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OSTRACODS OF THE FAMILY HOLLINIDAE
FROM THE BELL SHALE OF MICHIGAN

BY

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INTRODUCTION

THE ostracods described in this paper are from the Bell shale, the oldest formation of the Middle Devonian Traverse group of Michigan. They include three new genera and fifteen new species of the family Hollinidae. The species are markedly different from those described from the Bell shale by Van Pelt and by Warthin.

Some specimens noted in this paper are from samples of Bell shale collected by Dr. G. M. Ehlers in 1926. The authors are very grateful to Dr. Ehlers for the use of his collection and for his suggestions concerning the organization of this paper.

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

REGISTER OF LOCALITIES

The ostracods described in this paper were collected from the following localities of Bell shale exposures (see Map 1):

LOCALITY

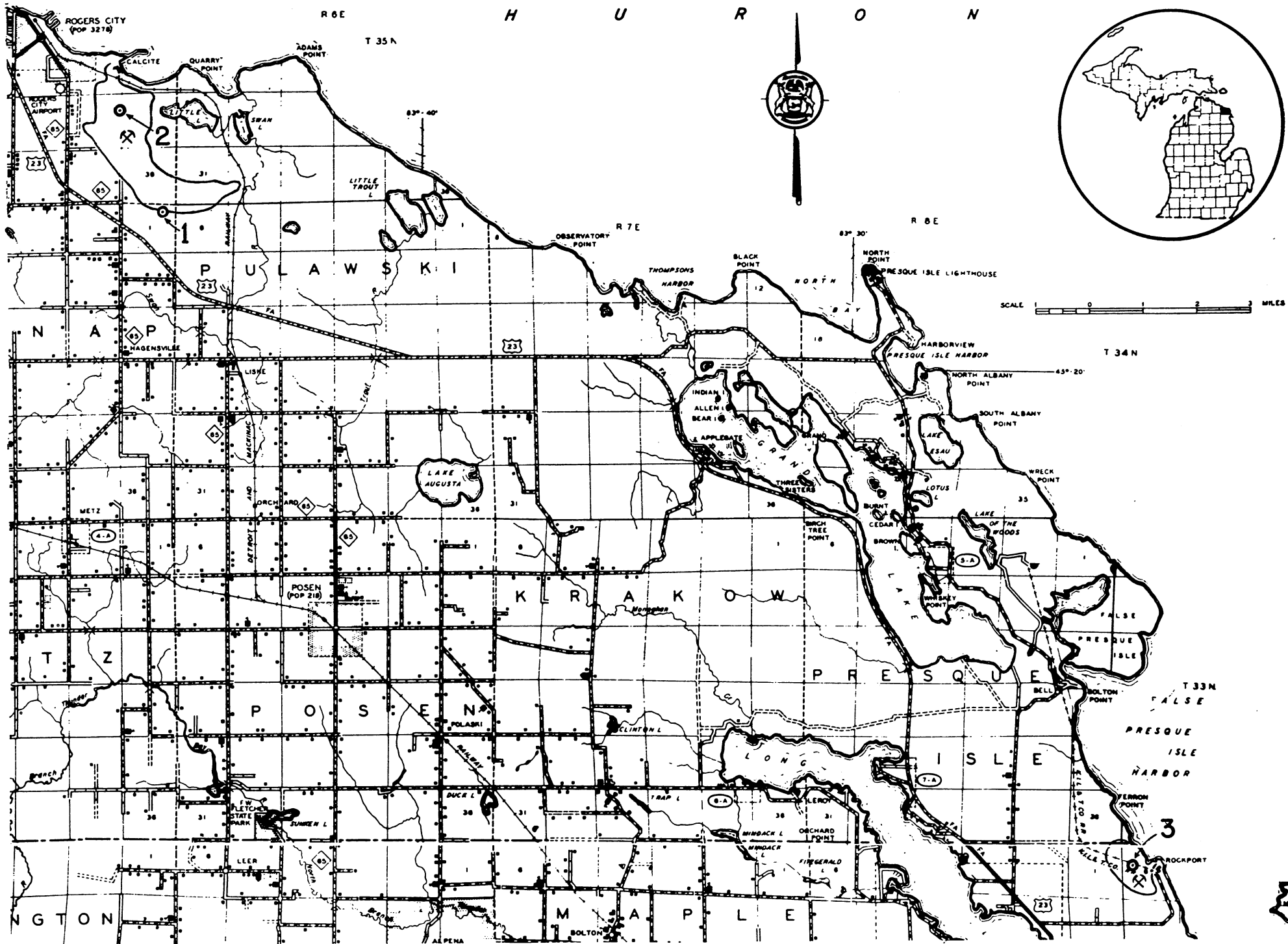
1. Lower Bell shale, NE. $\frac{1}{4}$ sec. 1, T. 34 N., R. 5 E., Michigan Limestone and Chemical Company Quarry at Calcite, adjoining Rogers City, Presque Isle County, from the contact with the underlying Rogers City limestone to six feet above the contact, above the quarry wall. Collected by Robert V. Kesling in 1949.
2. Bell shale sink filling in the Rogers City limestone, NE. $\frac{1}{4}$ sec. 26, T. 35 N., R. 5 E., Michigan Limestone and Chemical Company Quarry at Calcite, Presque Isle County. This particular outcrop of the Bell shale has now been completely removed by quarrying. Collected by George M. Ehlers in 1926.
3. Upper Bell shale, NW. $\frac{1}{4}$ sec. 6, T. 32 N., R. 9 E., abandoned quarry of the Kelly Island Lime and Transport Company, Rockport, Alpena County, in drainage ditch about $\frac{1}{4}$ mile from quarry buildings. Collected by Robert V. Kesling in 1949.

TERMINOLOGY OF HOLLINID OSTRACODS

The terminology in descriptions of ostracod carapaces has not been standardized, and scientific literature contains many synonyms and even homonyms applied to particular structures. Those who read and use descriptions of ostracods are sometimes uncertain of an author's meaning because of these inconsistencies. The authors of this paper hope that the following brief discussion of the terms and the labeling of the parts in the composite sketch of an ostracod (Fig. 1) will clarify their usage.

The only parts normally preserved as fossils are the two calcareous VALVES, which in life enclosed the soft tissues of the animal. These valves are oriented left and right, and together comprise the CARAPACE. As seen in lateral view, the outline of each valve may be conveniently divided into the DORSAL BORDER and the FREE BORDER. The free border is subdivided into the ANTERIOR, VENTRAL, and POSTERIOR BORDERS.

During the life of the ostracod, the valves were joined together dorsally by a hinge and could close by bringing the CONTACT MARGIN of one valve against that of the other. The dorsal edge of the hinge is known as the HINGE LINE. The hinge line and dorsal border coincide except in specimens having lobes extending above the hinge line. The distal edge of the contact margin is the FREE EDGE.



MAP 1. Parts of Presque Isle and Alpena counties, Michigan, giving localities of fossils. Inset of the state shows location of enlargement.

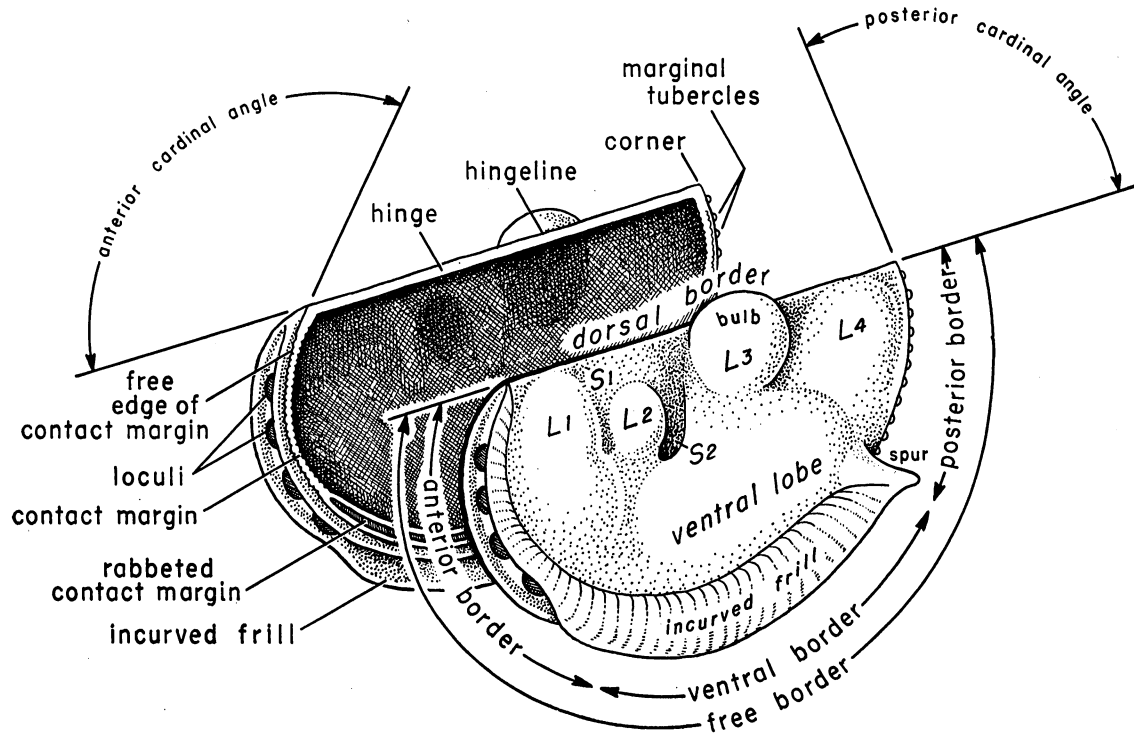


FIG. 1. Composite sketch of an ostracod of the Family Hollinidae. The various parts of the carapace are labeled with terms used in this paper.

The contact margins of certain Devonian ostracods have two or three edges parallel to their free edges; the ridges on one valve fit into the grooves between ridges on the opposite valve and form a strong closing structure. The contact margins with ridges and grooves are said to be RABBETED. If three ridges are present, the distal ridge is the FLANGE, the middle ridge is the SELVAGE, and the proximal ridge is the LIST; if only two ridges are present, they are interpreted as whichever two of these structures they may be by their positions and relations.

The LOBATION is the pattern of convexities on the surface of a valve. These convexities include gently arched elliptical areas called LOBES, small rounded prominences called NODES, hemispherical protuberances known as KNOBS, globose structures protruding above the hinge line called BULBS, and elongated raised areas known as RIDGES.

The anterior and ventral parts of the valves of hollinid ostracods bear VELATE STRUCTURES, such as curtain-like additions called FRILLS, small raised strips designated VELATE RIDGES, and flattened spinelike projections known as SPURS. Valves of the females in some species have each of the frills joined by transverse processes to a marginal ridge, leaving the interstices as deep pits called LOCULI. In many species the exterior of the frill is scalloped, so that the series of loculi have the shape of short coalesced cylinders.

On the basis of analogy with living ostracods, fossil specimens are oriented with the widest part of the carapace posterior, and the highest part of the carapace anterior. This makes the deepest sulcus slightly anterior, and the more tapered end of each valve posterior. Quadrilobate ostracods of the family Hollinidae usually have the four lobes unequal and the three sulci varying in depth and length; L1 (the anterior lobe) is usually gently convex; L2 (the median lobe) is smaller and nodelike; L3 (the third lobe) is knoblike or strongly rounded; and L4 (the fourth lobe) is gently convex with low relief. These four lobes are restricted to the dorsal half of the valve in some species and the ventral half is raised as a VENTRAL LOBE. S1 (the anterior sulcus) is usually rather shallow; S2 (the median sulcus) is deep and well-defined; and S3 (the posterior sulcus) in many valves is only a shallow groove.

The angle between the anterior free edge of the contact margin and the hinge line is the ANTERIOR CARDINAL ANGLE. The angle between the posterior free edge of the contact margin and the hinge line is the POSTERIOR CARDINAL ANGLE. The anterodorsal extremity of the lateral surface is the ANTERIOR CORNER, and the posterodorsal extremity is the POSTERIOR CORNER.

A sloping, nearly straight outline to the posteroventral border is termed the SWING, because it can be developed only when the ventral half of the valve is displaced or "swung" somewhat forward in relation to the dorsal half of the valve.

The DOMICILIUM is the part of the carapace occupied by the animal in life, and does not include the frills.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA

Superfamily Beyrichiacea

Family Hollinidae

Genus *Ctenoloculina* Bassler 1941

Tetradella (part) Warthin, 1934, p. 209.

Ctenoloculina Bassler, 1941, pp. 21-27.

Genotype.—*Tetradella cicatricosa* Warthin, 1934.

Ctenoloculina cicatricosa (Warthin)

(Pl. IV, Figs. 9-10)

Tetradella cicatricosa Warthin, 1934, p. 209, Pl. I, Figs. 4-6.

Tetradella cicatricosa Stewart, 1936, p. 748, Pl. 100, Figs. 23-24.

Tetradella cicatricosa Warthin, 1937, p. 54.

Ctenoloculina cicatricosa Bassler, 1941, pp. 21-27.

? *Ctenoloculina acanthophora* Swartz and Oriol, 1948, p. 553, Pl. 79, Figs. 8-14.

Remarks.—The specimens of *C. cicatricosa* occurring in the Bell shale are very similar to those from the Norway Point formation. Specimens include several adult females and many immature males.

The contact margins are complex. The contact margin of the right valve is rabbeted in the anterior and ventral parts, but not in the posterodorsal part; the proximal ridge seems to correspond to the selvage and the distal ridge seems to correspond to the flange of Cenozoic ostracods. The contact margin of the left valve is doubly rabbeted in the anterior and ventral parts, but the three ridges, apparently developed as the list, selvage, and flange, are partly fused in the posterior part. The two ridges on the right valve fit into the two grooves of the left valve, so that the left valve overlaps the right along the ventral free edge.

The hinge of the left valve has a crenulate ridge which is arched upward at the ends above the anterior and posterior sockets. The prominent ends of the right valve fit into these sockets.

Occurrence.—Numerous specimens from locality No. 1.

Types.—Hypotypes Nos. 26642-26643.

Genus *Tetrasacculus* Stewart 1936

Tetrasacculus Stewart, 1936, pp. 744-45.

Genotype.—*Tetrasacculus bilobus* Stewart, 1936.

Tetrasacculus bilobus Stewart

(Pl. I, Figs. 3-5)

Tetrasacculus bilobus Stewart, 1936, pp. 744-45, Pl. 100, Figs. 8-11.

Tetrasacculus minimus Warthin, 1937, p. 65.

Remarks.—Male specimens of this species from the Bell shale have a more complete velate ridge than does the male syntype illustrated by Stewart (1936, Pl. 100, Fig. 9). The reticulation of the Bell specimens is in somewhat higher relief than that shown in Stewart's original figures of the species (1936, Pl. 100, Figs. 9-10). Furthermore, the contact margin of the Bell specimens is distinctly tuberculate.

Occurrence.—Numerous specimens from locality No. 1.

Types.—Hypotypes Nos. 26653-26654.

Tetrasacculus magnivelatus, sp. nov.

(Pl. I, Figs. 6-7)

Description of female.—Carapace subelliptical. Dorsal border straight, anterior border subrounded, ventral border gently curved, and posterior border acutely tapering toward posterior corner. Unisulcate; sulcus deep and oblique, extending from midpoint of dorsal border to anteroventral area of valve, there terminating against the frill. Anterior part of valve rather flat; posterior part gently rounded. Small median node immediately anterior to sulcus.

Frill wide, its lateral surface relatively flat except for two grooves externally marking the boundaries of the loculi. Frill extending nearly half the distance from the ventral border to the dorsal border. Three complete loculi; one anterior, one anteroventral, and one ventral. Frill extending posterior to ventral loculum, but lacking the posterior transverse process necessary to form a fourth loculum.

Anterior cardinal angle approximately 120 degrees; posterior corner broken in holotype and posterior cardinal angle not measurable.

Small marginal ridge joined to rim of anterior loculum but distinctly separated from the rims of the anteroventral and ventral loculi. Surface of valve finely reticulate, frill relatively smooth.

Dimensions of adult female left valve, the holotype: length, 0.62 mm.; height, 0.32 mm.; and width, 0.18 mm.

No male specimens found.

Remarks.—This species differs from *Tetrasacculus bilobus* Stewart in having only three loculi instead of four, a wider frill, a more oblique sulcus, a more elongate carapace, and a small median node.

Occurrence.—Locality No. 2.

Type.—Holotype, an adult female left valve, No. 26715.

Genus *Ctenobolbina* Ulrich 1890

Ctenobolbina Ulrich, 1890, p. 108.

Genotype.—*Beyrichia ciliata* Emmons.

Remarks.—The hingement of ostracods of this genus occurring in the Bell shale is very similar to that in *Hollinella*. The left valve

has a slightly crenulate bar representing the hinge selvage, which is confluent with the selvage of the contact margin; near the anterior and posterior corners, this hinge selvage turns sharply upward above nearly triangular sockets. The right valve has two ridges, representing the hinge flange and hinge selvage, separated by a sharp groove; the ends of the hinge selvage project as poorly defined teeth.

***Ctenobolbina spicata*, sp. nov.**

(Pl. IV, Figs. 1-6)

Description of female.—Carapace subrectangular. Dorsal border straight; anterior border rounded; ventral border very gently rounded; posterior border nearly straight. Valves tapering posteriorly to posterior corner.

Sulcus deep, slanting slightly forward and down, terminating abruptly in the central part of valve. Inflated L1 and L3 ventrally confluent. L2 not present. Posterior one-sixth of valve forming L4, only gently rounded. Posterior border of valve with definite swing, turning abruptly to form an obtuse angle with the hinge line.

Frill slightly undulating, extending from anterior corner to posteroventral border of the valve. Frill granular but without striations or spines. Frill nearly vertical throughout its length.

Anterior cardinal angle approximately 125 degrees; posterior cardinal angle approximately 115 degrees. Hinge line slightly more than three-quarters of the length of the valve.

Surface distinctly granulose and ornamented with scattered blunt spines. Lobes with longer spines than rest of the valve.

Inflated L3 extending slightly above the hinge line, its spines extending farther above hinge line.

Dimensions of right valve, the allotype: length, 1.20 mm.; height, 0.84 mm.; and width, 0.38 mm.¹

Description of male.—Outline and ornamentation same as those of female. Posterior cardinal angle approximately 100 degrees. Frill

¹ "Allotype" designates a specimen of the sex opposite to that of the holotype, one selected to bring out the particular characteristics of that sex. It is a specially designated paratype. This is the usage proposed by Banks and Caudell (1912, p. 15).

wide and unornamented, flared outward, terminating in a large spine projecting outward and backward. Frill separated from ventral small marginal ridge by a smooth channel. Posterior border of male valve with much less swing than that of female valve. Sulcus more elongate than that of female. L3 only slightly more inflated than L1.

Dimensions of left valve, the holotype: length, 1.24 mm.; height, 0.82 mm.; and width, 0.34 mm.

Remarks.—This species differs from *Ctenobolbina papillata* (Tolmachoff) in having larger spines scattered over the surface, greater height, and greater extent of the lobes and from *Ctenobolbina papillosa* Ulrich in lacking a posterior sulcus.

The frill is fragile and easily broken. Specimens having a considerable proportion of the frill intact can easily be classified as males or females by the curvature of the frill.

Occurrence.—Locality No. 2.

Types.—Holotype, an adult male left valve, No. 26640; allotype, an adult female right valve, No. 26641; paratypes Nos. 26678-26680.

***Ctenobolbina pinguis*, sp. nov.**

(Pl. IV, Figs. 7-8)

Description.—Carapace large, elongate, subrectangular. Anterior and posterior borders subrounded, ventral border slightly rounded. L1 gently rounded, L3 inflated. Carapace in dorsal view showing large projection extending posterior to L3 and truncated abruptly at the posterior border.

Sulcus of each valve nearly central, shallow, vertical, extending two-thirds of the distance from the hinge line toward the ventral border. No lobes extending above the hinge line. L1 and L3 confluent ventral to the sulcus. L2 not present. L1 with a smooth protuberance at the anterior corner.

Frill small, extending from anterior corner to the posteroventral part of border.

Anterior cardinal angle approximately 120 degrees; posterior end subrounded.

Surface covered with discrete granules and scattered rounded tubercles, forming unusual and distinctive ornamentation.

Dimensions of complete carapace, the holotype: length, 1.58 mm.; height, 0.82 mm.; and width, 0.79 mm.

Remarks.—This large and beautifully ornamented species is not closely related to any other species of *Ctenobolbina* described from the Devonian. The smooth shoulder-like protuberances at the anterior corners are very distinct. Only one specimen has been found.

Occurrence.—Locality No. 1.

Type.—Holotype No. 26728.

Genus *Hollinella* Coryell 1928

Beyrichia Ulrich and Bassler, 1906, p. 156.

Hollina (part) Ulrich and Bassler, 1908, p. 315.

Hollinella Coryell, 1928, pp. 377-78.

Hollina (part) Knight, 1929, p. 240.

Basslerina Moore, 1929, p. 106.

Hollinella Kellett, 1929, pp. 196-217.

Hollinella Blake, 1930, pp. 297-98.

Hollinella Warthin, 1930, p. 57.

Hollinella Knight, 1930, p. 417.

Hollina (part) Latham, 1932, p. 360.

Hollinella Kellett, 1933, p. 69.

Hollinella Upson, 1933, p. 30.

Hollinella Morey, 1935, p. 479.

Hollinella Kellett, 1936, p. 779.

Hollinella Swartz, 1936, p. 551.

Hollinella Cooper, 1941, pp. 45-46.

Hollinella Cooper, 1946, pp. 87-97.

Hollinella Cooper, 1947, p. 85.

Genotype.—*Hollinella dentata* Coryell, 1928.

Remarks.—The hingement of *Hollinella* was described in detail by Kellett (1929, p. 199). The edge of the left valve is developed as a hinge selvage and fits into the grooved hinge of the right valve. The right valve has two distinct ridges, developed as a hinge flange and hinge selvage; the hinge selvage is confluent with the selvage of the contact margin. The corners of the right valve fit into the sockets of the left valve which are at the bases of protuberances.

Hollinella kolmodini (Jones)

(Pl. I, Fig. 10)

Beyrichia kolmodini Jones, 1890, p. 538, Pl. 20, Fig. 6.*Beyrichia* (?*Depranella*) *kalmodini* Ulrich, 1891, p. 190, Pl. 14, Figs. 1a-c.*Beyrichia kolmodini* Raymond, 1904, p. 174.*Hollina kolmodini* Ulrich and Bassler, 1908, p. 315, Pl. 42, Figs. 5-7.*Hollina kolmodini* Grabau and Shimer, 1910, p. 358, Figs. 1665f-h.*Hollina kolmodini* Moore, 1929, p. 100.*Hollinella kolmodini* Bassler and Kellett, 1934, p. 333.

Remarks.—The three specimens from the Bell shale have been compared with illustrations of *Hollinella devoniana* Van Pelt (1933, Pl. 39, Figs. 33-36) and of *Hollinella kolmodini* (Jones) (Ulrich and Bassler, 1908, Pl. 42, Figs. 5-7). The Bell specimens are very similar to those described and figured by Ulrich and Bassler as *Hollina kolmodini* (Jones) and are here assigned to that species. The L2 in *Hollinella kolmodini* (Jones) is separated from the L1, as is the case with the Bell shale specimens, and is not partly confluent with the L1 as described and illustrated for *Hollina devoniana* Van Pelt. No specimens of *Hollina devoniana* Van Pelt were found in the Bell shale.

Occurrence.—Locality No. 2.

Type.—Hypotype No. 26646.

***Hollinella acutangulata*, sp. nov.**

(Pl. V, Figs. 6-10)

Description of female.—One female specimen available; posterior end broken. Carapace pyriform in lateral view with posterior corner narrowly rounded. Dorsal border straight; anterior border rounded; ventral and posterior borders gently rounded. Carapace with definite swing. S2 long, reaching the ventral frill; dorsal two-thirds of sulcus vertical, ventral one-third of sulcus inclined forward and downward. S1 narrower than S2, vertical, extending from dorsal border to middle of valve.

L1 lobate, elongate vertically, almost confluent with the anterior part of the frill. L2 elongate vertically, confluent with L1 ventral to

S1. L3 elongate vertically, inflated, tangent to the dorsal border, posteriorly sharply set off from the gently rounded L4.

Anterior cardinal angle obtuse.

Frill moderately wide, extending from anterior corner approximately two-thirds of the distance around the free border, tapering posteriorly. Frill nearly vertical, slightly incurved in the anterior part. Surface finely papillose and further ornamented with scattered blunt spines which are particularly abundant on the posterior lobe.

Description of male.—Shape of carapace, lobation, and ornamentation same as female. Posterior part L4 extending above hinge line. L1 tapering dorsally, and separated from the frill by a shallow groove.

Frill approximately the same width as that of female, but curved outward.

Carapace in dorsal view flat-topped, wide, posteriorly narrow and tapering.

Dimensions of complete male carapace, the holotype: length, 1.29 mm.; height, 0.76 mm.; and width, 0.71 mm.

Remarks.—The definite swing of the valves, the posteriorly tapering frill, and the unusual ornamentation distinguish this from other species of *Hollinella* from the Bell shale. L3 is unusually elongate for species of this genus.

Occurrence.—Locality No. 3.

Types.—Holotype, a complete male carapace, No. 26648; allotype, an incomplete female left valve, No. 26702; paratype, a complete male carapace, No. 26703.

***Hollinella auroriradiata*, sp. nov.**

(Pl. VI, Figs. 3-4)

Description of female.—Carapace subrectangular. Anterior border subrounded, ventral border gently rounded, posterior border subrounded, dorsal border straight. S2 distinct, slightly anterior, extending to middle of valve, geniculate, dorsal two-thirds moderately deep and vertical, ventral one-third relatively shallow and directed forward and downward.

L1 gently rounded, separated from frill by groove, nearly confluent with the median lobe but separated from it by a shallow depression. L2 in form of slightly elongate node immediately adjacent to S2. L3 rounded, located immediately posterior to S2, distinctly delineated from L4 and from ventral lobe by shallow groove. Ventral lobe developed ventral to S2 and L3.

Frill wide, extending three-quarters of the distance around free border from anterior corner. Frill widest in anteroventral and ventral parts, terminating posteriorly in a large thick spur. Frill curved outward in anterodorsal part, straight in anterior part, and curved slightly inward in anteroventral and ventral parts. Frill granular, slightly striate.

Anterior cardinal angle obtuse; posterior cardinal angle nearly a right angle.

Surface granular, with few scattered blunt spines. Low spines extending above hinge line. Anterior corner with extension of frill into small blunt spine. Posterior corner extending above hinge line as flattened projection.

Dimensions of female left valve, the holotype: length, 1.33 mm.; height, 0.90 mm.; and width, 0.31 mm.

Description of male.—Shape of valve, lobation, and ornamentation same as those of female.

Frill wide, curved slightly outward throughout its length, terminating in large thickened spur.

Remarks.—This species from the Middle Devonian closely resembles *Hollinella radiata* (Jones and Kirkby), described by Cooper (1941, p. 46, Pl. 9, Figs. 42-44) from the Upper Mississippian Chester of Illinois. It differs from *H. radiata* by its slightly larger size and by the less rounded L2, which in *H. auroriradiata* is nearly confluent with L1.

Occurrence.—Locality No. 2.

Types.—Holotype, a female left valve, No. 26647; allotype, a male right valve, No. 26716; paratypes, two female valves, Nos. 26717 and 26720.

Hollinella bullata, sp. nov.

(Pl. I, Figs. 8-9)

Description of female.—Carapace elongate. Dorsal border straight, anterior border rounded, ventral border nearly straight, and posterior border subrounded. S2 extremely wide, terminating abruptly in middle of valve, slight anteroventral extension.

L1 a low gently rounded lobe nearly confluent with L2, an elongate node. L3 in form of a knob, tangent to dorsal border and immediately adjacent to S2. L4 low, gently rounded, distinctly separated from the knoblike L3 by a furrow and separated from the ventral lobe by a wide shallow depression. Ventral lobe low, confluent with L1 and truncating S2.

Anterior cardinal angle approximately 130 degrees; posterior cardinal angle approximately 120 degrees.

Frill narrow, extending three-quarters of the distance around the free border from the anterior corner, terminating in a thick blunt spur which projects strongly outward. Frill nearly straight, curved slightly inward.

Surface granulose, with scattered prominent tubercles particularly numerous on the knob.

Dimensions of female right valve, the holotype: length, 0.90 mm.; height, 0.43 mm.; and width, 0.26 mm.

Description of male.—Shape of valve, lobation, and ornamentation same as those of female.

Frill narrow, curved slightly outward.

Remarks.—This species is distinguished by the wide S2, the knoblike L3, and the outwardly directed spine at posterior end of the narrow frill.

Occurrence.—Locality No. 2.

Types.—Holotype, a female right valve, No. 26725; allotype, an incomplete male right valve, No. 26726.

Hollinella lativelata, sp. nov.

(Pl. V, Figs. 1-5)

Description of male.—Carapace large, subrectangular. Lateral surfaces parallel, relatively flat except for posterior knob of each

valve. Carapace narrow, with rather flat dorsal surface. Dorsal border straight, anterior and posterior borders subrounded, ventral border gently curved. S1 and S2 extending less than half the distance from dorsal border to ventral border, confluent in their dorsal half.

L1, L2, and ventral lobe confluent, with low relief. L3 developed as a knob, not confluent with the low even posterior one-third of valve (L4), and separated from the ventral lobe by a shallow groove. L2 small, tapering dorsally, terminating at junction of S1 and S2.

Anterior cardinal angle approximately 120 degrees; posterior cardinal angle approximately 100 degrees.

Frill very wide, thick, flared outward throughout its length, finely granulose, extending to posteroventral border. Posterior edge of frill slightly thickened. Hinge line as seen in dorsal view extending beyond anterior junction of frill and rest of valve.

Surface, except for frill, covered with papillae.

Dimensions of complete carapace, the holotype: length (including frill), 1.48 mm.; height, 1.00 mm.; width (through L3's), 0.53 mm. and width (through L1's), 0.43 mm.

Description of female.—Shape of carapace, lobation, and ornamentation same as those of male. Posterior knob larger and with greater relief, hemispherical.

Frill flat, confluent with L1 and ventral lobe, papillose except for finely granulose rim. Hinge line as seen in dorsal view extending beyond anterior junction of frill and rest of valve. Frill flared slightly outward in anterodorsal part, but incurved to meet opposite frill in anteroventral and ventral parts, forming cardioid opening anteriorly.

Dimensions of carapace, the allotype: length (including frill), 1.50 mm.; estimated height (frills broken in ventral parts), 0.94 mm.; width (through L3's), 0.66 mm. and width (through L1's), 0.37 mm.

Remarks.—This large distinctive species exhibits marked dimorphism in the shape and ornamentation of the frill. The female in dorsal view also has posterior knobs much larger and anterior lobes smaller than those of the male. This species is very different from all other *Hollinella* species described.

Occurrence.—Locality No. 1.

Types.—Holotype, a complete male carapace, No. 26689; allotype, an incomplete female carapace, No. 26690; paratype, another incomplete female carapace, No. 26691.

Hollinella magnilobata, sp. nov.

(Pl. I, Figs 11-13)

Description of male.—Carapace subelliptical. Dorsal border straight, anterior and posterior borders subrounded, ventral border gently curved. S2 deep, extending from the dorsal border to the middle of the domicilium; ventral part of sulcus twice as wide as central part, terminating very abruptly at ventral lobe. S1 narrow, moderately deep, half as long as S2, dorsally confluent with S2.

L1 gently arched, nearly confluent with ventral lobe. L2 developed as vertically elongate node, slightly above middle of domicilium. L3 large, knoblike, separated from ventral lobe and L4 by shallow groove, provided with a distinct short blunt spine in postero-dorsal part. Ventral lobe inflated, located ventral to knoblike L3 and S2, separated from L1 by shallow depression. L4 with low relief, provided with posterodorsal spinelike projection.

Anterior cardinal angle distinctly obtuse; posterior cardinal angle slightly obtuse.

Frill from anterior corner to posteroventral part of valve, wide ventrally, posteriorly acutely rounded, flat, slanting outward throughout its length.

Entire surface slightly granular, with irregular partly fused granules.

Dimensions of a left valve, a paratype: length, 0.82 mm.; height (including frill), 0.53 mm.; and width, 0.20 mm.

Description of female.—Shape of carapace, lobation, and ornamentation same as those of male. Knoblike L3 extending slightly above hinge line, without posterodorsal short spine of male.

Frill same length as that of male, confluent with rest of valve, vertical and not slanting outward, posteriorly gently tapering.

Dimensions of a left valve, the allotype: length, 0.87 mm.; height, 0.54 mm.; and width, 0.22 mm.

Remarks.—This small species of *Hollinella* has some resemblance to *H. kolmodini* (Jones), from which it differs in the presence of a wider and less inflated knoblike L3 and in the lack of ventral confluence of S1 and S2. The male differs from the female in the slope of the frill and in the presence of a posterodorsal spine on the posterior lobe.

Occurrence.—Locality No. 2.

Types.—Holotype, a complete male carapace, No. 26644; allotype, a female left valve, No. 26645; paratypes, two female valves and one male valve, Nos. 26722-26724.

***Hollinella porrecta*, sp. nov.**

(Pl. VI, Figs. 1-2)

Description.—Carapace elongate, subelliptical to subrectangular. Hinge line straight, anterior and posterior borders subrounded, ventral border gently curved. S2 deep, wide, terminating abruptly a short distance above middle of valve. S1 developed as shallow groove, shorter than S2.

L1, L2, ventral lobe, and L3 confluent. L1 relatively small, gently arched. L2 developed as linguiform projection from L1 and ventral lobe, terminating dorsally below dorsal margin. L3 developed as wide bulb extending above hinge line, only slightly posterior. Ventral lobe long, connecting the three principal lobes, sloping gently into posterior one-fourth of valve (L4).

Anterior cardinal angle approximately 115 degrees; posterior corner gently rounded.

Frill very narrow, only slightly more than a velate ridge, extending more than three-fourths of distance around free border from the anterior corner.

Surface slightly granular with irregular granules, further ornamented by scattered low tubercles.

Dimensions of a complete carapace, the holotype: length, 1.58 mm.; height (including L3), 0.81 mm.; height from hinge line to ventral border, 0.75 mm.; and width, 0.82 mm.

Remarks.—Only one specimen of this unusual species has been found. The tumid elongate carapace, large bulbs, rounded posterior

corners, anterior position of the median sulci, and narrow frills distinguish this large species from all other Devonian species of *Hollinella*.

Occurrence.—Locality No. 3.

Type.—Holotype, a complete carapace, No. 26727.

***Hollinella productilobata*, sp. nov.**

(Pl. III, Figs. 4-5)

Description.—Carapace subovate. Hinge line straight; dorsal and posterior borders rounded, ventral borders gently curved. S2 deep, extending to middle of valve, curved regularly throughout its length with the ends directed forward, dorsally confluent with S1. S1 shallower than S2 and approximately half as long, gently tapering ventrally.

L1 very gently arched, confluent with anteroventral part of L2. L2 vertical, elongate as a node, terminating dorsally below the dorsal border. L3 developed as a laterally expanded bulb adjacent to S2 and separated from ventral lobe and L4 by a shallow groove. Ventral lobe very gently arched, nearly confluent with L1 and L2, sloping gradually into slightly arched posterior one-fourth of valve (L4).

Anterior and posterior corners rounded.

Frill narrow, unornamented, extending from anterior corner to posteroventral part of valve, approximately the same width throughout its length.

Left valve overlapping right valve. Free edge ornamented with a row of short discrete tubercle-like denticles, closely spaced, forming the ventral border. Each valve ornamented with a second row of small tubercle-like denticles between the frill and the free edges of contact margin and extending from central anterior to central posterior areas of valve.

Surface decorated with discrete papillae and scattered tubercles. Tubercles uniform in size and height, extending slightly above level of papillae.

Dimensions of a carapace, the holotype: length, 1.10 mm.; height, 0.64 mm.; and width of left valve, 0.30 mm. (right valve deformed).

Remarks.—No dimorphism has been observed in this beautiful and distinctive species. The rounded corners, unusual ornamentation, and discrete tubercles along the free edge of the contact margin of the left valve distinguish this from other *Hollinella* species.

Occurrence.—Locality No. 1.

Types.—Holotype, a complete carapace, No. 26649; paratypes, three other carapaces, Nos. 26651, 26652, and 26714.

Genus *Parabolbina* Swartz 1936

Ctenobolbina (in part) Ulrich, 1900, p. 183.

Parabolbina Swartz, 1936, p. 570.

Genotype.—*Ctenobolbina granosa* Ulrich, 1900.

***Parabolbina pulchella*, sp. nov.**

(Pl. III, Figs. 6-7)

Description.—Only male valves found. Carapace elongate, subovate, bilobate. Dorsal border straight, anterior border subrounded, ventral border gently rounded, posterior border tapering and subrounded. Median sulcus deep, vertical, terminating abruptly above the middle of the valve.

L1, ventral lobe, and L3 confluent, gently arched. Carapace with slight inflation anterior to median sulcus, resembling an L2 but scarcely delineated from rest of valve.

Anterior cardinal angle approximately 115 degrees; posterior end rather acutely rounded.

Spurs at anteroventral and posteroventral parts of valve, large, blunt, ends broken.

Surface coarsely granular. Free border ornamented by widely spaced tubercles.

Dimensions of male right valve, the holotype: Length, 0.85 mm.; height, 0.45 mm., and width, 0.28 mm.

Remarks.—An immature specimen with the spurs of the male is designated as a paratype. In the Hollinidae species which have spurs on the adult male valves and frills on the adult female valves, all immature specimens have spurs and the general form of the male.

Occurrence.—Locality No. 2.

Types.—Holotype, an adult male right valve, No. 26650; paratype, an immature right valve, No. 26721.

Propectrum, gen. nov.

Description of male.—Carapace elongate, unisulcate. Hinge line straight. Median sulcus deep. L1, ventral lobe, and L3 confluent. Velate ridge or small frill in mid-ventral part of valve, terminating anteriorly in a large spur.

No females of this genus found.

Genotype.—*Propectrum platum*, sp. nov.

Propectrum platum, sp. nov.

(Pl. I, Figs. 1-2)

Description of male.—Carapace elongate, with definite swing, posteriorly pointed. Dorsal border straight, anterior border rounded, ventral border nearly straight, posterior border tapering to posterior corner. Median sulcus deep, vertical, extending from dorsal border to middle of valve, terminating in a pit.

L1, ventral lobe, and L3 confluent. L1 and ventral lobe inflated. L3 gently arched.

Anterior cardinal angle approximately 115 degrees; posterior cardinal angle approximately 75 degrees.

Small frill or velate ridge in central ventral part of valve, its posterior end curved upward, its anterior end terminating in a large palmate spur.

Surface deeply reticulate. Small hemispherical node with short, posterodorsally directed blunt spine, located in posterodorsal part of valve below hinge line. Free edge of valve with rounded marginal ridge.

Dimensions of adult left valve, the holotype: estimated length (posterior end broken), 0.60 mm.; height, 0.28 mm.; and width, 0.34 mm.

Remarks.—No dimorphism has been found. The development of the anterior spur suggests that the two specimens are both males. The immature specimen illustrated in Plate I, Figure 1, has the

posterior tapering of the carapace. This species does not closely resemble any other species described. It can be readily identified by the peculiar expanded spur in the anteroventral part of the valve.

Occurrence.—Locality No. 2.

Types.—Holotype, an incomplete adult left valve, No. 26686; paratype, an immature right valve, No. 26687.

Subligaculum, gen. nov.

Description of Male.—Carapace subovate to subrectangular, trilobate to quadrilobate. Spur in posteroventral part of valve, small frill in anteroventral part of valve.

Description of female.—Shape of carapace and lobation same as those of male. Frill wide, scalloped. Contact margins and hinging same as those of *Ctenoloculina cicatricosa* (Warthin). Doubly rabbeted anterior and ventral parts of contact margin of left valve of the genotype well shown in Plate VII, Figure 5.

Remarks.—The genus is distinguished by the unusual velate structures of the male. When the two valves of the female are in contact, their frills form four false chambers, with each frill forming a half of each of the four chambers.

Genotype.—*Subligaculum scrobiculatum*, sp. nov.

Subligaculum scrobiculatum, sp. nov.

(Pl. II, Figs. 1-4; Pl. VII, Figs. 1-8)

Description of male.—Carapace subovate. Dorsal border straight, anterior and posterior borders subrounded, ventral border gently rounded. S2 deep, vertical, ventrally branched with anterior branch extending below L2 and posterior branch leading to a posterior pit. Posterior pit deep, located in middle of L3, connected to S2 by deep furrow and to posteroventral part of free border by shallow groove. S1 shallow, reaching from the dorsal border to middle of valve.

L1 gently arched, confluent with ventral lobe. L2 developed as a rounded node, dorsally nearly tangent to dorsal border. L3 rounded, slightly inflated in its anterior part, bordering posterior pit dor-

sally and posteriorly, with the general shape of a half torus. Ventral lobe slightly inflated, terminated posteriorly by the pit and shallow groove.

Anterior cardinal angle approximately 120 degrees; posterior cardinal angle approximately 90 degrees.

Anteroventral frill slightly rounded, with tuberculate edge and two parallel rows of smaller tubercles on the lateral surface. Large posteriorly directed spur on posteroventral free border. Both frill and spine covered with granules.

Surface covered with large discrete granules.

Dimensions of right valve, the holotype: length, 0.72 mm.; height, 0.40 mm.; and width, 0.23 mm.

Description of female.—Surface ornamentation and lobation same as those in male. Frill wide, scalloped, with four external inflations marking positions of four internal pocket-like depressions; pocket-like depressions of each frill forming the halves of each of four spheroidal false chambers when the two valves are in contact. Valves approximately same size as those of the male.

Anterior cardinal angle 125 degrees; posterior cardinal angle 100 degrees.

Dimensions of right valve, the allotype: length, 0.76 mm.; height (including frill), 0.45 mm.; and width, 0.21 mm.

Remarks.—The unusual lobation, the location and size of the posterior pits, and the velate structures in both the male and the female are the distinguishing characteristics of this species.

Occurrence.—Locality No. 2.

Types.—Holotype, an adult male right valve, No. 26638; allotype, an adult female right valve, No. 26639; paratypes, three males, Nos. 26788-16790, and five females, No. 26783-26787.

***Subligaculum recurvisulcatum*, sp. nov.**

(Pl. II, Figs. 5-12)

Description of male.—Carapace subrectangular. Dorsal border straight, ventral border almost straight, anterior and posterior borders very gently curved. S2 shallow, extending from dorsal border

to center of valve, vertical, bifurcating ventrally. Posterior branch recurving to posteroventral part of free border, terminating posterior to spur. Anterior branch arching around L2, becoming indistinct. S1 very shallow.

Carapace trilobate. L1 present as a low-lying lobe, confluent with ventral lobe. L2 nodelike, with low relief. L3 low-lying.

Anterior cardinal angle 120 degrees; posterior cardinal angle 100 degrees.

Anteroventral frill slightly rounded, with tuberculate edge. Small posteriorly directed spur on posteroventral free border.

Dimensions of a complete carapace, the holotype: length, 0.78 mm.; height, 0.42 mm.; and width, 0.28 mm.

Description of female.—Surface ornamentation and lobation as in male. Frill wide, scalloped, with four inflations shaped like half spheroids; half spheroids of each frill forming halves of each of four false chambers when valves are in contact. Carapace slightly larger than male, with a subovate outline.

Anterior cardinal angle 125 degrees; posterior cardinal angle 95 degrees.

Dimensions of a complete carapace, the allotype: length, 0.88 mm.; height (including frill), 0.58 mm.; and width, 0.32 mm.

Remarks.—The unusual lobation, the shape of the sulcus, and the velate structures in both the male and the female are the distinguishing characteristics of this species. This species closely resembles *S. scrobiculatum*, the only marked difference being in the pattern of the sulci.

Occurrence.—Locality No. 1.

Types.—Holotype, an adult male carapace, No. 26681; allotype, an adult female carapace, No. 26682; paratypes, three females, Nos. 26683, 26684, and 26697, and five males, Nos. 26696 and 26698-26701.

Falsipollex, gen. nov.

Description of male—Carapace subovate, elongate. Hinge line straight. Posteroventral part of valve with definite swing. Trilobate

to quadrilobate. Two large posteriorly directed spurs on ventral free margin. L3 large.

Description of female.—General shape of carapace and lobation same as those of male. More pronounced swing in female. Female little more elongate. Frill very wide, extending from anteroventral corner along free border to slightly past center. L3 very large.

Remarks.—The genus is distinguished by the two unusual velate spurs of the male. The shape and direction of the spurs of the male and the short wide frill of the female are generic characters.

Genotype.—*Falsipollex altituberculatus*, sp. nov.

***Falsipollex altituberculatus*, sp. nov.**

(Pl. III, Figs. 1-3)

Description of male.—Carapace subovate, somewhat elongate with definite posteroventral swing. Dorsal border straight, anterior border subrounded, posterior border definitely rounded, ventral border gently rounded. S2 fairly deep, slightly inclined toward the posteroventral margin. S1 shallow, almost indistinct. S3 shallow, small, confluent with S2 by means of a groove below L3.

L1 elongate, with dorsal prominence projecting above hinge line, extending vertically downward to become confluent with the anterior spur. L2 present as a slightly developed node. L3 knoblike, extending above hinge line. L4 large, with low relief, extending vertically downward to become confluent with the posterior spur.

Anterior cardinal angle approximately 120 degrees; posterior end rounded.

No frill. Spurs large, semicircular in cross section, directed posteriorly, covered with tubercles.

Surface covered by raised tubercles not uniform in height or diameter.

Dimensions of left valve, the holotype: length, 1.02 mm.; height (not including spurs), 0.60 mm.; and width, 0.26 mm.

Description of female.—Carapace subpyriform, with pronounced swing. Hinge line straight, anterior border rounded, ventral border gently rounded, posterior border nearly straight and acutely rounded

at end. S2 wide and deep, slanting slightly backward from dorsal border, extending dorsally above L2. S1 shallow, indistinct.

L1 with dorsal protuberance above hinge line, confluent with ventral lobe. L2 low, not distinct. L3 developed as knob extending above hinge line, located adjacent to median sulcus, also confluent with ventral lobe. L4 gently arched.

Anterior corner broken; posterior cardinal angle approximately 110 degrees.

Frill very wide, extending from anterior corner to slightly more than half the distance along the free border, delineated from rest of valve by groove, covered with tubercles.

Surface covered with tubercles resembling those of male.

Dimensions of right valve, the allotype: length (including frill), 1.11 mm.; height (including frill), 0.68 mm.; and width, 0.27 mm.

Remarks.—The lobation of this species resembles that of *Hollinella*. The holotype is partly corroded and replaced with pyrite in the central region.

Occurrence.—Locality No. 2.

Types.—Holotype, an adult male left valve, No. 26636; allotype, an adult female right valve, No. 26637.

KEY TO GENERA OF HOLLINID OSTRACODS FROM THE BELL SHALE

This key includes only the genera of the family Hollinidae which occur in the Bell shale.

L3 inflated or bulblike, extending above hinge line

Dimorphism only present in curvature of frill

L3 inflated, L1 and L2 united and convex

as a unit.....*Ctenobolbina* Ulrich

L3 usually a knob or bulb, L2 distinct as a

small lobe or node.....*Hollinella* Coryell

Dimorphism pronounced, male with

spurs.....*Falsipollex*, gen. nov.

L3 usually not inflated, not extending above hinge line

Male with two spurs

Unisulcate, female with simple frill.....*Parabolbina* Swartz

Trisulcate, female with loculi in frill....*Ctenolocolina* Bassler

- Male without spurs, unisulcate, female with
loculi in frill.....*Tetrasacculus* Stewart
- Male with only anteroventral spur and
velate ridge.....*Proplectrum*, gen. nov.
- Male with posteroventral spur and small anteroventral
frill, female with scalloped frill....*Subligaculum*, gen. nov.

RELATIONSHIPS OF GENERA OF HOLLINID OSTRACODS
FROM THE BELL SHALE

Although the geologic ranges of many Paleozoic genera may be slightly extended by future paleontological work, the Middle Devonian seems to have been the time of rapid evolution of the hollinid ostracods. The genera which had appeared in the Ordovician changed their identity in the Middle Devonian by the loss of certain essential generic characters, by the addition of new characters, or as a result of a combination of these two factors.

Ctenobolbina and *Parabolbina*, as far as is known, occurred first in the Ordovician and became extinct in the Middle Devonian. Many new genera of the family, including *Hollinella*, *Tetrasacculus*, *Ctenoluculina*, *Falsipollex*, *Subligaculum*, and *Proplectrum*, appeared during the Middle Devonian. Some of these genera present in the Bell shale, show close relationships to *Ctenobolbina* and the others show close relationships to *Parabolbina* (Fig. 2.)

Hollinella has an inflated L3 similar to that of *Ctenobolbina*, from which it is presumed to have originated. *Hollinella*, however, has a bulb-shaped L3 and a distinct nodelike L2. *Falsipollex* has approximately the same lobation as *Hollinella*, but has a greater degree of dimorphism—*Falsipollex* males have large spurs and *Hollinella* males have the frill flared outward. The strong similarities of lobation suggest that *Falsipollex* and *Hollinella* came from a common lineage.

Tetrasacculus, *Ctenoluculina*, *Subligaculum*, and *Proplectrum* are presumed to have been derived from *Parabolbina*. All of these genera lack an inflated L3, although they have little else in common in their lobation. Females of *Tetrasacculus* and *Ctenoluculina* have greatly modified frills provided with loculi and probably came from a com-

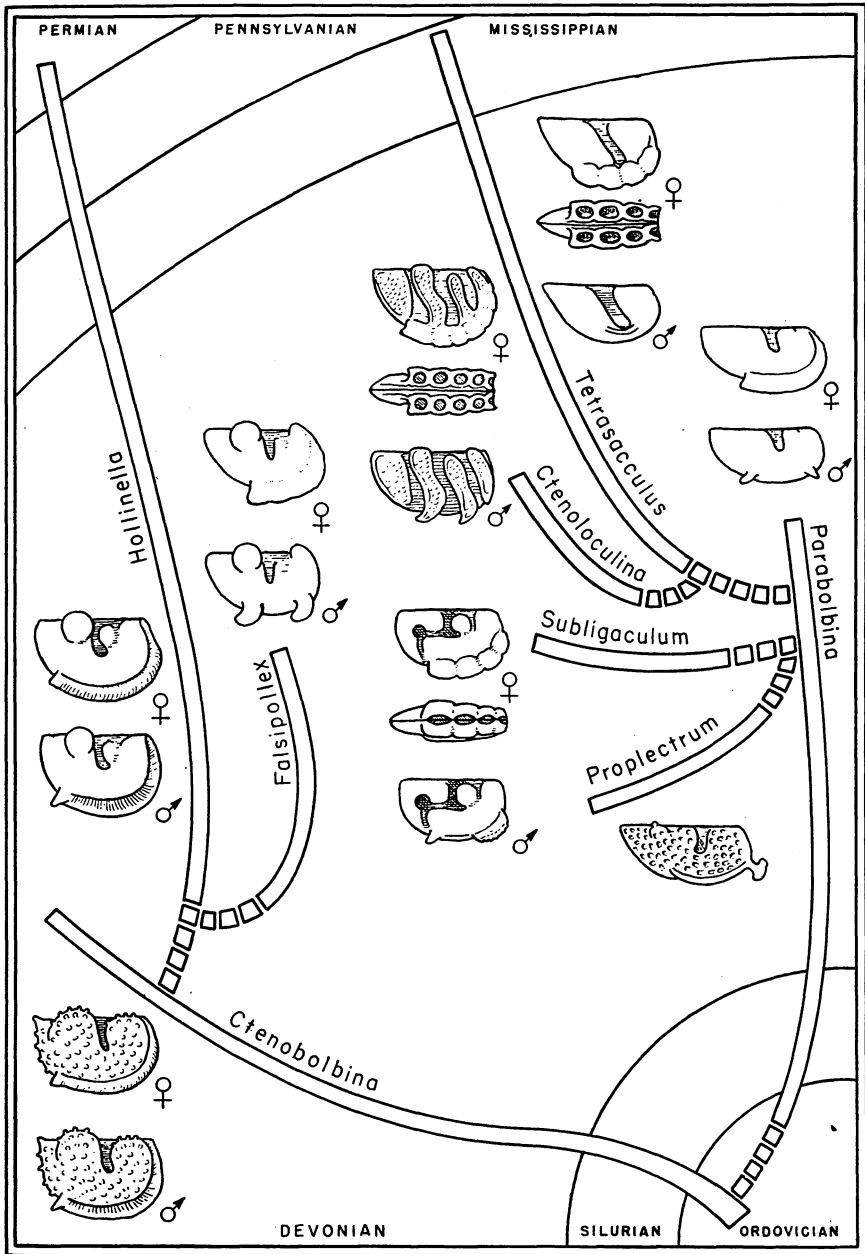


FIG. 2.—Geologic ranges and the relationships of genera of the family Hollinidae from the Bell shale, with sketches of adult male and female carapaces to illustrate dimorphism.

mon lineage. *Tetrasacculus* is bilobate, however, and *Ctenolocolina* is distinctly quadrilobate; furthermore, *Tetrasacculus* males have no spurs, and *Ctenolocolina* males have spurs only slightly different from those of *Parabolbina*. *Subligaculum* and *Proplectrum* both have the velate structures of the males modified from the simple spurs of the *Parabolbina* male. In *Subligaculum* the male has a small frill instead of a spur in the anteroventral part of each valve, and in *Proplectrum* the male has a large anteroventral palmate spur and no posteroventral spur. In *Subligaculum* there is also a development of L2 which is not present in *Proplectrum*. In *Subligaculum* the females have a scalloped frill on each valve; unfortunately, no females of *Proplectrum* have been found. In summary, *Tetrasacculus* and *Ctenolocolina* differ from *Parabolbina* primarily by modifications of the frill in the female, and *Subligaculum* and *Proplectrum* differ from *Parabolbina* primarily by strong modifications of the velate structures in the male; there are many variations between the lobation of *Parabolbina* and that of any one of its presumed derivatives.

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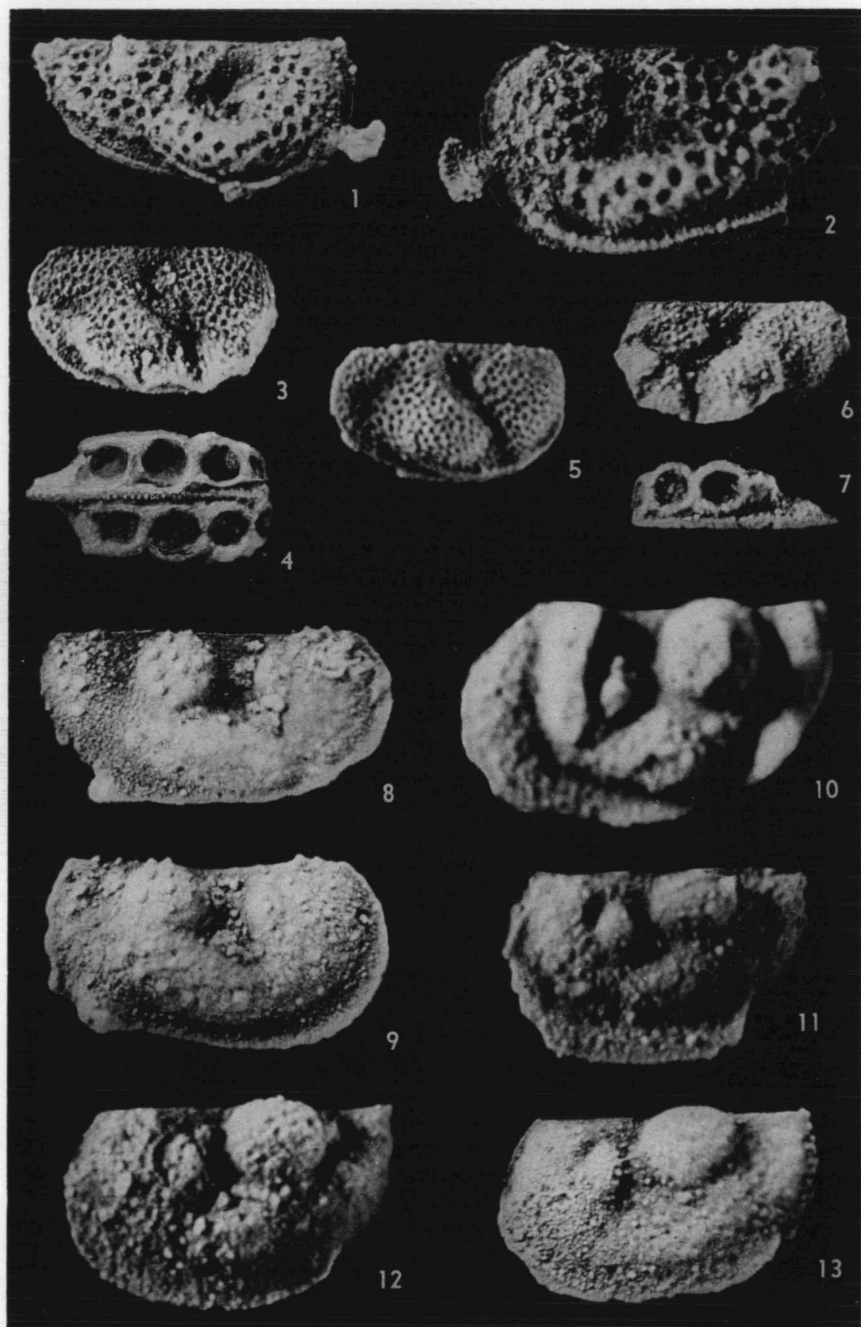
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PLATES

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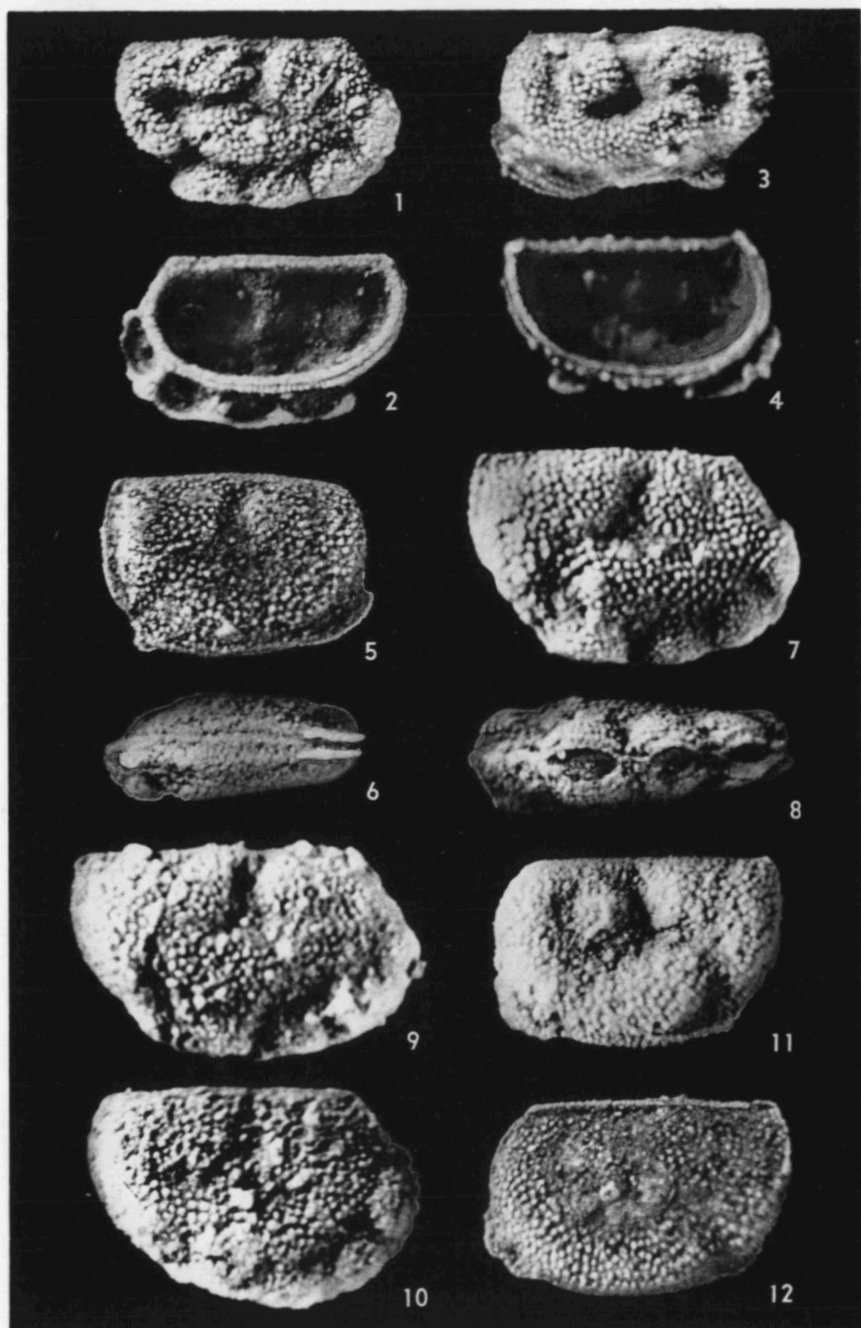
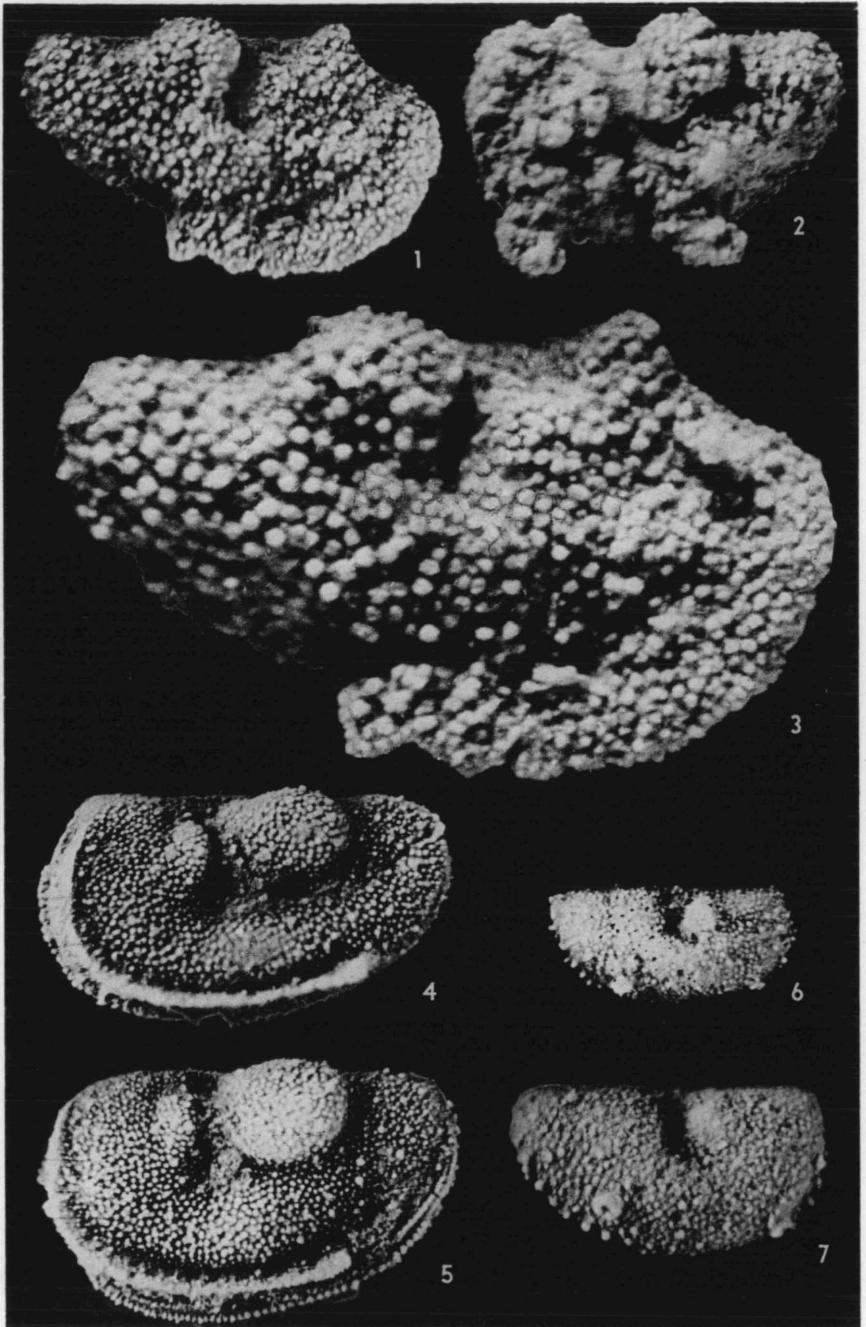


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FIGS. 1-2. Lateral and ventral views of female right valve. Allotype No. 26641.	
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FIG. 5. Lateral view of male left valve. Paratype No. 26678.	
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 <i>Ctenobolbina pinguis</i> , sp. nov.	 53
FIGS. 7-8. Dorsal and lateral views of complete carapace. Holotype No. 26728.	
 <i>Ctenoloculina cicatricosa</i> (Warthin)	 49
FIG. 9. Right lateral view of adult female carapace. Hypotype No. 26642.	
FIG. 10. Left lateral view of immature specimen. Hypotype No. 26643.	

PLATE IV

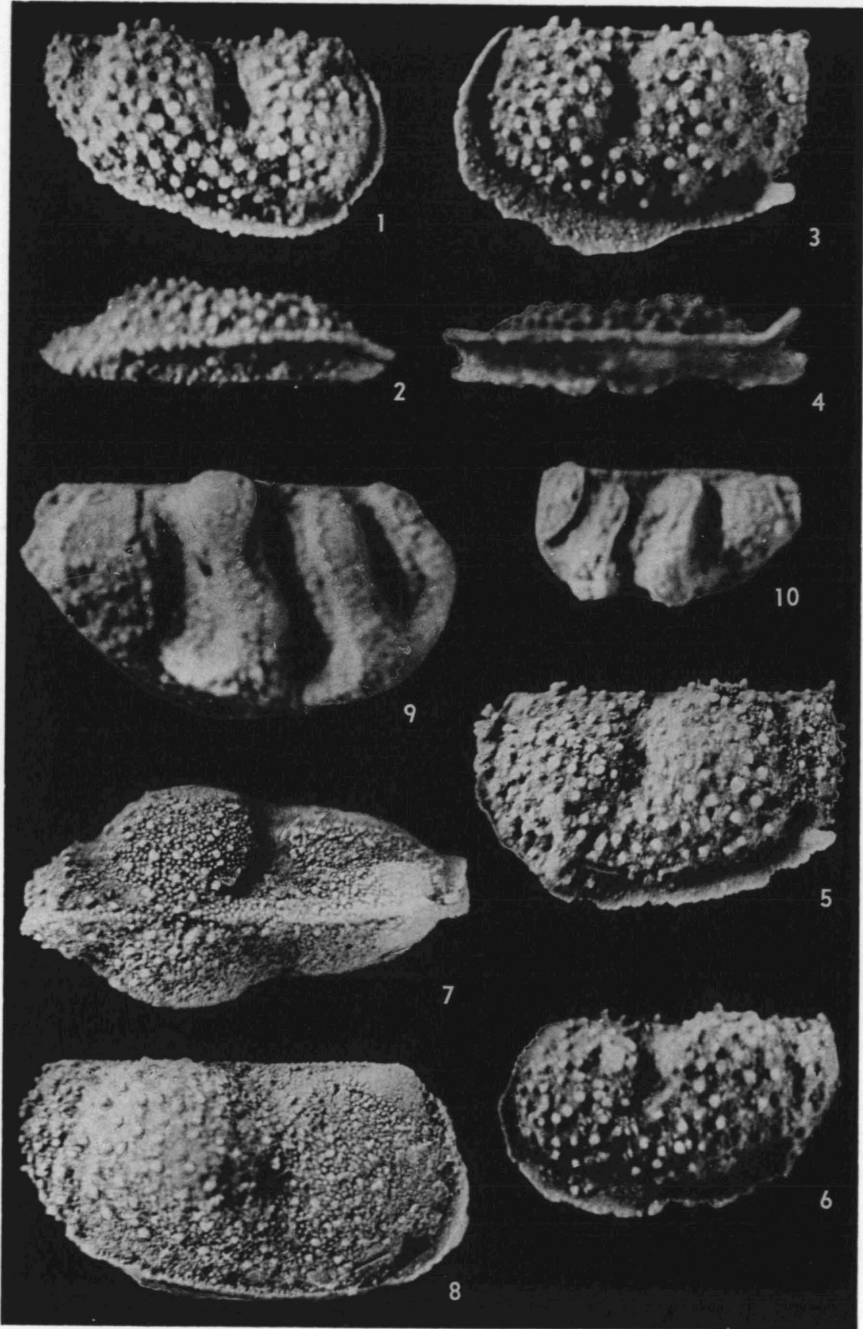
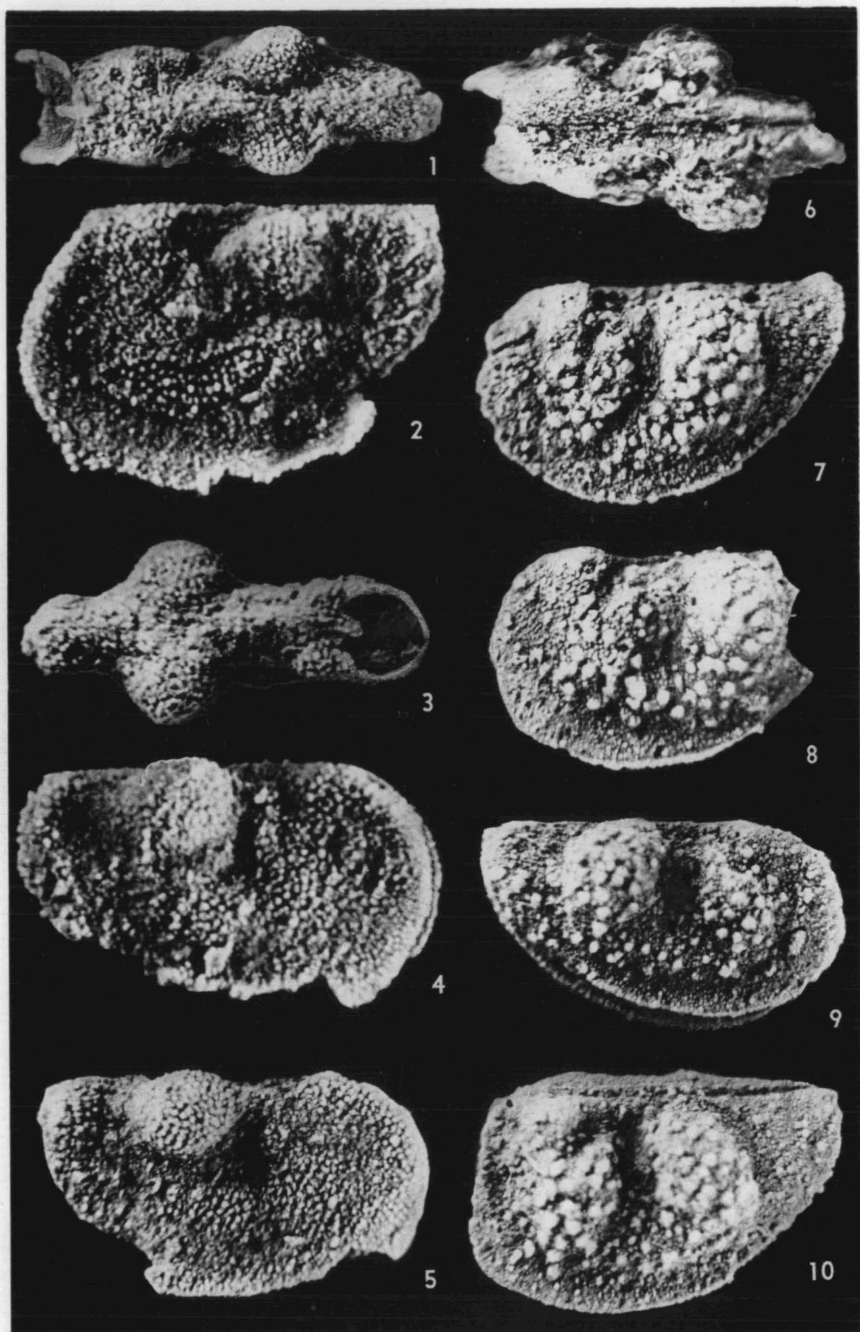


PLATE V



EXPLANATION OF PLATE V

(All figures $\times 38$)

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FIGS. 1-2. Dorsal and left lateral views of complete male carapace, Holotype No. 26689.	
FIGS. 3-4. Dorsal and right lateral views of female carapace. Allotype No. 26690.	
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<i>Hollinella acutangulata</i> , sp. nov.	55
FIGS. 6-7. Dorsal and left lateral views of complete male carapace. Holotype No. 26648.	
FIG. 8. Lateral view of partly broken female left valve. Allotype No. 26702.	
FIGS. 9-10. Right lateral and left lateral views of complete male carapace. Paratype No. 26703.	

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(All figures $\times 38$)

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<i>Hollinella porrecta</i> , sp. nov.	61
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<i>Hollinella auroriradiata</i> , sp. nov.	56
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PLATE VI

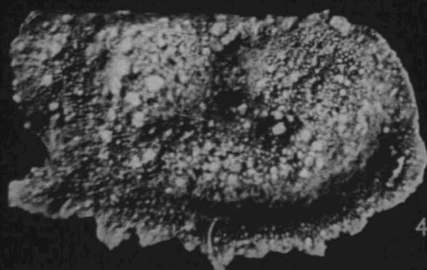
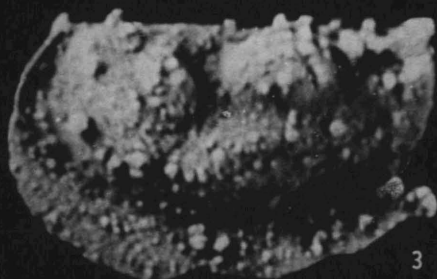
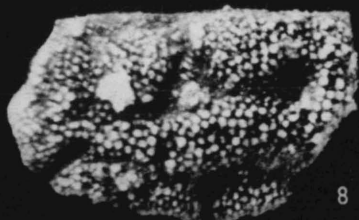
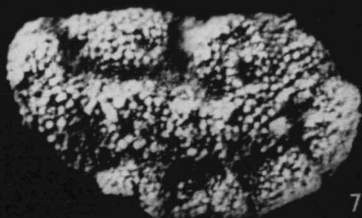
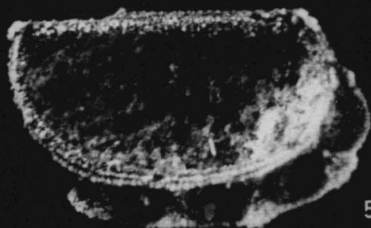
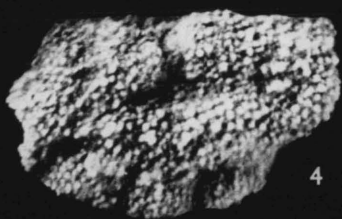
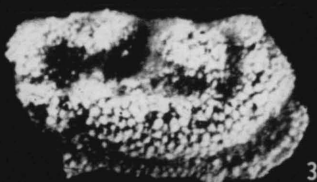
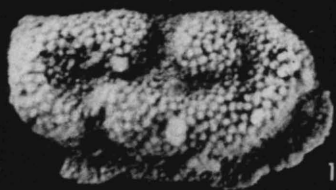


PLATE VII



EXPLANATION OF PLATE VII

(All figures $\times 60$)

	PAGE
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FIG. 1. Lateral view of male right valve. Holotype No. 26638.	
FIG. 2. Lateral view of male left valve. Paratype No. 26788.	
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VOLUME IX

1. Check List of Fossil Invertebrates Described from the Middle Devonian Traverse Group of Michigan, by Erwin C. Stumm. Pages 1-44. Price \$.75.
2. Ostracods of the Family Hollinidae from the Bell Shale of Michigan, by Robert V. Kesling and Gordon W. McMillan. Pages 45-81. Price \$.75.
3. Corals of the Devonian Traverse Group of Michigan. Part IV, *Billingsastraea*, by George M. Ehlers and Erwin C. Stumm. Pages 83-92. Price \$.50.

