Middle Permian brachiopods from Yamasuge in the Kuzu area, Ashio Mountains, central Japan

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Abstract

A Middle Permian brachiopod fauna consisting of seven species in six genera is described from the lower part of the Nabeyama Formation (*Parafusulina yabei* Zone, Murgabian or Wordian) of Yamasuge in the Kuzu area, Ashio Mountains, central Japan. New species described are *Tropidelasma yamasugensis* and *Cleiothyridina hayasakai*. The Yamasuge fauna is a correlative of the Nabeyama fauna from the Middle Permian of Nabeyama in the Kuzu area. There is a strong affinity between the Yamasuge fauna and the Middle Permian North American (West Texas) fauna.

Key words: Ashio Mountains, brachiopod, Nabeyama Formation, Middle Permian, Panthalassa, Yamasuge.

Introduction

Recently, the second author of the present paper (YO) sent a collection of brachiopods to the first author (JT) for analysis. The material was collected by the third author (HK) from a limestone quarry at Yamasuge in the Kuzu area of the Ashio Mountains, central Japan (Figs. 1, 2). The fossil-bearing black to grey limestones are assigned to the lower part of the Nabeyama Formation (*Parafusulina yabei* Zone of Kobayashi, 2006), which can be correlated with the Murgabian in the standard Permian time-scale in the Tethyan-Panthalassan region (Ueno, 1996; Leven, 2001, 2004) or with the lower Wordian in the united Permian time-scale (Jin et al., 1997).

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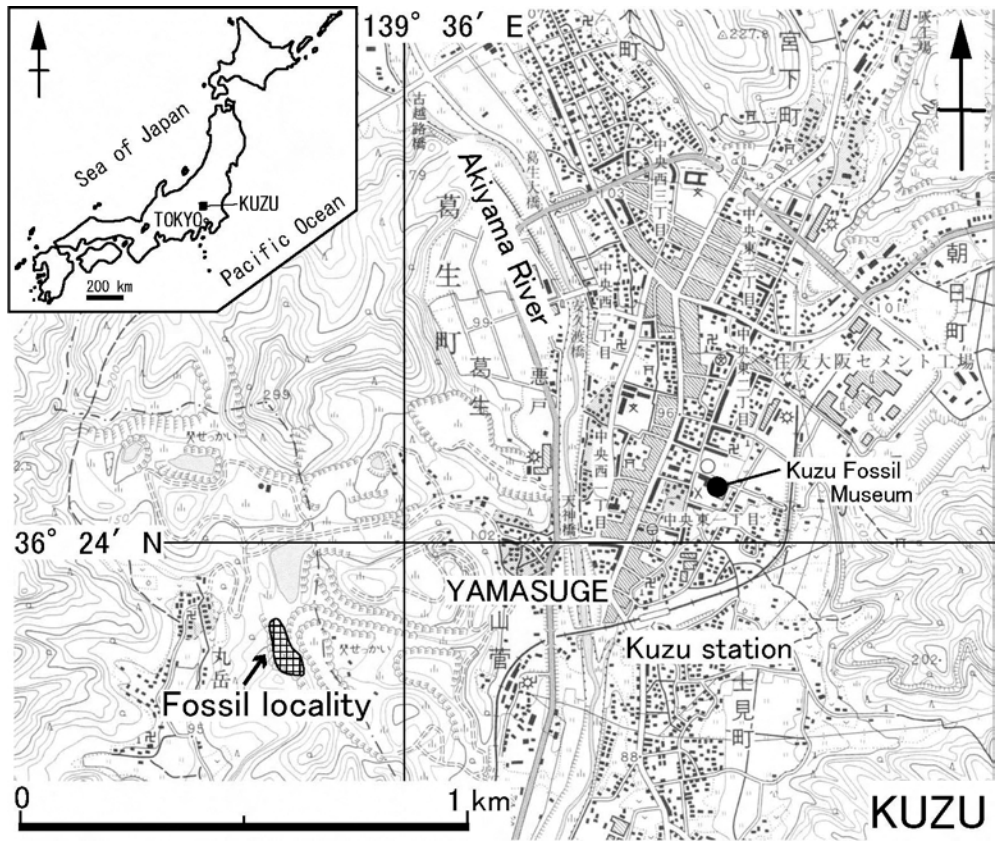


Fig. 1. Index map showing the fossil locality of Yamasuge in the Kuzu area, central Japan. Using the topographical map of "Tanuma" scale 1:25,000 published by the Geographical Survey Institute of Japan.

In the Kuzu area, Permian brachiopods were first reported by Hayasaka (1926) from the Nabeyama Formation of Nabeyama. Subsequently, collections have been systematically described by Hayasaka (1932, 1933) and Minato (1949) for the Nabeyama fauna, and by Hayasaka (1967) for the Yamasuge fauna. The following six species have been described from Yamasuge: *Cleiothydina* aff. *pectinifera* (Sowerby), *Camarophoria nucula* Schellwien, *Parenteletes* sp.? nov., *Productus* (*Echinoconchus*) *defensus* (Thomas), *Reticularia lineata* Martin, and ?*Schizophoria* sp. However, it is now timely to redescribe the species under a new taxonomy and to report new material from the Kuzu area.

In this paper, we describe the new material from Yamasuge and discuss the age of the fauna and its correlations. All the specimens described below are registered with the prefix KFM and housed in the Kuzu Fossil Museum in Kuzu, Sano City, Tochigi Prefecture, central Japan.

Yamasuge fauna

The brachiopods from Yamasuge described in the present report, along with the number of the specimens, are as follows:

Vediproductus sp. 3
Tropidelasma yamasugensis Tazawa, sp. nov. 1
Enteletes acutiplicatus Hayasaka, 1932 2
Orthotichia japonica Hayasaka, 1932 5
Cleiothyridina hayasakai Tazawa, sp. nov. 26
Cleiothyridina sp. 1
Arionthia cf. *lamaria* Cooper and Grant, 1976 1

Among these species, *Tropidelasma yamasugensis*, *Cleiothyridina hayasakai* and *Arionthia* cf. *lamaria* are comparable with the North American species described by Cooper and Grant (1974, 1976) from the Middle Permian (Wordian and Capitanian) of West Texas. Genera such as *Vediproductus* and *Enteletes* are Tethyan elements, and *Cleiothyridina* is a cosmopolitan genus. It is noteworthy that this fauna lacks Boreal elements. The faunal character of the Yamasuge fauna is indicative of an equatorial region of the Panthalassa proximal to West Texas, i.e., part of the continental shelf along the western margin of North America in the Middle Permian. This conclusion is consistent with the findings of Tazawa and Shen (1997), Tazawa et al. (1998) and Tazawa (2007), who proposed that the brachiopod fauna of the Mino Belt (s.l.), including the Ashio Belt, represents a mixture of the North American (West Texas) and the Tethyan faunas.

Systematic descriptions

(by JT)

Order Productida Sarytcheva and Sokolskaya, 1959
Suborder Productida Waagen, 1883
Superfamily Echinoconchoidea Stehli, 1954
Family Echinoconchidae Stehli, 1954
Subfamily Juresaniinae Muir-Wood and Cooper, 1960
Tribe Juresaniini Muir-Wood and Cooper, 1960
Genus *Vediproductus* Sarytcheva in Sarytcheva and Sokolskaya, 1965

Type species.—*Vediproductus vediensis* Sarytcheva in Sarytcheva and Sokolskaya, 1965.

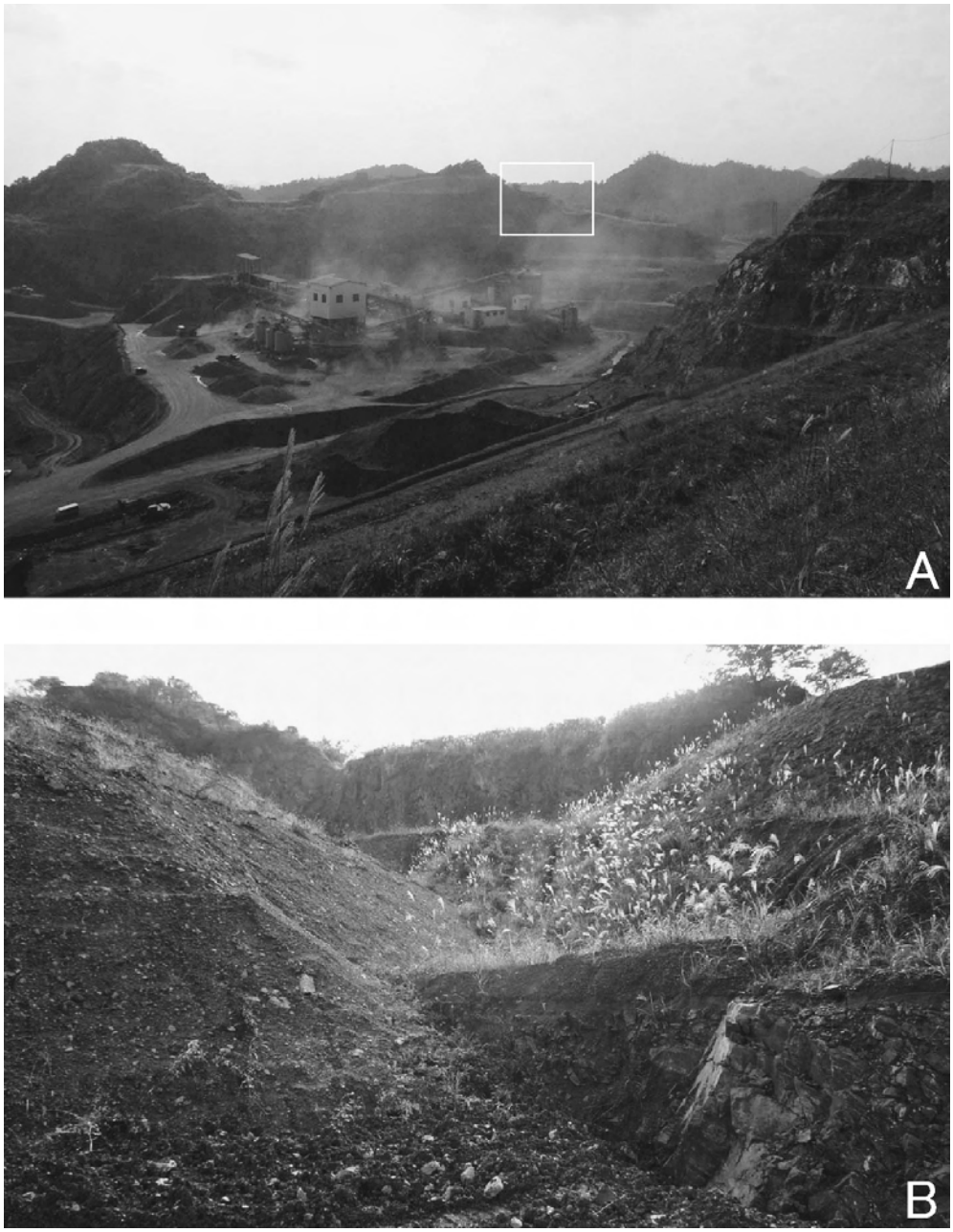


Fig. 2. A distant view (A) and close view (B) of the fossil locality of Yamasuge in the Kuzu area.

Vediproductus sp.
Figs. 3.1

Material.—Three specimens, incomplete three ventral valves, KFM1166, 1173A, 1191.

Description.—Shell large for genus, slightly wider subrectangular in outline, with greatest width slightly anterior to midvalve; length about 54 mm, width about 58 mm in the largest specimen (KFM1166). Ventral valve strongly convex in lateral profile; umbo narrow, strongly incurved; sulcus broad and shallow, but distinct. External surface of ventral valve ornamented with strong concentric bands, bearing numerous spine bases; bands numbering twenty or more in the largest specimen.

Remarks.—These specimens are safely assigned to the genus *Vediproductus* by their strongly convex ventral valve, ornamented by strong concentric bands with numerous spine bases. Within the group, the Yamasuge species is closely allied to *Vediproductus tongluensis* Liang (1990, p. 187, pl. 29, figs. 1-10) from the Lengwu Formation (Capitanian) of Zhejiang Province, South China in size, but it differs from the Chinese species in its wider outline.

The type species, *Vediproductus vediensis* Sarytcheva in Sarytcheva and Sokolskaya (1965, p. 221, pl. 35, figs. 1-3; text-fig. 33) from the Gnishik Horizon (Roadian) of Transcaucasus, differs from the Yamasuge species in its much smaller size.

Order Orthotetida Waagen, 1884
Suborder Orthotetidina Waagen, 1884
Superfamily Orthotetoidea Waagen, 1884
Family Schuchertellidae Williams, 1953
Subfamily Streptorhynchinae Stehli, 1954
Genus *Tropidelasma* Cooper and Grant, 1969

Type species.—*Tropidelasma culmenatum* Cooper and Grant, 1969.

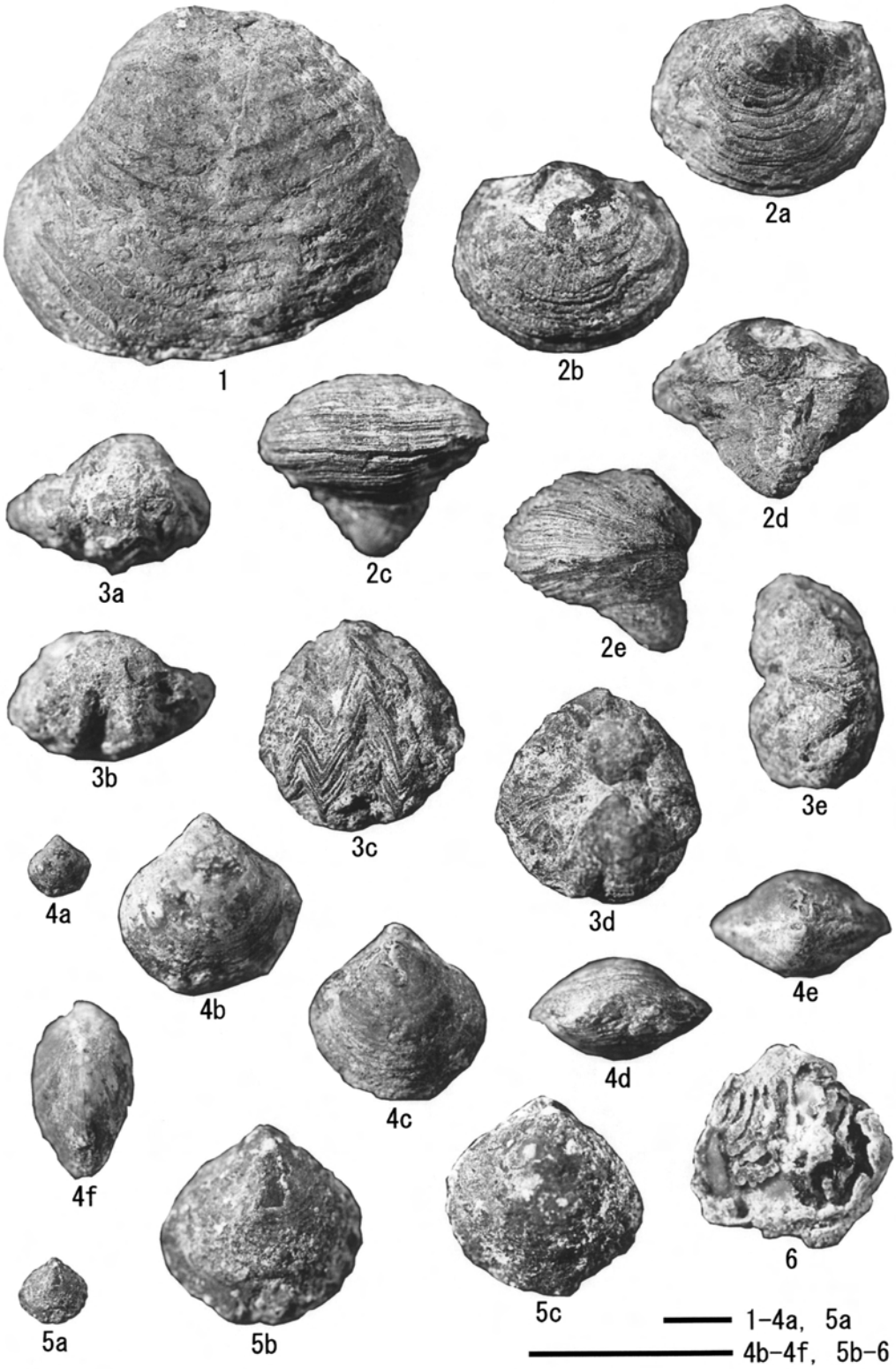
Tropidelasma yamasugensis sp. nov.
Figs. 3.2a-3.2e

Etymology.—Named after the fossil locality, Yamasuge in the Kuzu area.

Material.—One specimen, a conjoined valve, KFM1174B (holotype).

Diagnosis.—Large, moderately elongated *Tropidelasma*, with rectimarginate anterior commissure, and external ornament consisting of numerous fine capillae and irregular concentric lamellae.

Description.—Shell large for genus, conical in outline; hinge narrower than maximum width, latter occurring about midvalve; anterior commissure rectimarginate; length 29 mm, width 35 mm, thickness 30 mm in the sole specimen (KFM1174B). Ventral valve elongate,


1
2a
2b
2c
2d
2e
3a
3b
3c
3d
3e
4a
4b
4c
4d
4e
4f
5a
5b
5c
6
1–4a, 5a
4b–4f, 5b–6

strongly convex, and flared toward margin; umbonal region narrowly swollen, twisted and bent; interarea flat, forming elongated triangle, transversely scored by straight growth lines, and bisected by convex, large pseudodeltidium. Dorsal valve moderately convex, subelliptical in outline; umbo small; lateral slopes somewhat flattened, but anterior slope steep. External surface of both valves ornamented with numerous fine capillae and irregular concentric lamellae; 15-16 capillae in 5 mm, and 8-9 lamellae in 10 mm at about mid of ventral valve.

Remarks.—*Tropidelasma yamasugensis* sp. nov. resembles *Tropidelasma anthicum* Cooper and Grant (1974, p. 335, pl. 59, figs. 1-36; pl. 60, figs. 1-39) from the Word Formation of West Texas in its size, shape and external ornament of both ventral and dorsal valves. But the Texan species differs from the Yamasuge species in having more narrowly conical ventral valve.

The type species, *Tropidelasma culmenatum* Cooper and Grant (1969, p. 3, pl. 1, figs. 27-29; Cooper and Grant, 1974, p. 338, pl. 51, figs. 1-36; pl. 52, figs. 1-32; pl. 53, figs. 12-27; pl. 58, figs. 37-43) from the Neal Ranch Formation (Wolfcampian) of West Texas is easily distinguished from *Tropidelasma yamasugensis* in having narrower, much elongated ventral valve.

Order Orthida Schuchert and Cooper, 1932
Suborder Dalmanellidina Moore, 1952
Superfamily Enteletoidea Waagen, 1884
Family Enteletidae Waagen, 1884
Genus *Enteletes* Fischer de Waldheim, 1825

Type species.—*Enteletes glabra* Fischer de Waldheim, 1830.

Enteletes acutiplicatus Hayasaka, 1932
Figs. 3.3a-3.3e

Enteletes acutiplicatus Hayasaka, 1932, p. 551, pl. 5, figs. 2a, 2b; Hayasaka, 1933, p. 23, pl. 8, figs. 1a-1c.

Material.—Two specimens: (1) a conjoined valve, KFM1174A; (2) a ventral valve, KFM1183.

Remarks.—These specimens are referred to *Enteletes acutiplicatus* Hayasaka, 1932, from

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⬅ **Fig. 3.** 1: *Vediproductus* sp., ventral view of ventral valve, KFM1166. 2: *Tropidelasma yamasugensis* Tazawa, sp. nov., 2a, 2b, 2c, 2d, 2e: ventral, dorsal, anterior, posterior, and lateral views of conjoined valve, KFM1174B (holotype). 3: *Enteletes acutiplicatus* Hayasaka, 3a, 3b, 3c, 3d, 3e: ventral, dorsal, anterior, posterior, and lateral views of conjoined valve, KFM1174A. 4-6: *Cleiothyridina hayasakai* Tazawa, sp. nov., 4a, 4b, 4c, 4d, 4e, 4f: ventral, ventral, dorsal, anterior, posterior, and lateral views of conjoined valve, KFM1169A (holotype), 5a, 5b, 5c: ventral, ventral, and dorsal views of conjoined valve, KFM1174F, 6: dorsal view of abraded conjoined valve, showing spiralia, KFM1169E. Scale bars represent 1 cm.

the Middle Permian Nabeyama Formation of Nabeyama in the Kuzu area, Tochigi Prefecture, central Japan, on the basis of their large size (length 21 mm, width 31 mm, thickness 32 mm in the conjoined valve specimen, KFM1174A), few (6 in ventral valve, 5 in dorsal valve), strong costae with acute crests, and zig-zag growth lamellae developed near antero-lateral margins. *E acutiplicatus* has a pair of long, nearly parallel thin dental plates in the ventral valve (see, Hayasaka, 1933, p. 23, pl. 8, fig. 1a), which is the characteristic internal feature of the genus *Enteletes*.

Enteletes angulatus Girty (1908), originally described by Girty (1908, p. 295, pl. 26, figs. 3, 3a) from the Hueco Formation of the Diablo Mountains, West Texas, is similar in external ornament, but the Texan species is smaller than the present species.

Distribution.—Middle Permian (Roadian-Wordian) of Nabeyama and Yamasuga in the Kuzu area, Ashio Mountains, central Japan.

Family Schizophoriidae Schuchert and LeVene, 1929

Genus *Orthotichia* Hall and Clarke, 1892

Type species.—*Orthis*? *morganiana* Derby, 1874.

Orthotichia japonica Hayasaka, 1932

Figs. 4.2a, 4.2b, 5.1a, 5.1b

Orthotichia japonica Hayasaka, 1932, p. 551, pl. 5, fig. 3; Hayasaka, 1933, p. 20, pl. 3, figs. 1a, 1b; pl. 4, figs. 1a-2c; pl. 5, figs. a-d; pl. 6, fig. 1; text-fig. 3; Hayasaka and Hayasaka, 1953, pl. 5, fig. 2.

Material.—Five specimens, (1) three conjoined valves, KFM1165A, 1165B, 1173B; (2) a ventral valve, KFM1179; (3) a dorsal valve, KFM1170.

Remarks.—These specimens can be identified with *Orthotichia japonica* Hayasaka, 1932, from the Nabeyama Formation of Nabeyama in the Kuzu area, by their enormously large size (length 89 mm, width 98 mm in the largest specimen, KFM1165A), moderately to slightly inflated dorsibiconvex shell, and external ornament of both ventral and dorsal valves consisting of numerous capillae and irregular, fine concentric rugae.

Orthotichia jiangxiensis Hu and Jin in Hu (1983, p. 342, pl. 2, figs. 1a-1e), from the Hsiaochiangpien Limestone (upper Chihsian-lower Maokouan) of Jiangxi, South China, somewhat resembles *O. japonica* in having relatively large, moderately convex dorsal valve, but the former is much smaller than the latter.

Distribution.—Middle Permian (Roadian-Wordian) of Nabeyama and Yamasuga in the Kuzu area, Ashio Mountains, central Japan.

Order Athyridida Boucot, Johnson and Staton, 1964
Suborder Athyrididina Boucot, Johnson and Staton, 1964
Superfamily Athyridoidea Davidson, 1881
Family Athyrididae Davidson, 1881
Subfamily Cleiothyridininae Alvarez, Rong and Boucot, 1998
Genus *Cleiothyridina* Buckman, 1906

Type species.—*Atrypa pectinifera* Sowerby, 1840.

Cleiothyridina hayasakai sp. nov.
Figs. 3.4-3.6

Cleiothyridina aff. *pectinifera* (Sowerby): Hayasaka, 1967, p. 46, figs. 1a, 1b.

Etymology.—Named for Prof. Ichiro Hayasaka.

Material.—Twenty-six specimens: (1) twenty-five conjoined valves, KFM1169A (holotype), 1169B, 1169C, 1169D, 1174C, 1174D, 1174E, 1174F, 1174G, 1174H, 1174I; (2) an abraded conjoined valve, KFM1169E.

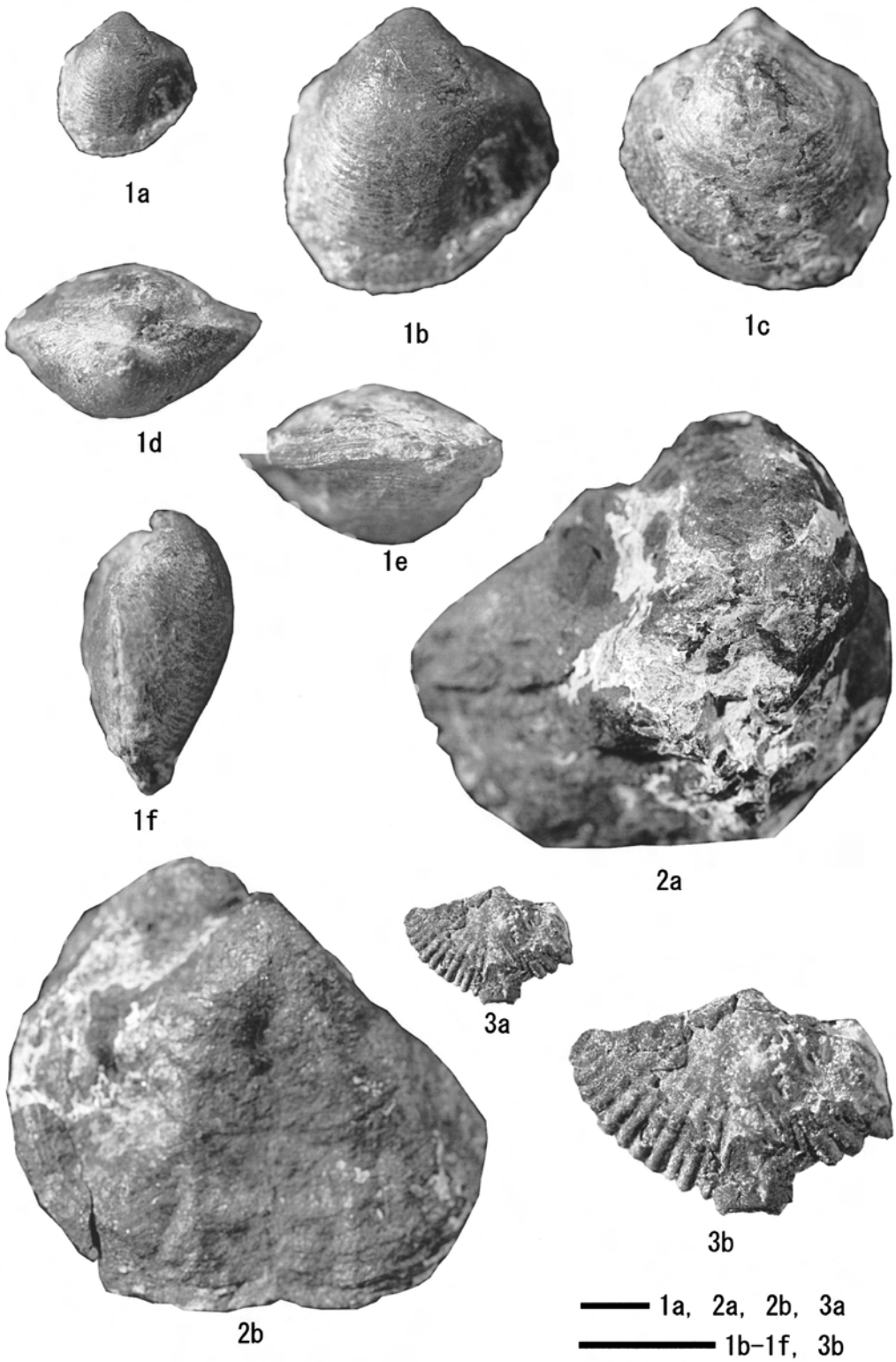
Diagnosis.—Small, equidimentional *Cleiothyridina*, having moderately biconvex shell with weakly uniplicate commissure.

Description.—Shell small for genus, subpentagonal in outline; hinge much shorter than greatest width at midvalve; commissure weakly uniplicate; length 9 mm, width 9 mm in the holotype (KFM1169A); length 10 mm, width 10 mm in the largest specimen (KFM1174F). Ventral valve moderately convex in lateral profile; umbo small, slightly attenuate; foramen subcircular; sulcus shallow and broad on a quarter anterior of the valve. Dorsal valve similarly convex to the opposite valve in lateral profile; umbo obtuse, projecting into umbonal region of ventral valve; fold low and broad near anterior margin of the valve. External surface of both valves ornamented with concentric growth lamellae with numerous fine flattened spines. Interior of dorsal valve with a pair of large spiralia.

Remarks.—This species was first described by Hayasaka (1967) as *Cleiothyridina* aff. *pectinifera* (Sowerby, 1840), collected from the same locality of Yamasuge. However, *Cleiothyridina pectinifera* differs from theYamasuge species in its more transverse outline and the rectimarginate commissure (see Brunton, 1980, figs. 13a-14b). The Yamasuge species is named here as *Cleiothyridina hayasakai* sp. nov., and redescribed based on the new material collected by Kojima.

Cleiothyridina pilularis Cooper and Grant (1976, p. 2137, pl. 650, figs. 50-83), from the Bell Canyon and Capitan Formations (Capitanian) of West Texas, is close to *Cleiothyridina hayasakai*, but it differs from the latter by its stronger uniplicate shell.

Cleiothyridina capillata (Waagen, 1883, p. 479, pl. 39, figs. 6-9; pl. 40, figs. 1-5; pl. 42,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3b
1a, 2a, 2b, 3a
1b–1f, 3b

figs. 1-5), from the Wargal and Chhidru Formations of the Salt Range, is also having weakly uniplicate commissure, but the Pakistani species differs from the Yamasuge species by its larger dimensions.

Cleiothyridina sp.
Figs. 4.1a-4.1f

Material.—One specimen, a conjoined valve, KFM1174J.

Remarks.—This specimen is safely assigned to the genus *Cleiothyridina* by its medium size (length 21 mm, width 20 mm), subcircular outline, moderately biconvex shell, ornamented with closely spaced concentric lamellae, splitting into numerous, extremely fine, flat spines (numbering 8-9 in 1 mm at about mid of the ventral valve). The Yamasuge specimen somewhat resembles *Cleiothyridina barbata* Chronic, 1949, from the Middle Pennsylvanian of Tarma, central Peru, in size and shape of the shell, but it differs from the Peruvian species in having finer spines on both ventral and dorsal valves. The above-described species, *Cleiothyridina hayasakai* sp. nov., is clearly distinguished from the present species by its much smaller size.

Order Spiriferida Waagen, 1883
Suborder Spiriferinidina Ivanova, 1972
Superfamily Pennospiriferinoidea Dagys, 1972
Family Pennospiriferinidae Dagys, 1972
Subfamily Punctospiriferellinae Dagys, 1974
Genus *Arionthia* Cooper and Grant, 1976

Type species.—*Arionthia blothrhachis* Cooper and Grant, 1976.

Arionthia cf. *lamaria* Cooper and Grant, 1976
Figs. 4.3a, 4.3b

Cf. *Arionthia lamaria* Cooper and Grant, 1976, p. 2754, pl. 729, figs. 16-40; pl. 730, figs. 27-53.

Material.—One specimen, an incomplete dorsal valve, KFM1176.

Description.—Shell medium size for genus, transversely trapezoidal in outline, with greatest

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⬅ **Fig. 4.** 1: *Cleiothyridina* sp., 1a, 1b, 1c, 1d, 1e, 1f: ventral, ventral, dorsal, anterior, posterior, and lateral views of conjoined valve, KFM1174. 2: *Orthotichia japonica* Hayasaka, 2a, 2b: ventral and dorsal views of conjoined valve, KFM1165B. 3: *Arionthia* cf. *lamaria* Cooper and Grant, 3a, 3b: dorsal view of dorsal valve, KFM1176. Scale bars represent 1 cm.

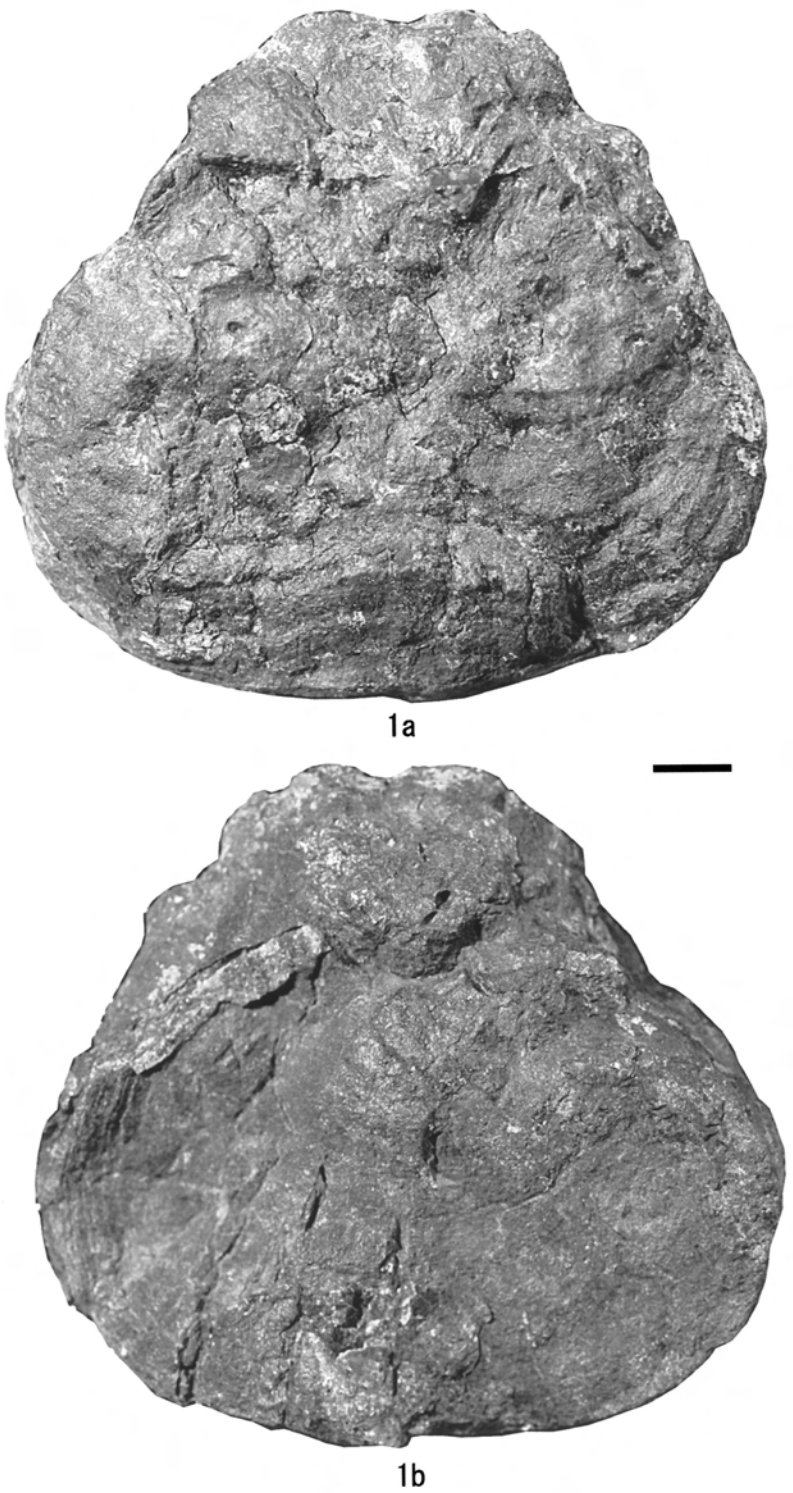

Fig. 5. 1: *Orthotichia japonica* Hayasaka, 1a, 1b: ventral and dorsal views of conjoined valve, KFM1165A. Scale bar represents 1 cm.

width slightly anterior to hinge; length 17 mm, width about 25 mm in the sole dorsal valve specimen (KFM1176). Dorsal valve flatly convex; umbo small, blunt; fold low, broad, and triplicate near the anterior margin; costae strong, rounded, most simple but one costae at the most inner side being bifurcate, numbering 10 on each side of lateral slopes. External surface of dorsal valve covered with no lamellae, pustules or spine bases.

Remarks.—The single dorsal valve specimen from Yamasuge is safely assigned to the genus *Arionthia* by having triplicated fold, simple or bifurcated costae, and the external surface without lamellae, pustules or spine bases.

This specimen resembles well *Arionthia lamaria* Cooper and Grant, 1976, from the Carlsbad (?), Capitan and Bell Canyon Formations (upper Guadalupian) of West Texas, in size, shape and external ornament of the dorsal valve, particularly the non-alate valve with broad, triplicate fold. But the poor preservation of the present material makes accurate comparison difficult.

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