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A NEW FAMILY AND GENUS OF OSTRACOD
FROM THE ORDOVICIAN
BILL'S CREEK SHALE OF MICHIGAN

BY
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INTRODUCTION

A NEW family of nondimorphic ostracods and its type genus, also new, are described in this paper. The genotype of the new genus was described many years ago from the Upper Ordovician Bill's Creek shale of Michigan and referred to the genus *Bollia*. Subsequently confused with a closely related species, it was later assigned to *Tetradella*. The species is now placed in the new genus erected here and the allied species, *Tetradella quadrilirata* (Hall and Whitfield), discussed. Because the new family resembles the Tetradellidae in being strongly quadrilobate, the latter family is redefined and restricted to such members as have the general shape, lobation, and dimorphism of *T. quadrilirata*, genotype of the type genus. Specimens of *Tetradella* sp. cf. *T. quadrilirata* have been used for comparison with *Quadrijugator permarginatus* (Foerste), genotype of the type genus of the new family.

In recent years the discovery of many new species has stimulated the study of the morphology and taxonomy of ostracods. A large number of the new species have structures which were previously unknown or imperfectly understood. New techniques of cleaning small fossils has revealed features which were once hidden or obscured by matrix. Discernment of small details of structure has yielded new criteria by which ostracods can be differentiated and brought about re-examination of the species established in the past. Investigation of ostracod carapaces discloses the inadequacy of most of the older descriptions. But additional research will be necessary before it is possible to understand the nature of species published when only a few structures were considered important for taxonomic differentiation and all others were overlooked or ignored.

On the west side of the Stonington Peninsula, Delta County, Michigan, strata of the upper part of the Upper Ordovician Bill's Creek shale outcrop in a low cliff facing Little Bay de Noc. In this shale are numerous ostracods, most of them quadrilobate specimens of one species. A thin layer which outcrops about the middle of the cliff, near the north line of section 23, T. 29 N., R. 22 W., Bay de Noc Twp., contains valves and carapaces of the quadrilobate species in such abundance that fifteen specimens have been found in one square inch of exposed surface. This ostracod also occurs at other places in Delta County, where the Bill's Creek shale outcrops, but not so prolifically.

The Bill's Creek shale species was classified by August F. Foerste (1917, pp. 124-25, Pl. VI, Figs. 33a-c) as *Bollia permarginata* Foerste. This ostracod clearly does not belong in *Bollia* nor, as the present authors understand the genus, even in the same family with that genus. Russell C. Hussey (1926, pp. 130-31, 183, Pl. II, Figs. 14-15; 1950, p. 15, Pl. II, Fig. 28; 1952, p. 42, Pl. IX, Figs. 11-12) called the perplexing ostracod *Tetradella regularis* (Emmons), but it is definitely not that species either and its inclusion in the genus *Tetradella* and the family Tetradellidae is considered by us to be untenable.

In the course of investigating the Bill's Creek shale specimens, it was necessary to study those of the species *regularis* (Emmons) and *Tetradella* sp. cf. *T. quadrilirata* (Hall and Whitfield) from the Upper Ordovician rocks of the southwestern Ohio region. The first of these ostracods was named *Beyrichia regularis* by Emmons (1855, p. 219, Fig. 74b), later called *Bollia regularis* by Ulrich (1894, p. 669) and others, and *Tetradella regularis* by Hussey (1926, p. 131), who had also applied this name to Bill's Creek ostracods which are not conspecific with *regularis*. We believe that the species *regularis* does not belong in *Beyrichia*, nor in *Bollia*, nor in *Tetradella*, but that it is congeneric with the *permarginata* of Foerste and, therefore, place it (with that species) in the new genus *Quadrijugator*.

S. A. Miller (1875, p. 351) considered *Beyrichia regularis* Emmons to be a synonym of *Beyrichia quadrilirata* Hall and Whitfield and also (1892, p. 711) of *Tetradella quadrilirata* (Hall and Whitfield). To add to the taxonomic confusion, Keenan (1951, pp. 570-71, Pl. 79, Figs. 26-28) described an ostracod from the Upper Ordovician Maquoketa shale of Missouri, one not conspecific with Emmon's species having the same trivial name, as *Tetradella regularis* Keenan. Keenan's form, which is not known to be dimorphic, may not belong in *Tetradella*. Additional study of his species is needed before a re-evaluation of his generic assignment can be made. But if, as his description suggests, the Maquoketa species proves to be congeneric with the species named *Beyrichia regularis* by Emmons, then

Keenan's specific name will become a junior homonym without taxonomic validity and the *Maquoketa* ostracod will be without a name.

The authors are very grateful to Dr. W. H. Shideler, of the Geology Department of Miami University, who generously supplied specimens from the Ordovician rocks of southwestern Ohio for study and comparison. They also wish to express their appreciation to Dr. C. A. Arnold, Dr. G. M. Ehlers, and Dr. L. B. Kellum for their helpful criticism of this paper.

All specimens are catalogued and deposited in the Museum of Paleontology of the University of Michigan.

REGISTER OF LOCALITIES

The specimens upon which the description of *Quadrijugator permarginatus* (Foerste) is based were collected from the Upper Ordovician Bill's Creek shale at the following localities.

LOCALITY

1. Low cliff on the west side of Stonington Peninsula facing Little Bay de Noc, near the north line of NE. $\frac{1}{4}$ sec. 23, T. 29 N., R. 22 W., Bay de Noc Twp., Delta County, Michigan. Specimens are present in all beds examined at this place, but are particularly numerous in a thin layer near the middle of the cliff. Other beds of the Bill's Creek shale outcrop to the north and south along the shore to make up 21 feet total thickness of the formation exposed on Stonington Peninsula. Beds dip east-southeast. Collected by G. M. Ehlers and R. V. Kesling.
2. Type exposure of Bill's Creek shale along Bill's Creek, about $5\frac{1}{2}$ miles northeast of the town of Rapid River, NW. $\frac{1}{4}$ sec. 7, T. 41 N., R. 20 W., Masonville Twp., Delta County, Michigan. A few specimens occur in the argillaceous limestone near the top of the exposure. Collected by R. C. Hussey.
3. Railway cut of the Minneapolis, St. Paul, and Sault Ste. Marie Railway, about $1\frac{1}{2}$ miles west-northwest of Ensign, near center sec. 35, T. 41 N., R. 21 W., Ensign Twp., Delta County, Michigan. A few specimens occur in the argillaceous limestone. Collected by R. C. Hussey.
4. Exposures on the George DeMitt farm, SW. $\frac{1}{4}$ sec. 4, T. 40 N., R. 21 W., Ensign Twp., Delta County, Michigan. Collected by R. C. Hussey.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA

Superfamily Beyrichiacea

Quadrijugatidae, fam. nov.

Type genus.—*Quadrijugator*, gen. nov.

Description.—Carapace nearly equivalved. Hinge line straight. Valves

subquadrate to subelliptical in lateral view, subquadrate in ventral view, and subquadrate in end view.

Each valve quadrilobate. Lobes distinct, elongate vertically, in some genera ridgelike. Some or all of the four lobes joined ventrally to a ventral ridge. No lobes joined to the velate structure. Marginal and velate structures present in addition to the ventral ridge. Ventral ridge, by its position, corresponding to a carina.

No dimorphism known; certainly, none in the form of the velate structures.

Remarks.—Dimorphism is a very important diagnostic character in certain families of Paleozoic ostracods. In the Beyrichiidae, one of the dimorphs of each species has a pouch; in the Hollinidae and the Tetradelidae, one of them has a velate structure larger or different; in the Sigmoidopsiidae, one has larger carinate structure than the other; in the Kloedenellidae, the posterior part of the carapace of one is larger than in the other; and in the Zygobolbidae, one of them has an anteroventral enlargement. The Tetradelidae, as characterized by the type genus, *Tetradella*, is a dimorphic family closely related to the Hollinidae. All species of the families listed have not been studied in detail. Insofar as is known, however, each species in a dimorphic family exhibits only the kind of dimorphism which characterizes its family. Since dimorphism is pronounced and clearly defined in the above ostracods, nondimorphic genera or species should be separated from them and assigned to other families.

Ostracods of the Quadrijugatidae, fam. nov., resemble those of the family Tetradelidae in being quadrilobate, but differ from them in lacking dimorphism (see Fig. 1). They have four ridgelike lobes, a ventral ridge, a marginal ridge, and a velate structure. In addition to species of the type genus, *Quadrijugator*, gen. nov., the new family includes nondimorphic European species at present assigned to *Tetradella*, such as *T. grewingki* (Bock) and *T. lanceolata* Hessland, which have four ridgelike lobes joined to a ventral ridge, a marginal ridge, and a wide frill. These species should be placed in a new genus of the family Quadrijugatidae. The new family also includes the genera *Ceratopsis* Ulrich (1894, p. 676), *Glossopsis* Hessland (1949, p. 296), and *Ogmoopsis* Hessland (1949, p. 324).

Ostracods of the Quadrijugatidae, fam. nov., resemble those of the family Drepanellidae in lacking dimorphism, but differ from them in lobation (Fig. 1). A genus of the family Drepanellidae always has an L2, S2, and L3, although the S2 may be shallow and inconspicuous. In addition, it may have a ridgelike L1 and L4 joined together by a ventral ridge which corresponds to a velate ridge (as in *Ulrichia* and *Bollia*); a ridgelike L1

continuous with a ventral ridge (as in *Waldronites* and *Drepanella*); a short ventrocentral ridge yoking the ventral ends of L2 and L3 (as in *Bollia*); and/or irregular or lobelike L2, L3, and L4 (as in *Drepanella*). The drepanellid genus which most closely resembles the quadrijugatid genera is *Bollia*. *Bollia* has the lobes elongate and sometimes ridgelike,

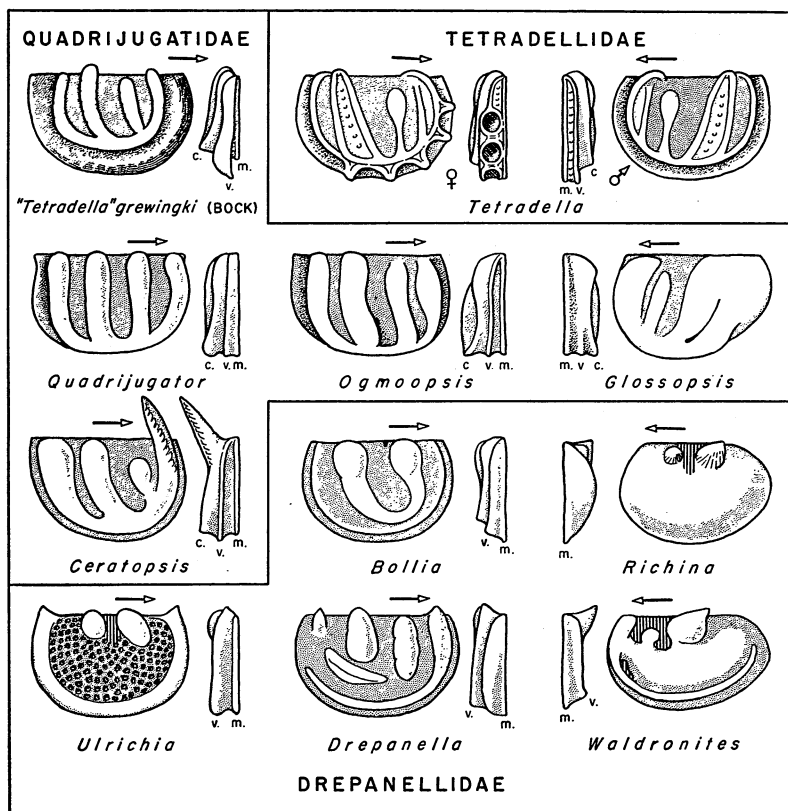


FIG. 1. Sketches of lateral and anterior views of ostracods of the families Quadrijugatidae, Tetradellidae, and Drepanellidae. "*Tetradella*" *grewingki* (Bock) is regarded as a species of an unnamed genus in the Quadrijugatidae. The abbreviations used in the anterior views are: *m*, marginal ridge; *v*, velate ridge or frill; and *c*, carina. An arrow points toward the anterior end in each lateral view.

but, unlike *Quadrijugator*, it has L1 joined to L4 by one ventral ridge, by its position a velate ridge, and L2 joined to L3 by another ridge, by its position a carina; it does not have L2 or L3 joined to the same ventral ridge as L1 or L4 and it does not have a velate ridge between the marginal ridge and the ventral ridge.

Henningsmoen (1953, p. 262) described the family Sigmoidopsiidae thus:

Carinal structure well developed. Carinal dimorphism, some individuals having the carinal structure better developed than others. Velate structure may be missing. No dorsal ridge. 1-3 sulci. Median sulcus (S2) usually very long, but may be short. S3 more persistent than S1.

He (p. 262) divided the Sigmoidopsiidae into two subfamilies:

Subfamily Sigmoidopsiinae:—As family, but velate structure always present. When the median sulcus is long, it is characteristically sigmoidal.

Subfamily Glossopsiinae:—As family, but velate structure is missing or very faintly developed. Median sulcus always long, not sigmoidal. The ventral ends of S1 and S2 are their most persistent parts.

Henningsmoen (1953, p. 266) included the genera *Sigmoidopsis* Henningsmoen 1953, *Ogmoopsis* Hessland 1949, *Sigmobolbina* Henningsmoen 1953, *Carinobolbina* Henningsmoen 1953, *Bolbina* Henningsmoen 1953, ? *Kiesowia* Ulrich and Bassler 1908, ? *Ctenobolbina* Ulrich 1890, and ? *Winchellatia* Kay 1940 in his subfamily Sigmoidopsiinae; *Glossopsis* Hessland 1949 and *Aulacopsis* Hessland 1949 in his subfamily Glossopsiinae. *Sigmoidopsis*, the type genus of the Sigmoidopsiidae, according to Henningsmoen's (1953, pp. 204-5) description, includes the dimorphic species formerly assigned to *Ceratopsis*. *Ceratopsis platyceras* Öpik is the genotype of *Sigmoidopsis* and the following species are included in the genus in the original description: *Sigmoidopsis obliquejugata* (Schmidt), *S. perpuncta* (Öpik), *S. rostrata* (Krause), and *S. schmidtii* (Bonnema).

The Quadrijugatidae differ from the Sigmoidopsiidae in lacking carinal dimorphism. The authors of this paper have assigned *Ogmoopsis* and *Glossopsis* to the Quadrijugatidae, because the existence of dimorphism in these genera has not been clearly demonstrated.

Quadrijugator, gen. nov.

Genotype.—*Bollia permarginata* Foerste, 1917, pp. 124-25, Pl. VI, Figs. 33a-c.

Description.—Carapace nearly equivalved. Hinge line straight. Valves subquadrate to subelliptical in lateral view, elongate subquadrate in ventral view, and subquadrate in end view.

Each valve distinctly quadrilobate. Lobes nearly equal, vertical, present as four, strongly elevated, long ridges with their distal surfaces evenly rounded. Some or all of the four vertical ridges joined at their ventral ends to a ventral ridge; no lobes joined to the velate ridge. The ventral ridge, by its position, a carina. Marginal ridge and velate ridge nearly fused, separated only by a shallow, indistinct groove. Low, flat area on the posterior end of the valve.

Hinge of right valve with a low ridge, indistinct in the center of the hinge and highest at the ends. Hinge of left valve with a long groove, shallow in the central part and deepest at the ends.

No dimorphism known.

Remarks.—*Quadrijugator* differs from *Tetradella*, which it resembles in being distinctly quadrilobate, in having all lobes nearly alike and in lacking dimorphism. This genus is closely related to certain Ordovician ostracods erroneously assigned to *Tetradella*, such as the European species called *T. grewingki* (Bock) (Öpik, 1940, p. 139, and others), *T. lanceolata* Hessland (1949, pp. 346–48, Pl. IX, Figs. 10, 13, 17, and 20), and *T. teres* Hessland (1949, pp. 348–52, Pl. IX, Figs. 12, 14–16, 18, and 19) and the American species called *T. subquadrans* Ulrich (1890, p. 115, Figs. 2a–c); none of them are known to be dimorphic. *Quadrijugator* is unlike these ostracods in having a velate ridge nearly fused with the marginal ridge instead of a wide frill distinctly separated from the marginal ridge. The European species which have been mentioned and *Tetradella subquadrans* should be removed from *Tetradella* and classified as a new genus of the Quadrijugatidae.

The name of this genus is derived from Latin *quadrijugator*, m. (“that which has four yoked together”) and refers to the vertical lobes joined to a ventral ridge. The Latin *quadrijugi*, m. pl., designated a team of four horses abreast, as were used in chariot races.

Quadrijugator permarginatus (Foerste)

Bollia permarginata Foerste, Foerste, 1917, pp. 124–25, Pl. VI, Figs. 33a–c.

Tetradella regularis (Emmons), Hussey, 1926, pp. 130–31, Pl. II, Figs. 14–15; Hussey, 1950, p. 15, Pl. II, Fig. 28; Hussey, 1952, p. 42, Pl. IX, Figs. 11–12.

Description.—Carapace nearly equivalved. Hinge line straight. Valves subquadrate in lateral view, elongate subquadrate in ventral view, and quadrate in end view. Anterior border gently curved, nearly straight; anteroventral border curved with radius of curvature equal to about one-half the height of the valve; ventral border gently curved with radius of curvature equal to about twice the height; posteroventral border curved about as sharply as the anteroventral; and posterior border gently curved, nearly straight. Greatest length along the hinge in some specimens, through the center of the valves in others. Greatest height posterior. Greatest width through L3 in most specimens, through L2 in some.

Each valve distinctly quadrilobate. Each of the four lobes present as a very strongly elevated, long, narrow ridge ventrally confluent with a

ventral ridge of about the same elevation and shape in cross section. Distal surfaces of the four vertical ridges and the ventral ridge evenly arched. The four vertical ridges nearly equal. L2 dorsally more bulbous than the other three ridges. As seen in a front view of the carapace, the surface of the vertical ridges gently convex distally. In some valves L2 and L3 converging toward the ventral part of the valve but not meeting and with distinctly separate junctions with the ventral ridge; in others, L2 and L3 nearly parallel. As seen in dorsal view, L3 yoked to L4 by a low saddle-shaped structure across the dorsal end of S3. Front edge of L1 forming the anterior border. L4 and adjoining part of the ventral ridge nearly parallel to the posterior border, but separated from it by a low, flat sickle-shaped part of the valve. Low, flat posterior part of the valve, as seen in lateral view, forming less than one-tenth the area of the valve. Sulci deep, long, steep-sided, with bottom nearly flat. S1 the narrowest sulcus, ventrally acuminate. S2 and S3 nearly equal in most specimens, bluntly terminated ventrally.

Marginal ridge and velate ridge nearly fused, separated by a shallow, indistinct groove. Marginal and velate ridges together forming a broad rim along the free edge.

Corners of the valve extended as subtriangular projections at each end of the hinge, making the measurement of the cardinal angles difficult. Each cardinal angle, measured with its apex at the tip of the subtriangular projection, about 90 degrees.

In the interior of each valve, L1 forming a curved narrow trough, L2, L3, and L4 forming long broad troughs, and the ventral ridge forming a long fissure.

Hinge of the left valve with a long groove, shallow in the middle and deepest at the ends. Hinge of right valve with a narrow low ridge, indistinct in the central part of the hinge and highest at the ends.

Dimensions of hypotype, a right valve, No. 30023: length, .93 mm.; height, .65 mm.; and width, .32 mm.

Remarks.—A. F. Foerste first recognized that this species was distinct from the ostracod named *Beyrichia regularis* by Emmons. He stated (1917, p. 124) that it had a "carapace . . . closely resembling the specimen from the Arnheim member of the Richmond identified by Ulrich and Bassler . . . as *Bollia regularis* (Emmons). It differs chiefly in the prominence and continuity of the ventral part of the marginal ridge." Foerste, in his descriptions and particularly in his figures (Pl. VI, Figs. 33a-c), overemphasized the part of the ventral ridge between L2 and L3, for he said (p. 124): "The two middle ridges are slightly more elevated than the anterior and

posterior branches of the marginal ridge, and are connected at the base so as to produce a more or less U-shaped aspect." It may have been this part of his description which caused some of the confusion in taxonomy, for it fits Emmon's species more closely than Foerste's. Both Foerste and Hussey oriented this species in the opposite direction from that employed in this paper. Foerste wrote (p. 124): "The anterior branch of the marginal ridge . . . is located at a distinct interval from the anterior margin of the carapace."

Occurrence.—Upper Ordovician Bill's Creek shale; localities 1–4. Hussey (1926, p. 183) also recorded this species (under the name *Tetradella regularis*) from the basal part of the Bay de Noc member of the Stonington formation, which overlies the Bill's Creek shale on the Stonington Peninsula about ¼ mile south of locality 1. It seems probable that, during the time when the basal beds of the Bay de Noc member were being laid down, these ostracods were eroded from nearby outcrops of the Bill's Creek shale and incorporated in basal Bay de Noc sediments.

Types.—Hypotypes, one carapace, No. 30039; fourteen right valves, Nos. 30010, 30012–30013, 30016–30018, 30020–30025, and 30040–30041; and five left valves, Nos. 30011, 30014–30015, 30019, and 30026.

Quadrijugator regularis (Emmons)

(Pl. II, Figs. 30–41)

Beyrichia regularis Emmons, Emmons, 1855, p. 219, Fig. 74b.

Beyrichia regularis Emmons, Miller, 1875, p. 351 [erroneously considered synonymous with *Beyrichia quadrilirata* Hall and Whitfield]; Miller, 1877, p. 212 [erroneously considered synonymous with *Beyrichia quadrilirata* Hall and Whitfield]; Walcott, 1884, p. 88; Lesley, 1889, p. 91, text fig.; Miller, 1889, p. 535 [erroneously considered synonymous with *Beyrichia quadrilirata* Hall and Whitfield] Jones, 1890, p. 13; Miller, 1892, p. 711 [erroneously considered synonymous with *Tetradella quadrilirata* (Hall and Whitfield)].

Bollia regularis (Emmons), Ulrich, 1894, p. 669; Ulrich and Bassler, 1908, p. 288, Figs. 12–14; Bassler, 1915, p. 129; Foerste, 1917, p. 124; Bassler and Kellett, 1934, p. 219; Shimer and Shrock, 1944, p. 667, Pl. 281, Figs. 27–28.

not *Tetradella regularis* (Emmons), Hussey, 1926, pp. 130–31, Pl. II, Figs. 14–15; Hussey, 1950, p. 15, Pl. II, Fig. 28; Hussey, 1952, p. 42, Pl. IX, Figs. 11–12.

not *Tetradella regularis* Keenan, Keenan, 1951, pp. 570–71, Pl. 79, Figs. 26–28.

Remarks.—Because *Quadrijugator regularis* (Emmons) has many features like those of *Quadrijugator permarginatus* (Foerste), the two species have sometimes been confused. Both species are about the same size. Each has long ridges with evenly rounded distal surfaces for L1, L2, L3, and L4; a ventral ridge which corresponds, by its position, to a carina;

the marginal and velate ridges nearly fused, separated only by a shallow groove; a low, flat sickle-shaped area on the posterior part of each valve; and subtriangular projections at the end of the hinge.

Certain conspicuous differences, however, easily distinguish *Quadrijugator regularis* from *Q. permarginatus*. In *Q. regularis* the ventral ridge is absent between L1 and L2, has the same elevation as the lobes between its junctions with L2 and L3, and is very low and saddle-like between L3 and L4, whereas in *Q. permarginatus* this ridge has nearly the same elevation as the lobes throughout its length. The ventral ridge in *Q. regularis* is located above the ventral border, but in *Q. permarginatus* it reaches to the ventral border and part of it extends below the marginal and velate ridges. The posterior border in *Q. regularis* has a much shorter radius of curvature than that in *Q. permarginatus*.

Emmons (1855, p. 219) first described this species as part of an agnostid crustacean. He believed that all species of *Beyrichia* were deformed cephalons or pygidia of agnostids.

Occurrence.—Upper Ordovician, Richmond group, Waynesville formation, lower 8 feet of the Clarksville member. Near Oxford, Ohio. Collected by Dr. W. H. Shideler.

Types.—Hypotypes, four left valves, Nos. 30042–30044 and 30048; and three right valves, Nos. 30045–30047.

Family Tetradellidae Swartz, restricted

Type genus.—*Tetradella* Ulrich, 1890, pp. 112–14, by designation of Swartz, 1936, p. 551.

Remarks.—This family is limited to those genera which have dimorphism like that of the type genus. Tetradellid ostracods have straight hinges, valves of nearly the same size, long narrow lobes, plenate end anterior, and L/R overlap. One dimorph of each species has a different velate structure from the other. The Tetradellidae differ from the closely related Hollinidae in their lobation. The tetradellids have an L3 that is about the same size as at least one other lobe; the hollinids have an L3 that is larger than any other lobe and distinctly larger and bulbous in many genera and species.

Genus *Tetradella* Ulrich

Genotype.—*Beyrichia quadrilirata* Hall and Whitfield, 1875, p. 105, Pl. 4, Figs. 6–7, by subsequent designation of Ulrich, 1890, p. 112.

Remarks.—The genus *Tetradella* includes many nondimorphic species which now properly go in *Quadrijugator*, gen. nov. But, as elaborated

above, all European species assigned to *Tetradella*, such as *T. grewingki* (Bock) (Fig. 1) belong in a new and as yet undescribed genus of the Quadrijugatidae, fam. nov. Because of the need to distinguish between *Quadrijugator*, type genus of the Quadrijugatidae, and *Tetradella*, type genus of the Tetradellidae, figures and descriptions of specimens of *Tetradella* sp. cf. *T. quadrilirata* (Hall and Whitfield) are given. It is hoped that they will add to the knowledge of the important but frequently misunderstood ostracod *T. quadrilirata*.

Tetradella quadrilirata (Hall and Whitfield)

Beyrichia quadrilirata Hall and Whitfield, Hall and Whitfield, 1875, p. 105, Pl. 4, Figs. 6-7.

Beyrichia quadrilirata Hall and Whitfield, Miller, 1875, p. 351 [erroneously considered synonymous with *Beyrichia regularis* Emmons]; Miller, 1877, p. 212 [erroneously considered synonymous with *Beyrichia regularis* Emmons]; Miller, 1889, p. 535 [erroneously considered synonymous with *Beyrichia regularis* Emmons].

Strepsula quadrilirata (Hall and Whitfield), Ulrich, in part, 1889, pp. 54-55, Pl. 9, Fig. 12; Lesley, 1890, p. 1100, text fig.

Tetradella quadrilirata (Hall and Whitfield), Ulrich, 1890, pp. 112, 114; Miller, 1892, p. 711 [erroneously considered synonymous with *Beyrichia regularis* Emmons]; Ulrich and Bassler, 1908, pp. 306-7, not Pl. 39, Figs. 4-5; Cumings, 1908, pp. 1048-49, Pl. 53, Figs. 4, 4a; Grabau and Shimer, 1910, p. 353, not Figs. 1658f, g; Bassler, 1915, pp. 1263-64; Ladd, 1929, p. 370; Bassler and Kellett, 1934, p. 482, not Fig. 11, No. 3; Kay, 1934, p. 338; Swartz, 1936, p. 551, not Pl. 81, Fig. 2b; Kay, 1940, p. 265; Schmidt, 1941, pp. 40-41; Shimer and Shrock, 1944, p. 667, not Pl. 281, Figs. 44-45; Wright, 1948, p. 46, not Pl. 5, Figs. 27-28; Dalvé, 1948, pp. 42, 46, 52, 55; Hessland, 1949, p. 340.

not *Tetradella quadrilirata* (Hall and Whitfield), Ulrich, 1894, pp. 679-80, Pl. 46, Figs. 1-5; Bassler, 1913, Fig. 1425j; Kesling, 1951, Pl. VII, Figs. 5a-c.

Remarks.—Other references to *Tetradella quadrilirata* (Hall and Whitfield) as the genotype of *Tetradella*, in addition to those listed in the synonymy above, may occur in the literature. Ulrich (1889, p. 55) was the first paleontologist to recognize differences between specimens from the Upper Ordovician Cincinnati series and the original illustrations. He stated:

When I first found specimens of this type and compared them with Hall and Whitfield's description and figures of their *Beyrichia quadrilirata*, I was struck by the differences here mentioned, and, naturally enough, believed I had found, if not a distinct species, at any rate a well-marked variety. Since then I have succeeded in collecting no less than fifty species of Ostracoda from the Hudson River or Cincinnati group, and still my collection is without an example of *B. quadrilirata* as originally figured and described. It would be strange indeed if, after all my search, this species should have been overlooked. Such an event, though possible, is not at all probable.

I am, therefore, reluctantly obliged to believe that the discrepancies between the original figures and the specimens identified by collectors of Hudson River group fossils with *B. quadrilirata*, are really the result of imperfect observation. I would be very diffident about making this charge were I not able to prove inaccuracies in their figures of the much better known species *B. oculifera*, Hall, and *B. Chambersi*, Miller.

But he included *Tetradella* specimens from the Middle Ordovician Trenton group in *T. quadrilirata*, for he continued:

This species is one of the most abundant of the Ostracoda of the upper beds of the Hudson River group, and it occurs at many localities in Ohio and Indiana. I have collected it also at High Bridge, Ky., where it occurs in the Birdseye limestone, and from the Trenton shales at Minneapolis, Minn. The specimens from these lower horizons are almost identical with fig. 12, the modifications being too trivial to merit recognition here.

The ostracods from the Trenton group classified by Ulrich (1894, p. 669, Figs. 1-4) as *Tetradella quadrilirata* were considered by Kay (1934, p. 339) to be *T. ellipsilira* Kay. Kay's figures (1934, Pl. 45, Figs. 10-15) substantiate this synonymy. Kay's taxonomic handling of his new species, however, led to a false concept of his intent. In his systematic descriptions (1934, p. 339) he listed "*Tetradella ellipsilira* Kay, n. name," but in his explanation of Plate 45 (p. 336) he referred to "*Tetradella ellipsilira* Kay, n. sp." In the synonymy of *T. ellipsilira*, he listed "*Tetradella quadrilirata* Ulrich, 1894" but "not *Beyrichia quadrilirata* Hall and Whitfield, 1785" [sic]. Kay designated a holotype from his own specimens. His description and figures constitute the first recognition that this species differed from others already described and was, therefore, new. The fact that Ulrich had in 1894 described specimens of *T. ellipsilira* would not prevent Kay's species from being called a "new species," inasmuch as Ulrich was in error when he referred his specimens to *Tetradella quadrilirata* (Hall and Whitfield). Kay called attention to differences between *T. ellipsilira* and *T. quadrilirata*, so there is no doubt he intended to set up a new species. His error was in using the designation "n. name" instead of "n. sp." in his description.

Schmidt (1941, p. 41) assumed that Kay wished to propose a new name for *Tetradella quadrilirata* and protested strongly because Kay did not select one of Ulrich's specimens as a lectotype for *T. ellipsilira*, if it was a new species (which Schmidt doubted). Schmidt believed Kay's species to be invalid and Kay's specimens to be *Tetradella quadrilirata* (Hall and Whitfield). Schmidt wrote (p. 41):

Kay 1934 revidiert den Genotypus, sowie *T. lunatifera* (Ulrich). Er stellt dabei zwei neue "Arten" auf (im Text steht "new name" und unter den Abb. "n. sp.") und zwar *T. ellipsilira* = *T. quadrilirata* Ulrich 1894 non *T.* (= "Beyr.") *quadrilirata* H. & WH. 1875, und *T. ulrichi* = *T. lunatifera* Ulrich 1894 non *T.* (= "*Strepula*") *lunatifera* Ulrich 1889. Eine Angabe über die Zuordnung von *T.* (= "*Strepula*")

quadrilirata Ulrich 1889 fehlt in der Synonymliste. Der Text lässt weiter nur die Annahme zu, dass Kay die Typen und Paratypoide (von 1889 und 1894) zu den betreffenden Arten nicht kennt, auch werden keine neuen Belegstücke für die beiden revidierten Arten *T. quadrilirata* und *T. lunatifra* abgebildet. Für seine beiden neuen Arten bestimmt Kay Gehäuse aus dem eigenen Material zu Holotypen, nach seiner Bezeichnungsweise "new name" müsste er jedoch die Exemplare zu Ulrich 1894 als Lecto-Typen bestimmen. Nun sind aber überhaupt die Unterschiede, die eine Aufteilung rechtfertigen sollen, so gering, dass sie ohne weiteres auf Zeichenfehler in den älteren Arbeiten (1875, 1889) zurückgeführt werden können; Ulrich erörtert auch schon 1889 selber ausführlich derartige Möglichkeiten, ohne dass Kay darauf eingeht. Deshalb müssen wir Swartz 1936 beipflichten, der bereits die richtige Abgrenzung der "Arten" von Kay bezweifelt. Kann keine neue Abbildung und Beschreibung der Typen der beiden älteren Arten gegeben werden (wegen Zerstörung oder Verlust), so sind die entsprechenden neuen Arten einzuziehen.

Since the species *Tetradella quadrilirata* and *T. ellipsilira* are certainly congeneric, they establish the range of the genus *Tetradella* from Middle to Upper Ordovician.

Tetradella sp. cf. *T. quadrilirata* (Hall and Whitfield)

(Pl. II, Figs. 1-24)

Description of male.—Carapace nearly equivalved. Carapace subelliptical in lateral view, sublanceolate to subquadrate in ventral view, and subdeltoid in end view. Hinge line straight. Anterior and posterior borders evenly curved with radius of curvature about .36 mm.; ventral border curved with radius of curvature about 2.00 mm.

A conspicuous low part of the lateral surface forming a band about .10 mm. wide around entire free border, shaped like a broad extended U, distinctly separated from the sharply elevated part of the valve with the lobes. As seen in ventral and end views, this low part of the lateral surface forming a flat platform proximal to the velate ridge.

Lobate part sharply elevated from rest of valve. A crest parallel to the free border around three sides of the lobate part of the valve, interpreted as a ventral crest confluent anteriorly with part of L1 and posteriorly with L4. The ventral crest, by its position, a carina. L1 a vertically elongate lobe with two distinctive crests; both crests confluent ventrally with the ventral crest. Rear crest of L1 straight, nearly vertical, terminating dorsally a little below the front crest. Front crest of L1 curved evenly throughout its length, joining the ventral crest in a smooth continuous curve, its dorsal part extending above the hinge line and terminating near the hinge line immediately over L2. L2 cudgel-shaped, widest in dorsal part, terminating dorsally about .05 mm. below the dorsal border, surmounted by a crest ventrally joining with the ventral crest, nearly vertical, sloping slightly

forward and down. L3 lunate, both sides convex posteroventrad, surrounded by a crest; the crest dorsally acuminate a little above the hinge line, ventrally acuminate at its junction with the ventral crest. The rear half of the crest around L3 sloping forward to join the ventral crest in a smooth continuous curve. L4 rather small and inconspicuous but surmounted by a crest; crest parallel to the posterior border, its dorsal part not as strongly elevated as the crest around L3 but joining it. S1 long, nearly vertical, slightly inclined anteroventrad, its sides nearly parallel, ventrally truncated by the ventral crest. S2 the deepest and largest sulcus, very wide in its dorsal part, extending from the dorsal border to the ventral crest. S3 shallow, crescent-shaped, narrow, surrounded by the crest of L4 and the rear half of the crest of L3. As seen in dorsal view, the greatest width through the middle of the front half of the crest around L3.

Anterior cardinal angle about 120 degrees; posterior cardinal angle slightly less.

Marginal ridge and velate ridge about equally elevated. Velate ridge extending a little distad to marginal ridge throughout its length, completely concealing it in a lateral view. Surface smooth except for a slightly irregular row of small papillae between the velate and marginal ridges from one corner to the other and a row of five or six somewhat larger papillae along the middle of L3, the larger papillae fragile and broken from many specimens in cleaning.

Dimensions of a right valve, No. 30031: length, 1.06 mm.; height, .65 mm.; and width, .29 mm.

Description of female.—Dorsal and posterior part of each valve identical with those of the male. Four large loculi in the anterior and anteroventral parts of each valve, proximally extending nearly to the marginal ridge and distally extending nearly to the ventral crest and the anterior crest of L1. Each loculus large, round, and bordered by a crest. The loculi interrupting the velate ridge and dissecting it. Rear part of the velate ridge joined to the posterior part of the crest around the rear loculus; each of three very short segments of the velate ridge located between adjacent loculi and joined at ends to the crests of the two loculi, linking them together; anterodorsal part of the velate ridge joined at bottom end to the crest around the front loculus. Crests around the three rear loculi joined to the superjacent parts of the ventral crest at the points of tangency; the crest around the front loculus joined to the postjacent part of the front crest of L1 at the point of tangency.

Dimensions of a right valve, No. 30037: length, 1.03 mm.; height, .69 mm.; and width, .32 mm.

Remarks.—The specimens described here are conspecific with those which have been considered by Dr. Shideler (personal communication) to be *Tetradella quadrilirata* (Hall and Whitfield). They do not, however, fit identically the original illustrations of Hall and Whitfield, which show an ostracod without crests on the lobes, without a velate ridge, and without a low flat area of the lateral surface between the free border and the lobate part of the valve.

Occurrence.—Upper Ordovician, Richmond group, basal beds of the Elkhorn formation. Near Fair Haven, Ohio. Collected by Dr. W. H. Shideler. Dalvé (1948, pp. 42, 46, 52) recorded *Tetradella quadrilirata* from the Elkhorn formation and also from the Waynesville, Liberty, and Whitewater formations.

Types.—Specimens, three female left valves, Nos. 30028, 30033, and 30038; three female right valves, Nos. 30027, 30032, and 30037; three male left valves, Nos. 30029, 30030, and 30034; and three male right valves, Nos. 30031, 30035, and 30036.

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EXPLANATION OF PLATE I

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PLATE I

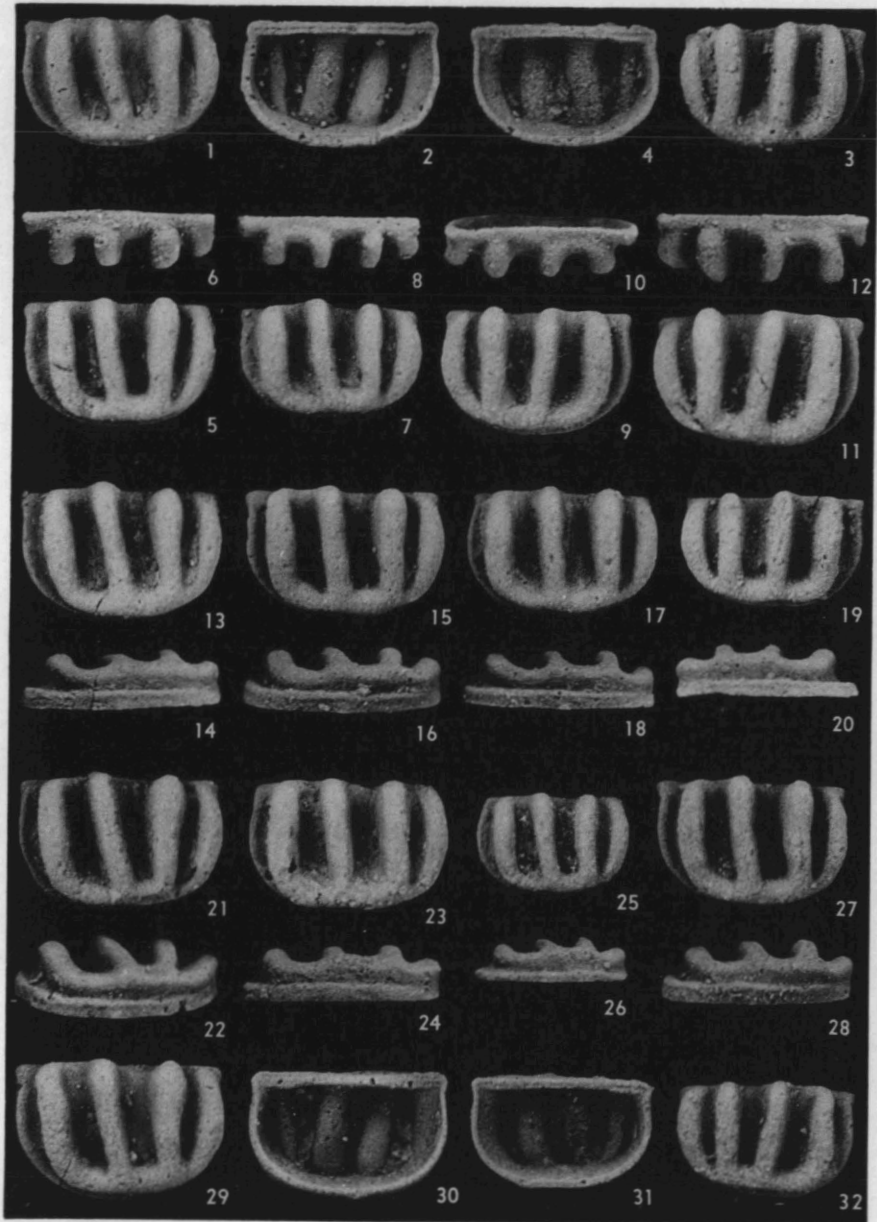
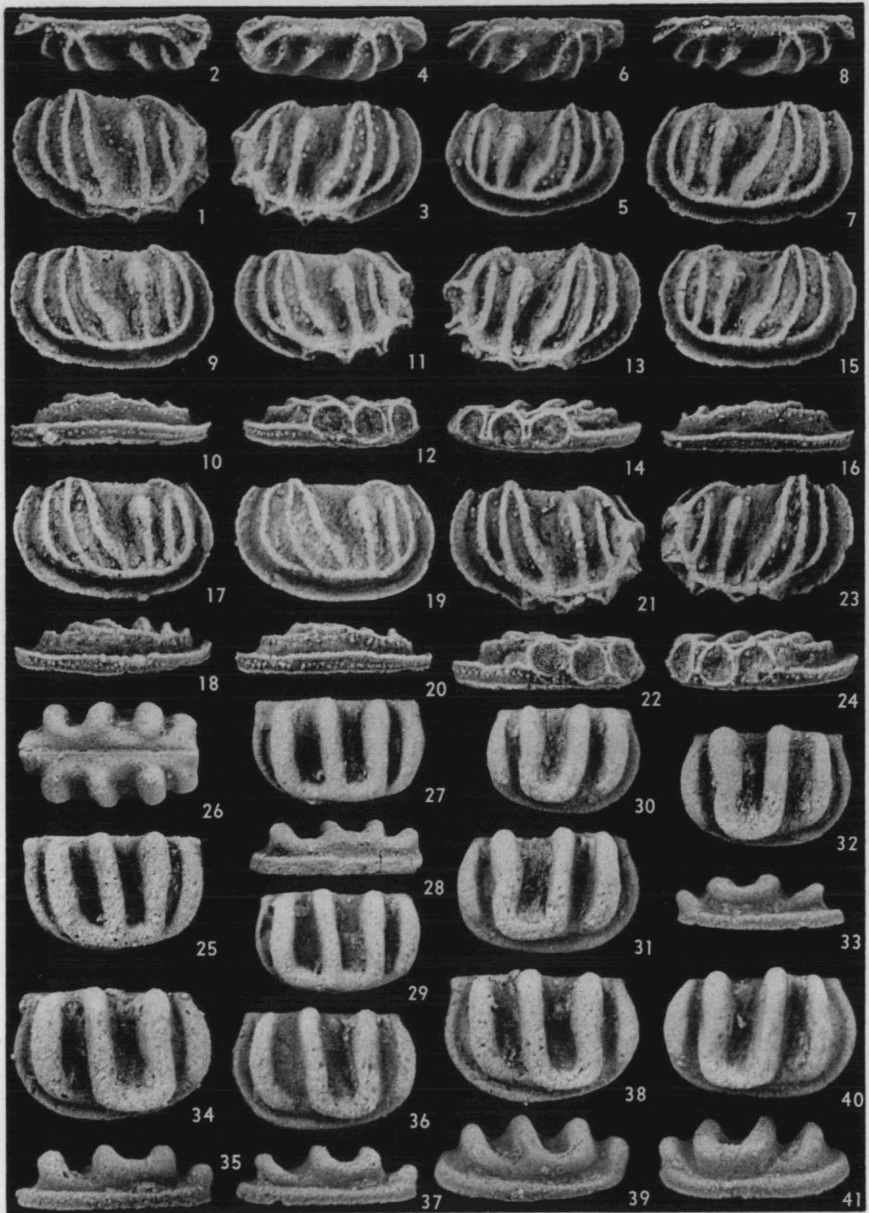


PLATE II



EXPLANATION OF PLATE II

(All figures $\times 30$)

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