

## Middle Permian Ostracodes from the Iwaizaki Limestone, Northeast Japan

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### ABSTRACT

Twenty-two species distributed among 13 genera, of which 15 species of nine genera are described for the first time from the middle Permian Iwaizaki Limestone in the southern part of the Kitakami Massif in northeast Japan.

### Introduction

In the spring of 1963, the writer was fortunate in collecting some ostracod fossils from a single locality of the Iwaizaki Limestone. The fossils were etched out from the black limestone of unit G which is the zonule of *Yabeina shiraiwensis* (Morikawa *et al.*, 1958; Morikawa, 1960) in the Iwaizaki Limestone situated in the southern part of the Kitakami Massif, northeast Japan. The ostracod specimens were obtained by etching the black limestone specimens in 15 percent solution of acetic acid for two weeks. A total of 252 specimens of complete carapaces and separated free valves were obtained.

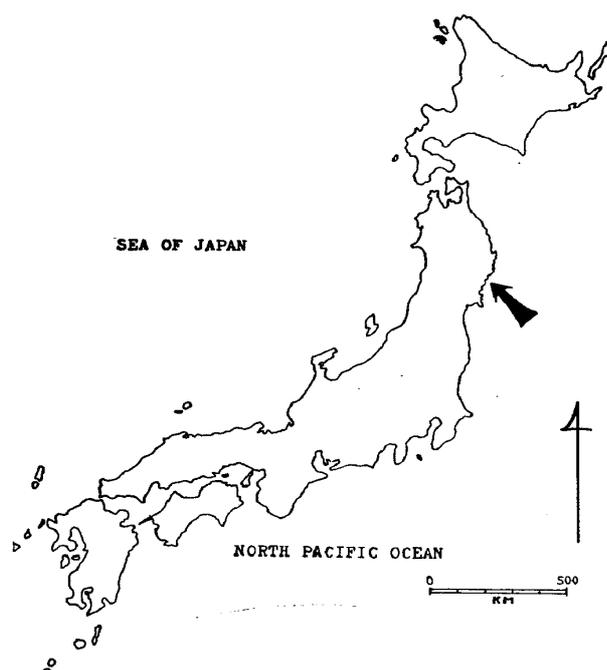
A paleontological study on these middle Permian ostracodes resulted in discrimination of 22 species distributed among 13 genera; these are described in the present work. Among them 15 species distributed among nine genera are described as new to science.

As shown in Table 1, unit G of the Iwaizaki Limestone is characterized by *Polytylites kitanipponica* Ishizaki, *Roundyella neopapillosa* Ishizaki, and *Cavellina? nipponica* Ishizaki.

The writer is deeply indebted to Professor Kotora Hatai of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University for his kind reading of the manuscript, and Professors Kiyoshi Asano and Jun-ichi Iwai of the same institute for their encouragement in many ways. Acknowledgements are also extended to Professor Ivar Hessland of the Geologiska Institutionen, Universitet of Stockholm for his kind advice concerning the present work.

### The Iwaizaki Limestone

As shown in Text-fig. 1, the Iwaizaki Limestone is distributed in a small area at Iwaizaki, Hashikami Village, Motoyoshi County, Miyagi Prefecture, northeast Japan. The Iwaizaki Limestone forms an abrasion platform about 800 meters long in north-south direction and 400 meters wide in east-west. It has been studied by many geologists and paleontologists of Japan, and among the literature published to date, the stratigraphical and paleontological studies by Morikawa *et al.* (1958) and Morikawa (1960) are noteworthy. The Iwaizaki Limestone consists chiefly of limestone facies with intercalations of slates, sandstones, and alternations of sandstone and slate. Morikawa *et al.* (1958) recognized nine units, which were numbered from A to I based upon their lithologic characters as follows (in descending order).



Text-fig. 1. Map showing the location of the Iwaizaki Limestone.

- I unit: black slates (more than 100 meters thick)
- H unit: alternations of slate and black limestone (35 m)
- G unit: black limestones (8 m)
- F unit: gray limestones (38 m)
- E unit: black limestones (7 m)
- D unit: limestones (65 m)
- C unit: alternations of sandstone, slate, and black limestone (34 m)
- B unit: whitish gray limestones (7 m)
- A unit: sandy slates (5 m)

These units from A to H are conformable with one another and form a homoclinal structure, dipping to the west at angles of about 60 degrees or more. The contact between the unit H and I is said to be a fault.

They studied the fusulinids derived from the respective units and recognized three zonules; these are summarized as follows (in descending order).

1) *Yabeina shiraiwensis* zonule: this is characterized exclusively by *Yabeina shiraiwensis* Ozawa with the rare occurrence of *Verbeekina*; it includes the units E, F, and G.

2) *Pseudofusulina paramotohashii* zonule; this yielded *Pseudofusulina paramotohashii* Morikawa, *Pseudof. paramotohashii oyaensis* Morikawa, and *Pseudof. paratschernyschewi* Morikawa; it includes the unit D.

3) *Parafusulina matsubaishi* zonule: this is characterized by *Parafusulina matsubaishi* Huzimoto; it includes the unit C.

#### Note on the Samples Treated

The ostracod specimens treated in the present paper were collected by the writer from unit G of the Iwaizaki Limestone (= *Yabeina shiraiwensis* zonule of Morikawa *et al.*, 1958). Several thin sections made of the rock revealed the shells of *Yabeina shiraiwensis* Ozawa.

For the purpose of concentrating the ostracod specimens, the method of etching stated below was followed. At first, the limestone fragments (1,000 gr. in total) were crushed to sizes of about one to three cubic centimeters. Then, they were put into buckets and soaked in a 15 percent solution of acetic acid for two weeks. After the limestone pieces were dissolved, the silicified ostracod specimens and other organic remains were washed well with tap water several times through a 130 mesh sieve, and then dried. The dried materials were spread on a dish, and the silicified ostracod specimens were picked up with a fine brush under the binocular microscope.

From the dissolved rock sample, 252 ostracod specimens were picked up. These comprised complete carapaces and separated free valves of the ostracodes.

### Ostracod fauna from Unit G of the Iwaizaki Limestone

As shown in Table 1 and stated above, the Iwaizaki Limestone (unit G) yielded abundant ostracod specimens, as compared with other Paleozoic limestones of Japan, although our knowledge is inadequate.

Literature bearing on the Paleozoic ostracodes of Japan is very scanty and therefore our knowledge in concern is inadequate. Generally the majority of the species described from the Paleozoic rocks of Japan are new to science. Therefore, correlation by the ostracodes is difficult. However, a few specimens from the middle Permian Iwaizaki Limestone (unit G) are identified or compared with species recorded from foreign countries, and this may be an aid in intercorrelation.

Examining the respective species and their frequency, it may be said that unit G of

Table 1. Systematic list of the species and individual number of the ostracodes from the Iwaizaki Limestone (unit G).

specific names	numbers of		ratio to total number (%)	
	complete carapace	free valve		
<i>Hollinella elliptica</i> Ishizaki, n. sp.	0	4	1.6	
<i>Aurikirkbya formula</i> Ishizaki, n. sp.	0	2	0.8	
<i>A. subkellertae</i> Ishizaki, n. sp.	0	7	2.8	
<i>Kirkbya atolla</i> Ishizaki, n. sp.	0	8	3.2	
<i>K. centrotumida</i> Ishizaki, n. sp.	0	3	1.2	
<i>K. magniforma</i> Ishizaki, n. sp.	0	5	2.0	
<i>K. multicresta</i> Ishizaki, n. sp.	1	7	3.2	
<i>K. subnipponica</i> Ishizaki, n. sp.	0	8	3.2	
<i>K. subquadriforma</i> Ishizaki, n. sp.	0	3	1.2	
<i>Amphissites centronotus</i> (Ulrich and Bassler)	0	3	1.2	
<i>Ectodemites globosa</i> Ishizaki, n. sp.	0	2	0.8	
<i>Polytylites kitanipponica</i> Ishizaki, n. sp.	0	23	9.2	
<i>Roundyella neopapillosa</i> Ishizaki, n. sp.	2	61	25.2	
<i>Bairdia eucurvia</i> Ishizaki, n. sp.	2	2	1.6	
<i>B. nagaiwensis</i> Ishizaki	2	0	0.8	
<i>B. cf. oklahomaensis</i> Harlton	12	1	5.2	
<i>B. trianguliformis</i> Chen	6	5	4.4	
<i>Bairdiacypris deloi</i> Bradfield	1	0	0.4	
<i>Ceratobairdia? ambigua</i> Ishizaki, n. sp.	8	10	7.2	
<i>Spinobairdia</i> sp.	0	2	0.8	
<i>Cavellina? nipponica</i> Ishizaki, n. sp.	34	3	14.8	
<i>Tubulibairdia venusta</i> (Chen)	8	9	6.8	
Miscellanea	0	8	3.2	
total	22 species	76	176	108.0%

the Iwaizaki Limestone is characterized by abundant *Polytylites kitanipponica* Ishizaki, *Roundyella neopapillosa* Ishizaki, and *Cavellina? nipponica* Ishizaki, all of which amount to or near 10 per cent of the fauna.

The subordinate ostracod species are *Kirkbya atolla* Ishizaki, *K. multicresta* Ishizaki, *K. subnipponica* Ishizaki, *Bairdia* cf. *oklahomaensis* Harlton, *B. trianguliformis* Chen, *Ceratotobairdia? ambigua* Ishizaki, and *Tubulibairdia venusta* (Chen). Among them *Bairdia trianguliformis* Chen and *Tubulibairdia venusta* (Chen) were reported from the lower Permian Chihhsia Limestone of Lungtan, Nanking, China. *Bairdia* cfr. *oklahomaensis* Harlton in the present fauna is very closely allied to the named species reported from the Pennsylvanian of various regions of the United States of America.

A few specimens of *Amphissites centronotus* (Ulrich and Bassler), and *Bairdiacypris deloi* Bradfield were found in the present collection. The former is distributed from the Mississippian to the Permian of North America, Russia, Germany, and Belgium. The latter species has been reported from the Pennsylvanian of Oklahoma, Illinois, and Missouri in the United States of America.

Therefore, so far as the known species are concerned, the ostracodes from the unit G are comparable with ones which have been reported from older strata in foreign countries.

The discovery of *Bairdia nagaiwensis* Ishizaki in the present fauna extends its range from the middle Permian to the middle Pennsylvanian Nagaiwa Formation (Ishizaki, 1963) of northeast Japan.

It is very interesting that two separated free valves, here identified with the genus *Spinobairdia* were found in the present ostracod collection. The genus *Spinobairdia* Morris and Hill, 1952, was first proposed based upon *Spinobairdia kellestae* Morris and Hill from the middle Silurian Newsom Shale of Tennessee. At the time of proposal of the genus, they also described *Spinobairdia shideleri* Morris and Hill. Since then, no species assignable to the genus have been reported. Therefore, whether the genus *Spinobairdia* should be accepted to extend up to the middle Permian from the middle Silurian is a problem to be settled by further study.

All of the specimens described in this work are from a single locality and horizon of the Iwaizaki Limestone already mentioned. For this reason repetition of the locality name under each species will be avoided. The materials are all preserved in the collection of the Institute of Geology and Paleontology, Tohoku University, Sendai (abbr. IGPS).

### Systematic Description

- Subclass Ostracoda Latreille, 1806
- Order Palaeocopida Henningsmoen, 1953
- Suborder Beyrichicopina Scott, 1961
- Superfamily Hollinacea Swartz, 1936
- Family Hollinidae Swartz, 1936
- Genus *Hollinella* Coryell, 1928
- Hollinella elliptica* Ishizaki, n. sp.
- Pl. 16, figs. 1, 2

*Description*:—Carapace rather large, subelliptical with nearly straight hinge line. Trilobate. In lateral view, carapace subelliptical with dorsal margin nearly straight to broadly concave except for posterior third where posterodorsal lobe over-reaches broadly. Ventral margin broadly arching; centroventral margin nearly straight, but antero- and postero-ventral more narrowly rounded and upturned to meet anterior and posterior marginal lines, respectively. Anterior margin rather narrowly and smoothly rounded; upper and lower margins nearly symmetrical, process backward. Anterior cardinal angle

obtuse. Posterior margin broadly rounded; upper margin broadly arching, extending forward to meet dorsal margin nearly at right angle (= posterior cardinal angle), lower margin more narrowly and smoothly rounded, meet ventral margin in semi-circular arch. Maximum length above mid-height, greatest height anteriorly, and thickest at posterior third (= posterodorsal lobe). Carapace trilobate with short ventral lobe. Anterodorsal lobe (L1) narrow, low, vertical in upper half but gently turned backward before ventromedian portion, and tend to connect with ventral lobe. Dorsal-median lobe (L2) distinguished from L1 by shallow and narrow S1, medium in height, but small and spheroidal in lateral view. Posterodorsal lobe (L3) most prominent, separated from L2 by deeper S2, typical bulb directed posterodorsally, and widely over-reaches dorsal margin. S1 narrow and shallow, nearly straight from anterodorsal to anteromedian parts, opening dorsally. S2 narrow, from middorsal to median portions opening dorsally and widen but tend to be shallow in V-shape ventrally, narrowest between L2 and L3. Ventromedian lobe short, arching nearly in parallel to ventral margin from just below L3 anteroventrally — almost indiscernible below L2. Frill narrow but long, extending nearly along entire ventral margin; striate in some parts. Carapace not reticulate, granulose.

*Dimensions:* — Holotype (Pl. 16, fig. 1, IGPS coll. cat. no. 85770) 1.21 mm long, 0.68 mm high, 0.23 mm thick (in median parts), and 0.31 mm thick (in L3 area); paratype (Pl. 16, fig. 2, IGPS coll. cat. no. 85771) 1.07 mm long and 0.58 mm high.

*Remarks:* — The present species is more or less similar to *Hollinella cuspidulbata* Kesling and Tabor from the middle Devonian Genshaw Formation of the Traverse Group in Michigan, but differs in the much more prominent L3 which over-reaches the dorsal margin in lateral view.

The present species is also somewhat similar to *Hollinella sella* Stover from the Windom Shale, middle Devonian Moscow Formation of the Hamilton Group in northwestern Genesee County, northwestern New York in general outline of the carapace, but differs in having more prominent posterodorsal lobe (L3) which is directed posterodorsally.

The present species is characterized by the prominent posterodorsal lobe (L3) which over-reaches the dorsal margin and is directed posterodorsally.

*Occurrence:* — Common.

Superfamily Kirkbyacea Ulrich and Bassler, 1906

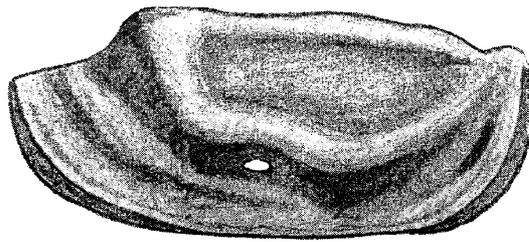
Family Kirkbyidae Ulrich and Bassler, 1906

Genus *Aurikirkbya* Sohn, 1950

*Aurikirkbya formula* Ishizaki, n. sp.

Pl. 16, figs. 3, 4; text-fig. 2

*Description:* — Carapace small, subelliptical with straight hinge line, ornamented with distinct posterodorsal lobe and succeeding ventral ridge. In lateral view, carapace subelliptical. Maximum length dorsally, greatest height medially, maximum thickness near posterior fifth. Dorsal margin irregular; anterior seventh of dorsal margin linear, at posterior two thirds inflated gradually backward due to distinct posterodorsal lobe and subordinate dorsal swelling (or sort of ridge), maximum inflation at posterior fifth, behind which abrupt pinching of dorsal margin nearly at right angles with axis of carapace and nearly straight backward, although hinge line nearly straight in inside view. Ventral margin gently and broadly arching for almost entire length; anterior and posterior terminals more narrowly rounded, upturned to meet anterior and posterior marginal lines in smooth antero- and postero-dorsal margins. Anterior margin rather broadly rounded, processes anterodorsally; anterior cardinal angle acute or some at right angles. Posterior margin more narrowly rounded, tends to turn forward near upper terminal of posterior



Text-fig. 2. *Aurikirkbya formula* Ishizaki, n. sp., holotype specimen, lateral view. (line indicates length of 0.50 mm)

margin; posterior cardinal angle obtuse. Distinct ventrodorsal lobe over-reaches widely dorsal margin, sinuous prominent ventral ridge which is succeeded by posterodorsal lobe posteriorly (most prominent below posterodorsal ridge to centroventral portion and pinching near anteromedian portion), dorsal subordinate ridge over-reaches dorsal margin and succeeded by posterodorsal lobe, shallow longitudinal depression above posteromedian portion forward between ventral and dorsal ridges, distinct ventromedian kirkbyan pit, and two marginal rims. Posterior shoulder distinct, anterior feeble but discernible. Reticulation not seen, granulose.

*Dimensions:* - Holotype (Pl. 16, fig. 3; text-fig. 2, IGPS coll. cat. no. 85772) 0.78 mm long, 0.39 mm high, and 0.29 mm thick; paratype (Pl. 16, fig. 4, IGPS coll. cat. no. 85773) 0.61 mm long and 0.34 mm high.

*Remarks:* - Concerning the shape of the posterodorsal lobe and lacking of the posterior spine, the present species is more or less similar to *Aurikirkbya auriformis* Sohn described from the upper part of the Leonard or the lower part of the Word Formation of Brewster County, Texas, but differs by the characteristic dorsal margin; the posterodorsal lobe and the succeeding forward swelling over-reaching the hinge line along almost the entire marginal line from the posterodorsal lobe forward.

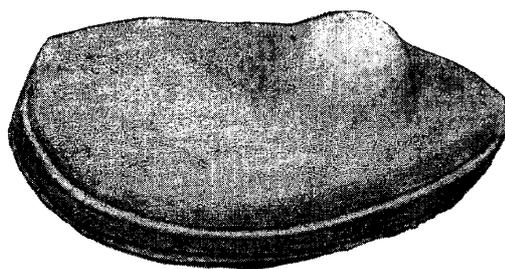
The present species is easily distinguishable from *Aurikirkbya subkellestae* Ishizaki proposed in the present work in the different shape of the posterodorsal lobe, succeeding ventral and dorsal swelling.

*Occurrence:* - Rare.

*Aurikirkbya subkellestae* Ishizaki, n. sp.

Pl. 16, figs 5, 6; text-fig. 3

*Description:* - Carapace small, subelliptical with distinct posterodorsal lobe, two marginal rims, reticulation. In lateral view, carapace subelliptical with anterior swelling. Greatest length near dorsal margin, greatest height somewhat anteriorly, greatest thickness medially. Dorsal margin nearly straight except for posterior third where posterodorsal lobe over-reaches dorsal margin. Anterior cardinal angle obtuse, posterior acute. Ventral margin broadly arching; anterior third narrowly rounded, upturned, posterior third broader, smooth, without angularity with posterior margin. Anterior margin extended anteroventrally, narrowly rounded, contact with ventral margin in rounded smooth angle. Posterior margin is of posterior third of ventral margin. Ornamentation of distinct posterodorsal lobe over-reaching dorsal margin, two marginal rims from antero- to postero-dorsal terminals, feeble embryo of anterodorsal lobe, feeble reticulation, and rather distinct ventral kirkbyan pit. Anterior and posterior swellings (or shoulders) more or less discernible.



Text-fig. 3. *Aurikirkbya subkellettae* Ishizaki, n. sp., holotype specimen, lateral view. (line indicates length of 0.50 mm).

*Dimensions:* - Holotype (Pl. 16, fig. 5; text-fig. 3, IGPS coll. cat. no. 85774) 0.71 mm long and 0.40 mm high; paratype (Pl. 16, fig. 6, IGPS coll. cat. no. 85775) 0.54 mm long and 0.27 mm high.

*Remarks:* - *Aurikirkbya subkellettae* Ishizaki is ornamented with reticulations, two marginal ridges, and a prominent posterodorsal node, but without such distinct anterodorsal node and ventral swelling as seen in aurikirkbyan species described to date.

*Aurikirkbya kellettae* (Harlton) described by Bradfield (1935) from the shale below the Otterville Limestone of Oklahoma seems to be ornamented with rather strong posterodorsal node, and less prominent anterodorsal and ventral swellings. In such features, the present species and *Aurikirkbya kellettae* (Harlton) are probably more or less allied with one another in the morphology of the carapace as stated above.

The present species is distinguishable from *Aurikirkbya formula* Ishizaki described in the present work in having less prominent narrow ventral ridge.

*Occurrence:* - Rare.

Genus *Kirkbya* Jones, 1859

*Kirkbya atolla* Ishizaki, n. sp.

Pl. 16, figs. 7, 8a, b

*Description:* - Carapace large, suboblong with sinuous dorsal margin, two distinct dorsal shoulders, subcentral oblong elevation, fine reticulation parallel with ventral margin, and circular distinct kirkbyan pit. In lateral view, carapace suboblong, tumid, greatest length dorsally, maximum height before middle, greatest thickness behind center. Dorsal margin sinuous; anterior and posterior thirds narrowly convex, median third more broadly concave because of distinct shoulders. Ventral margin broadly arching; nearly straight in medial, more narrowly but smoothly upturned at anterior and posterior terminals to meet anterior and posterior margins. Anterior margin nearly straight at upper two thirds, more narrowly rounded in lower margin. Both, anterior and posterior cardinal angles distinct and acute. Ventral angle obtuse, smoothly rounded. Anterior and posterior dorsal shoulders nearly symmetrical, distinct, overreach hinge line broadly. Subcentral oblong elevation distinct above kirkbyan pit parallel with axis of carapace; gently sloped toward dorsal, anterior and posterior margins, but much steeply in ventral side. Kirkbyan pit distinct, large, circular, situated below center of carapace. Reticulation fine, nearly parallel with ventral margin. Two marginal rims developed nearly along entire free margin. In inside view, hinge line straight, anterior cardinal angle obtuse, but posterior acute.

*Dimensions:* - Holotype, adult right valve (Pl. 16, figs. 8a, b, IGPS coll. cat. no.

85777) 1.62 mm long, 0.95 mm high, and 0.51 mm thick; paratype, immature right valve (Pl. 16, fig. 7, IGPS coll. cat. no. 85776) 1.02 mm long and 0.51 mm high.

*Remarks:* – The present species resembles *Kirkbya inornata* Roth described from the lower Pennsylvanian Seville Limestone in Mercer County, Illinois by Cooper (1946) in general characters of the carapace but differs in having fine reticulation arranged nearly parallel with the ventral margin of the former.

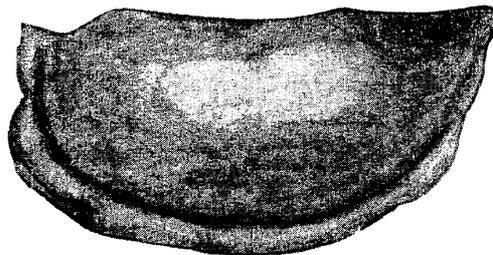
The present species is also somewhat similar to *Kirkbya clarocarinata* Knight described from the middle Pennsylvanian Stanton Limestone of Kansas by Kellett (1933) and from the Missourian Lane Shale of the Kansas City Group in Nebraska by Johnson (1936) in general carapace shape, but are distinguishable in having more distinct dorsal shoulders.

*Occurrence:* – Common.

*Kirkbya centrotumida* Ishizaki, n. sp.

Pl. 16, figs. 9a-c; text-fig. 4

*Description:* – Carapace medium to large, subquadrate, tumid, hinge line broadly concave, central broad conical elevation. In lateral view, carapace subquadrate, tumid, maximum length near dorsal margin, greatest height at or somewhat before middle, greatest



Text-fig. 4. *Kirkbya centrotumida* Ishizaki, n. sp., holotype specimen, lateral view. (line indicates length of 0.50 mm)

thickness at or slightly before median. Dorsal margin broadly concave; anterior and posterior shoulders slightly over-reach dorsal margin. Ventral margin broadly arching, more or less swing anteroventrally; anterior third rather narrowly rounded, and posterior two thirds more broadly rounded. Anterior margin nearly straight; upper margin straight, lower narrowly rounded to meet ventral margin. Anterior cardinal angle distinct, but obtuse. Anterior ventral angle smoothly rounded, acute. Posterior margin broadly rounded; upper half broadly arching, lower margin more narrowly rounded to meet ventral margin. Posterior cardinal angle distinct, acute. Posterior ventral angle rounded, obtuse. Subcentral conical elevation distinct; gradually and smoothly inclined in all directions. One marginal rim; frill along anterior and ventral margins. Surface granulose. Kirkbyan pit rather small, below subcentral conical elevation. Shoulders not distinct. Hinge line straight.

*Dimensions:* – Holotype, left valve (Pl. 16, figs. 9a-c; text-fig. 4, IGPS coll. cat. no. 85778) 1.08 mm long, 0.59 mm high, and 0.29 mm thick; paratype, left valve (Pl. 16, fig. 10, IGPS coll. cat. no. 85779) 1.36 mm long, 0.96 mm high, and 0.45 mm thick.

*Remarks:* – The present species has several characteristic features, the central surface

of the valve is occupied by a broad conical elevation and no distinct shoulders are developed near the dorsal margin.

Judging from such features, *Kirkbya centrotumida* Ishizaki is more or less similar to *Kirkbya moorei* Kellett described from the lower Permian (Wolfcampian) Wreford Formation of the Chase Group, in Geary County, Kansas, but differs in having more distinct anteroventral swing, acute posterior cardinal angle, and conical elevation situated more dorsally.

*Occurrence*: - Rare.

*Kirkbya magniforma* Ishizaki, n. sp.

Pl. 17, figs. 1a-c

*Description*: - Carapace large, subquadrate, dorsal margin sinuous, dorsal shoulder distinct, elevation subcentral. In lateral view, carapace subquadrate, tumid, greatest length dorsally, greatest height at or slightly before middle, greatest thickness behind median. Dorsal margin sinuous; anterior and posterior thirds narrowly convex, median third concave because of distinct shoulders. Ventral margin broadly arching, swing somewhat anteroventrally. Anterior and posterior margins broadly arching; upper margin nearly straight, lower margin broadly rounded, turned to meet ventral margin. Ventral angle broadly rounded, obtuse. Cardinal angles approximately right angled. Dorsal shoulders distinct, broadly over-reach dorsal margin. Subconical subcentral elevation behind center. Surface granulose. Two ventral marginal rims; frill along lower half of anterior and ventral margins. In inside view, hinge line straight, cardinal angles approximately right angled.

*Dimensions*: - Holotype, right valve (Pl. 17, figs. 1a-c, IGPS coll. cat. no. 85783) 1.15 mm long, 0.86 mm high, and 0.47 mm thick.

*Remarks*: - The present species is more or less similar to *Kirkbya magna* Roth described by Cooper (1946) from the lower Pennsylvanian (Atokan) Seville Limestone in Mercer County, Illinois, but differs in having higher carapace and more feeble shoulders.

The writer considers that the specimen referred to *Kirkbya magna* by Cooper (1946), judging from the illustration, may be a species different from that first proposed by Roth (1929) on the materials from the lower Pennsylvanian Wapanucka Limestone, in Pontotoc County, Oklahoma, because of the less developed shoulders and the lower carapace of the latter.

*Kirkbya magniforma* Ishizaki may be distinguished from *Amphissites subcentronotus* Hou from the lower Permian Chihsia Limestone, Changyang district, Hupei Province, China in having distinct dorsal shoulders.

*Occurrence*: - Common.

*Kirkbya multicresta* Ishizaki, n. sp.

Pl. 17, figs. 6, 7

*Description*: - Carapace rather large, suboblong, dorsal margin slightly sinuous with distinct coarse longitudinal crests. In lateral view, carapace suboblong, dorsal margin sinuous; anterior and posterior thirds of margin narrowly convex because of less prominent dorsal shoulders, but gently concave in median third. Ventral margin broadly arching; median three fifths nearly straight, anterior terminal narrowly rounded and upturned to meet anterior margin, posterior terminal broadly rounded and upturned to meet posterior terminal. Anterior margin narrowly but smoothly rounded; upper and lower margins nearly symmetrical. Anterior cardinal angle not distinct, nearly right angled. Anterior ventral angle smooth, but slightly acute. Posterior margin rather broadly rounded; upper margin nearly straight, lower margin broadly rounded, turned forward to meet ventral

margin. Posterior cardinal angle rather distinct, acute. Posterior ventral angle smooth, obtuse. Carapace surface with dorsal shoulders, distinct kirkbyan pit, marginal ridges, crests, and feeble reticulation. Dorsal shoulders not distinct, but over-reach hinge line slightly; anterior shoulder less in length and height than posterior shoulder. Kirkbyan pit below center of carapace distinct, more or less elliptical in shape. Crests rather coarse, arranged nearly parallel with ventral margin, especially distinct in lower half of carapace, and bound with feeble reticulation in upper half. Ventral crests which bound reticulation with longitudinal one not distinct; found only in upper half of carapace. Three marginal ridges distinct along entire free margins. Hinge line straight, dorsal shoulders more or less over-reach hinge line.

*Dimensions*: – Holotype, left valve (Pl. 17, fig. 6, IGPS coll. cat. no. 85786) 1.15 mm long, 0.53 mm high, and 0.31 mm thick; paratype, right valve (Pl. 17, fig. 7, IGPS coll. cat. no. 85787) 0.60 mm high and 0.33 mm thick.

*Remarks*: – The present species is distinguishable from *Kirkbya atolla* Ishizaki described in the present paper in having distinct coarse crests arranged longitudinally, by the feeble reticulation, and no distinct dorsal shoulders.

*Occurrence*: – Common.

*Kirkbya subnipponica* Ishizaki, n. sp.

Pl. 17, figs. 2a, b, 3

*Description*: – Carapace rather small, semicircular with more or less sinuous dorsal margin, feeble reticulation, two narrow marginal rims, moderate shoulders. In lateral view, carapace nearly semicircular, greatest length dorsally, greatest height medially, and greatest thickness at or slightly behind center. Dorsal margin sinuous; anterior and posterior thirds narrowly but smoothly convex because of shoulders, median third broadly concave. Ventral margin broadly arching throughout, slightly swing anteroventrally. Anterior margin rounded, narrower than posterior; upper margin nearly vertical but lower margin turned backward to meet ventral margin. Anterior cardinal angle nearly right angled, ventral angle broadly well rounded. Posterior margin broadly rounded but more narrowly in lower margin; upper margin nearly straight, processes ventromedially, lower margin broadly rounded, turned forward to meet ventral margin. Posterior cardinal angle distinct, acute, posterior ventral margin well rounded, obtuse. Carapace with feeble reticulation, more or less distinct dorsal shoulders, two narrow marginal rims, mound-like posterior elevation. Mound-like elevation not distinct, situated at or slightly behind central part of carapace. Marginal rim narrow, two in number, extending along entire free margin; they are nearly equal in width; and inner rims do not reach down to ventral contact margin. Dorsal shoulders gentle, over-reach hinge line rather widely, especially in posterior one. Reticulation feeble, fine on entire surface of carapace. Hinge line straight.

*Dimensions*: – Holotype, left valve (Pl. 17, figs. 2a, b, IGPS coll. cat. no. 85784) 0.76 mm long, 0.50 mm high, and 0.28 mm thick; paratype, left valve (Pl. 17, fig. 3, IGPS coll. cat. no. 85785) 0.83 mm long, 0.51 mm high, and 0.28 mm thick.

*Remarks*: – The present species resembles *Kirkbya obliqua* Bradfield described from the upper Pennsylvanian (Missourian) Hoxbar Formation of the southern edge of Ardmore, Carter County, Oklahoma in most characters. The slight difference found between them is that the species at hand has more or less narrower inner rim which does not reach down to the ventral contact margin, in contrast to species from the upper Pennsylvanian Hoxbar Formation.

The present species is also somewhat similar to *Kirkbya fernglenensis* Benson from the Mississippian Fern Glen Formation of St. Louis County, Missouri in some respects,

but is distinguishable from the latter in having higher and obtuse carapace.

*Occurrence:* – Common.

*Kirkbya subquadriforma* Ishizaki, n. sp.

Pl. 16, fig. 11; Pl. 17, figs. 8a, b

*Description:* – Carapace large, subquadrate, tumid, with nearly straight dorsal margin and feeble reticulation. In lateral view, carapace subquadrate, tumid, maximum length dorsally, maximum height somewhat before median, maximum thickness median. Dorsal margin nearly straight to slightly sinuous; anterior and posterior quarters rather narrowly convex, median two quarters broadly concave owing to shoulders. Ventral margin broadly rounded; anterior terminal narrowly upturned to meet anterior margin. Anterior margin nearly straight in upper and narrowly rounded, turned backward to meet ventral margin. Posterior margin nearly straight in upper two thirds and narrowly rounded, turned forward to meet ventral margin in lower third. Anterior cardinal angle obtuse, nearly at right angles. Posterior cardinal angle acute. Anteroventral angle marking some right angles. Posteroventral angle obtuse. Anterior and posterior shoulders discernible, slightly over-reach dorsal margin. Surface distinctly tumid above kirkbyan pit. Lateral depression before and behind kirkbyan pit. Kirkbyan pit distinct, moderate in size. Reticulation feeble. Two marginal rims; narrow frill ventrally. Hinge line nearly straight.

*Dimensions:* – Holotype, left valve (Pl. 17, figs. 8a, b, IGPS coll. cat. no. 85781) 1.28 mm long, 0.94 mm high and 0.52 mm thick; paratype, right valve (Pl. 16, fig. 11, IGPS coll. cat. no. 85780) 1.26 mm long, 0.79 mm high, and 0.45 mm thick.

*Remarks:* – In surface ornamentation, especially the swelling and depression on the carapace, the present species somewhat resembles *Kirkbya bellula* Chen from the lower Permian, lower part of the Chihhsia Limestone, at Lungtan, Nanking, China, but differs in having more obtuse cardinal angles.

The present species is distinguishable from *Ectodemites globosa* Ishizaki described in the present paper in having more acute posterior cardinal angle and different reticulation, although both are more or less similar to one another in general characters.

*Occurrence:* – Rare.

Family Amphissitidae Knight, 1928

Genus *Amphissites* Girty, 1910

*Amphissites centronotus* (Ulrich and Bassler)

Pl. 17, figs. 4, 5; text-fig. 5

*Kirkbya centronota* Ulrich and Bassler, 1906, p. 159, pl. 11, figs. 16, 17. (not seen *vide* Ellis and Messina, 1952, Catalogue of Ostracoda vol. 1 p 1-2, 1 fig.)

*Amphissites centronota* Harlton, 1927, p. 207, pl. 32, figs. 10a, b; Bradfield, 1935, p. 59, pl. 4, fig. 3.

*Amphissites centronotus* Knight, 1928, p. 259, pl. 32, fig. 6a-e, pl. 34, figs. 2; Delo, 1930, p. 160, pl. 12, fig. 9; Warthin, 1930, p. 66, pl. 5, figs. 4a-c; Kellett, 1933, p. 95, pl. 16, figs. 16-22; Upson, 1933, p. 42, pl. 3, figs. 7a-c; Johnson, 1936, p. 30, pl. 3, figs. 12-14; Scott and Borger, 1941, p. 354, pl. 49, fig. 7; Cooper, 1946, p. 98, pl. 15, figs. 19, 20; Marple, 1952, p. 934, pl. 134, fig. 15.

*Amphissites cf. centronotus* Sohn, 1954, p. 13, pl. 3, figs. 15-21, pl. 3, figs. 1-3.

*Amphissites centronotus elongatus* Payne, 1937, p. 280, pl. 38, figs. 2a-c; Cooper, 1946, p. 98, pl. 15, figs. 23-25.

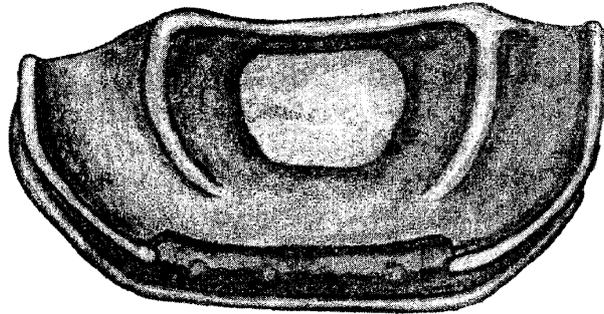
*Amphissites robustus* Cooper, 1946, p. 100, pl. 15, figs. 34-36.

*Amphissites rugosus* Marple, 1952, p. 935, pl. 134, figs. 17, 18.

*Amphissites similis* Morey, 1936, p. 115, pl. 17, fig. 6.

*Amphissites traversus* Cooper, 1946, p. 100, pl. 15, figs. 1, 2.

*Dimensions:* – Homotype (Pl. 17, fig. 5; text-fig. 5, IGPS coll. cat. no. 85789) 0.66 mm long and 0.35 mm high; figured specimen (Pl. 17, fig. 4, IGPS coll. cat. no. 85788) 0.66 mm long and 0.37 mm high.



Text-fig. 5. *Amphissites centronotus* (Ulrich and Bassler), homotype specimen, lateral view. (line indicates the length of 0.50 mm)

*Remarks:* – The present specimens coincide with the specimens illustrated by Ulrich and Bassler (1906) from the lower Permian Cottonwood Formation of the Council Grove Group in Cottonwood Falls, Chase County, Kansas in general characters.

So far as literature is concerned, *Amphissites centronotus* (Ulrich and Bassler) is obviously one of the widely known species and ranges from the Mississippian to the Permian of North America, Russia, Germany, and Belgium.

*Occurrence:* – Rare.

Genus *Ectodemites* Cooper, 1941

*Ectodemites globosa* Ishizaki, n. sp.

Pl. 18, figs. 1a, b, 2

*Description:* – Carapace large, subquadrate, tumid, coarsely reticulated, kirkbyan pit large. In lateral view, carapace subquadrate, tumid, anteroventral swing, greatest length somewhat below mid-height, greatest height before medial, and greatest thickness near center. Ventral margin sinuous; anterior and posterior thirds rather narrowly convex owing to swellings (shoulders), median third gently concave. Ventral margin broadly arching; anterior half more narrowly, posterior half broadly rounded because of anteroventral process. Anterior margin gently rounded; upper half gently turned posteriorly, anterior cardinal angle obtuse, lower half smoothly turned backward, anteroventral angle smooth, but acute. Posterior margin nearly straight, slightly convex; posterior cardinal angle obtuse to near right angles, lower margin broadly arching, posteroventral angle smooth, obtuse. Anterior and posterior shoulders distinct, node-like, especially near upper margin, over-reach dorsal margin. Central swellings obvious above kirkbyan pit. Some depression nearly parallel with ventral margin for short distance before and behind kirkbyan pit. Kirkbyan pit large, distinct. Two narrow marginal rims ventrally. Reticulation rather coarse. Hinge line essentially straight.

*Dimensions:* – Holotype, right valve (Pl. 18, figs. 1a, b, IGPS coll. cat. no. 85793) 1.29 mm long, 0.97 mm high, and 0.51 mm thick; paratype, right valve (Pl. 18, fig. 2, IGPS coll. cat. no. 85794) 1.33 mm long, 1.08 mm high, and 0.57 mm thick.

*Remarks:* – *Ectodemites globosa* Ishizaki described in the present paper has the

highest carapace among the species of the genus known to date.

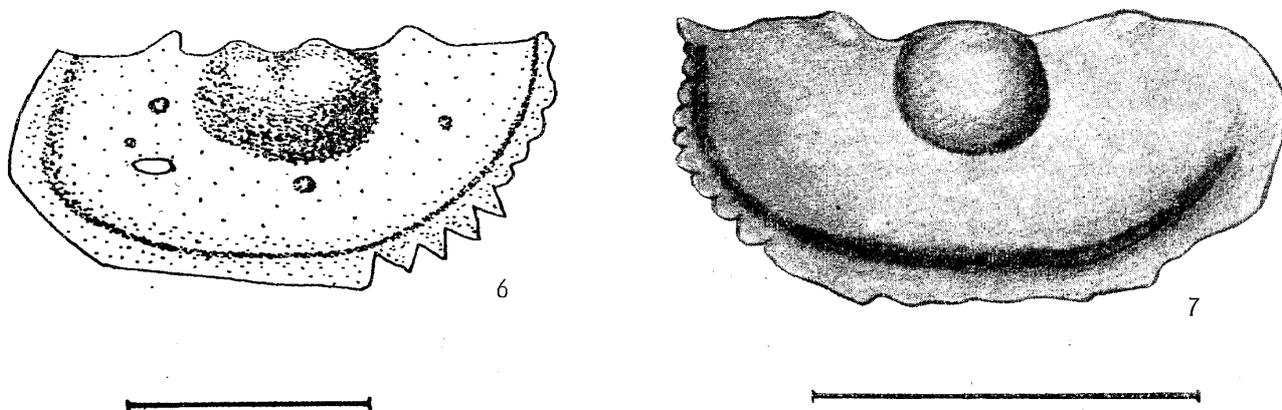
*Occurrence*: - Rare.

Genus *Polytylites* Cooper, 1941

*Polytylites kitanipponica* Ishizaki, n. sp.

Pl. 18, figs. 3-6; text-figs. 6, 7

*Description*: - Carapace medium in size, subquadrate in lateral view with anteroventral process developed more or less. Dorsal margin nearly straight but somewhat convex for short distance at anterior, posterior with less developed nodes near dorsal margin. Ventral margin essentially broadly arched; anterior termination rather sharply upturned and conjunct anterior marginal line nearly perpendicular to axis of carapace, posterior termination broadly arching, gently upwards. Anterior margin more narrowly rounded



Text-figs. 6, 7. *Polytylites kitanipponica* Ishizaki, n. sp., lateral view; 6-holotype, 7-paratype. (line indicates the length of 0.50 mm)

and contacts with dorsal margin in blunt anterior cardinal angle. Posterior margin broadly rounded with distinct acute cardinal angle. Maximum length dorsally, greatest height medially, and thickest centrally. Ventral marginal ridge distinct, marginal denticles developed along posterior third and striated frill along anterior two thirds of lower margin in typical specimen. Surface with centrodorsal prominent node nearly semicircular in lateral view, two subordinate nodes (terminating in small spines) overreaching dorsal margin near anterodorsal and posterodorsal quarters, two or three papillae situated linearly downward from subordinate nodes, and feeble reticulation. Distinct sulci unobservable.

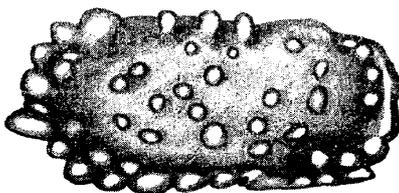
*Dimensions*: - Holotype, adult male (Pl. 18, fig. 3; text-fig. 6, IGPS coll. cat. no. 85795) 1.10 mm long, 0.52 mm high, and 0.44 mm thick; paratype, adult female (Pl. 18, fig. 4; text-fig. 7, IGPS coll. cat. no. 85796) 0.94 mm long and 0.56 mm high; paratype (Pl. 18, fig. 6, IGPS coll. cat. no. 85798) 0.90 mm long and 0.57 mm high; paratype (Pl. 18, fig. 5, IGPS coll. cat. no. 85797) 0.78 mm long, 0.38 mm high, and 0.33 mm thick.

*Remarks*: - The present species rather closely resembles *Polytylites superus* (Croneis and Gale) reported by Cooper (1941) from the Menard Formation of Illinois, but differs in the possessing less developed terminal nodes (or spines) on the dorsal margin, as compared with the latter species.

*Occurrence*: - Rather abundant.

Family Scrobiculidae Posner, 1951  
 Genus *Roundyella* Bradfield, 1935  
*Roundyella neopapillosa* Ishizaki, n. sp.  
 Pl. 18, figs. 7, 8; text-fig. 8

*Description*: — Carapace small, suboblong, granulose with small spines, especially concentrated along terminal portion and scattered on surface. In lateral view, carapace sub-oblong, greatest length at or somewhat above mid-height, greatest height near middle, and greatest thickness near center. Dorsal margin nearly straight to broadly arching; margin near both terminals narrowly but smoothly rounded to meet end margins; cardinal angle



Text fig. 8. *Roundyella neopapillosa* Ishizaki, n. sp. (line indicates the length of 0.50 mm)

indistinct. Ventral margin nearly straight in middle and upturned near both terminals; ventral angles smoothly, narrowly rounded. End margins nearly symmetrical, narrowly but smoothly rounded. Carapace granulose, ornamented with spines. Ventral and end margins extend beyond free edge of contact margin. Spines scattered on central surface, concentrated along end and ventral margins, succeeded in series inside margin, and few along dorsal margin.

*Dimensions*: — Holotype, male (Pl. 18, fig. 7; text-fig. 8, IGPS coll. cat. no. 85799) 0.62 mm long, 0.34 mm high, and 0.15 mm thick; paratype (Pl. 18, fig. 8, IGPS coll. cat. no. 85800) 0.66 mm long and 0.36 mm high.

*Remarks*: — *Scaberina nodomarginata* was named by Bradfield in 1935 for a specimen from the Pennsylvanian Union Dairy Limestone of the Hoxbar Formation, at southern Ardmore, Oklahoma. Subsequently, Cooper (1946) considered that *Amphissites simplicissima* Knight and *Scaberina nodomarginata* Bradfield may be conspecific, because the surface reticulations are filled with matrix, leaving the protruding spines. More recently, Sohn (1954, 1961) examined sections of the typical specimens and concluded that *Scaberina nodomarginata* Bradfield is a valid species.

The present species closely resembles *Scaberina nodomarginata* Bradfield from the Pennsylvanian Union Dairy member of the Hoxbar Formation at Carter County, Oklahoma in having the spines situated mainly along the end margins, but differs from the latter in that the former has a more elongate carapace and several spines near the dorsal margin.

*Occurrence*: — Abundant.

Order Podocopida Müller, 1894  
 Suborder Podocopina Sars, 1866  
 Superfamily Bairdiacea Sars, 1888  
 Family Bairdiidae Sars, 1888  
 Genus *Bairdia* McCoy, 1844  
*Bairdia eucurvia* Ishizaki, n. sp.  
 Pl. 18, figs. 9a, b, 10

*Description*:—Carapace large, oblong, subcrescentic, dorsal margin broadly convex, ventral margin gently concave, bluntly rounded anterior margin, more or less distinctly pointed posterior terminal. In lateral view, carapace oblong, subcrescentic in shape. Greatest length below mid-height, greatest height near mid-length, and maximum thickness medial. Dorsal margin broadly arching, but posterior fifth of marginal length nearly straight, turned abruptly downward to meet posterior margin. Ventral margin more or less sinuous; middle third of length smooth but distinctly concave, anterior and posterior thirds moderately convex; margin near posterior terminal turned upward and nearly straight for short distance. Anterior margin bluntly rounded, nearly symmetrical with smooth, well rounded dorsal and ventral angles. Posterior margin more or less narrowly pointed at below mid-height; upper and lower margins nearly straight, and both meet in distinctly projected point at posterior extremities; ventral and dorsal angles obtuse, but with more or less distinct angulation. In dorsal view, carapace lenticular in shape, nearly symmetrical, tapering gradually toward extremities; both anterior and posterior slopes essentially convex. Left valve over-reaches right valve widely along dorsal margin, but remaining margin hardly observable. Surface smooth.

*Dimensions*:—Holotype, a complete specimen (Pl. 18, figs. 9a, b, IGPS coll. cat. no. 85802) 1.73 mm long, 0.92 mm high, and 0.76 mm thick; paratype, right valve (Pl. 18, fig. 10, IGPS coll. cat. no. 85801) 1.74 mm long and 0.89 mm high.

*Remarks*:—*Bairdia eucurvia* Ishizaki is somewhat similar to *Bairdia glennensis* Harlton described from the upper Pennsylvanian to the lower Permian strata of Kansas, but differs in having the posterior terminals pointed at a higher level.

The present species resembles *Bairdiacypris curvis* (Cooper) which was first described by Cooper (1941) and reexamined by Sohn (1960) from the Pennsylvanian Paint Creek Formation of Illinois, but differs in having a more or less convex dorsal margin.

*Occurrence*:—Common.

*Bairdia nagaiwensis* Ishizaki  
 Pl. 19, figs. 1a, b

*Bairdia nagaiwensis* Ishizaki, 1963, p. 168–169, pl. 9, figs. 4a, b.

*Dimensions*:—Metatype, a complete specimen (Pl. 19, fig. 1a, b, IGPS coll. cat. no. 85805) 1.16 mm long, 0.74 mm high, and 0.57 mm thick.

*Remarks*:—The specimens from the middle Permian Iwaizaki Limestone are identical with *Bairdia nagaiwensis* Ishizaki which was originally described from the lower Pennsylvanian Nagaiwa Formation at Nagaiwa, Hikoroichi town, Ofunato City, Iwate Prefecture in many important features of the carapace.

The chronological range of *Bairdia nagaiwensis* Ishizaki is at least from the lower Pennsylvanian to the middle Permian.

*Occurrence*:—Rare.

*Bairdia* cf. *oklahomaensis* Harlton  
 Pl. 19, figs. 2, 3

Compared with:—

*Bairdia oklahomaensis* Harlton, 1927, p. 209, pl. 33, fig. 7; Harlton, 1929, p. 156, pl. 3, figs. 5a, b; Warthin, 1930, p. 69, pl. 5, figs. 8a, b; Bradfield, 1935, p. 85, pl. 5, figs. 9a, b; Cooper, 1946, p. 48, pl. 3, figs. 15, 17, 18, 19, 20; Cordell, 1952, p. 88, pl. 18, figs. 21-24; Marple, 1952, p. 930, pl. 133, figs. 6-11.

*Bairdia auricula* Knight, 1928, p. 319, pl. 43, figs. 3a, b; Warthin, 1930, p. 68, pl. 5, figs. 7a, b.  
*Bairdia dornickhillensis* Harlton, 1929, p. 268, pl. 2, figs. 12a, b; Bradfield, 1935, p. 78, pl. 5, figs. 3a, b.

*Bairdia seminalis* Payne, 1937, p. 285, pl. 39, figs. 9a, b.

*Orthobairdia oklahomaensis* Sohn, 1960, p. 66, 67, pl. 3, figs. 13-21.

*Dimensions*: - Compared complete specimen (Pl. 19, fig. 3, IGPS coll. cat. no. 85807) 1.04 mm long, 0.62 mm high, and 0.44 mm thick; compared left valve (Pl. 19, fig. 2, IGPS coll. cat. no. 85806) 1.32 mm long and 0.74 mm high.

*Remarks*: - In the shape of the lateral view, the specimens from the middle Permian Iwaizaki Limestone are closely allied to *Bairdia oklahomaensis* Harlton reported from the Pennsylvanian strata of the United States of America. The slight differences noticed between them are that the former is rather asymmetrical, the anterior terminal is more or less bluntly rounded and the posterior terminal is narrowly tapering, in dorsal view, in contrast to the latter of which the terminals are nearly symmetrical and more narrowly terminated forward. From the similarity of the general shape of the carapace, the writer considers them to be conspecific with slight doubt.

The specimens under consideration are more or less similar to *Bairdia whortani* Kellett which was first described by Kellett (1935) from the middle Pennsylvanian Kanwake Shale of Kansas and reexamined by Sohn (1960) in some respects, but are distinguishable from the latter in having more distinctly convex dorsal margin.

*Occurrence*: - Common.

#### *Bairdia trianguliformis* Chen

Pl. 19, figs. 4a, b, 5

*Bairdia trianguliformis* Chen, 1958, *Acta Pal. Sinica*, v. 6, no. 2, p. 244, pl. 6, figs. 9-12.

*Dimensions*: - Homotype, a complete specimen (Pl. 19, figs. 4a, b, IGPS coll. cat. no. 85808) 1.74 mm long, 0.87 mm high, and 0.72 mm thick (complete specimen); figured specimen, right valve (Pl. 19, fig. 5, IGPS coll. cat. no. 85809) 1.38 mm long and 0.66 mm high.

*Remarks*: - The present specimens are similar to *Bairdia trianguliformis* Chen described from the lower Permian Chihsia Limestone of Lungtan, Nanking, China in the essential characters of the carapace.

The present species is also similar to *Bairdia attenuata* Girty described from the upper Mississippian (Chesterian) Fayetteville Shale of Washington County, Arkansas in lateral view, but is distinguishable from the latter in that the slopes of the former are entirely straight to slightly concave in dorsal view, whereas those of the latter have rather broad convexity.

*Occurrence*: - Rather common.

#### Genus *Bairdiacypris* Bradfield, 1935

##### *Bairdiacypris deloi* Bradfield

Pl. 16, fig. 12

*Bairdiacypris deloi* Bradfield, 1935, p. 93, pl. 7, figs. 8a, b, 9a, b; Cooper, 1946, p. 53, pl. 4, figs. 22, 23; Cordell, 1952, p. 95, pl. 19, figs. 19, 20; Sohn, 1960, p. 58, pl. 2, fig. 29, pl. 3, figs. 1-5.

*Dimensions*: - Homotype, a complete specimen (Pl. 16, fig. 12, IGPS coll. cat. no.

85782) 1.10 mm long, 0.47 mm high, and 0.42 mm thick.

*Remarks:* - *Bairdiacypris deloi* Bradfield was first proposed on the materials from the Pennsylvanian Hoxbar Formation at the south edge of Ardmore, Oklahoma. Thereafter, the named species has been reported by Cooper (1946) and Cordell (1952) from the Pennsylvanian "Centralia" zone of Illinois and the Ladore Formation to the Oread Formation of Missouri.

The present material consists of only one complete specimen, which seems to be closely similar to the named species in many important features of the carapace, the general shape of the carapace in lateral view, in dorsal view, and in their dimensions.

If the present identification is accepted, the named species ranges from the Pennsylvanian to the middle Permian.

*Occurrence:* - Very rare.

Genus *Ceratobairdia* Sohn, 1954

*Ceratobairdia? ambigua* Ishizaki, n. sp.

Pl. 19, figs. 6a, b, 7, 8

*Description:* - Carapace large, bairdiidae in shape, tumid ventrally, left valve over-reaches right valve dorsally. In lateral view, carapace subtriangular, more or less swing posterodorsally, greatest length well below mid-height, greatest height nearly medial, greatest thickness at or slightly behind mid-ventral part. Left valve over-reaches right valve dorsally; broadly dorsal-medial, but narrowly antero- and postero-dorsal areas. Left valve considerably higher than right valve. Dorsal margin rather narrowly arching; central third of margin narrowly convex, anterior slope nearly straight but slightly concave at its terminal, posterior slope more distinctly concave at its terminal. Ventral margin broadly arching, but more narrowly upturned to meet end margins at their terminals. Anterior margin more broadly pointed than posterior; upper margin broadly concave, lower margin broadly convex, pointed well below mid-height. Posterior margin acuminate, pointed well below midheight, upturned distinctly; upper margin narrowly concave, lower margin broadly convex. Venter flat, ventral alae distinct, long, extending from anterior terminal to before postero quarter. In dorsal view, carapace inflated lenticular in shape, maximum thickness at or slightly behind mid-length, tapering abruptly toward terminals; both slopes nearly symmetrical in length, anterior slope nearly straight, posterior slope slightly concave. Surface smooth, except for ventral alae.

*Dimensions:* - Holotype, a complete specimen (Pl. 19, figs. 6a, b, IGPS coll. cat. no. 85810) 1.94 mm long, 1.16 mm high, and 1.08 mm thick (complete specimen); paratype, left valve (Pl. 19, fig. 7, IGPS coll. cat. no. 85811) 1.32 mm long and 0.94 mm high; paratype, right valve (Pl. 19, fig. 8, IGPS coll. cat. no. 85812) 1.34 mm long and 0.76 mm high.

*Remarks:* - The present species is more or less similar to *Ceratobairdia dorsospinosa* Sohn from the uppermost part of the Word Formation of Brewster County, Texas in the general features of the carapace, but differs in having no dorsal spine.

The genus *Ceratobairdia* Sohn, 1954 was proposed based on *Ceratobairdia dorsospinosa* Sohn and is distinguishable from the other bairdiidae ostracod genera in having flat venters, ventrolateral ridges or alae which terminate in small ridges or in well developed backward-pointing spines, and dorsal spines or knobs on the larger valve. Sohn (1954) included *Bairdia wordensis* Hamilton from the lower Word Formation in Glass Mountains, Texas into the genus *Ceratobairdia*.

*Ceratobairdia? ambigua* Ishizaki resembles the species included in the genus *Ceratobairdia* Sohn, 1954, in having the flat venters and alae which terminate in small ridge-like points, but somewhat differs in having no distinct dorsal spine or knob on the left valve.

Therefore, the present species is assigned to the genus *Ceratobairdia* Sohn, 1954, with question.

*Occurrence*: - Common.

#### Genus *Spinobairdia* Morris and Hill, 1952

The genus *Spinobairdia* was first proposed by Morris and Hill in 1952, based upon *Spinobairdia kellettae* Morris and Hill from the middle Silurian Newsom Shale of Tennessee. At that time, they also described *Spinobairdia shideleri* Morris and Hill. Since then, no species assignable to the genus under consideration has been recorded.

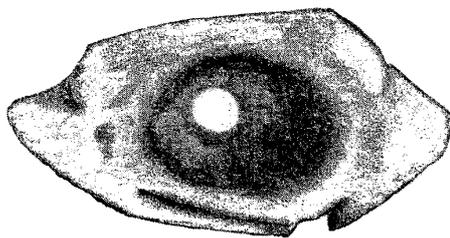
The forms assignable to the genus have a shape very similar to *Bairdia* in general outline of the carapace and the characteristic subcentral node (or spine) on each valve.

*Spinobairdia* sp. which is described in the present paper occurred from the middle Permian Iwaizaki Limestone. It shows the typical carapace shape of the genus *Spinobairdia*, that is to say, it has a more or less *Bairdia*-like carapace shape with a distinct subcentral prominence. The writer suggests that the genus *Spinobairdia* Morris and Hill may extend from the middle Silurian to the middle Permian, if the specimens from the Iwaizaki Limestone are congeneric with the Silurian genus.

#### *Spinobairdia* sp.

Pl. 19, figs. 9, 10; text-fig. 9

*Description*: - *Bairdia*-like carapace with subcentral prominent spine. Carapace medium in size, shape in lateral view thickened subfusiform, greatest length somewhat below midheight, greatest height anteriorly. Dorsal margin probably broadly arching (exact marginal line obscure because centrodorsal marginal part is broken off); anterior dorsal margin nearly a third of marginal length, almost linear, inclined to anterior terminal, posterior slope distinct, narrowly concave for short distance near posterior terminal. Ventral margin broadly arching; anteroventral margin nearly straight, abruptly upturned near anterior third to terminal, centroventral margin more or less broadly concave, posteroventral margin slightly upturned near posterior third to terminal, forming broadly arched marginal line. Anterior terminal nearly at mid-height. Anterior margin narrowly convex anteriorly forming angle less than right at anterior terminal; upper half broadly concave, lower margin nearly straight. Posterior terminal well below mid-height.



Text-fig. 9. *Spinobairdia* sp. (line indicates the length of 0.50 mm)

Posterior margin shorter than anterior, narrowly pointed at terminal with upward process; upper margin directed steeply downward in upper half and backward horizontally in lower

half, forming sharp concavity, nearly at right angle near middle of upper marginal length, lower margin rather gentle, broadly convex, contact with upper margin forming narrow backward pointed termination. Contact margin unknown. Inner marginal zone rather broad, especially along posterodorsal to posteroventral marginal areas. Surface smooth with only one prominent subcentral spine slightly directed posterodorsally.

*Dimensions*: - Figured specimen (Pl. 19, fig. 9; text-fig. 9, IGPS coll. cat. no. 85813) 1.36 mm long, 0.76 mm high, and 0.46 mm thick.

*Remarks*: - Some morphological resemblance is found between the present specimens and the middle Silurian *Spinobairdia kellettae* Morris and Hill, but the former are easily distinguishable from the latter in the more thicker test, shape and much more prominent subcentral spine.

A new specific name should be given to the forms found from the Iwaizaki Limestone, but no name is proposed for them because there are only two more or less fragmental valves in the collection.

*Occurrence*: - Very rare.

Suborder Metacopina Sylvester-Bradley, 1961

Superfamily Healdiacea Harlton, 1933

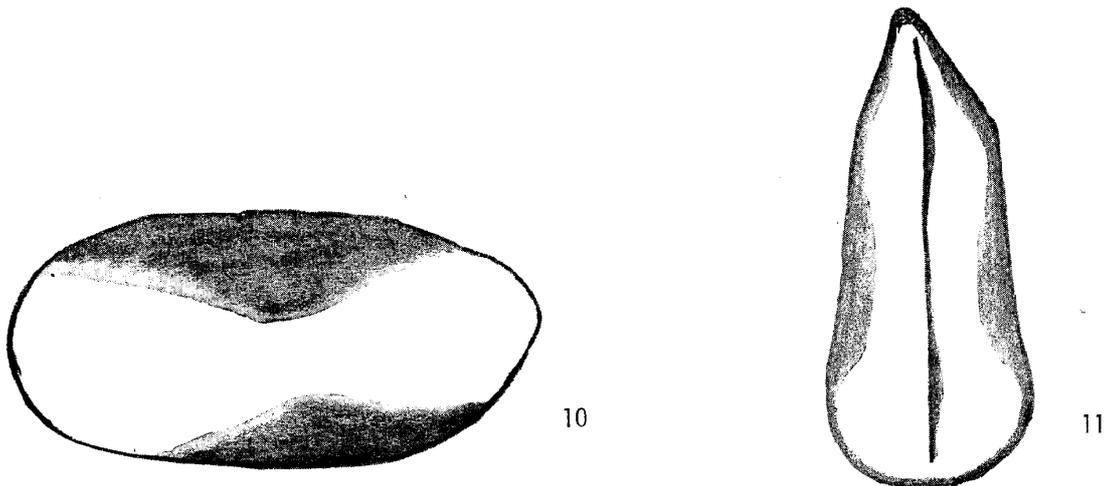
Family Cavellinidae Egorov, 1950

Genus *Cavellina* Coryell, 1928

*Cavellina? nipponica* Ishizaki, n. sp.

Pl. 17, figs. 9a, b, 10, 11; text-figs. 10, 11

*Description*: - Carapace oblong to subovate with smoothly rounded anterior end and posteroventrally truncated posterior end. Right valve larger, over-reaches left valve along entire margin except for posteroventral portion. Surface smooth. In lateral view, carapace oblong to subovate, maximum length slightly above mid-height, greatest height medial to somewhat behind medial, greatest thickness posteriorly. Dorsal margin nearly straight; anterior quarter more narrowly rounded, posterior quarter nearly straight but turned



Text-figs. 10, 11. *Cavellina? nipponica* Ishizaki, n. sp., 10-right side lateral view of holotype specimen, 11-dorsal view of the same specimen. (line indicates length of 0.50 mm)

downward to meet posterior margin at posterior quarter. Ventral margin broadly arching; more narrowly rounded near end margins; posterior terminal turned abruptly upward to meet posterior margin and forms distinct posteroventral truncation. Anterior margin well rounded, nearly symmetrical in shape. Posterior margin more narrowly rounded but more or less distinctly pointed at above mid-height in some specimens; posteroventral truncation distinct; posterodorsal subordinate truncation obscure in lateral right view, but more distinct in lateral left view. In dorsal view, carapace somewhat asymmetrical, mustard-like in shape, tapering and narrowly pointed anteriorly, tumid, more broadly and bluntly rounded posteriorly; somewhat depressed at dorsal-median portion of some specimens. Right valve over-reaches broadly left valve along nearly entire margin except for posteroventral part where both valves are nearly equivalved. Surface smooth.

*Dimensions*: - Holotype, a complete specimen (Pl. 17, figs. 9a, b; text-figs. 10, 11, IGPS coll. cat. no. 85790) 1.08 mm long, 0.59 mm high, and 0.36 mm thick and 0.44 mm thick at midlength and posterior part (at maximum); paratype, a complete specimen (Pl. 17, fig. 11, IGPS coll. cat. no. 85792) 1.08 mm long, 0.60 mm high, and 0.41 mm thick and 0.45 mm thick at midlength and posterior part (at maximum); paratype, right valve (Pl. 17, fig. 10, IGPS coll. cat. no. 85791) 0.88 mm long and 0.46 mm high.

*Remarks*: - The present species is more or less similar to *Cavellina rotunda* Cooper (1946) from the Des Moinesian Lonsdale Zone of western Illinois in some respects, but differs in having an arching venter.

*Occurrence*: - Abundant.

Family Pachydomellidae Berdan and Sohn, 1961

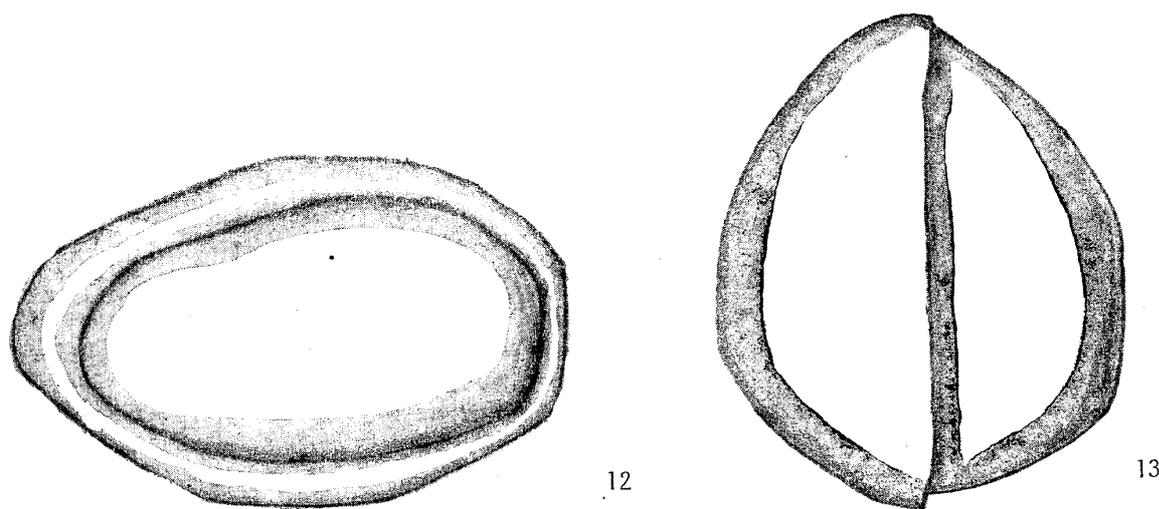
Genus *Tubulibairdia* Swartz, 1936

*Tubulibairdia venusta* (Chen)

Pl. 18, figs. 11a, b, 12a, b; text-figs. 12, 13

*Microcheilinella venusta* Chen, 1958, p. 253, pl. 2, figs. 12-17.

*Dimensions*: - Homotype, a complete specimen (Pl. 18, figs. 11a, b; text-figs. 12, 13, IGPS coll. cat. no. 85803) 0.57 mm long, 0.42 mm high, and 0.44 mm thick (complete



Text-fig. 12, 13. *Tubulibairdia venusta* (Chen), homotype, 12-right side, lateral view, 13-dorsal view. (line indicates length of 0.50 mm)

specimen); figured specimen, left valve (Pl. 18, figs. 12a, b, IGPS coll. cat. no. 85804) 0.64 mm long, 0.44 mm high, and 0.29 mm thick.

*Remarks:* – The present specimens are closely allied to *Microcheilinella venusta* Chen reported from the lower Permian, upper part of the Chihhsia Limestone, at Lungtan, Nanking, China in many important features of the carapace, although the present ones are somewhat higher compared with those of the latter.

The named species was first described by Chen (1958) from China under the genus *Microcheilinella* Geis, 1933. However, an examination of the specimens from northeast Japan shows that Chen's species may better be placed in the genus *Tubulibairdia* Swartz, 1936 from the following reasons.

1) The carapace is considerably thick, 2) the ventral margins of the specimens at hand are rather broadly convex, in contrast to the species belonging to *Microcheilinella*, 3) the height of the carapace is considerably high, and 4) the left valve over-reaches the right valve broadly along the dorsal and ventral margins and narrowly along the end margins.

*Occurrence:* – Rather common.

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Plates 16—19

## Plate 16

Figs. 1, 2. *Hollinella elliptica* Ishizaki, n. sp.

1-holotype, lateral view of right valve (IGPS coll. cat. no. 85770). 2-paratype, lateral view of right valve (IGPS coll. cat. no. 75771)  $\times$  44.

Figs. 3, 4. *Aurikirkbya formula* Ishizaki, n. sp.

3-holotype, lateral view of right valve (IGPS coll. cat. no. 85772)  $\times$  68. 4-paratype, lateral view of right valve (IGPS coll. cat. no. 85773)  $\times$  72.

Figs. 5, 6. *Aurikirkbya subkelllettae* Ishizaki, n. sp.

5-holotype, lateral view of left valve (IGPS coll. cat. no. 85774). 6-paratype, lateral view of left valve (IGPS coll. cat. no. 85775)  $\times$  73.

Figs. 7, 8. *Kirkbya atolla* Ishizaki, n. sp.

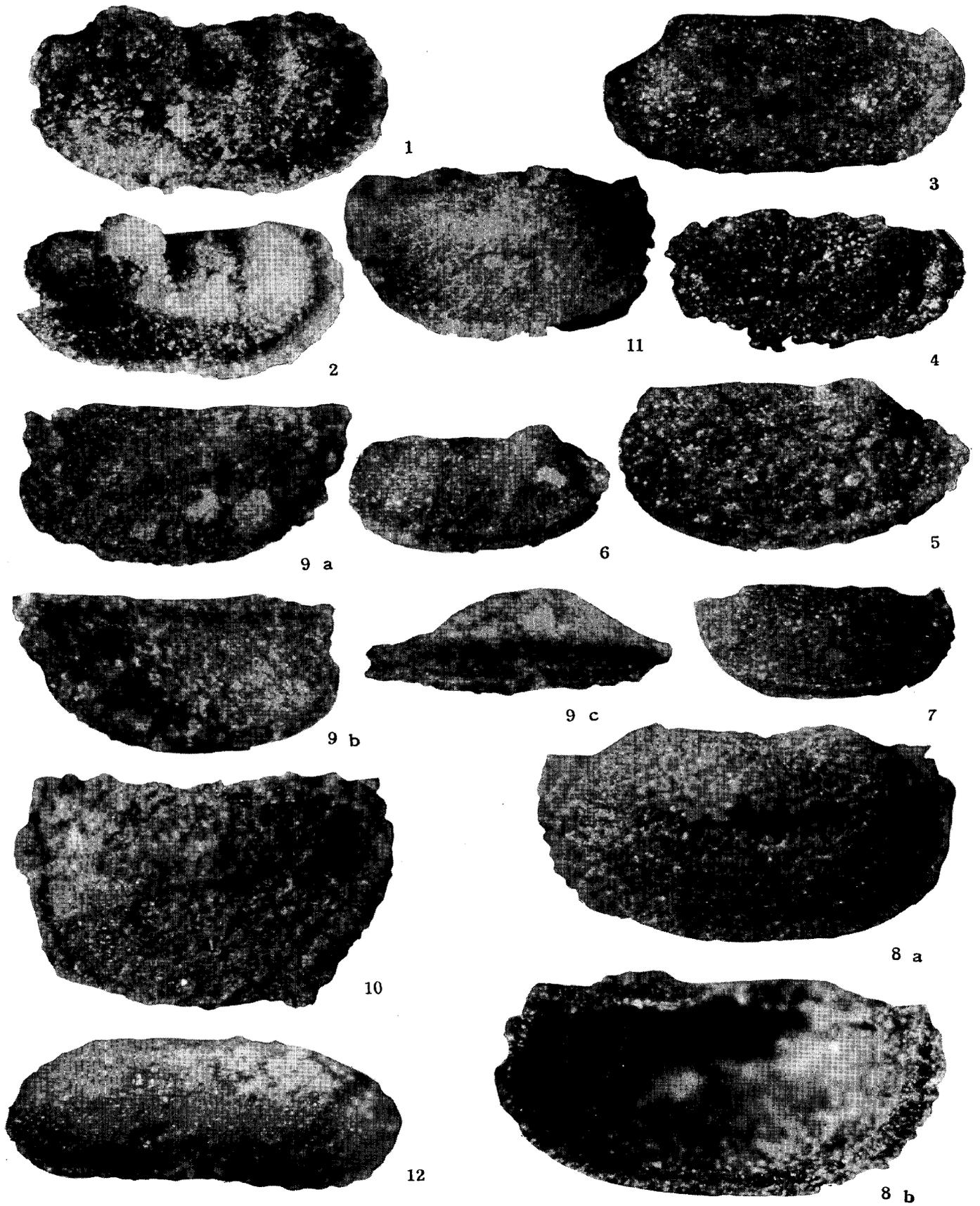
7-paratype, external lateral view of right valve (IGPS coll. cat. no. 85776)  $\times$  42. 8a-holotype, external view of right valve (IGPS coll. cat. no. 85777)  $\times$  38. 8b-internal view of the same specimen  $\times$  41.

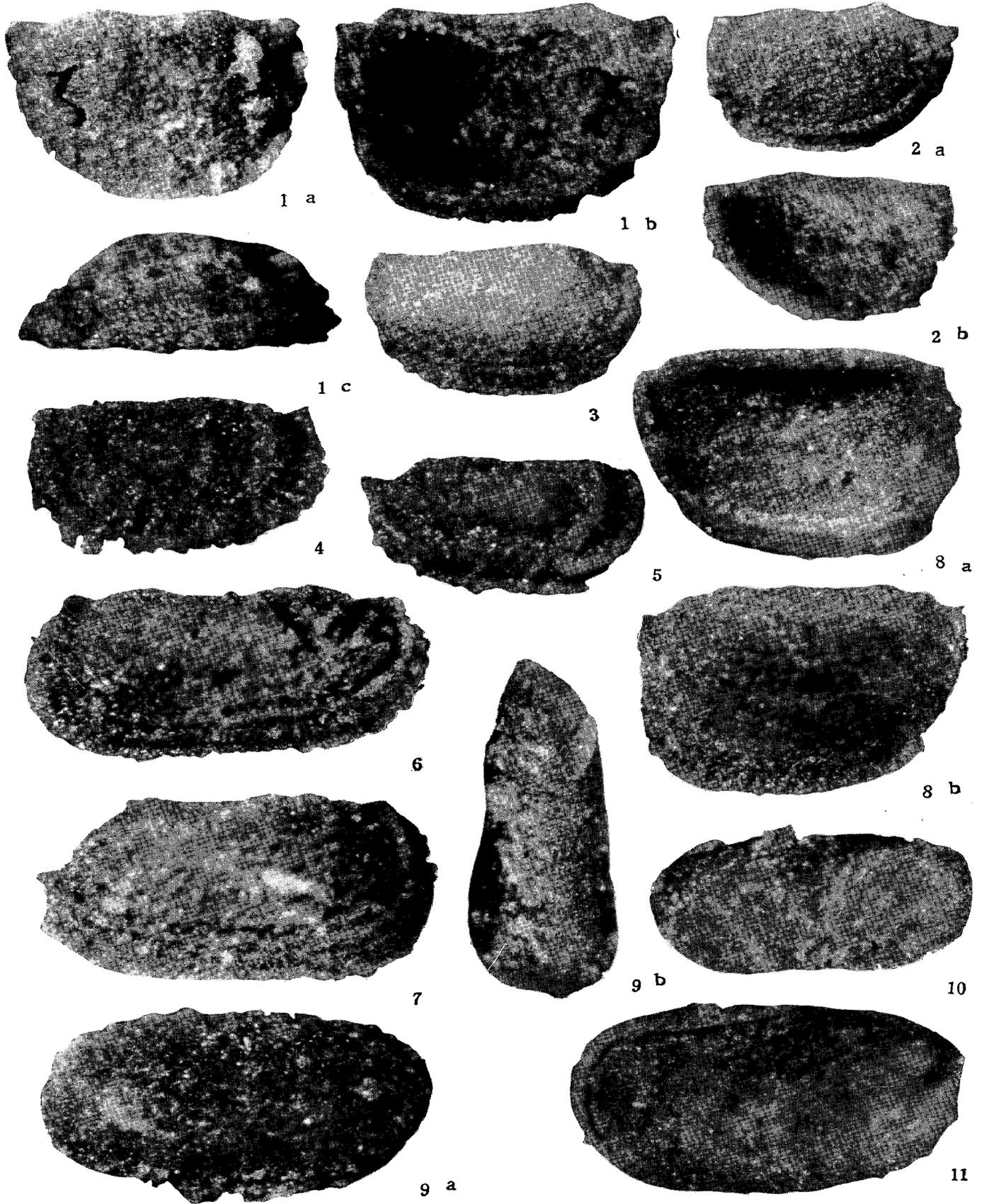
Figs. 9, 10. *Kirkbya centrotumida* Ishizaki, n. sp.

9a-holotype, external lateral view of left valve (IGPS coll. cat. no. 85778). 9b-internal view of the same specimen. 9c-ventral view of the same specimen  $\times$  43. 10-paratype, lateral view of the left valve (IGPS coll. cat. no. 85779)  $\times$  41.

Fig. 11. *Kirkbya subquadriforma* Ishizaki, n. sp., paratype, lateral view of right valve (IGPS coll. cat no. 85780)  $\times$  38.

Fig. 12. *Bairdiacypris deloi* Bradfield, homotype, right side lateral view of complete specimen (IGPS coll. cat. no. 85782)  $\times$  54.





## Plate 17

- Fig. 1. *Kirkbya magniforma* Ishizaki, n. sp.  
1a-holotype, external lateral view of right valve (IGPS coll. cat. no. 85783)  $\times$  38. 1b-internal view of the same specimen  $\times$  43. 1c-ventral view of the same specimen  $\times$  38.
- Figs. 2, 3. *Kirkbya subnipponica* Ishizaki, n. sp.  
2a-holotype, external lateral view of left valve (IGPS coll. cat. no. 85784). 2b-internal view of the same specimen  $\times$  48. 3-paratype, external view of left valve (IGPS coll. cat. no. 85785)  $\times$  48.
- Figs. 4, 5. *Amphissites centronotus* (Ulrich and Bassler) 4-holotype, lateral view of right valve (IGPS coll. cat. no. 85788)  $\times$  67. 5-holotype, lateral view of right valve (IGPS coll. cat. no. 85789)  $\times$  62.
- Figs. 6, 7. *Kirkbya multicresta* Ishizaki, n. sp.  
6-holotype, lateral view of left valve (IGPS coll. cat. no. 85786). 7-paratype, lateral view of right valve (IGPS coll. cat. no. 85787)  $\times$  51.
- Fig. 8. *Kirkbya subquadriforma* Ishizaki, n. sp.  
8a-holotype, internal view of left valve (IGPS coll. cat. no. 85781). 8b-external view of the same specimen  $\times$  38.
- Figs. 9-11. *Cavellina? nipponica* Ishizaki, n. sp.  
9a-holotype, left side lateral view of complete specimen (IGPS coll. cat. no. 85790). 9b-dorsal view of the same specimen  $\times$  53. 10-paratype, lateral view of right valve (IGPS coll. cat. no. 85791)  $\times$  53. 11-paratype, left side lateral view of complete specimen (IGPS coll. cat. no. 85792)  $\times$  53.

## Plate 18

Figs. 1, 2. *Ectodemites globosa* Ishizaki, n. sp.

1a-holotype, external lateral view of right valve (IGPS coll. cat. no. 85793). 1b-internal view of the same specimen  $\times 38$ . 2-paratype, external view of right valve (IGPS coll. cat. no. 85794)  $\times 37$ .

Figs. 3-6. *Polytylites kitanipponica* Ishizaki, n. sp.

3-holotype, male, lateral view of left valve (IGPS coll. cat. no. 85795)  $\times 49$ . 4-paratype, female, lateral view of right valve (IGPS coll. cat. no. 85796)  $\times 46$ . 5-paratype, immature female, lateral view of right valve (IGPS coll. cat. no. 85797)  $\times 49$ . 6-paratype, immature male, lateral view of right valve (IGPS coll. cat. no. 85798)  $\times 49$ .

Figs. 7, 8. *Roundyella neopapillosa* Ishizaki, n. sp.

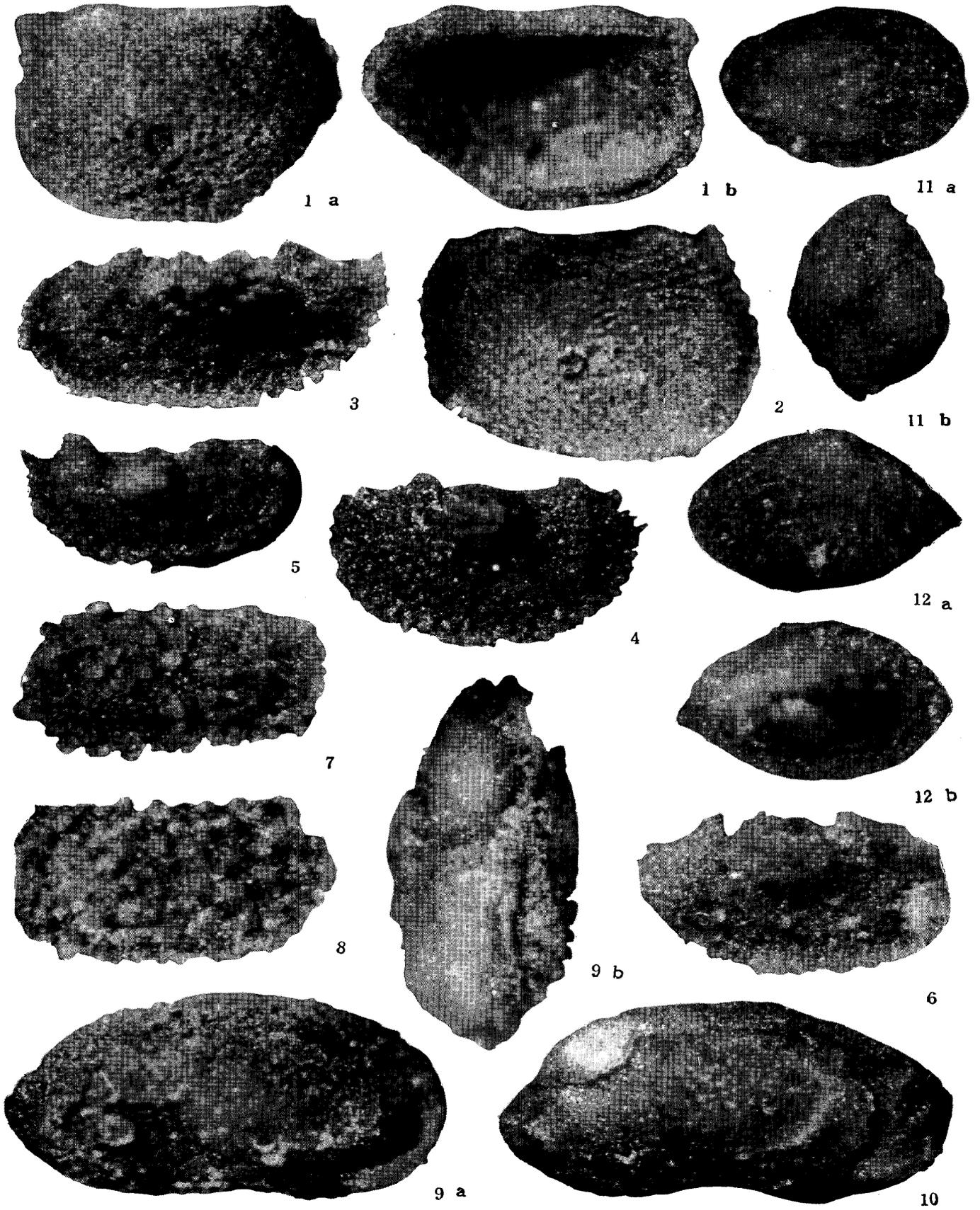
7-holotype, external lateral view (IGPS coll. cat. no. 85799)  $\times 73$ . 8-paratype, external lateral view (IGPS coll. cat. no. 85800)  $\times 73$ .

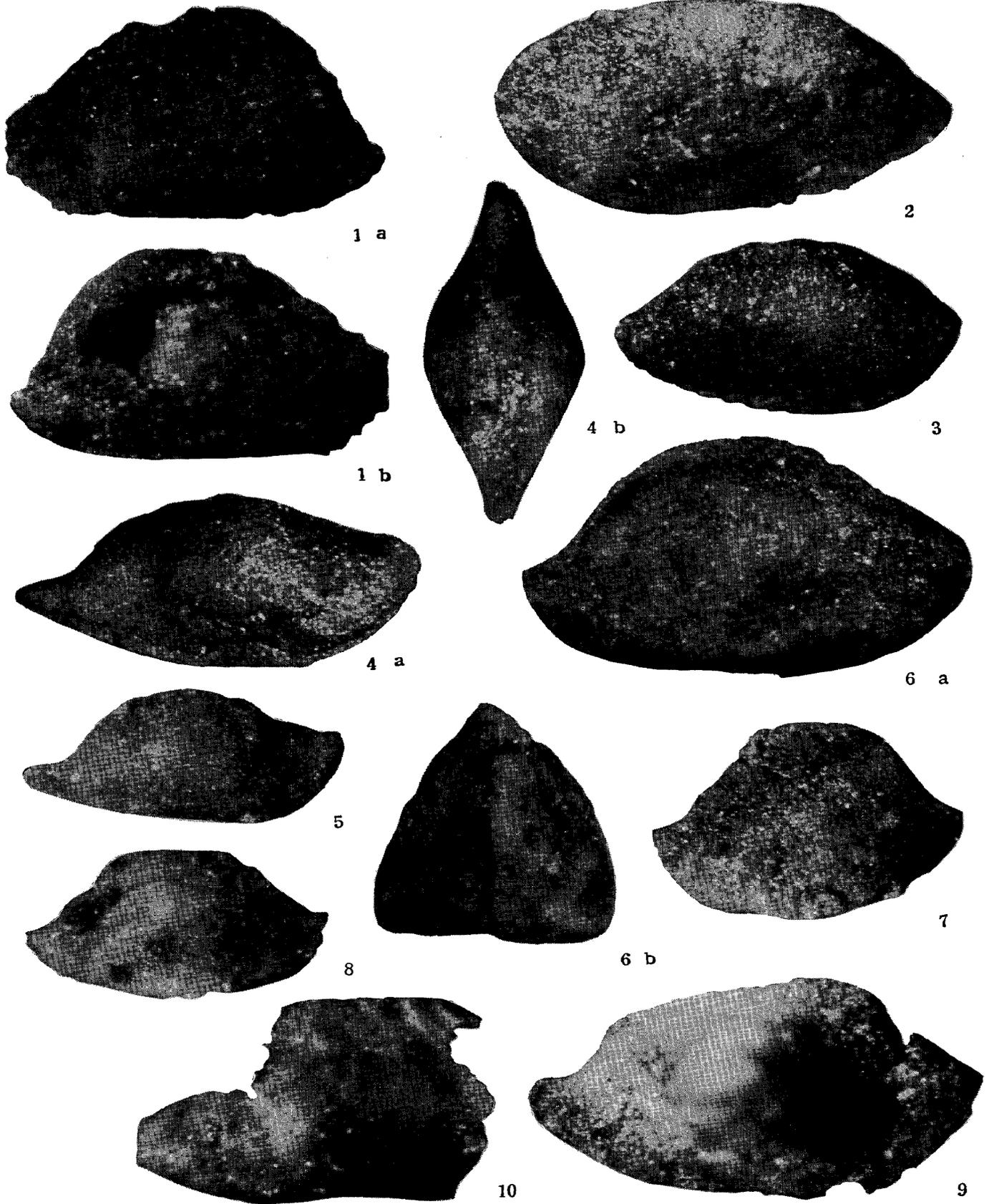
Figs. 9, 10. *Bairdia eucurvia* Ishizaki, n. sp.

9a-holotype, right side lateral view of complete specimen (IGPS coll. cat. no. 85802). 9b-dorsal view of the same specimen  $\times 36$ . 10-paratype, lateral view of right valve (IGPS coll. cat. no. 85801)  $\times 38$ .

Figs. 11, 12. *Tubulibairdia venusta* (Chen)

11a-holotype, right side lateral view of complete specimen (IGPS coll. cat. no. 85803). 11b-dorsal view of the same specimen  $\times 63$ . 12a-external lateral view of left valve (IGPS coll. cat. no. 85804). 12b-internal view of the same specimen  $\times 63$ .





## Plate 19

**Fig. 1.** *Bairdia nagaiwensis* Ishizaki

1a-metatype, left side lateral view of complete specimen (IGPS coll. cat. no. 85805). 1b-right side lateral view of the same specimen  $\times 47$ .

**Figs. 2, 3.** *Bairdia* cf. *oklahomaensis* Harlton

2-lateral view of left valve (IGPS coll. cat. no. 85806)  $\times 50$ . 3-right side lateral view of complete specimen (IGPS coll. cat. no. 85807)  $\times 53$ .

**Figs. 4, 5.** *Bairdia trianguliformis* Chen

4a-homotype, right side lateral view of complete specimen (IGPS coll. cat. no. 85808). 4b-dorsal view of the same specimen  $\times 34$ . 5-lateral view of right valve (IGPS coll. cat. no. 85809)  $\times 34$ .

**Figs. 6-8.** *Ceratobairdia? ambigua* Ishizaki, n. sp.

6a-holotype, right side lateral view of complete specimen (IGPS coll. cat. no. 85810). 6b-anterior view of the same specimen  $\times 34$ . 7-paratype, lateral view of left valve (IGPS coll. cat. no. 85811)  $\times 34$ . 8-paratype, lateral view of right valve (IGPS coll. cat. no. 85812)  $\times 34$ .

**Figs. 9, 10.** *Spinobairdia* sp.

9-lateral view of right valve (IGPS coll. cat. no. 85813)  $\times 49$ . 10-lateral view of fragmental right valve (IGPS coll. cat. no. 85814)  $\times 49$ .