:	0.46 (5)	0.22 (5)	0.51 (3)	1.343 (3)
30.0—38.5	0.42—0.46	0.18—0.21	0.49—0.53	1.250—1.333
mean:	0.44 (15)	0.20 (9)	0.51 (10)	1.295 (11)
40.3—49.3	0.42—0.47	0.19—0.20	0.48—0.53	1.286—1.392
mean:	0.44 (6)	0.20 (3)	0.51 (5)	1.333 (5)
50.1 (1)	0.43	—	0.50	1.333

Table 6.

L	H/L	B/L	S/L	f/b
13.4—19.6	0.48—0.50	0.22—0.24	0.49—0.51	1.300—1.333
mean:	0.49 (4)	0.23 (4)	0.50 (4)	1.316 (4)
20.0—29.1	0.45—0.49	0.22—0.24	0.48—0.52	1.273—1.368
mean:	0.47 (12)	0.23 (11)	0.49 (12)	1.309 (12)
30.5—39.1	0.46—0.48	0.21—0.24	0.46—0.51	1.259—1.360
mean:	0.47 (9)	0.22 (8)	0.49 (9)	1.312 (8)
40.6—45.0	0.46—0.48	0.22—0.24	0.44—0.48	1.286—1.346
mean:	0.47 (5)	0.23 (4)	0.46 (5)	1.319 (5)

Table 7.

L	H/L	B/L	S/L	f/b
10.4—10.8	0.50—0.52	—	—	—
mean:	0.51 (2)	0.22 (1)	—	—
11.1—18.5	0.46—0.51	0.21—0.24	0.49—0.51	1.263—1.388
mean:	0.49 (10)	0.22 (9)	0.50 (4)	1.326 (4)
20.2—28.9	0.45—0.49	0.21—0.23	0.47—0.51	1.250—1.381
mean:	0.47 (10)	0.22 (4)	0.48 (6)	1.307 (5)
30.2—36.8	0.45—0.47	0.22—0.23	0.45—0.48	1.250—1.333
mean:	0.46 (10)	0.22 (6)	0.47 (4)	1.290 (4)
42.4 (1)	0.44	0.20	—	—

It will be seen from tables 5, 6, and 7 that in all the valves more than 20 mm long the ratio H/L is below 0.50, ranging from 0.42 to 0.49, and in these valves the ratio S/L ranges from 0.44 to 0.53. A comparison with tables 1, 2, and 3 (only valves more than 21 mm long are considered) shows that in ssp. *hyperborea* the ratio H/L ranges from 0.49 to 0.54, and the ratio S/L from 0.41 to 0.49, thus differing slightly from those found in ssp. *limatuloides*. — The mean values and the mean errors of the ratio f/b have been calculated as follows:

1.315 ± 0.005 , 20 valves from N.W. Iceland;

1.312 ± 0.003 , 30 valves from E. Iceland;

1.307 ± 0.007 , 13 valves from the Finmark-Lofoten.

Three of the largest specimens of ssp. *limatuloides* at hand measured: $L \times H$, and $f \times b$ (right valve): 50.1×21.6 mm, 36×27 hinge-teeth, Fossfj., N.W. Iceland; 49.0×21.6 mm, 41×31 hinge-teeth, N. Iceland; 35.0×16.3 mm, 36×27 hinge-teeth, the Finmark.

Ssp. *limatuloides* is connected with ssp. *hyperborea* by transitional forms known from both recent and more ancient times. As mentioned above, a rather great range of variation of the ratios H/L and S/L is found in the specimens from the Kara Sea and the Murman Coast (cf. p. 10, tab. 4). Notably, the specimens from the Murman Coast may be regarded as transitional. This is evident from the fact that the lowest values of the ratio H/L and the highest values of S/L are found in specimens from the latter area; these values are marked with an asterisk. Further, some specimens at hand from the E. coast of Iceland approach ssp. *hyperborea* rather much, and a few specimens from the Nanûserq Fjord differ from the other specimens at hand from S.E. Greenland by approaching ssp. *limatuloides* in some degree. Some dead valves and shell fragments, too—probably subfossil—derived from Grøn fjord, Northern

Norway, are of a transitional appearance; particularly as to the ratios H/L and S/L they resemble the typical *Y. hyperborea*.

Therefore, it may be discussed whether or not it is legitimate to separate the *Yoldia* from Iceland and the Finmark-Lofoten as a new subspecies. The elongated shape of their shells seems to be associated with less arctic hydrographic conditions, compared with those under which the typical *hyperborea* lives, and it is a question whether or not this elongation of the shell is only a phenotypical one.

It was observed, however, that very often all the specimens from the same sample differed in the same manner from those taken in other localities. In *Y. hyperborea* the free-swimming stage of the larvae is probably of short duration, perhaps of about the same duration as in the closely related *Y. limatula*, in which it may last up to 100 hours under laboratory conditions (cf. DREW 1899a and b). This assumption, together with the fact that *Y. hyperborea* very often inhabits long and narrow fjords, may explain the abundance of local forms or races.

Since all the specimens at hand from Iceland and from the Finmark-Lofoten—with the exception of the few transitional forms—differ in the same characteristic way from ssp. *hyperborea*, the author preferred to erect them as a new subspecies.

Distribution: Ssp. *hyperborea* is known from ?Nova Scotia¹⁾; Wellington Channel (REEVE 1855); Jones Sound and Smith Sund (GRIEG 1909); ?at the mouth of Hudson Strait²⁾; W. Greenland from 60°45' N. to 72°53' N. lat.; E. Greenland, along the S.E. coast, and at the mouth of Scoresby Sund; Spitzbergen; the Barents Sea; the Murman Coast; Waigatsch; Novaya Zemlya; the White Sea; the Kara Sea; the eastern part of the Siberian Ice-Sea; the Bering Strait; and ?along the N. coast of Alaska³⁾. Vertical range: About 5 to 677 m (West Greenland).

The subspecies *limatuloides* is common in the Icelandic fjords of the west, north-west, north, and east coasts, but is lacking at the south coast; from Norway it is known to occur from the southern islands of the Lofoten to the Eastern Finmark. Vertical range: About 5 to 170—210 m (N. Iceland).

¹⁾ VERRILL 1884, p. 226, writes: "Hitherto it has not been recognized as an inhabitant of the American coast, but it is not uncommon off the coast of Nova Scotia. It was dredged by the U. S. Fish Commission at station 55, in 33 fathoms; stations 61—63 and 63—67, in 20—41 fathoms, 1877." This find, however, needs further confirmation. According to later fauna lists, *Y. hyperborea* has never since been met with in this area.

²⁾ DALL 1924, p. 34A, as *Y. limatula* SAY.

³⁾ DALL 1919b, p. 5A and 8A, as *Y. limatula* SAY (+ *hyperborea* LOVÉN).

Yoldia limatula (SAY).

(Cf. pl. 1, fig. 3, and pl. 2, figs. 8 and 9).

Synonyms: *Nucula limatula* SAY 1831.*Leda (Yoldia) limatula* STIMPSON 1851.Figures: *Nucula limatula* SAY 1831, pl. 12, 3 figs.; *Yoldia limatula*, in: GOULD & BINNEY 1870, p. 155, fig. 462; VERRILL & BUSH 1897, p. 60, fig. 12; DAUTZENBERG & FISCHER 1912, pl. 11, figs. 7—8.

Diagnosis: SAY 1831.

Type locality: "Nahant, Massachusetts, from stomach of fish."

Description: Shell rather thin, in young specimens somewhat iridescent, transversely ovate, very much elongated, in adult specimens the length being more than twice the height, much compressed, slightly gaping at both ends. The umbo a little in front of the middle, not prominent, inclined backwards. The anterior and the ventral margins almost regularly rounded and entire, hinge-margin behind the umbo almost rectilinear nearly to the tip, compressed, the compression clearly demarcated by a furrow not reaching the tip; the latter a little recurved, pointed, and not truncated. Surface with very minute growth lines, otherwise smooth and covered with a light green to brownish, glazingly varnished periostracum, with an occasional darker zone, and two or three lighter, radiating bands. Inner side bluish-white, somewhat pearly, with very fine radiating lines or striae. Resilifer small, deep, and concave, nearly equilateral-triangular. Anterior series of hinge-teeth slightly bent, posterior series almost straight or bent upwards nearest the resilifer. Teeth rather prominent, excavated on their outer faces, their summits forming a regular arch. The number of teeth may exceed 26 on the anterior, and 22 on the posterior side; the ratio of the number of teeth in front of/behind the umbo about 1.1—1.2. The pallial sinus relatively wide, its inner part rounded, the ventral mantle-line and the basal limit of the sinus meeting in a more or less pronounced tip. The line or band which marks the limit of the genital mass and digestive gland rather rounded. Scars of adductor muscles small. — The dimensions of the shell may amount to: "Length, one and nine-tenths inches; height, nine-tenths of an inch; breadth, five-tenths of an inch" (GOULD 1870, p. 155).

Measurements: 28 specimens have been measured (East Port, N. England, 1; Casso Bay, Maine, 4; Massachusetts Bay, 1; Vineyard Sound, 7; Guildford, Conn., 7; "Northern E. America", 7; New York Bay, 1 specim.) and the measurements are compiled in table 8.

It will be seen that the ratio H/L decreases slightly with increasing length, and in all valves more than 13 mm long it was found to be less than 0.50. The ratio S/L was generally found to exceed 0.50, and it also seems to decrease with an increase of length.

Table 8.

L	H/L	B/L	S/L	f/b
9.7—11.8	0.47—0.51	0.22—0.25	—	1.133—1.133
mean:	0.49 (5)	0.24 (4)	0.53 (1)	1.133 (2)
12.0—17.3	0.46—0.51	0.22—0.23	0.50—0.54	1.125—1.211
mean:	0.48 (14)	0.23 (7)	0.52 (8)	1.74 (10)
20.0—27.2	0.44—0.48	0.22—0.22	0.49—0.52	1.136—1.182
mean:	0.46 (7)	0.22 (4)	0.51 (4)	1.155 (4)
30.3 (1)	0.48	—	0.51	1.217 (1) ¹⁾

¹⁾ Valve broken, reconstructed.

The ratio f/b shows rather great variation—1.125—1.217—and the mean value and the mean error of f/b from 17 valid counts were calculated to be 1.167 ± 0.004 .

The three largest specimens at hand measured: L×H, and f×b (right valve): 30.3×14.6 mm, 28×23 hinge-teeth, reconstructed shell, East Port, N. England; 27.2×12.8 mm, 24×21 hinge-teeth, Casco Bay, Maine; 25.7 × 11.3 mm, 26×22 hinge-teeth, Guildford, Conn.

A comparison of the ratios H/L, B/L, and S/L with those found in *Y. hyperborea* shows little difference as regards these ratios. Notably the ratios of ssp. *limatuloides* are almost the same as those of *Y. limatula* (cf. tables 5, 6, and 7). However, the mean values of the ratio f/b are clearly different in *Y. limatula* and *Y. hyperborea*, being 1.167 and 1.307—1.326, respectively. And further, as already mentioned, they differ in other characters of the shell, which are, no doubt, of specific value.

Distribution: Along the east coast of North America from the Gulf of St. Lawrence to North Carolina (JOHNSON 1934), and along the N. American Pacific coast from the Arctic Ocean to San Diego, California (DALL 1921)¹⁾.

Vertical range: 6—490 m (VERRILL 1884).

Yoldia sapotilla (GOULD).

(Cf. pl. 1, fig. 4, and pl. 2, figs. 6 and 7).

Synonyms: *Nucula sapotilla* GOULD 1841.

? *Nucula Gouldii* DE KAY 1843—"perhaps a shorter variety of *Yoldia sapotilla*" (VERR. & SMITH 1874).

Leda (*Yoldia*) *sapotilla* STIMPSON 1851.

Figures: *Nucula sapotilla* GOULD 1841, fig. 61; *Yoldia sapotilla*, in: GOULD & BINNEY 1870, p. 159, fig. 466; VERR. & BUSH 1897, p. 61, fig. 16.

Diagnosis: GOULD 1841, p. 100.

¹⁾ See p. 14 and p. 24.

Description: Shell thin and fragile, in young specimens translucent, oblong-ovate, compressed, posterior part narrowed and slantingly truncated, gaping a little at both ends. The umbo a little in front of the middle, not elevated, but rather inflated laterally. Antero-dorsal and anterior margins regularly semi-oval, ventral margin somewhat stretched; dorsal margin behind the umbo almost straight to the tip, sharply compressed, but the compression not demarcated; beneath the posterior tip a sinuation in the margin, a wave-like swell running from the umbo to this sinuation; very often a suggestion of a similar formation in the antero-ventral margin. Surface smooth, with only very fine concentric lines. The periostracum thin and glossy, light yellowish-green or olive, with occasional concentric zones of a darker hue. Inner side yellowish-white with bluish-white zones, somewhat pearly. Resilifer deep, concave, and almost triangular in outline. Anterior series of hinge-teeth slightly bent, posterior series almost straight. Teeth small and crowded nearest the umbo, increasing rapidly in size towards the outer ends of the series, rather long and comparatively strongly built at the middle part of the series, excavated at their outer faces. Ratio of number of teeth in front of/behind the umbo about 1.0—1.1. Pallial sinus wide and deep, inner limit more or less rounded, often with a rounded angle at the ventral side; the line or band marking the extension of the genital mass and the digestive gland generally with a rounded angle opposite the anterior row of teeth. — "Length, nine-tenths of an inch" (GOULD 1870).

Measurements: 20 shells were measured, viz. from East Port, N. England, 9; Grand Manan, 4; Off Martha's Vineyard, 6; Iceland, 65°42' N. lat. 13°57' W. long., 1. The measurements and ratios are compiled in table 9.

Table 9.

L	H/L	B/L	S/L	f/b
9.4 (1)	0.57	—	0.51	1.067
12.4—16.9	0.52—ca. 0.55	0.26—0.28	0.49—0.51	1.056—1.117
mean:	0.53 (10)	0.27 (2)	0.50 (7)	1.100 (8)
17.4—21.2	0.51—0.54	0.26—0.30	0.50—0.52	1.044—1.095
mean:	0.53 (5)	0.28 (4)	0.51 (4)	1.060 (4)
24.0—26.8	0.51—0.55 ¹⁾	0.27—0.29	0.49—0.53	1.038—1.095
mean:	0.53 (4)	0.28 (3)	0.51 (3)	1.061 (3)

¹⁾ Single left valve, rather much eroded.

It will be noticed that the ratio H/L is above 0.50, ranging from 0.51—0.57, being highest in small specimens. The ratio S/L ranges

around 0.50, viz. from 0.49—0.52. The ratio B/L was found to range from 0.26 to 0.30, which shows the shells of *Y. sapotilla* to be a little more convex than those of both *Y. limatula* and *Y. hyperborea*. The ratio f/b was found to range from 1.038 to 1.117. The mean value and the mean error of this ratio for 16 valves were calculated to be 1.083 ± 0.002 , thus being markedly smaller than those found in *Y. hyperborea* and *Y. limatula*.

Y. sapotilla attains only about half the maximum length of *Y. hyperborea* or *Y. limatula*. The two largest shells at hand measured: L $\times$ H, and f $\times$ b (right valve): 26.8×14.2 mm, 27×26 hinge-teeth, and 24.0×12.5 mm, 24×22 hinge-teeth, both taken "Off Martha's Vineyard".

According to the characteristic differences between the shells of the above-treated species and those of *Y. sapotilla*, it can hardly be doubted that the latter is a separate species.

Among the specimens of *Y. hyperborea* at hand from Iceland a tube was found with a pair of valves, labelled as from Iceland¹). These valves agree perfectly with the *Y. sapotilla* from N. America, being only a little more elongated than usual. They were connected and filled with fine greyish clay; the outer ligament and the resilium were entirely lacking, but otherwise the valves are in a good state of preservation. They are certainly subfossil. *Y. sapotilla* has hitherto never been met with in the waters around Iceland, neither alive nor as a fossil.

Distribution: *Y. sapotilla* is known from Labrador to North Carolina (JOHNSON 1934).

Vertical range: 8—190 m (Casco Bay and Bay of Fundy).

Yoldia myalis (COUTHOUY).

(Cf. pl. 1, fig. 5, and pl. 2, figs. 5 and 10).

Synonyms: *Nucula myalis* COUTHOUY 1838.

Nucula oblongoides WOOD 1840.

Nucula cascoensis MIGHELS & ADAMS 1844.

Leda (Yoldia) myalis STIMPSON 1851.

Figures: *Nucula myalis* COUTH. 1838, pl. 3, fig. 7; *Nucula cascoensis* MIGH. & AD. 1844, pl. 4, fig. 6; *Yoldia myalis* GOULD & BINNEY 1870, p. 160, fig. 467.

Diagnosis: COUTHOUY 1838, pp. 62—63.

Type locality: "Stomach of cod from Massachusetts Bay."

Description: Shell ovate, moderately convex, thin, not translucent, highest at the umbo, the length less than twice the height,

¹) $65^{\circ}42'$ N. lat., $13^{\circ}57'$ W. long., 60 faths., end of July 1903; "Thor", st. 189. — Recorded as *Y. limatula* in the journal of the expedition.

slightly gaping at both ends. Anterior portion of the shell largest, semi-elliptical; posterior portion sub-triangular, postero-dorsal margin straight to the very tip, sharp and compressed, the compression distinctly demarcated by a furrow. The tip obtusely pointed where the regularly curved ventral margin meets the dorsal margin, though there may be a slight sinuation just below the tip. Umbones small, a little behind the centre, very little protruding above the hinge-margin. Surface somewhat undulated by distant concentric ridges. Periostracum olive-coloured, with alternating darker and lighter zones, with a silky lustre, due to dense, microscopical, concentric, slightly undulated lines. Inner side yellowish-white, glossy, with minute radiating lines or striae. Resilifer deep, triangular in outline. The anterior series of teeth slightly bent, the posterior one almost straight; the two series forming an obtuse angle at the umbo. Teeth small nearest the latter, increasing in distance towards the outer ends, longest at about the middle of each series, deeply excavated on their outer faces. Ratio of teeth in front of/behind the umbo about 1.2—1.3. A thickening of the shell radiates from the umbo in a postero-ventral direction. Pallial sinus wide, comparatively short, and more or less rounded at its inner limit. The line marking the extension of the genital mass and the digestive gland irregularly rounded. Impressions of the adductor muscles relatively large.—“Length, one and one-tenth of an inch; height, seven-tenths of an inch; breadth, seven-twentieths of an inch” (GOULD 1870).

Measurements: The material at the disposal of the author being scarce, only a few valves could be measured, and some of them had injured margins. Hence, the measurements and ratios of these valves are somewhat uncertain, and are given in brackets.

Table 10.

Locality	L	H	S	H/L	S/L	f	b	f/b
East Port, N. England	(21.0)	(11.5)	—	(0.55)	—	—	—	—
— — —	17.0	8.9	7.3	0.52	0.43	19	15	1.267
— — —	(12.6)	6.8	(5.4)	(0.54)	(0.43)	18	15	1.200 ¹⁾
— — —	(12.6)	6.8	(5.3)	(0.54)	(0.42)	19	15	1.267
— — —	12.6	6.9	5.6	0.55	0.44	16	13	1.231 ¹⁾
— — —	10.3	5.6	4.3	0.54	0.42	15	12	1.250
Casco Bay, Maine	13.3	7.2	5.8	0.55	0.44	17	13	1.308
— — —	(13.3)	7.2	(5.9)	(0.55)	(0.44)	17	13	1.308 ¹⁾

¹⁾ Left valves.

From the few calculated ratios it will be seen, however, that the ratio H/L is clearly above 0.50, viz. ranging from 0.52 to 0.55, and that

the ratio S/L ranges from 0.42 to 0.44, thus being somewhat smaller than found in the other species. The ratio f/b of seven valves has been found to range from 1.200 to 1.308, the mean value and the mean error from four right valves are calculated to be 1.273 ± 0.008 , thus lying between the mean values of the ratio f/b as found in *Y. hyperborea* and *Y. limatula*. Still, an exact calculation of the mean value and the mean error of the ratio f/b of *Y. myalis* must be based upon a larger material than the present.

However, from the other characteristics of the shell, e. g. the distinctly demarcated compression behind the umbo, the structure of the periostracum, and the development of the scars and lines on the interior, it is quite evident that *Y. myalis* is as different from *Y. hyperborea* as from the other species of *Yoldia* dealt with here. Therefore, the suggestion put forward by GOULD and other authors that *Y. hyperborea* should be identical with *Y. myalis*, is quite unwarranted.

Both the description and the figure of "*Nucula cascoensis*" given by MIGHELS & ADAMS (1844) agree with the opinion that this form is very likely a variety, or, more probably, represents young specimens of *Y. myalis*, and it has therefore been accepted as a synonym of the latter.

Distribution: Along the East American coast from the Hudson Strait (WHITEAVES 1901) to Massachusetts (JOHNSON 1934), and along the North American west coast from the north coast of Alaska (DALL 1919b), to Puget Sound (DALL 1921); and at the Tchuktchee peninsula (DALL, STIMPSON, according to KRAUSE 1885).

Vertical range: 13—150 m (JOHNSON 1934).

In order to facilitate the determination of the species dealt with here, the most evident characters in which they differ are given in the following brief key.

Key to the species.

1. Umbo clearly behind the middle; periostracum with dense microscopical, concentric lines; length less than twice the height; scars of the adductors rather large (cf. pl. 1, fig. 5, pl. 2, figs. 5 and 10) *Y. myalis*.
 Umbo near the middle; periostracum almost smooth, more or less varnished; scars of the adductors relatively small..... 2.
2. Umbo slightly in front of the middle; no distinct antero-ventral sinuation in the shell margin 3.
 Umbo slightly behind the middle; a distinct antero-ventral sinuation in the shell margin..... 4.

3. Length less than twice the height; a postero-ventral sinuation in the shell margin (cf. pl. 1, fig. 4, pl. 2, fig. 6)..... *Y. sapotilla*.
Length more than twice the height (adults); ventral shell margin entire;
posterior tip pointed; pallial sinus rounded (cf. pl. 1, fig. 3, pl. 2, fig. 8).
Y. limatula.
4. Postero-ventral sinuation in the shell margin; pallial sinus with an angle nearest the umbo *Y. hyperborea*.
a) posterior end not acuminate; the length of adults about, or less than, twice the height (cf. pl. 1, fig. 1, pl. 2, fig. 3) ssp. *hyperborea*.
b) posterior end acuminate; tip somewhat pointed; the length of adults more than twice the height (cf. pl. 1, fig. 2, pl. 2, figs. 1—2. ssp. *limatuloides*.
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V. COMMENTS ON THE RATIOS OF THE VALVES

From the tables in the text it will appear that, as to their ratios H/L, B/L, and S/L, *Y. limatula*, *Y. sapotilla*, and *Y. hyperborea* are so much alike that these ratios are of little use in the distinction between the three species. Only the proportions in *Y. myalis* seem to differ perceptibly from those of the species mentioned above.

The ratio of the hinge-teeth in front of/behind the umbo, however, seems to be more suitable for an identification. In the following diagram the mean value (m), three times the mean error ($\overline{m}$), and the range of variation (v) of the ratio f/b , as found in the four species, are depicted.

The values of *Y. hyperborea* for the different regions are specified, in order to show the deviations of the ratio f/b . From the diagram, however, it appears that good accordance is found as to the values in *Y. hyperborea* from different regions, only the example from W. Iceland differing somewhat. This is because the specimens are derived from one sample, in which all the shells had the posterior portion curiously deformed¹⁾.

It was examined whether the total number of hinge-teeth plotted against the length of the shell, might be used as a distinguishing character in the four species. The result was negative, as the total number of teeth in shells of about the same length overlap in the different species. Only *Y. myalis* seems often to possess comparatively fewer hinge-teeth.

As already mentioned, a diagrammatic test shows no correlation between the ratio f/b and the length of the valve. As the ratio f/b can be regarded as another expression of the proportion of the anterior to the posterior part of the shell, the ratio of the growth in front of behind the umbo seems to be almost constant. At any rate, this holds good of specimens of *Y. limatula*, *Y. sapotilla*, and *Y. hyperborea* exceeding about 12 mm in length. As shown in pl. 2, figs. 4, 7, and 9, the characteristic position of the umbo develops rather early in these three species.

¹⁾ See also the footnote p. 10.

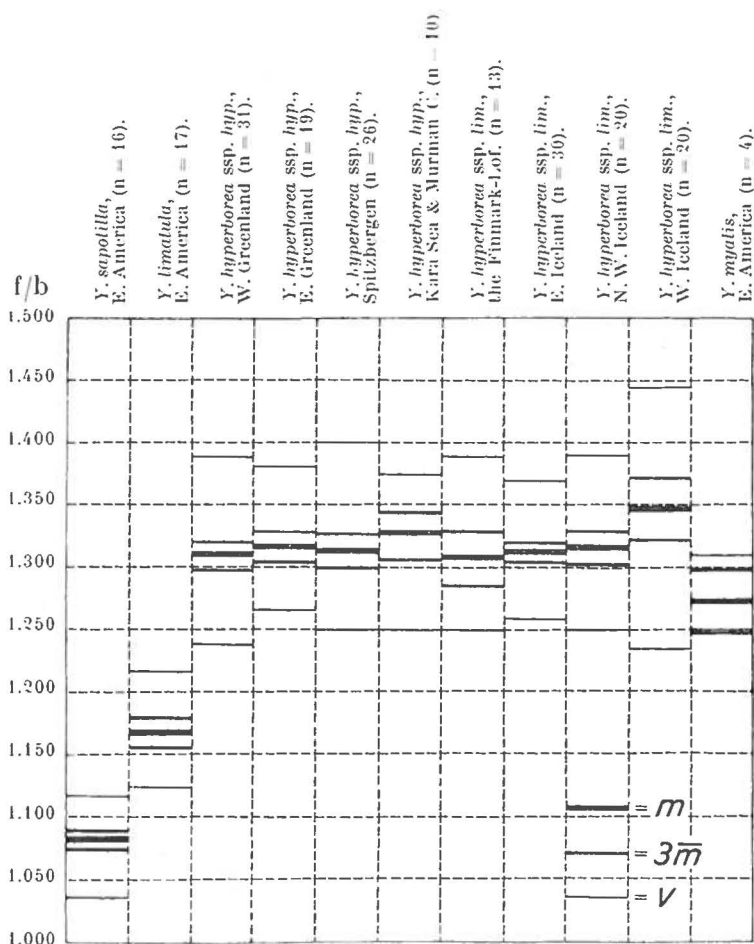


Diagram showing the mean values (m), $3 \times$ the mean errors ($3m$), and the range of variations (v) of the ratio f/b (number of teeth in front of / behind the umbo) in different species of *Yoldia*. — See also the text.

VI. ZOOGEOGRAPHICAL REMARKS

As appears from the Introduction, many authors have united two or more of the species dealt with here; it will therefore be rather difficult, by studying the literature, to find out which species are actually concerned in the individual cases. Hence our knowledge of their real distribution is uncertain, and consequently the zoogeographical conclusions based upon it must likewise be uncertain. Further, the available data on the paleontology of the species are, no doubt, rather incomplete. The results of future investigations, in this connection especially along the coasts around the Northern Seas, may contribute new facts, which will necessitate a modification of our present interpretations.

Notably, our knowledge of the recent distribution of *Y. limatula* and *Y. hyperborea* in the regions of the Bering Sea and adjacent waters is uncertain, for DALL, who has published most papers about the molluscs of these regions, did not keep the two species apart (cf. DALL 119b, p. 5A). But judging from the fairly well-known recent distribution of *Y. limatula* along the east coast of N. America, viz. from N. Carolina to the Gulf of St. Lawrence, and the hydrographical conditions prevailing there, the species recorded by DALL from the north coast of Alaska was not, probably, *Y. limatula*, but more likely *Y. hyperborea*. Anyhow, the latter is known with certainty from the Bering Sea regions (cf. LECHE 1883, p. 444; KRAUSE 1885, p. 25), its distribution being on the whole more northerly than that of *Y. limatula*.

It seems beyond doubt that at the present day *Y. limatula* inhabits two separate regions, viz. mainly the boreal regions of the Pacific and the Atlantic coasts of N. America, respectively, being unable to live under truly arctic conditions. Such a discontinuous distribution is not uncommon among boreal and subarctic marine species. Thus, L. S. BERG (1934) lists many examples of this phenomenon, and its possible causes are dealt with and discussed in a rather comprehensive literature. Not entering further into the various theories set forth to explain a discontinuous distribution among northern marine species, some conclusions drawn by the various authors seem to be certain, and may be summed up as follows:

In Pliocene times—very likely in the upper Pliocene—there existed a freer connection between the marine faunas of the North Atlantic and the Bering Sea regions so that subarctic and even boreal species were enabled to extend their distribution—in one or the other direction—north of the continents. Probably, the warm post-glacial period offered another possibility for an exchange of boreal faunal elements; nor can the possibility of a more effective connection of the two boreal regions during the inter-glacial periods be rejected¹).

Y. limatula is recorded as a Pliocene fossil from S. Carolina, and as a post-Pliocene one from Canada, Virginia, N. and S. Carolina (VERRILL & SMITH 1874, p. 395). In addition, it is known from Pleistocene deposits in California and from the St. Paul Island (DALL 1899, pp. 545—46, as *Y. limatula*, var.). — SOOT-RYEN (1932, p. 19), like DALL, includes *Y. hyperborea* in *Y. limatula*, and writes (p. 25): “The recent Pelecypods first met with in Miocene deposits on the western coast of North America are, according to HÄGG (1924), DALL (1896, 1909): . . . perhaps also *Yoldia limatula*.” No doubt, SOOT-RYEN confuses *Y. limatula* with *Y. lanceolata* SWB., which species DALL records from some Miocene rocks at Coas Bay, Oregon (1909, p. 475), for SOOT-RYEN also mentions the former species from the Pliocene of England. As far as is known, however, *Y. limatula* has never been found—neither as a fossil nor recent—in Europe. In this case, at any rate, the species concerned is *Yoldia lanceolata*, which is now restricted to the northern part of the Pacific (KRAUSE 1885, OLDROYD 1924).

Thus, *Y. limatula* dates back to the Pliocene time, and obviously it has been able to expand its area of distribution in earlier times to the two boreal coast stretches of N. America which are now separated by arctic waters. On the basis of the available data, however, it seems impossible to ascertain the route along which it extended its distribution from its possible place of origin in the Pliocene of South Carolina.

Yoldia sapotilla is known as a Pleistocene fossil from New Brunswick (MATTHEW, according to DAWSON 1893, p. 241). — DAWSON (op. cit., p. 242) also mentions some fossil shells from the Leda-clay at Rivière-du-Loup, S.E. Canada, “which approach *Y. sapotilla* in form, though they have the number of hinge-teeth of *Y. limatula*.” This, however, may just as well be an intermediate form between *Y. limatula* and *Y. hyperborea*, since DAWSON did not distinguish between the latter and *Y. sapotilla*. — In this connection it may be reasonable to call attention to the find of a probably subfossil pair of

¹) Cf. DALL 1910, 1920; JENSEN & HARDER 1910; HOFSTEN 1915; SOOT-RYEN 1932; L. S. BERG 1934; SV. EKMAN 1953. — See also J. P. SMITH (1919, pl. 9 and p. 139), whose opinions as to the age of a shell-bed at Nome, Alaska, and the climate of western N. America during the Pliocene time are in contrast to those of DALL.

valves of *Y. sapotilla* off the N. coast of Iceland (cf. p. 18). This find might indicate that in the younger Quaternary the distribution of *Y. sapotilla* ranged farther eastward than at present when it is confined to the east coast of N. America.

Yoldia hyperborea is known from the late-glacial period from several localities in Norway, i. a. from the Oslo area (BRÖGGER 1900—01) and from the Trondhejm area (ØYEN 1915). They both record ssp. *hyperborea*, a form which should be regarded as ssp. *limatuloides*, and some transitional forms. From northern Jutland, Denmark, it is known from the end of the last interglacial and the last glacial periods (JESSEN 1936, pp. 183—184)¹⁾. JEFFREYS (1884, p. 320) records it as "*Yoldia limatula* SAY" from the "Basement" clay at Bridlington Quay, East England, and KNIPOWITSCH (1900) from many post-Pliocene deposits at the river Dvina, N. Russia. BARDARSON (1922, p. 355) mentions it as "*Yoldia* sp. (*hyperborea*?)" from the Late-Glacial at Breidifjörður, W. Iceland, and DAN LAURSEN (1946, p. 26) records it as a Quaternary fossil²⁾ from Vansittard Island, south of the Melville Peninsula, and from several marine deposits in the Christianshåb district, West Greenland (1950).

Thus, all the known finds of fossil and subfossil *Y. hyperborea* from regions bordering on the North Atlantic, suggest that it is probably of Atlantic origin, and a late immigrant into the Bering Sea and the Siberian Ice-Sea.

Both *Y. hyperborea* and *Y. sapotilla* show a rather short range in geological time. Their development is probably due to the shifting of the faunistic boundaries during the different periods of the Ice Age. For obvious reasons it is tempting to consider *Y. limatula* to be most closely associated as to origin with these two species.

Yoldia myalis is known from the upper strata of the European Pliocenebasin. TESCH (1912, p. 9) records it from the Amstelian of the Netherlands; WOOD (1872—74, pp. 114—115) from several localities in England as "*Leda myalis* COUTH." and "*Leda oblongoides* WOOD"³⁾. — The author has studied some valves of *Yoldia* from the Crag formation at Tjornes, Iceland⁴⁾. These had been erroneously identified as "*Yoldia hyperborea* Lov.", but clearly proved to belong to *Y. myalis*. This in addition confirms the well-known resemblance between the Crag faunas

¹⁾ These fossil fragments, which the author had the opportunity to see, indicate that already at the end of the last Interglacial *Y. hyperborea* was of the same appearance as now.

²⁾ From personal experience the author is convinced of the correctness of this identification.

³⁾ After comparing recent *Y. myalis* with a valve of "*Leda oblongoides* WOOD" from the English Crag, the author is strongly inclined to regard them as belonging to the same species.

⁴⁾ Ten more or less complete valves from Hallbjarnarstadir-Kambur.

of Iceland and England. — WOOD (loc. cit.) records *Y. myalis* (with "*L. oblongoides*") from England from as late a period as the lower and the middle Glacial. Then it probably became extinct in Europe, but is met with in the Leda-clay of Labrador (PACKARD 1867). Since *Y. myalis* is not known as a fossil from the west coast of N. America, it very likely immigrated rather late into this region. Probably, the immigration took place during an inter-glacial or the warm post-glacial period.

According to the available literature, *Y. myalis* has not been found living from N. Alaska to the Hudson Strait, and therefore its recent distribution should be considered discontinuous like that of *Y. limatula*.

The occurrence of *Y. myalis* in the Pliocene of Iceland adds another example to the records of molluscs found as Pliocene fossils in Iceland, which are now known to live in the North-Western Atlantic or/and the Bering Sea only, such as *Venericardia borealis* (CONRAD), *Liomesus canaliculatus* (DALL), *Macra solidissima* (DILLWYN), and *Urosalpinx cinerea* SAY¹).

It is noteworthy that the areas of distribution of *Y. myalis*, *Y. limatula*, and *Y. sapotilla* overlap to some extent, viz. along the N. American west coast those of the former two species overlap from Alaska to Puget Sound, and those of all three species along the east coast of N. America from the Gulf of St. Lawrence to Massachusetts. *Y. hyperborea*, too has perhaps been found to live within the latter region (cf. p. 14, footnote 1), but apart from these areas the distributions of the four species differ. This partial overlapping of distribution does not support the view that they are varieties of the same species; for nothing is known about the existence of any recent intermediate forms between the four species dealt with here.

¹) This species has recently been casually introduced with oyster spat into England.

SUMMARY

The shells of *Yoldia hyperborea* (LOV.) TORELL, *Y. limatula* (SAY), *Y. sapotilla* (GOULD), and *Y. myalis* (COUTHOUY) are re-described, figured, and their proportions calculated (see the key on p. 20).

The elongated *Y. hyperborea* from Iceland and Northern Norway is erected as subspecies *limatuloides*, n. ssp.

The total number of hinge-teeth was found to be of little use for an identification; on the other hand, the ratio of the number of hinge-teeth in front of/behind the umbo in these species was found to be useful for the purpose.

It was attempted to give a survey of the distribution of the four species in space and time. Some results as to their migration in ancient times were obtained (pp. 21—25).

From morphological features of the shells as well as from paleontological data, it appears that *Y. limatula*, *Y. sapotilla*, and *Y. hyperborea* form a group of closely related species, to which *Y. myalis* has a somewhat more distant relationship.

Y. myalis is recorded from the Crag formation, and *Y. sapotilla* as probably subfossil, both from Iceland.

LITERATURE

- BARDARSON, G. G., 1922. Fossile Skalaſlejringar ved Breidifjörður i Vest-Island. — Geol. fören. Stockholm förhdl., Bd. 43, Stockholm 1922.
- 1925. A stratigraphical survey of the Pliocene deposits at Tjörnes, in Northern Iceland. — K. Danske Vid. Selsk. Biol. Medd., Vol. 4, No. 5, København 1925.
- BERG, L. S., 1934. Über die amphiboreale (diskontinuierliche) Verbreitung der Meeresfauna in der nördlichen Hemisphäre. — Zoogeographica, Bd. II, 1933/35, Jena.
- BRÖGGER, W. C., 1900—01. Om de senglaciale og postglaciale nivåforandringer i Kristianiafeltet (Molluskfaunan). — Norges geol. unders., No. 31, Kristiania.
- BUSH, K. J., 1884. Catalogue of *Mollusca* dredged on the coast of Labrador by the Exped. of Stearn. — Proc. U. S. Nat. Mus., vol. 6, 1883, Washington.
- COLLIN, J., 1887. Brachiopoder, Muslinger og Snegle fra Karahavet. Dijnphna Tøgtets Zoolog.-bot. Udbytte. København.
- COUTHOUY, J. P., 1838. Description of new species of *Mollusca* and Shells in Massachusetts Bay. — Boston Journ. Nat. Hist., vol. 2, 1838—39, Boston.
- DALL, W. H., 1885. Report on the Mollusks. Report of the International Polar Expedition to Point Barrow, Alaska. Part IV, Washington.
- 1896a. Diagnoses of new species of Mollusks from the west coast of America. — Proc. U. S. Nat. Mus., vol. 18, Washington.
- 1896b. Report on Coal and Lignite of Alaska. — 17th Ann. Rep. U. S. Geol. Surv. 1895—96. Washington.
- 1899. The Mollusk Fauna of the Pribilof Islands. Extracted from: The Fur Seals and Fur-Seal Islands of the North Pacific Ocean, Part III, pp. 539—546. Washington.
- 1907. On Climatic Conditions at Nome, Alaska, during the Pliocene, etc. — Amer. Journ. Sci., vol. 23, pp. 457—458.
- 1909. Contributions to the Tertiary Paleontology of the Pacific coasts. I. The Miocene of Astoria and Coas Bay, Oregon. — U. S. Geol. Surv. Prof. Paper. No. 59. Washington.
- 1910. Notes on Post-glacial evidence of climatic changes in North America as indicated by marine fossils. — Repr. from "Postglaziale Klimaveränderungen", pp. 365—366. Stockholm 1910.
- 1919a. Paleontology. On some Tertiary fossils from the Pribilof Islands. — Wash. Acad. Sci., vol. 9, no. 1.
- 1919b. Mollusks, Recent and Pleistocene. Rep. Can. Arct. exp. 1913—18, vol. VIII, part A. Ottawa.
- 1920. Pliocene and Pleistocene fossils from the Arctic coast of Alaska, etc. — U. S. Geol. Surv. Prof. Paper 125—C, pp. 23—37.
- 1921. Summary of the marine shell-bearing mollusks of the Northwest Coast of America. — U. S. Nat. Mus. Bull. 112. Washington.

- DALL W. H. 1924. Mollusks, Recent and Pleistocene. Suppl. Rep. Can. Arct. Exp. 1913—18, vol. VIII, part A. Ottawa.
- DAUTZENBERG, PH. & FISCHER, H., 1912. Mollusques provenant des campagnes de l'Hirondelle de la Princesse Alice dans les mers du Nord. — Rés. Camp. Sci. Albert I de Monaco. Fasc. XXXVII. Monaco 1912.
- DAWSON, J.W., 1893. The Canadian Ice Age. Montreal 1893.
- DE KAY, J. E., 1843. Natural History of New York. Part V, *Mollusca*.
- DREW, G. A., 1899a. *Yoldia limatula*. — Mem. John Hopkins Univ. Biol. Lab., vol. IV, part 3.
- 1899b. Some Observations on the Habits, Anatomy and Embryology of Members of the *Protobranchia*. — Anat. Anz., Bd. 15, Nr. 24. Jena.
- 1900. Locomotion in *Solenomya* and its Relatives. — Anat. Anz., Bd. 17, Nr. 15. Jena.
- EKMAN, SV., 1953. Zoogeography of the Sea. London 1953.
- EYERDAM, W., 1924. Marine shells of Drier Bay, Knight Island, Prince William Sound, Alaska. — Nautilus, Vol. 38, No. 1. Boston.
- FRIELE, H. & GRIEG, J. A., 1901. The Norwegian North-Atlantic Expedition 1876—78. *Mollusca* III. Kristiania.
- GOULD, A. A., 1841. Report on the *Invertebrata* of Massachusetts. Cambridge.
- GOULD, A. A. & BINNEY, W. G., 1870. Report on the *Invertebrata* of Massachusetts. 2^d edition. Boston.
- GRIEG, J. A., 1909. Brachiopods and Molluscs, with a Supplement to the Echinoderms. — Rep. Sci. Norw. Arct. Exp. "Fram" 1898—1902. Vol. III, No. 20. Kristiania.
- HARNER, F.W., 1914—20. The Pliocene *Mollusca* of Great Britain. Vol. I—II. Paleontographical Society. London.
- HOFSTEN, N., 1915. Die Echinodermen des Eisfjordes. — K. Sv. Vet. Akad. Handl., Bd. 54, No. 2. Stockholm.
- HÄGG, R., 1904. *Mollusca* und *Brachiopoda* gesammelt von der schwedischen zoologischen Polarexpedition nach Spitzbergen, dem nordöstlichen Grönland und Jan Mayen i. J. 1900. I. *Lamellibranchia*. — Arkiv f. Zoologi, Bd. 2, No. 2. Stockholm 1904.
- 1924. Stängenaskraniets skalbank. — Geol. fören. förhdl., Bd. 46, H. 5. Stockholm.
- JEFFREYS, J. G., 1884. List of Shells obtained from the "Basement" Clay at Bridlington Quay. — Quarterly Journ. Geol. Society, XV, pp. 319—322, 1884.
- JENSEN, AD. S. & HARDER, P., 1910. Post-glacial changes of climate in Arctic regions as revealed by investigations of marine deposits. — Repr. from "Postglaziale Klimaveränderungen", pp. 399—407. Stockholm 1910.
- JESSEN, A., 1936. Vendsyssels Geologi. — Danmarks geol. Unders., V. Række, Nr. 2. 2^d Edition. København.
- JOHNSON, C.W., 1915. Fauna of New England. 13, List of the *Mollusca*. — Occ. papers Boston Soc. Nat. Hist., vol. 7. Boston.
- 1926. A list of the Molluscs collected by Mr. Owen Bryant along the coasts of Labrador, New Foundland and Nova Scotia. — Nautilus Philad., Vol. 40, pp. 22—25.
- 1934. List of marine *Mollusca* of the Atlantic coast from Labrador to Texas. — Proc. Boston Soc. Nat. Hist., vol. 40.
- KNIPOWITSCH, N., 1896. Eine zoolog. Exkursion im nordwestlichen Theile des Weissen Meeres im Sommer 1895. — Ann. Mus. Zool., Tome 1. St. Pétersbourg 1896.

- KNIPOWITSCH, N. 1900. Zur Kenntnis der geologischen Geschichte d. Fauna des Weissen und des Murman-Meeres. — Verh. Russ. Mineral. Ges., Ser. 2, Bd. 38, No. 1. Petersburg 1900.
- 1901. Explorations Zoolog. sur le bateau casse-glace "Ermak", 1901. — Ann. Mus. Zool., Tome 6, No. 2—3. St. Pétersbourg 1901.
- KRAUSE, A., 1885. Ein Beitrag zur Kenntnis der Molluskenfauna des Beringsmeeres. *Brachiopoda et Lamellibranchiata*. — Arch. f. Naturgesch., Bd. 51, H. 1.
- LAURSEN, DAN, 1946. Quaternary shells. Report of the Fifth Thule Expedition 1921—24. Vol. I, No. 7. Copenhagen 1946.
- 1950. The stratigraphy of the marine Quaternary deposits in West Greenland. — Medd. om Grønland, Bd. 151, No. 1. København.
- LECHE, W., 1878. Öfersikt öfver de af Svenska Exped. till Novaja Semlja och Jenissej 1875 och 1876 insamlade hafsmollusker. — K. Sv. Vet. Akad. Handl., Bd. 16, No. 2. Stockholm.
- 1883. Öfersikt öfver de af Vega-Expeditionen insamlade arktiska hafsmolluskerna. I. *Lamellibranchiata*. Vega-Exped. Vetensk. Iakttagelser, Vol. 3. Stockholm.
- MADSEN, F. J., 1949. Marine *Bivalvia*. — The Zoology of Iceland, vol. 4, part 63. Copenhagen.
- MIGHELS, J. W. & ADAMS, C. B., 1844. Description of 24 species of the shells of New England. — Boston Journ. Nat. Hist., vol. 4, 1843—44. Boston.
- MORSE, E. S., 1919. Observations on Living Lamellibranchs of New England. — Proc. Boston Soc. Nat. Hist., vol. 35, no. 5.
- MÖLLER, H. P. C., 1842. *Index Molluscorum Groenlandiae*. — Naturh. Tidskr., Bd. 4, 1842—43. Kjøbenhavn.
- MORCH, O. L. A., 1857. Fortegnelse over Grønlands Bløddyr. Naturh. Bidrag til en Beskrivelse af Grønland af I. Reinhardt, etc. Kjøbenhavn.
- 1871. On the *Mollusca* of the Crag formation of Iceland. — Geol. Magazine, Vol. VIII, No. 9. London.
- 1875. *Prodromus Faunae Molluscorum Groenlandiae*. Admiralty. London.
- ODHNER, N. HJ., 1910. Marine *Mollusca* of Iceland in the collections of the Swedish State Museum. — Arkiv f. Zoologi, vol. 7. Stockholm.
- 1915. Die Molluskenfauna des Eisfjordes. — K. Sv. Vet. Akad. Handl., Bd. 54, Nr. 1. Stockholm.
- OLDROYD, I. S., 1924. Marine shells of Puget Sound and vicinity. — Publ. Puget Sound Biol. Stat., vol. 4. Seattle.
- PACKARD, A. S., 1863. List of animals dredged near Caribou Island, southern Labrador. — Canad. Natural., vol. 8, no. 6, Montreal.
- 1867. Observations on the Glacial Phenomena of Labrador and Maine, with a view of the recent invertebrate fauna of Labrador. — Mem. Boston Soc. Nat. Hist. N. S., Vol. 1, Part 2. Boston.
- 1884. Additional list of *Mollusca* from Labrador (included in the paper of K. J. Bush, 1884—which see).
- POSSELT, H. J. & JENSEN, AD. S., 1898. Grønlands Brachiopoder og Bløddyr. In: *Conspectus Faunae Groenlandiae*. — Medd. om Grønland, Bd. 23, Kjøbenhavn.
- REEVE, L., 1855. Account of the shells. In: E. BELCHER, The last of Arctic Voyages. Vol. 2. London.
- SARS, G. O., 1878. Bidrag til Kundskaben om Norges Arktiske Fauna. I. *Mollusca regionis arcticae Norvegiae*. Christiania.
- SARS, M., 1851. Beretning om en Sommeren 1849 foretagen Zoolog. Reise i Lofoten og Finmarken. — Nyt Mag. f. Naturv., Bd. 6, H. 2, Kristiania.

- SAY, R., 1831. American Conchology, part 2.
- SMITH, J. P., 1919. Climatic Relations of the Tertiary and Quaternary Faunas of the Californian Region. — Proc. Calif. Acad. Sci., Vol. IX, No. 4. San Francisco.
- SOOT-RYEN, T., 1932. *Pelecypoda* with a discussion of possible migrations of Arctic pelecypods in Tertiary times. — The Norwegian North Polar Exp. with the "Maud" 1918—1925. Scient. Results, Vol. V, No. 12. Bergen.
- STIMPSON, W., 1851. Shells of New England. Boston.
- TESCH, P., 1912. Beiträge zur Kenntnis der Marinen Mollusken im West-Europäischen Pliocänbecken. — Mededeel. van de Rijksopsp. van Delfstoffen. No. 4. S. Gravenhage.
- THORSON, G., 1951. *Scaphopoda, Placophora, Solenogastres*, etc. The Godthaab Exp. 1928. — Medd. om Grønland, Bd. 81, No. 2, København.
- TORELL, O., 1859. Bidrag till Spitzbergens Molluskfauna. Stockholm.
- VERRILL, A. E., 1884. Second catalogue of *Mollusca* recently added to the Fauna of the New England coast, etc. — Trans. Conn. Acad., Vol. 6.
- VERRILL, A. E. & BUSH, K. J., 1897. Revision of the genera of *Ledidae* and *Nuculidae* of the Atlantic coast of the United States. — Amer. Journ. Sci., Vol. 3, pp. 51–63.
- VERRILL, A. E. & SMITH, S. I., 1874. Report upon the invertebrate animals of Vineyard Sound, etc. — Rep. U. S. Comm. Fish., 1871—72, part 1. Washington.
- WHITEAVES, J. F., 1901. Catalogue of the Marine *Invertebrata* of Eastern Canada. — Geol. Surv. of Canada, 1901. Ottawa.
- WOOD, S. V., 1848—61. A Monograph of the Crag *Mollusca*. Vol. I—II. Paleontographical Society. London.
- 1872—74. Vol. III (Supplement). Ibid.
- ØYEN, P. A., 1915. Kvartær-Studier i Trondhjemsfeltet. III. — Kgl. Norske vid. Selsk. Skrifter, 1914, No. 6. Trondhjem.

PLATES

Plate 1.

Inner side of left valve.

Fig. 1. *Y. hyperborea* (Lov.) TORELL, ssp. *hyperborea*, N. Stromfjord, W. Greenland.
— Fig. 2. *Y. hyperborea* (Lov.) TORELL, ssp. *limatuloides* n., Fossfjord (Arnarfj.),
N.W. Iceland, type specimen of subspecies. — Fig. 3. *Y. limatula* (Say), Casco Bay,
Maine. — Fig. 4. *Y. sapotilla* (Gould), Iceland, 65°42' N., 13°57' W. — Fig. 5.
Y. myalis (Couth.), East Port, N. England, inner side of right valve.

Drawings by POUL H. WINTHER.

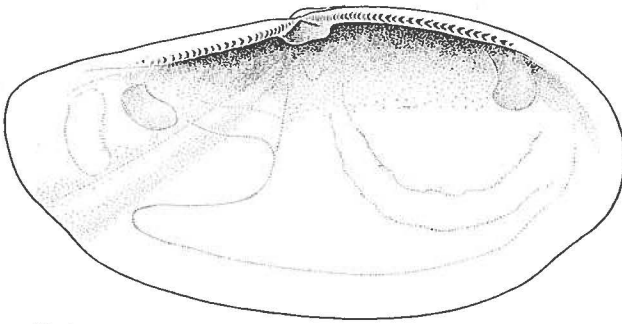


Fig. 1.
Yoldia hyperborea (Lovén) Torell,
ssp. hyperborea.

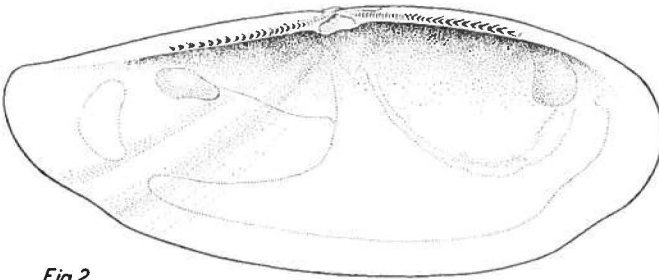


Fig. 2.
Yoldia hyperborea (Lovén) Torell,
ssp. limatuloides, n. ssp.

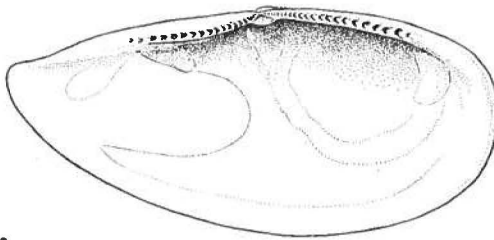


Fig. 3.
Yoldia limatula (Say).

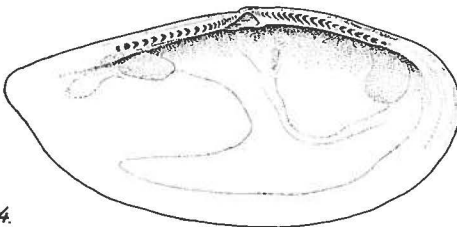


Fig. 4.
Yoldia sapotilla (Gould).

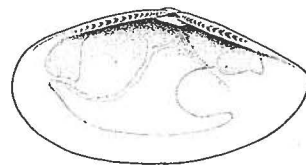


Fig. 5.
Yoldia myalis (Couthouy).

2cm