

Early Permian (Sakmarian) brachiopods from the Nagaiwa–Sakamotozawa area, South Kitakami Belt, northeastern Japan, Part 3: Productidina

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Abstract

In this third manuscript in a series, the following 10 species of productid brachiopods (suborder Productidina), including one new species, are described from the lowest part of the Sakamotozawa Formation (Sakmarian) in the Nagaiwa–Sakamotozawa area, South Kitakami Belt, northeastern Japan: *Echinauris opuntia* (Waagen), *Reticulatia* cf. *donetziana* (Licharew), *Echinaria* sp., *Juresania* sp., *Waagenoconcha humboldti* (d'Orbigny), *Edriosteges* cf. *multispinosus* Muir-Wood and Cooper, *Linoproductus simensis* (Tschernyschew), *Auriculispina kanmerai* Tazawa and Shintani, sp. nov., *Terrakea* sp. and *Cyclacantharia* sp. The Nagaiwa–Sakamotozawa fauna is a mixed Boreal–Tethyan fauna, with a predominance of Boreal elements.

Key words: early Permian, mixed Boreal–Tethyan fauna, Nagaiwa–Sakamotozawa area, productid brachiopods, South Kitakami Belt.

Introduction

Tazawa and Shintani (2010) and Shintani (2011) described an early Permian (Sakmarian) brachiopod fauna from the lowest part of the Sakamotozawa Formation in the type locality, the Nagaiwa–Sakamotozawa area, South Kitakami Belt, northeastern Japan. Tazawa and Shintani (2010) described three species: *Waagenoconcha humboldti*, *Scacchinella* sp. and *Rhynchopora* sp.; and Shintani (2011) described five orthotetoid species: *Meekella striatocostata*, *M. nagaiwensis*, *Derbyia crassa*, *D. dorsosulcata* and *D. sakamotozawensis*.

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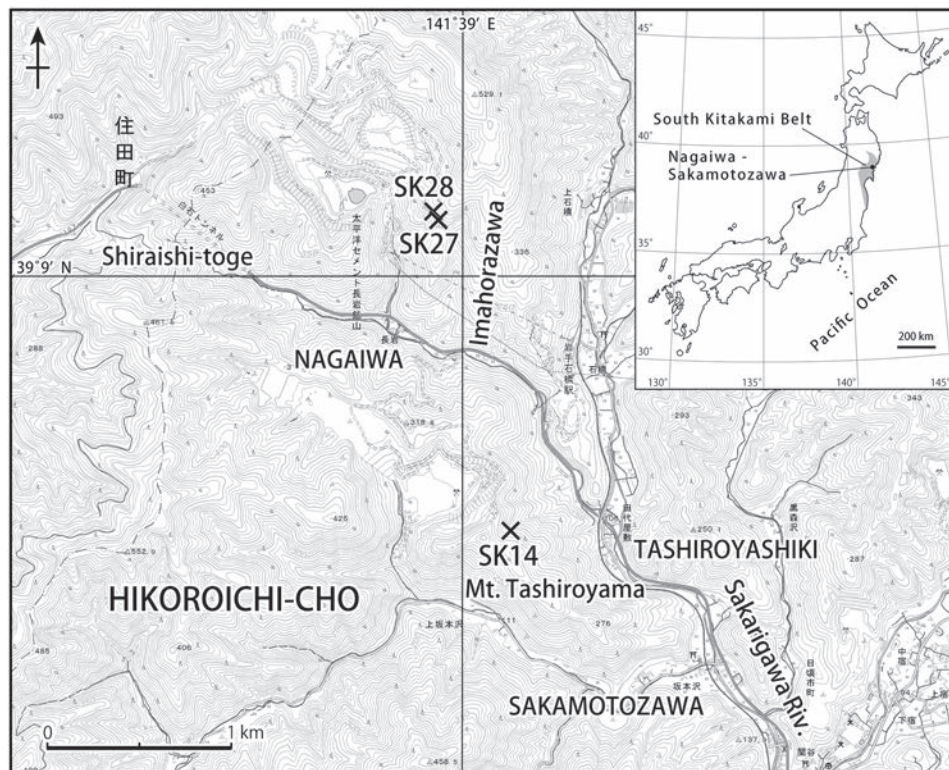


Fig. 1. Map showing the fossil localities, SK14, SK27 and SK28 in the Nagaiwa–Sakamotozawa area, using the topographic map of “Sakari” scale 1 : 25,000, published by the Geospatial Information Authority of Japan.

Thus, the present paper is the third report on the Nagaiwa–Sakamotozawa fauna.

This paper describes 10 species of productid brachiopods (suborder Productidina, Waagen, 1883), including one new species: *Echinaris opuntia* (Waagen, 1884), *Reticulatia* cf. *donetziana* (Licharew, 1938), *Echinaris* sp., *Juresania* sp., *Waagenoconcha humboldti* (d’Orbigny, 1842), *Edriosteges* cf. *multispinosus* Muir-Wood and Cooper, 1960, *Linoproductus simensis* (Tschernyschew, 1902), *Auriculispina kanmerai* Tazawa and Shintani, sp. nov., *Terrakea* sp. and *Cyclacantharia* sp. The geographic locations and stratigraphical horizons of the three fossil localities (SK14, SK27 and SK28), at which these species were found, are explained in detail by Shintani (2011, p. 75–76), and indicated in Figs. 1 and 2, respectively.

Among the productid species listed above, *Juresania* sp., *Waagenoconcha humboldti*, *Auriculispina kanmerai* and *Terrakea* sp. are Boreal (antitropical) elements, whereas *Echinaris opuntia* and *Cyclacantharia* sp. are Tethyan (tropical) elements. Therefore, the early Permian (Sakmarian) productid brachiopod fauna from the Nagaiwa–Sakamotozawa area is regarded as a mixed Boreal–Tethyan fauna with a predominance of Boreal elements.

The specimens described here were prepared by the second author (T. Shintani), and

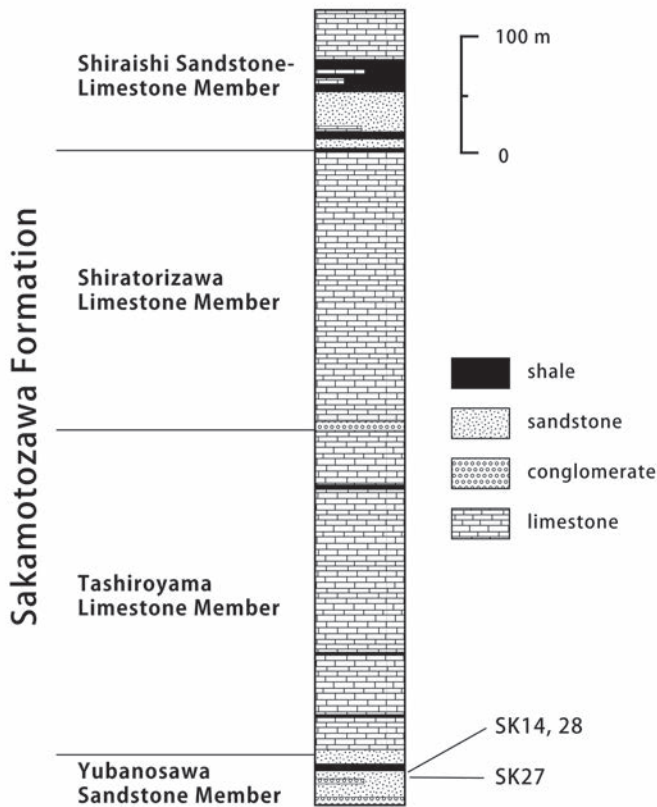


Fig. 2. Generalized columnar section of the Sakamotozawa Formation in the Nagaiwa–Sakamotozawa area, showing the fossil horizons, SK14, SK27 and SK28 (after Shintani, 2011).

are now registered and housed in the Department of Geology, Niigata University, Niigata, Japan, under the prefix NU-B.

Systematic descriptions

Order Productida Sarytcheva and Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily Marginiferoidea Stehli, 1954

Family Costispiniferidae Muir-Wood and Cooper, 1960

Subfamily Costispiniferinae Muir-Wood and Cooper, 1960

Genus *Echinauris* Muir-Wood and Cooper, 1960

Type species.—*Echinauris lateralis* Muir-Wood and Cooper, 1960.

Echinauris opuntia (Waagen, 1884)

Fig. 3.5

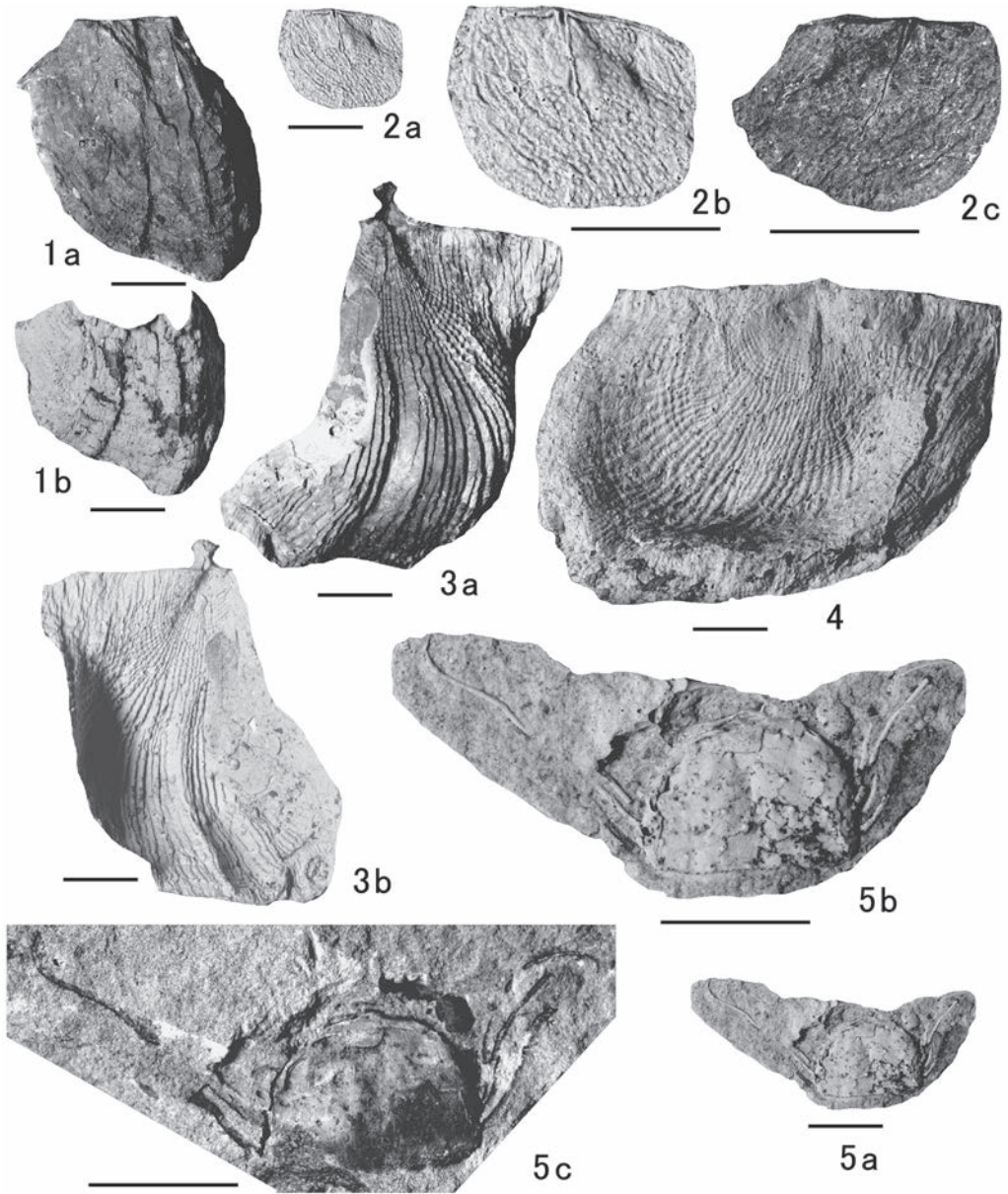


Fig. 3. 1. *Echinaria* sp., 1a, 1b, internal mould and external latex cast of ventral valve, NU-B1899; 2. *Juresania* sp., 2a, 2b, 2c, internal latex cast and internal mould of dorsal valve, NU-B1900; 3, 4. *Reticulatia* cf. *donetziana* (Licharew); 3a, 3b, internal mould and external latex cast of dorsal valve, NU-B1874; 4. external latex cast of dorsal valve, NU-B1874; 5. *Echinauris opuntia* (Waagen); 5a, 5b, 5c, external latex cast and internal mould of ventral valve, NU-B1867. Scale bars represent 1 cm.

Productus opuntia Waagen, 1884, p. 707, pl. 79, figs. 1, 2.

Echinauris opuntia (Waagen): Grant, 1968, p. 27, pl. 8, figs. 1–8; pl. 9, figs. 1–8; Licharew and Kotlyar, 1978, pl. 20, fig. 14; Shen et al., 2000, p. 742, figs. 10.24–10.32; Shen and Shi, 2009, p. 158, figs. 3Y–3CC.

Material.—One specimen from locality SK27, external and internal moulds of a ventral valve, NU-B1867.

Remarks.—This specimen can be referred to *Echinauris opuntia* (Waagen, 1884), redescribed by Grant (1968, p. 27, pl. 8, figs. 1–8; pl. 9, figs. 1–8), from the Wargal Formation of the Salt Range, Pakistan, by its small, slightly transverse, rounded subtriangular ventral valve (length 11 mm, width 14 mm), with numerous long, thin spines on the lateral slopes. The type species, *Echinauris lateralis* Muir-Wood and Cooper (1960, p. 222, pl. 68, figs. 1–13), from the Word Formation of the Glass Mountains, western Texas, differs from the present species in the larger size and in having stronger and thicker spines on the ventral valve.

Distribution.—Sakmarian–Changhsingian: eastern Russia (South Primorye), northeastern Japan (Nagaiwa–Sakamotozawa in the South Kitakami Belt), central-southern China (Guangxi), southwestern China (Xizang) and Pakistan (Salt Range).

Superfamily Productoidea Gray, 1840

Family Dictyoclostidae Stehli, 1954

Subfamily Dictyoclostinae Stehli, 1954

Genus *Reticulatia* Muir-Wood and Cooper, 1960

Type species.—*Productus huecoensis* King, 1931.

Reticulatia cf. *donetziana* (Licharew, 1938)

Figs. 3.3, 3.4

Cf. *Productus donetzianus* Licharew, 1938, p. 78, pl. 1, fig. 5; Licharew, 1939, p. 91, pl. 20, figs. 5, 6.

Material.—Two specimens from locality SK27: (1) external and internal moulds of a dorsal valve, NU-B1873; (3) external mould of a dorsal valve, NU-B1874.

Description.—Shell medium in size for genus, transversely subrectangular in outline, with greatest width at hinge; length about 38 mm, width about 55 mm in the larger dorsal valve specimen (NU-B1874). Dorsal valve slightly concave, with broad and flattened visceral disc, strongly geniculated at anterior margin, and followed by a long trail with bordering reflexed flange, 8–9 mm length; ears large, slightly concave; fold low and narrow in trail.

External surface of dorsal valve ornamented by numerous costae and concentric rugae on visceral disc, costae only in trail; costae strong and round with narrow interspaces, becoming finer and more numerous in trail, and numbering 4–5 in 5 mm at midlength; rugae regularly developed, numbering 7–8 in 5 mm at midlength. Interior of dorsal valve with a large trilobed cardinal process. Other internal structures obscure.

Remarks.—These specimens resemble *Reticulatia donetziana* (Licharew, 1938), from the Upper Carboniferous (Kasimovian) of the Donetz Basin, western Russia, in having a peculiar bordering flange at antero-lateral margins of the dorsal valve. The same ringlike structure has been described and figured by Sutton (1942, p. 464, pl. 71, figs. 12, 13) in the specimens of *Reticulatia americana* (Dunbar and Condra, 1932) from the Pennsylvanian of Illinois, USA. The Kitakami species more like the Russian species than the American species in size, shape and external ornament of the dorsal valve.

Superfamily Echinoconchoidea Stehli, 1954

Family Echinoconchidae Stehli, 1954

Subfamily Echinoconchinae Stehli, 1954

Tribe Echinoconchini Stehli, 1954

Genus *Echinaria* Muir-Wood and Cooper, 1960

Type species.—*Productus semipunctatus* Shepard, 1838.

Echinaria sp.

Fig. 3.1

Material.—One specimen from locality SK27, external and internal moulds of a ventral valve, NU-B1899.

Remarks.—This specimen is a fragment of dorsal valve, lacking the posterior portion, but it is safely assigned to the genus *Echinaria* by its large, elongate ventral valve (length more than 37 mm, width about 28 mm), with narrow and moderately deep sulcus, and ornamented by numerous broad concentric lamellae, with 3–4 rows of spine bases on each lamella. The species identification is, however, difficult owing to the poorly preserved specimen.

Subfamily Juresaniinae Muir-Wood and Cooper, 1960

Tribe Juresaniini Muir-Wood and Cooper, 1960

Genus *Juresania* Fredericks, 1928

Type species.—*Productus juresanensis* Tschernyschew, 1902.

Juresania sp.

Fig. 3.2

Material.—One specimen from locality SK27, internal mould of a dorsal valve, NU-B1900.

Remarks.—This specimen can be assigned to the genus *Juresania* by its small-sized (length 24 mm+, width 27 mm) dorsal valve, with flat visceral disc, covered internally by numerous concentrically arranged endospines, and in having a long, thin brevisseptum and short converging buttress plates enclosing end of brevisseptum and the more posterior antron. The Kitakami species somewhat resembles *Juresania juresanensis* (Tschernyschew, 1902, p. 276, 620, pl. 29, figs. 1, 2; pl. 47, figs. 1, 2; pl. 53, fig. 4), from the Cora Limestone of Timan, northern Russia and from the *Schwagerina* Limestone (Sakmarian) of the Urals, central Russia, in size and shape of the dorsal valve, but accurate comparison is difficult due to the poorly preserved specimen.

Family Waagenoconchidae Muir-Wood and Cooper, 1960

Subfamily Waagenoconchinae Muir-Wood and Cooper, 1960

Tribe Waagenoconchini Muir-Wood and Cooper, 1960

Genus *Waagenoconcha* Chao, 1927

Type species.—*Productus humboldti* d'Orbigny, 1842.

Waagenoconcha humboldti (d'Orbigny, 1842)

Fig. 4.1

Productus humboldti d'Orbigny, 1842, p. 54, pl. 5, figs. 4–7; Tschernyschew, 1902, p. 275, 620, pl. 53, figs. 1–3; Kozłowski, 1914, p. 40, pl. 7, figs. 7–9; Fredericks, 1925, p. 19, pl. 2, fig. 84.

Waagenoconcha humboldti (d'Orbigny): Chao, 1927, p. 86, pl. 15, figs. 2, 3; Sarytcheva and Sokolskaya, 1952, p. 98, pl. 15, fig. 109; Chronic, 1953, p. 86, pl. 15, figs. 4–7; Muir-Wood and Cooper, 1960, p. 252, pl. 89, figs. 6–10; Samtleben, 1971, p. 60, pl. 2, figs. 17–19; Ifanova, 1972, p. 102, pl. 3, figs. 11–13; Tazawa, 1974, p. 125, pl. 1, figs. 2, 3; pl. 2, fig. 1; pl. 4, fig. 6; Duan and Li, 1985, p. 108, pl. 35, figs. 2, 3; Wang and Zhang, 2003, p. 94, pl. 9, figs. 5–7; pl. 15, figs. 8–10; Tazawa and Shintani, 2010, p. 56, figs. 4, 5.

Material.—One specimen from locality SK27, external mould of a dorsal valve, NU-B1872.

Remarks.—The material available is a dorsal valve specimen, transversely subrectangular in outline (length 19 mm, width 38 mm), with hinge slightly shorter than the maximum width; almost flat visceral disc, strongly geniculated at anterior margin, and followed by a short trail; external surface of the ventral valve is ornamented by numerous

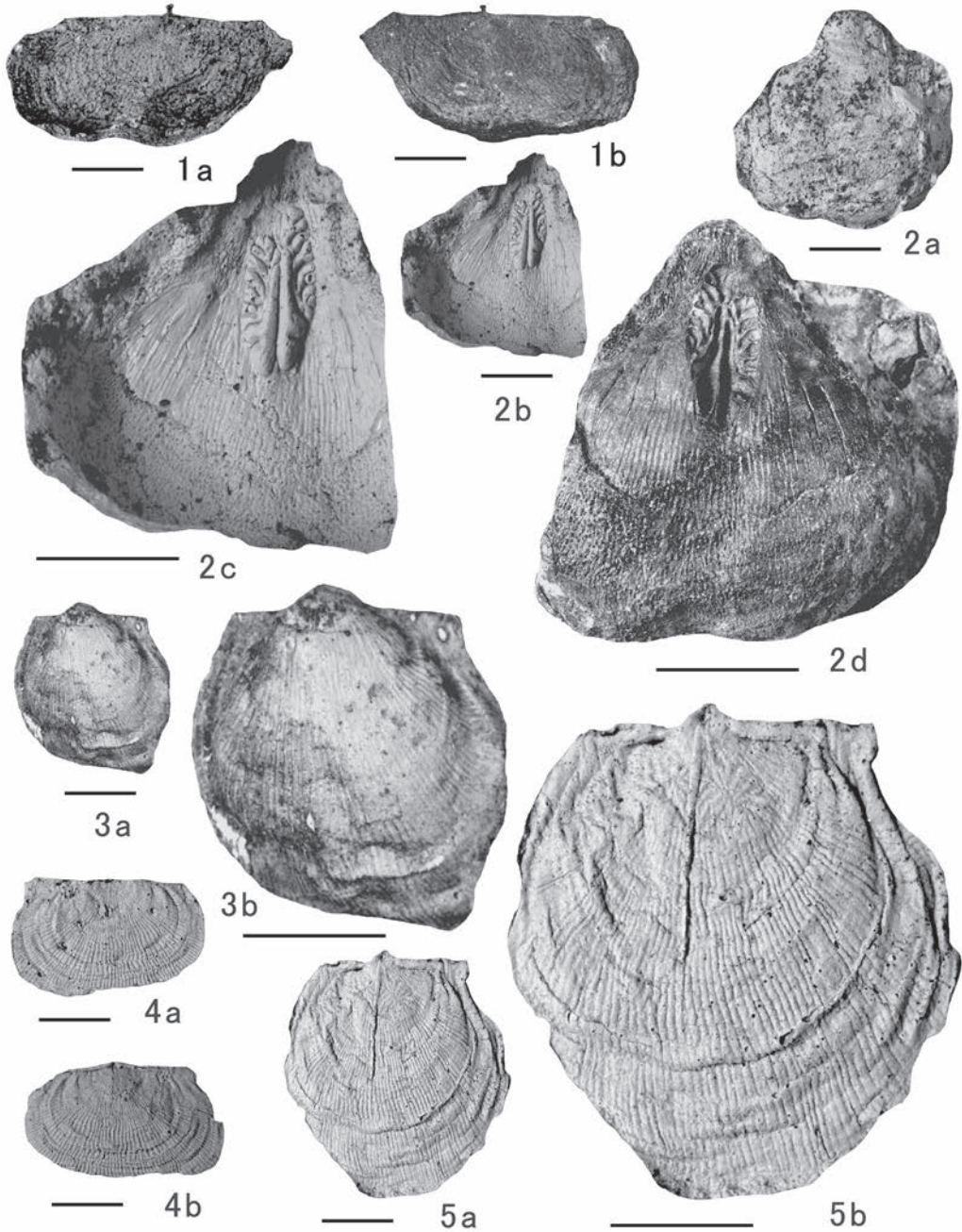


Fig. 4. 1, *Waagenoconcha humboldti* (d'Orbigny); 1a, 1b, external latex cast and external mould of dorsal valve, NU-B1872; **2,** *Edriosteges cf. multispinosus* Muir-Wood and Cooper; 2a, 2b, 2c, 2d, external latex cast, internal latex cast and internal mould of ventral valve, NU-B1868; **3–5,** *Linoproductus simensis* (Tschernyschew); 3a, 3b, external latex cast of ventral valve, NU-B1875; 4a, 4b, external latex cast and internal latex cast of dorsal valve, NU-B1879; 5a, 5b, internal latex cast of dorsal valve, NU-B1881. Scale bars represent 1 cm.

fine quincuncially arranged spine bases and several strong concentric rugae.

This specimen can be referred to *Waagenoconcha humboldti* (d'Orbigny, 1842), originally described from the Lower Permian (Asselian) of Yarbichambi, Bolivia, in size, shape and external ornament of the dorsal valve. Recently Tazawa and Shintani (2010) described *W. humboldti* from the basal part of the Sakamotozawa Formation at the locality SK27 in the Nagaiwa–Sakamotozawa area, South Kitakami Belt. The present specimen resembles well the previously described specimens from the Nagaiwa–Sakamotozawa area. Comparison with other *Waagenoconcha* species has been fully discussed by Tazawa and Shintani (2010, p. 57).

Distribution.—Gzhelian–Capitanian: western Russia (Moscow Basin), northern Russia (Timan, Pechora Basin and northern Urals), northern China (Inner Mongolia), eastern Russia (South Primorye), northeastern Japan (Nagaiwa–Sakamotozawa in the South Kitakami Belt) and Bolivia.

Superfamily Aulostegoidea Muir-Wood and Cooper, 1960

Family Echinostegidae Muir-Wood and Cooper, 1960

Subfamily Echinosteginae Muir-Wood and Cooper, 1960

Genus *Edriostege* Muir-Wood and Cooper, 1960

Type species.—*Edriostege multispinosus* Muir-Wood and Cooper, 1960.

Edriostege cf. *multispinosus* Muir-Wood and Cooper, 1960

Fig. 4.2

Cf. *Edriostege multispinosus* Muir-Wood and Cooper, 1960, p. 104, pl. 17, figs. 1–10.

Material.—Two specimens from locality SK28: (1) external and internal moulds of a ventral valve, NU-B1868; (2) internal mould of a ventral valve, NU-B1869.

Description.—Shell medium in size for genus, equidimensional subquadrate in outline, widest at anterior one-third; length 33 mm, width about 34 mm in the larger specimen (NU-B1868). Ventral valve strongly convex medianly, flattened toward umbo, and with shallow sulcus on trail. External surface of ventral valve ornamented by numerous fine spines and obscure concentric lamellae; strong spines in group on ears and lateral slopes. Interior of ventral valve with narrow dendritic posterior and lobate anterior adductor scars, set on low median ridge; diductor scars large, broad, and longitudinally striated.

Remarks.—The Sakamotozawa species resembles well the type species, *Edriostege multispinosus* Muir-Wood and Cooper, 1960, from the upper Leonard Formation of western Texas, in size and outline of the ventral valve, but accurate comparison is difficult owing to

lack of the opposite valve.

Edriosteges sp. A, described by Tazawa and Araki (2014, p. 47, fig. 3.5) from the Upper Permian Nabekoshiyama Formation of Nabekoshiyama in the Kesenuma area, South Kitakami Belt, differs from the present species in the subtriangular outline of the ventral valve.

Superfamily Linoproductoidea Stehli, 1954

Family Linoproductidae Stehli, 1954

Subfamily Linoproductinae Stehli, 1954

Tribe Linoproductini Stehli, 1954

Genus *Linoproductus* Chao, 1927

Type species.—*Productus cora* d'Orbigny, 1842.

Linoproductus simensis (Tschernyschew, 1902)

Figs. 4.3–4.5

Productus simensis Tschernyschew, 1902, p. 286, 626, pl. 35, fig. 7; pl. 55, figs. 2–5.

Linoproductus simensis (Tschernyschew): Volgin, 1960, p. 72, pl. 8, fig. 1; Zhao, 1965, p. 425, pl. 1, figs. 6, 7; Bamber and Waterhouse, 1971, pl. 16, figs. 8, 11; Sergunkova and Zhizhilo, 1975, p. 62, pl. 9, figs. 9, 10; pl. 10, figs. 8, 9; Lee and Gu, 1976, p. 258, pl. 139, figs. 9–12; Kalashnikov, 1980, p. 47, pl. 10, figs. 8, 9 only; Lee et al., 1980, p. 376, pl. 152, fig. 11; Tazawa et al., 2001, p. 38, figs. 2D–2J.

Linoproductus neimongolensis Lee and Gu, 1976, p. 258, pl. 178, figs. 1–10.

Material.—Seven specimens from locality SK27: (1) external and internal moulds of two ventral valves, NU-B1875, 1876; (2) external and internal moulds of three dorsal valves, NU-B1877–1879; (3) external mould of a dorsal valve, NU-B1880; (4) internal mould of a dorsal valve, NU-B1881.

Description.—Shell small in size for genus, slightly elongated oval in outline, hinge slightly shorter than greatest width at midlength; ears small, well demarcated from visceral region; cardinal extremities obtuse, angular; length 37 mm, width 35 mm in the largest dorsal valve specimen (NU-B1881); length 25 mm, width 23 mm in best preserved ventral valve specimen (NU-B1875). Ventral valve strongly and unevenly convex in lateral profile, most convex at umbonal region, not geniculated; sulcus absent. Dorsal valve slightly concave in both lateral and anterior profiles, with almost flat visceral disc; no fold. External surface of ventral valve ornamented by numerous costellae and some rugae; costellae numbering 11–12 in 5 mm at midlength; rugae developed on ears and lateral slopes; some

spine bases on ears. External ornament of dorsal valve like those of ventral valve, but rugae more irregularly developed on the visceral disc. Interior of dorsal valve with a long median septum extending to midlength of the valve; a pair of strong but short lateral ridges, and large dendritic adductor scars.

Remarks.—These specimens are referred to *Linoproductus simensis* (Tschernyschew, 1902), from the *Schwagerina* Limestone (Sakmarian) of the Urals, in size, shape and external ornament of the ventral valve. *Linoproductus neimongolensis* Lee and Gu, 1976, from the Lower Permian of the Dongujimqinqi area, Inner Mongolia, is a junior synonym of *L. simensis*. Shells described by Chao (1927, p. 137, pl. 14, figs. 6–8) as *Linoproductus simensis* (Tschernyschew), from the Visean of Guizhou, southwestern China, differs from *L. simensis* in having stronger and fewer costellae (9–10 in 5 mm).

Linoproductus hayasakai Tazawa (1979, p. 26, pl. 4, figs. 5–11), from the lower Kamiyasse Formation (Wordian) of Wayama in the Kesenuma area, South Kitakami Belt, differs from *L. simensis* in its larger, transverse shell and in having stronger costellae (7–9 in 5 mm) on the ventral valve.

Distribution.—Kasimovian–Roadian: northern Russia (northern and southern Urals), Uzbekistan (Fergana), northern China (Inner Mongolia), northeastern Japan (Nagaiwa-Sakamotozawa in the South Kitakami Belt) and northern Canada (Yukon Territory).

Family Kansuellidae Muir-Wood and Cooper, 1960

Subfamily Auriculispinae Waterhouse, 1986

Tribe Auriculispinini Waterhouse, 1986

Genus *Auriculispina* Waterhouse, 1975

Type species.—*Cancrinella levis* Maxwell, 1964.

Auriculispina kanmerai sp. nov.

Figs. 5.1–5.3

Etymology.—Named for late Professor Kametoshi Kanmera.

Material.—Twelve specimens from locality SK27: (1) external and internal moulds of five ventral valves, NU-B1882 (holotype), NU-B1883–1886; (2) internal moulds of three ventral valves, NU-B1887–1889; (3) external and internal moulds of two dorsal valves, NU-B1890, 1891; (4) internal mould of two dorsal valves, NU-B1892, 1893.

Diagnosis.—Small-sized *Auriculispina*, ornamented with 7–8 capillae per 2 mm in ventral valve.

Description.—Shell small in size for genus, transversely subquadrate in outline, with greatest width at about midlength; length 7 mm, width about 9 mm in the holotype (NU-

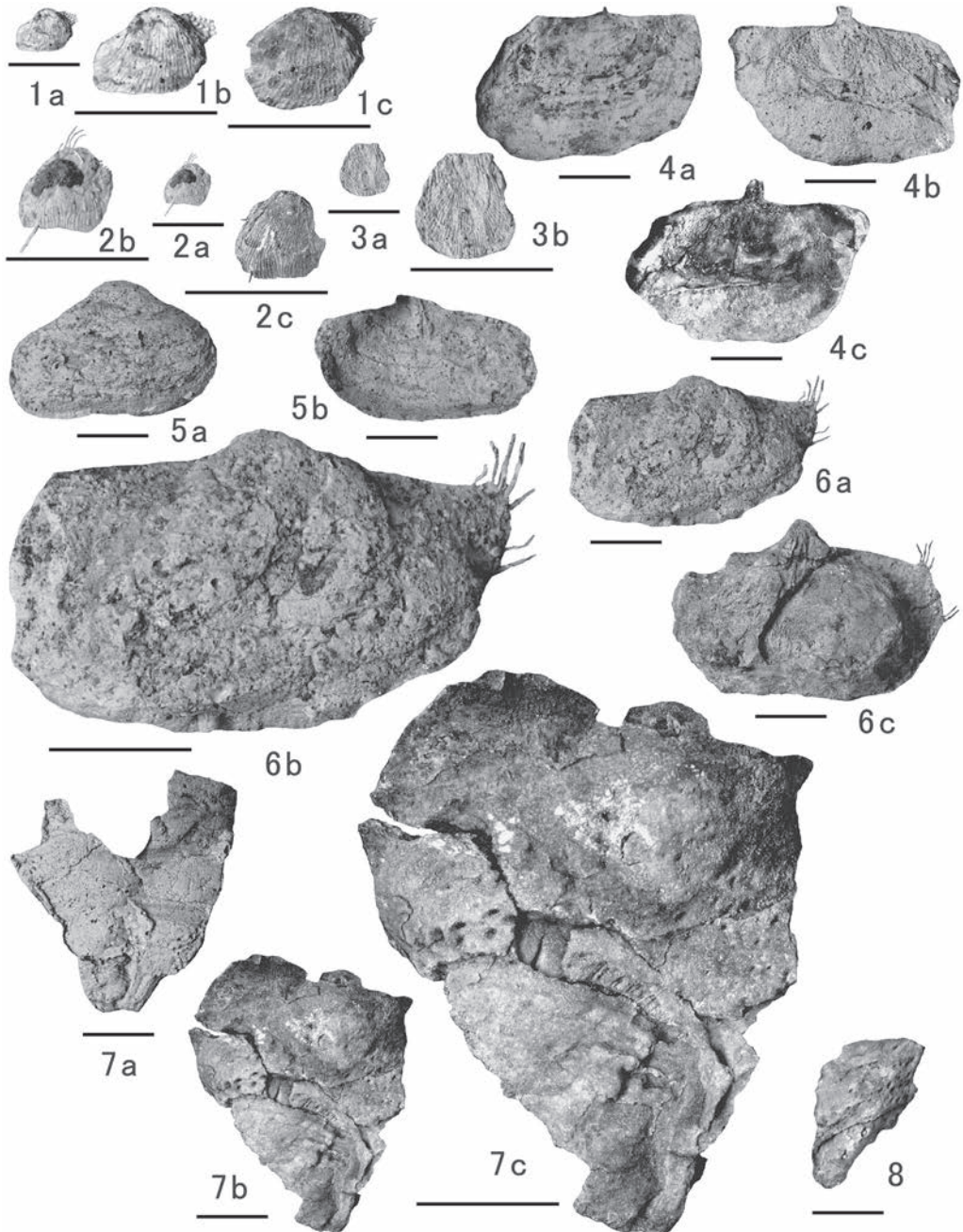


Fig. 5. 1-3, *Auriculispina kanmerai* Tazawa and Shintani, sp. nov.; 1a, 1b, 1c, external latex cast and internal mould of ventral valve, NU-B1882 (holotype); 2a, 2b, 2c, external latex cast and internal mould of ventral valve, NU-B1884; 3a, 3b, internal latex cast of dorsal valve, NU-B1893; 4-6, *Terrakea* sp.: 4a, 4b, 4c, external latex cast, internal latex cast and internal mould of dorsal valve, NU-B1897; 5a, 5b, external latex cast and internal latex cast of ventral valve, NU-B1894; 6a, 6b, 6c, external latex cast and internal mould of ventral valve, NU-B1895; 7, 8, *Cyclacantharia* sp.: 7a, 7b, 7c, external latex cast and internal mould of ventral valve, NU-B1870; 8, internal mould of ventral valve, NU-B1871. Scale bars represent 1 cm.

B1882). Ventral valve gently convex; ears moderate size, gently convex; no sulcus. Dorsal valve slightly concave; no fold. External surface of ventral valve ornamented by numerous fine capillae, some weak rugae and numerous spines; capillae often irregular and flexuous, numbering 7–8 in 2 mm at midlength; rugae developed near anterior margin; spine bases cluster on ears and scattered over valve. Dorsal valve capillate, without spines or spine bases. Internal structures of both valves not well preserved.

Remarks.—*Auriculispina kanmerai* Tazawa and Shintani, sp. nov. most resembles *Auriculispina capillata* (Waterhouse, 1988, p. 156, fig. 8), from the Grant Formation (Asselian–Sakmarian) of the Canning Basin, western Australia, in size and shape of the shell, but the present new species differs from the Australian species in having finer capillae on the ventral valve.

The type species, *Auriculispina levis* (Maxwell, 1964, p. 34, pl. 6, figs. 15–18), from the Upper Carboniferous and the Lower Permian (Sakmarian) of the Yarrol Basin, eastern Australia, is readily distinguished from *A. kanmerai* by the larger and more transverse shell and in having coarser capillae on the ventral valve.

Subfamily Paucispinauriinae Waterhouse, 1986

Tribe Paucispinauriini Waterhouse, 1986

Genus *Terrakea* Booker, 1930

Type species.—*Productus brachythaerus* Morris in de Strezelecki, 1845.

Terrakea sp.

Figs. 5.4–5.6

Material.—Five specimens from localities SK28 and SK14: (1) external and internal moulds of two ventral valves, NU-B1894, 1895; (2) internal mould of a ventral valve, NU-B1896; (3) external and internal moulds of two dorsal valves, NU-B1897, 1898.

Description.—Shell large in size for genus, transversely subrectangular in outline, with greatest width at midlength; length 28 mm, width 38 mm in the largest specimen (NU-B1895). Ventral valve strongly and unevenly convex in lateral profile, most convex at umbonal region, flattened in visceral disc, geniculated and followed by a short trail; ears small, slightly convex; sulcus very shallow if it is present; lateral slopes steep. Dorsal valve moderately concave, with broad, flat visceral disc, geniculated, and followed by a short trail. External surface of ventral valve ornamented by numerous rugae and fine spine bases; spine bases clustered on ears and scattered on visceral region. External ornament of dorsal valve similar to the opposite valve, but spine bases are finer than those of the ventral valve. Ventral interior with broad, longitudinally striated diductor scars and elongate oval, finely

dendritic adductor scars. Dorsal interior with a long median septum and short, slightly diverging lateral ridges. Adductor muscle scars large, finely dendritic.

Remarks.—These specimens can be assigned to the genus *Terrakea* by their size, shape and external ornament of both ventral and dorsal valves. The Sakamotozawa species somewhat resembles the type species, *Terrakea brachythaera* (Morris in de Strezelecki, 1845), redescribed and refigured by Briggs (1998, p. 176, figs. 87A–87I), from the Broughton Formation of the Sydney Basin, eastern Australia, in outer configuration, but accurate comparison is difficult due to the ill-preserved specimens.

Terrakea nabekoshiyamensis Tazawa (2012, p. 26, figs. 4.13, 4.14), from the Nabekoshiyama Formation of Nabekoshiyama in the Kesenuma area, South Kitakami Belt, is a transverse species, but it differs from the present species by the much smaller dimensions.

Superfamily Richthofenioida Waagen, 1885

Family Teguliferinidae Muir-Wood and Cooper, 1960

Subfamily Cyclacanthariinae Cooper and Grant, 1975

Genus *Cyclacantharia* Cooper and Grant, 1969

Type species.—*Cyclacantharia kingorum* Cooper and Grant, 1969.

Cyclacantharia sp.

Figs. 5.7, 5.8

Material.—Two specimens from locality SK14: (1) external and internal moulds of a ventral valve, NU-B1870; (2) internal mould of a ventral valve, NU-B1871.

Remarks.—These specimens are safely assigned to the genus *Cyclacantharia* by their highly cone-shaped ventral valve (height about 40 mm in the larger specimen, NU-B1870), without a median septum and with numerous strong spine bases all around the inside of the cup aperture. The Kitakami species resembles the type species, *Cyclacantharia kingorum* Cooper and Grant (1969, p. 7, pl. 5, figs. 13–16) from the Word Formation of western Texas, in size and shape of the ventral valve. However, accurate comparison is difficult because of ill preservation of the present material.

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