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NOTES ON TWO ORDOVICIAN OSTRACODS FROM ESTONIA

BY

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CONTENTS

INTRODUCTION

No note had previously been taken of certain features of two species of Estonian ostracods. Recently acquired specimens make their study possible. In this paper the false pouch of the female dimorph of *Rakverella bonnemai* Öpik is described and illustrated for the first time and the frills of the male and female dimorphs of *Opikium tenerum* (Öpik) are discussed. The individuals, in which these characters were observed, were embedded in two small fragments of kuckersite, a rare kind of bituminous deposit. The sample, weighing about 3 ounces, was given to me by Mr. Raymond R. Hibbard, of Buffalo, New York. The accompanying label reads "Kukruse C2, near Kohtla." Kukruse C2 is another name for the upper Middle Ordovician Kuckers shale or Brandschiefer. Kohtla (or Kothla or Kokhtla) is a town in eastern Estonia (now Estonian S.S.R. of the U.S.S.R.) on the Gulf of Finland, 114 miles west-southwest of Leningrad and about 32 miles east of Rakvere (formerly Wesenberg). Both the rock and the shale are named for Kuckers, an Estonian village at or near the present town of Kohtla.

The matrix of the samples is reddish brown on the weathered surfaces and buff brown on the unweathered; the fossils are white. Microscopic examination of the matrix reveals it to be a mat of very small crushed resinous bodies. This exceptional Ordovician deposit is so rich in fatty or waxy hydrocarbons that it can be ignited with a match. The composi-

tion of kuckersite offers a clue to the conditions under which it was deposited. Kuckersite (Zalessky, 1920, pp. 77–94; Lindenbein, 1921*b*, pp. 71–74; Kogerman, 1935, pp. 301–5) is a boghead that consists almost exclusively of the remains of *Gloeocapsomorpha prisca* Zalessky (Zalessky, 1917, pp. 36–41), a colonial unicellular alga closely related to the living genus *Gloeocapsa*. *Gloeocapsomorpha prisca* was assigned by Zalessky (1920, p. 89) to the Cyanophyceae and by Lindenbein (1921*a*, p. 62) to the Protophyceae. The hydrocarbon content of the formation was known long ago. Andrée (1935, p. 462) quotes the following interesting account by J. Georgi in *Geographisch-physikalischen Beschreibung des russischen Reiches,* published in Königsberg in 1791–98. Georgi, who knew of the burning properties of kuckersite from its use by shepherds, recorded the presence of marine fossils and tested the rock for the percentage of pitch.

Braunliche, schiefernde, tonige und mergelige Bergpecherde im estländischen Gouvernement, im Wesenberg'schen Kreise auf dem Gute Tolks, als eine bis 3 Fuss mächtige ausgebreitete Lage. Sie brennt mit Flamme ohne üblen Geruch. 10 Unzen dieser Erde enthalten bis 4 Unzen Bergharz und 25 Grane Kochsalz. Man findet überall Meeresbrut in derselben. Die Hirten bedienen sich dieser Erde zur Unterhaltung ihres Nachtfeuers.[1]

Kuckersite has been burned, alone or mixed with oil, as a fuel for power production, treated to produce gas, and distilled in special retorts for petroleum (Kogerman, 1935, p. 303). The residues from its distillation are used as pitch in roofing felt and as asphalt for street paving (Andrée, 1935, p. 466). The oil from the rock is of the asphalt-base type. Kogerman (1935, p. 302) wrote:

Im Hinblick auf den chemischen Charakter der aus ihnen gewonnen Öle können die Brennschiefer, ebenso wie die Naturnaptha, in 2 Gruppen eingeteilt werden: die 'Asphalt-brennschiefer' und die 'Paraffinbrennschiefer.' Als Beispiel der 1. Gruppe kann der estländische Brennschiefer erwähnt werden . . . . Der estländische Brennschiefer—Kuckersit—ist ein Mineral von hellbrauner bis dunkelbrauner Farbe. Es ist einer der ältesten und reichsten Brennschiefer der ganzen Welt; die Fundstätte liegt im unteren Silur (Ordovitium) und gehört zu der Kuckersstufe.[2]

The rock itself contains approximately 65 per cent carbon and 8 per

[1] "Brownish, slaty, clayey, and marly bituminous earth in the Estonian province, in the Wesenberg region at the Gute Tolks, occurs as a spread out deposit up to 3 feet thick. It burns with a flame without the usual odor. 10 ounces of this earth contains up to 4 ounces of asphalt and 25 grains of table salt. One finds marine fossils throughout the deposit. The shepherds use this earth for the maintenance of their night fires."

[2] "With regard to the chemical character of the oil obtained from them, the fuel shales can be divided into two groups, just as can natural petroleum: the 'asphalt fuel shales' and the 'paraffine fuel shales.' As an example of the first group, the Estonian fuel shale can be mentioned . . . . The Estonian fuel shale—kuckersite— is a mineral of bright brown to dark brown color. It is one of the oldest and richest fuel shales of the entire world; the occurrence is in the lower Silurian (Ordovician) and belongs to the Kuckers formation."

cent hydrogen (Twenhofel, 1932, p. 408). Its carbon content is about equal to that of recent alga sapropels; the hydrogen content only a little less. The organic content of Kuckers shale is further increased by irregular black lenses of asphaltite scattered throughout. The asphaltite has about the same composition as the asphalt residues from the distillation of kuckersite oil. It is 84 per cent carbon, 9 per cent hydrogen, and 7 per cent oxygen, nitrogen, and sulfur (Kogerman, 1933, pp. 220–21).

Obviously the Kuckers shale was deposited in a toxic environment, for only in the absence of bacteria could hydrocarbons be preserved in so nearly their original composition. The ostracods and bryozoa must have been transported into this unusual death trap and burial ground. Uniform conditions existed over a broad area; the length of the formation's outcrop is about 50 miles. Moreover, they probably persisted for a long time, inasmuch as the deposit, after compaction, is 13 feet thick. Modern bogheads or sapropels of related algae collect in waters that are never more than 4 meters in depth and usually less than 1 meter (Zalessky, 1920, p. 90). An original toxicity may also account for the excellent preservation of delicate structures on the fossils, because few or no scavengers could survive in such waters.

The ostracods in the sample are exceedingly fragile and must be cleaned with a fine needle. Complete carapaces are filled with nearly transparent crystalline calcite. Separate valves are translucent to transparent and very thin. It may be that the original deposition was in slightly acid water that etched away some of the shell material. If so, the action was uniform, for all specimens have the same thickness of valve and the same retention of ornamentation.

To Mr. Raymond R. Hibbard I am very grateful for the gift of the sample. Dr. A. Öpik, who is now at the Bureau of Mineral Resources, Canberra, Australia, generously confirmed the classification of *Rakverella bonnemai* and offered many helpful notes on taxonomy. Dr. C. A. Arnold, Dr. G. M. Ehlers, and Dr. L. B. Kellum kindly criticized the typescript of this paper.

The new specimens referred to are deposited and catalogued in the Museum of Paleontology of the University of Michigan.

Genus *Rakverella* Öpik

Rakverella Öpik, 1937, p. 45.
Dicranella (in part) Schmidt, 1941, p. 48.
Rakverella Agnew, 1942, p. 760; Cooper, 1942, p. 775; Henningsmoen, 1953, pp. 218, 267.

Genotype.—By original designation, *Rakverella spinosa* Öpik (1937, p. 45, Fig. 6, Pl. 9, Fig. 6).

Familial position.—Öpik (1937, p. 45) originally assigned *Rakverella* to the family Beyrichiidae Ulrich, 1894. Schmidt suggested that *Rakverella* might be a junior synonym of *Dicranella* and he allotted *Dicranella* to the subfamily Ctenonotellinae Schmidt, 1941, of the family Hollinidae Swartz, 1936 (1941, p. 48):

Die neue Gattung *Rakverella* Öpik 1937, über deren Beziehungen zu anderen Gattungen der Autor selber wenig aussagt (der von ihm nur angedeutete Vergleich mit *Beyrichia* widerspricht der übrigen Beschreibung und den Abbildungen) scheint sich von *Dicranella* lediglich durch anderen Erhaltungszustand oder reichere Verzierung der Schale zu unterscheiden . . . Deshalb halten wir, soweit ohne Kenntnis der Originale ein Urteil möglich ist, die Aufstellung der Gattung *Rakverella* für ungerechtfertigt.[3]

Agnew (1942, p. 760) placed *Rakverella* in the family Piretellidae Öpik, 1937. Henningsmoen (1953, p. 267) put it in the subfamily Piretellinae Öpik, 1937, and with question assigned the subfamily to the family Tetradellidae Swartz, 1936.

In a letter dated November 10, 1954, Dr. A. A. Öpik wrote me:

As far as I remember, the piretellids and *Rakverella* were considered as two separate lineages with different ancestors in the lower Ordovician Pakri Sandstone (about upper Canadian). This work, however, will remain unpublished and unfinished, and a taxonomist must be satisfied with the published material.

I think that phylogenetic considerations provide 'reasons of necessity' for establishing taxonomic units, especially genera. The method, however, must be strictly morphological. The concept of the 'volume' of a genus is, however, subjective. So, I have no objection if *R. bonnemai* becomes a new genus, and your fine specimen deserves to be published anyway . . . .

Simply, there are other perspectives in the taxonomy of ostracods than the current ones, and I believe that one or another modern scheme may contain at least a part of the true answer — the more so since the general frame-work created by Ulrich and Bassler is already correct.

Familial assignment of *Rakverella* depends upon knowledge of the dimorphism in the genus. Although Henningsmoen (1953, p. 218) wrote, "The writer has in addition seen individuals of *Rakverella* with the frill incurved to form a false pouch very similar to that in *Piretella,*" he gave no details or illustrations of the false pouch and he did not say whether the females belonged to the type species, *R. spinosa,* or to another. *Rakverella bonnemai* Öpik has a female dimorph with a false pouch (see description, below, and Pl. I, Figs. 1*a*–6). Until such time as *Rakverella spinosa* Öpik can be shown to have a female dimorph with a similar

[3] "The new genus *Rakverella* Öpik 1937, about whose relations to other genera the author himself said little (the only comparison suggested by him, with *Beyrichia,* contradicts the rest of the description and the figures), seems to differ from *Dicranella* merely by other preservation or richer ornamentation of the carapace . . . . Therefore, we hold, insofar as a decision is possible without knowledge of the original, the erection of the genus *Rakverella* to be unjustified."

false pouch, *R. bonnemai* cannot be proved to be congeneric with it and the assignment of *R. bonnemai* to *Rakverella* must remain tentative. As that family is accepted today, *Rakverella bonnemai* does not belong to the Beyrichiidae. This family has been much amended from its original description and is now restricted to genera with a brood pouch in one dimorph. *R. bonnemai* has the same kind of dimorphism as that in species of *Piretella* and *Hollina*. Because the females in these two genera both have the frills strongly incurved to form false pouches, I consider them to be members of one family. *R. bonnemai* with its incurved frill, therefore, belongs to the family Hollinidae, as does *Piretella*.

Rakverella bonnemai Öpik
(Pl. I, Figs. 1–6; Fig. 1)

Rakverella bonnemai Öpik, 1937, p. 46, Pl. 9, Fig. 4; Pl. 15, Figs. 10–11; Henningsmoen, 1953, p. 218.

? Tetradella? pectinata Öpik, 1937, p. 29, Pl. 4, Fig. 9; Pl. 7, Figs. 4–5; Pl. 10, Fig. 16; Pl. 15, Fig. 12.

? Tetradella? sp. aff. *pectinata* Öpik, 1937, p. 30, Pl. 9, Fig. 5; Pl. 15, Fig. 15.

The specimens Öpik described in 1937 were deposited in the University of Tartu and are not available. Without seeing them I cannot decide whether *Tetradella? pectinata* and *Tetradella?* sp. aff. *T. pectinata* represent valid species or, as Henningsmoen suggested (1953, p. 218), are synonyms of *Rakverella bonnemai* Öpik.

Description of female carapace.—Carapace apparently better preserved than in the specimens earlier described. Overlap left/right. Carapace, exclusive of ends of lobes, subpyriform to subelliptical, in lateral view; elongate subquadrate, in dorsal view; and subcuneate to subovate, in end view. Greatest height nearly median, slightly anterior. Greatest width, exclusive of lobes, through anterior half of carapace.

Hinge line straight. Anterior border round with radius of curvature a little more than half the height; ventral border subround with radius of curvature about equal to the height; posteroventral border gently indented just behind the frill; and posterior border about 90 degrees of arc with radius of curvature a little less than the height. Posterodorsal end elongate. Anterior cardinal angle about 120 degrees; posterior cardinal angle about 100 degrees.

Lobes confined to the central and dorsal parts of each valve; rest of lateral surface of the valve nearly flat, slightly depressed in the posterior part. L1, L2, and L3 arranged in the shape of a modified script W; L1 joined to L3 by a curved U-shaped ridge to which L2 is appended. Dorsal end of L1 broken from each valve at the level of the hinge line,

about one-sixth the length from the anterior corner; from thence, L1 sloping posteroventrad and merging into U-shaped ridge leading into L3. L2 very small, in the anterocentral region, joined to the anterior limb of the U-shaped ridge just mentioned, extending posterodistad, and ending in a rather sharp tip. L3 very large; its proximal half broad, including the rear limb of the U-shaped ridge and a slope on the posterocentral part of the valve; distal half hornlike, extending posterodorsodistad, taper-

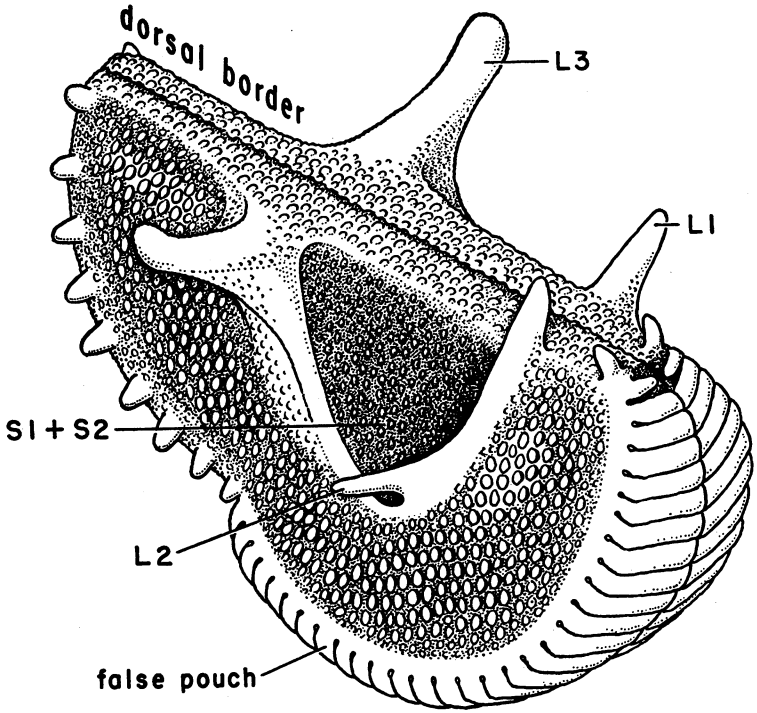

FIG. 1. Reconstruction of a complete female carapace of *Rakverella bonnemai* Öpik.The isometric sketch is based on the specimen in Plate I, Figs. 1*a*–6, several fragments, and illustrations in Öpik, 1937, Pl. 15, Figs. 10–11.

ing. Tip of L3 broken from each valve. L1 in a plane nearly parallel to that of the contact margin; L2 and L3 each set at about a 45 degree angle to the plane of the contact margin, but extending in different directions. S1 and S2 fused into one area. No distinct evidence of an L4 or an S3.

Frill strongly incurved, extending from the anterior corner to the posteroventral part of each valve. The two frills form a false pouch

(details of the frill discussed below). Nine short stout spines about equally spaced extend from the rear edge of the frill to the posterior corner. Each spine flared outward a little. Lateral surface and dorsum, exclusive of the lobes and the distal part of the frill, covered with papillae of various sizes. Papillae extend onto the proximal part of the frill. In the papillose area of the lateral surface, the papillae in the distal margin small, all others large, distinct, and high. Papillae on the dorsum intermediate in size. Papillae rapidly decreasing in size from the lateral surface onto the rear part of L3; rest of L3 granulose to smooth. L1 granulose to smooth. L2 smooth. Surface in S1 and S2 with scattered small low papillae. Outer layer broken from most of the rear half of the carapace, revealing very small low papillae on the underlying layer. A small spine at the anterodorsal corner, extending up and slightly back, its tip broken in each valve.

The rear half of the contact margin bordered by small low closely spaced papillae or denticles. The anterior half of the contact margin hidden by the false pouch.

The female carapace differs in certain respects from the specimens of *Rakverella bonnemai* described and figured by Öpik, which are believed to be males. The lobes of the present specimen appear to extend farther laterally than those of Öpik's specimens, which may have been crushed. The female carapace has wide, strongly incurved frills, whereas the male valves have narrow, flat frills. Furthermore, the female seems to have short spines on the posteroventral part of each valve immediately behind the frill, although in my specimen they may have been abraded somewhat. The male has very long thin spines in the corresponding area.

False pouch of female.—Each frill consists of 29 or 30 spines, closely set and apparently fused only along their lines of juncture. The spines radiate from a narrow ridge around the papillose lateral area in the anterior and ventral part of the valve. This low, unornamented ridge is about level with the tops of the papillae. About one-fourth of the length from its juncture with the ridge, each spine is sharply geniculate; its proximal part lies in the plane of the lateral surface but its distal part is parallel to the marginal surface. The two frills form a false pouch. The tips of the spines in one frill meet those of the other, when the two valves are closed. To this the anterodorsal spine in each frill may be an exception, for it appears to be a little shorter than the other spines.

Broken sections of the frills show that the spines are filled with a clear crystalline calcite, which contrasts sharply with the white opaque calcium carbonate in the cylindrical outer walls. It is assumed that the spines were hollow before fossilization. The spines composing the false

pouch in *Rakverella bonnemai* are not as strongly fused as those in *Piretella acmaea* Öpik, the type species of *Piretella* (Öpik, 1937, Pl. 7, Figs. 6–9). The false pouches of the two species, however, have the same shape.

Schmidt (1941, p. 48) suggested that Rakverella was a junior synonym of *Dicranella* Ulrich, 1894. It is true that *Rakverella bonnemai* and *R. spinosa* have lobation like that of *Dicranella bicornis* Ulrich (Ulrich, 1894, Pl. 46, Figs. 39–40), but the *Rakverella* species are highly ornamented and have a frill of fused spines, whereas *Dicranella bicornis* has smooth valves and a solid frill. *Rakverella* and *Dicranella* are probably distinct genera.

Type.—Hypotype No. 32076. A restoration based on this specimen and on several fragments and Öpik's figures is shown in Figure 1.

Genus *Opikium* Agnew

Biflabellum Öpik, 1935, p. 86, 1937, p. 38, *non* Döderlein, 1913, p. 131.
Öpikium Agnew, 1942, p. 757.

Genotype.—By original designation of Agnew, 1942, p. 757, *Biflabellum tenerum* Öpik, 1935, p. 86.

Familial position.—In the original description, Öpik did not suggest a familial position for his genus *Biflabellum* (1935, p. 86). In 1937, however, he placed it in the family Beyrichiidae (pp. 38–39):

> This genus is closely related to *Dibolbina* Ulrich and Bassler. The female of *Dibolbina* has a globular brood pouch as an enlargement of the false border or frill. *Biflabellum* is distinguished from *Dibolbina* by the absence of this brood pouch. The female *Biflabellum* has a curved, convex false border . . . . The ordovician *Biflabellum* and the upper silurian *Dibolbina* are two closely related genera, and *Biflabellum* appears as the immediate ancestor of *Dibolbina*. In this case the derivation of *Dibolbina* and *Biflabellum* immediately from the true *Beyrichia* is impossible, since *Beyrichia* has well developed brood pouch, whereas *Biflabellum* is without it and in the more advanced *Dibolbina* this branch of Beyrichiacea has independently developed a *Chilobolbina*-like brood pouch.

In my opinion *Öpikium* and *Dibolbina* are not as closely related as Öpik suggested. The female of *Öpikium* has a false pouch that is formed by the strongly incurved frill and is completely outside the contact margin of the valves; the female of *Dibolbina* has an entirely different dimorphic structure, a true pouch opening into the rest of the valve inside the contact margin. On the basis of the dimorphism, *Öpikium* can be more closely compared with its Ordovician contemporaries *Piretella, Rakverella,* and *Bromidella,* and with the Devonian *Hollina.* On the other hand, *Dibolbina* is closely related to *Chilobolbina* and *Apatobolbina.* These three last genera belong in the Beyrichiidae, in spite of the fact that their frills are much broader than that of *Beyrichia.* Schmidt (1941, p. 33) discussed *Biflabel-*

lum under the heading of the subfamily Hollininae Schmidt, 1941, of the family Hollinidae Swartz, 1936, but he did not list it as one of the genera assigned to that subfamily (1941, p. 32). Schmidt wrote (pp. 33–34):

Bei der Gattung *Biflabellum* Öpik ist es uns nicht gelungen, die Familienzugehörigkeit zu entscheiden . . . . Was die Beziehungen von *Biflabellum* anbelangt, so verweisen wir auf die ausführlichen Angaben von Öpik 1937 (S. 39), vor allem auf die Vergleiche mit den 'monosulcaten' Arten von *Ctenobolbina,* sowie mit *Hollina, 'Uhakiella'* und den Eurychilininae. Darüber hinaus heben wir noch einige Merkmale hervor, die wir an den Abbildungen Öpik's erkennen. *Biflabellum tenerum* (Taf. 5 Fig. 3 u. Taf. 14 Fig. 12) zeigt einen kräftigen gekrümmten Stachel als Abschluss des Velums, genau vergleichbar mit den Verhältnissen bei *Hollina radiata* . . . . Allerdings ist bei *Biflabellum* die Furche ventral noch weiter verlängert als bei der eben genannten Art [*Ctenobolbina emaciata*] denn sie erreicht in voller Entwicklung die Ansatzstelle des Velums. Das ist ein verbreitetes Merkmal der Ctenentominae.

In dieser merkwürdigen Verknüpfung der Merkmale, sowie in der ganz aussergewöhnlich reichen Entfaltung des Velums liegt die Unmöglichkeit begründet, die Gattung *Biflabellum* zur Zeit befriedigend einzuordnen. Bis zu einer Lösung dieser Schwierigkeiten schliessen wir diese Gattung behelfsmässig den Hollininae an.[4]

Agnew (1942, p. 759) created *Öpikium* as a new name for *Biflabellum* Öpik *non* Döderlein, and retained Öpik's assignment to the Beyrichiidae. Henningsmoen (1953, p. 267) placed *Öpikium* in the subfamily Piretellinae Öpik, 1937, and with question assigned the subfamily to the family Tetradellidae Swartz, 1936. His diagnoses of the family Tetradellidae (p. 262), the subfamily Piretellinae (p. 263), and the family Hollinidae (p. 264) are as follows:

Family Tetradellidae:—Velate structure entire or restricted. Velate dimorphism (incurved frill or part of the frill in some individuals) or dimorphic pits between velate and carinal structure, or no dimorphism. Carinal structure may be developed as a ridge (L1 + connecting ridge + L4), or not separated from the extralobate area. Dorsal ridge may be present. 1–3 long or short sulci. Lateral crests may be present.

Subfamily Piretellinae:—As family, but velate structure restricted (not developed posteriorly). May show dimorphism, some individuals having the frill incurved, sometimes to form a velate pouch (false pouch).

[4] "In the genus *Biflabellum* Öpik we did not succeed in deciding the family membership . . . . As concerns the relationship of *Biflabellum,* we refer to the full details by Öpik 1937 (p. 39), above all to the comparison with the 'monosulcate' species of *Ctenobolbina,* as well as with *Hollina, 'Uhakiella',* and the Eurychilininae. In addition, we would emphasize further a characteristic which we recognize in Öpik's illustrations. *Biflabellum tenerum* shows a strong, bent spur as the termination of the frill, exactly comparable with the structure in *Hollina radiata* . . . Of course, the sulcus is still more elongate in *Biflabellum* than in *Ctenobolbina emaciata,* since it reaches in full development to the attachment of the frill. This is a widespread characteristic of the Ctenentominae.

"Because of this remarkable combination of characteristics, as well as the complete, exceptionally full development of the frill, it is impossible to classify satisfactorily the genus *Biflabellum* at the present time. Until there is a solution of these difficulties, we assign the genus temporarily to the Hollininae."

Family Hollinidae:—Velate structure well developed, restricted, often with a postero-ventral spine or spur. Different types of velate dimorphism. 1–3 sulci. Median sulcus long or short, in the latter case often widening ventrally. Dorsal part of L3 often bulb-like.

Öpikium is not excluded from either the Tetradellidae or the Hollinidae by these diagnoses. Its closer affinities, however, are with the genus *Hollina* rather than the genus *Tetradella*. For example, in *Öpikium* the female has a frill incurved to form a false pouch like that in *Hollina* rather than loculi as in *Tetradella;* the ventral part of each valve is inflated, as in *Hollina,* and is not a ridgelike carina like that in *Tetradella;* and the lobation is not limited to elongate vertical ridges as in *Tetradella*. The family Hollinidae contains genera with several kinds of lobation and dimorphism. Even though it differs greatly from them in lobation, *Öpikium* is, I believe, a hollinid and related to other Ordovician genera with the same kind of dimorphism, such as *Piretella, Bromidella,* and *Rakverella*. Early Paleozoic ostracod faunas are still so incompletely known that details of phylogenetic relationships remain unconfirmed or tentative. Whether lobation and dimorphism are closely associated in the evolution of the hollinids and tetradellids has not yet been worked out.

Öpikium tenerum (Öpik)

(Pl. I, Figs. 7*a*–10*b*)

Biflabellum tenerum Öpik, 1935, p. 86, Fig. 40; Öpik, 1937, p. 40, Pl. 5, Figs. 1–4; Pl. 14, Fig. 12.

Öpikium tenerum Agnew, 1942, p. 757; Henningsmoen, 1954, p. 82.

? Entomis (Primitia ?) flabellifera Krause, 1892, p. 388; Bonnema, 1909, p. 70, Pl. 5, Figs. 1–5.

? non Biflabellum flabelliferum Öpik, 1937, p. 39.

Henningsmoen (1954, p. 82) believes that *Öpikium tenerum* (Öpik) may be a junior synonym of the species that Krause (1892, p. 388) described from the drift in northern Europe as *Entomis (Primitia?) flabellifera*. He also believes that the species called *Biflabellum flabelliferum* by Öpik (1937, p. 39) is not conspecific with the *Entomis (Primitia?) flabellifera* of Krause. Henningsmoen suggested that the Middle Ordovician ostracod selected by Öpik as the type species for his genus *Biflabellum* was, in fact, the one already described by Krause. If that is true, Öpik's type species should be listed as *Öpikium flabelliferum* (Krause). Furthermore, if it is not actually *Öpikium flabelliferum* (Krause), then the Upper Ordovician ostracod listed by Öpik (1937, p. 39) is still nameless. I retain here the trivial name *tenerum* without prejudice either for its retention or abandonment. Additional evidence is needed to justify the revisions suggested by Henningsmoen.

Nature of frills.—The frills of female and male valves of this species are very different from the solid velate structures characteristic of many Devonian hollinid ostracods. In broken specimens it can be seen that the striae mark the lateral limits of separate tubules and that the tubules are filled with a clear calcite similar to that within complete carapaces. Each tubule, I believe, was originally hollow and the frill not a solid sheet of calcium carbonate attached to the rest of the animal's carapace, but rather a fused fringe of tubules. The juncture of the frill with the rest of the carapace does not reveal any perforations leading into the tubules. It could not be ascertained whether the proximal openings of the tubules were sealed off by secretions of the hypodermis during the animal's life or had become filled with secondary calcium carbonate during fossilization.

Frill of female.—The frill of the female (Pl. I, Figs. 7*a–b*, 8*a–b*) extends from the anterior to the posteroventral border. It has a terminal spinelike thickening at the posterior end, is strongly incurved, particularly in the anteroventral part, and is ornamented by a reticulation of striae perpendicular to its edge and very small crests concentric to its edge (Pl. I, Figs. 8*a–b*). The small crests, slightly irregular and somewhat undulating, are continuous from the outer surface of one tubule to the next. The continuity suggests that they were formed immediately after the last molting of the animal by hypodermal cells along the proximal edge of the frill and, hence, that the frill was secreted before the rest of the carapace.

Frill of male.—The frill of the male is much wider than that of the female and is not incurved in any part. The anterior part flares outward only slightly, but the posterior is set at an angle of about 45 degrees to the plane of closure (Pl. I, Figs. 9*a–b*). It also differs from that of the female in the nature of the low crests. In the male frill the crests are straight, decrease in height at each stria, and are about the same size (Pl. I, Figs. 10 *a–b*). In that of the female they are somewhat irregular and undulating, continue without interruption across the striae, and are larger in the anteroventral area than elsewhere. The tubules are not set onto the rest of the carapace along a line. Some (Pl. I, Figs. 10*a–b*) are set lower than others and intercalate with them near the middle of the frill. A few bifurcate in their distal parts. This staggering of tubules at the proximal end and intercalation in the distal part are directly responsible for the broad flare of the frill.

Types.—Hypotypes Nos. 32077–32078.

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PLATE

EXPLANATION OF PLATE I

(All figures × 25 except as noted)

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FIGS. 1*a–b*, 2*a–b*. Stereoscopic left lateral and right lateral views of an almost complete female carapace. Hypotype No. 32076.

FIGS. 3*a–b*. Stereoscopic dorsal views of right valve and part of left valve of same specimen.

FIG. 4–6. Dorsal, anterior, and ventral views of same specimen.

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FIGS. 7*a–b*, 8*a–b*. Stereoscopic lateral view of a right female valve and stereoscopic enlargement of a part of same specimen. Hypotype No. 32077. Figures 8*a–b*, × 50.

FIGS. 9*a–b*, 10*a–b*. Stereoscopic lateral view of a right male valve and stereoscopic enlargement of a part of same specimen. The distal margin is broken from the ventral and posterior parts of the frill. Unbroken frills in male valves are much wider than those of females. Hypotype No. 32078. Figures 10*a–b*, × 50.

PLATE I