Scacchinella (Productida, Brachiopoda) from the Lower Permian of Akasaka, Mino Belt, central Japan, with a review of its world distribution

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Abstract

Scacchinella gigantea Schellwien, 1900 is described from the lower part (*Parafusulina* Zone, Kungurian) of the Akasaka Limestone in the Akasaka area, Mino Belt, central Japan. A review of all occurrences of *Scacchinella* indicates that this genus ranges from Late Carboniferous (Gzhelian) to Late Permian (Changhsingian). Palaeobiogeographically, the distribution of *Scacchinella* is restricted to the Palaeoequatorial region and bi-temperate transitional zones, but it has never been recorded from the Boreal and Gondwanan regions.

Key words: Akasaka Limestone, brachiopod, Lower Permian, Mino Belt, palaeobiogeography, *Scacchinella*.

Introduction

Permian reef-type limestone of Akasaka occurs as one of the allochthonous blocks in the Jurassic melange of the Mino Belt, central Japan. These limestone blocks were considered to be derived from the Permian mid-oceanic (Panthalassan) carbonate buildups on seamount on the basis of palaeomagnetic (Hattori and Hirooka, 1979), sedimentological (Sano, 1988; Sano and Kanmera, 1996), lithological (Jones et al., 1993) and palaeontological studies (Ozawa,

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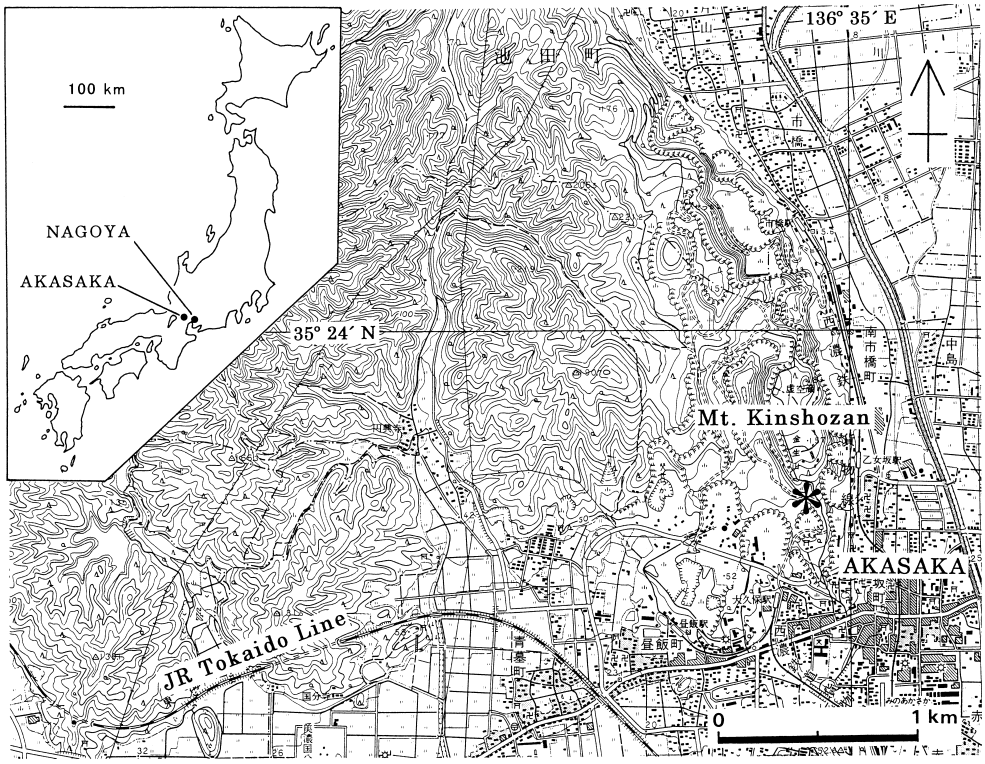

Fig. 1. Map showing the fossil locality (asterisk). Using the topographical map of "Ogaki" scale 1:25,000 published by the Geographical Survey Institute of Japan.

1987; Tazawa, 1998). Brachiopod is one of the major fossil groups in the limestone blocks. However, the taxonomic studies on the Permian brachiopod faunas are poor. In the Akasaka Limestone, only the following 6 species in 6 genera hitherto have been described by Hayasaka (1932), Ando (1986, 1990a, b), Tazawa et al. (1998), Shen et al. (1999) and Okumura and Tomida (2000): *Scacchinella* sp., *Geyerella* sp., *Leptodus nobilis* (Waagen), *Coscinophora magnifica* Cooper and Grant, *Enteletes suessi* Schellwien and *Peltichia akasakensis* (Ozawa). A similar brachiopod fauna, consisting of 13 species in 12 genera, was previously described by Tazawa and Shen (1997) from another Permian limestone block of Hiyomo in the Mino Belt, central Japan. The Hiyomo fauna is characterized by a distinctive Tethyan-North American mixed character, which has been considered to be in the mid-equatorial region of the Panthalassa and palaeobiogeographically assigned to the Tropical Panthalassan Zone by Tazawa (1998).

In this paper we describe two specimens of *Scacchinella,* collected by the third author (TO) from the lower part (Kasumi Zone of Wakimizu, 1902; *Parafusulina* Zone of Ishii et al.,

1981; *Parafusulina granum-avenae* Zone of Zaw, 1999) of the Akasaka Limestone at Kinshozan in the Akasaka area (Fig. 1). In addition, the stratigraphical and geographical distributions of the genus *Scacchinella* are summarized. The specimens described are registered and housed in the Department of Geology, Faculty of Science, Niigata University, Japan.

Distribution of *Scacchinella*

Scacchinella is an aberrant, specialized Aulostegoidea with highly conical ventral valve cemented by apex and anchored by rhizoid spines. It is colonial in habit and forms bioherms and patches of moderate size (Cooper and Grant, 1975). The stratigraphical and geographical distributions of this genus are summarized as follows and shown in Fig. 2 and Table 1.

The earliest occurrence of *Scacchinella* is from the Upper Carboniferous (Gzhelian) *Uddenites*-bearing Shale Member of the Gaptank Formation in West Texas, USA (Cooper and Grant, 1975). It becomes common in the Lower and Middle Permian and has been recorded from the Sakmarian to Artinskian Trogkofel Limestone of Yugoslavia and the Wordian Sosio Limestone, Sicily (Gemmellaro, 1891, 1892, 1897; Schellwien, 1900; Greco, 1947), the Lower Permian of the northern Caucasus and Fergana (Licharew, 1928; Volgin, 1986), the Lower Permian (?) of the Urals (Muir-Wood and Cooper, 1960), the Lower Permian Wolfcamp, Leonard and Bone Spring Formations in West Texas (King, 1931; Stehli, 1954; Cooper and Grant, 1975), the lower part of the Akasaka Limestone (Kungurian), Mino Belt, central Japan (Ando, 1986, 1990a, b; Okumura and Tomida, 2000; this paper), the upper part of the Kanokura Formation (Capitanian) of the southern Kitakami Mountains, northeast Japan (Minato et al., 1979; Tazawa and Araki, 1999), and the Middle to Upper Permian Productus Limestone (not sub-divided into Lower-, Middle- and Upper-) of the Salt Range, Pakistan (Reed, 1931). The latest record of *Scacchinella* is from the Changhsingian Takhatbulak Formation in the southeastern Pamir (Grunt and Dmitriev, 1973; Kotlyar et al., 2004). The specimen figured as *Scacchinella* (?) sp. by Diener (1903, pl. 3, figs. 10a, b) from the Permian exotic block of central Himalayas is very likely an orthotetid rather than a *Scacchinella* in view of its surface ornament and having a convex pseudodeltidium. To sum up, *Scacchinella* ranges from the latest Carboniferous (Gzhelian) to the latest Permian (Changhsingian).

Geographically, *Scacchinella* first occurred in the western margin of North America during the latest Carboniferous. It has been found in the Palaeotethys, the southern part of the Ural seaway and the mid-equatorial Panthalassa in Early Permian, and the western Palaeotethys, southern Kitakami, northern peri-Gondwanan margin and the western margin of North America in the Middle Permian. It was only found from the western Palaeotethys in the Late Permian. Therefore, *Scacchinella* is generally restricted to the Palaeoequatorial region and bi-temperate transitional zones, but it has never been found from the high-latitude Boreal and Gondwanan regions.

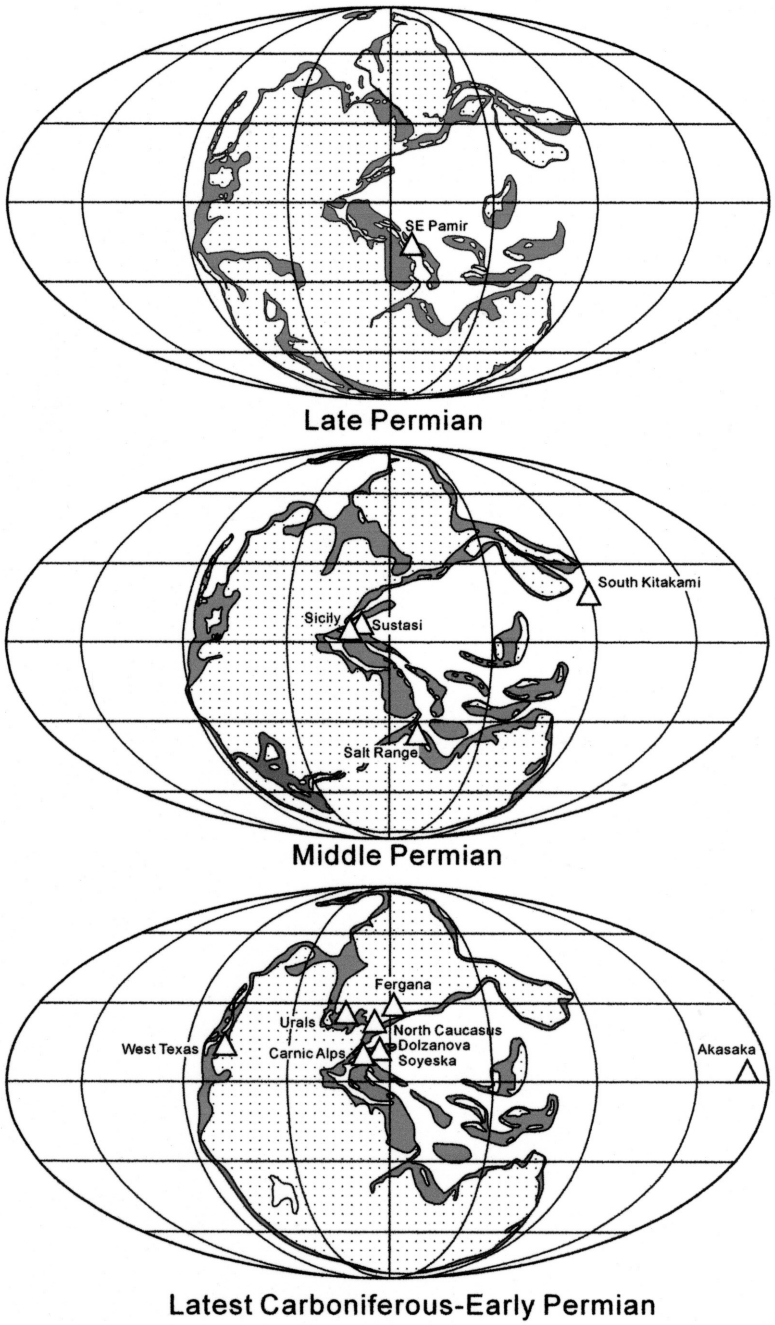

Fig. 2. Palaeogeographical distributions of *Scacchinella* (white triangle) during the latest Carboniferous to the Late Permian time. Base maps after Ziegler et al. (1997).

Table 1. Stratigraphical and geographical distributions of *Scacchinella* species.

Species used in this paper	Locality	Formation	Age	References
Scacchinella depressa Gemmellaro, 1897	Sicily, Italy	Sosio Lst.	Wordian	Gemmellaro, 1897
Scacchinella variabilis Gemmellaro, 1897	Sicily, Italy	Sosio Lst.	Wordian	Gemmellaro, 1891, 1892, 1897; Greco, 1947
Scacchinella sp.	Akasaka, Japan	Akasaka Lst.	Kungurian	Hayasaka, 1925; Ando, 1986, 1990a, b; Okumura & Tomida, 2000
Scacchinella gigantea Schellwien, 1900	Fergana, Uzbekstan	unknown	Lower Permian	Licharew, 1928; Volgin, 1986
Scacchinella gigantea Schellwien, 1900	Dolzanova Soteska, Slovenia; Carnic Alps, Austria	Trogkofel Lst.	Sakamrian-Artinskian	Schellwien, 1900; Heritsch, 1938; Ramovs, 1963, 1965, 1968
Scacchinella gigantea Schellwien, 1900	Southern Kitakami, Japan	Upper Kanokura Fm.	Capitanian	Tazawa & Araki, 1999
Scacchinella gigantea Schellwien, 1900	Sustasi, Montenegro	Sosio Lst.	Wordian	Kostic-Podgorska, 1958; Pesic et al., 1989
Scacchinella gigantea Schellwien, 1900	Akasaka, Japan	Akasaka Lst.	Kungurian	Ando, 1995
Scacchinella cf. *gigantea* Schellwien, 1900	South Kitakami, Japan	Upper Kanokura Fm.	Capitanian	Minato et al., 1979
Scacchinella cf. *gigantea* Schellwien, 1900	Akasaka, Japan	Akasaka Lst.	Roadian or Kungurian	Hayasaka, 1932; Ando, 1986
Scacchinella yakowlewi Licharew, 1928	North Caucasus, Armenia	unknown	Lower Permian	Licharew, 1928
Scacchinella sp.	Salt Range, Pakistan	Productus Lst.	Permian	Reed, 1931
Scacchinella variabilis var. *erecta* Gregorio, 1930	Sicily, Italy	Sosio Lst.	Wordian	Gregorio, 1930
Scacchinella americana Stehli, 1954	West Texas, USA	Bone Spring Fm.	Kungurian	King, 1931; Cooper & Grant, 1975
Scacchinella sp.	Ural Mts.	unknown	?Lower Permian	Muir-Wood & Cooper, 1960
Scacchinella licharewi Grunt in Grunt & Dmitriev, 1973	SE Pamir	Takhtabulak Fm.	Changhsingian	Grunt & Dmitriev, 1973
Scacchinella exasperata Cooper & Grant, 1975	West Texas, USA	Lenox Hills, Hueco Fm.	Sakmarian	Cooper & Grant, 1975
Scacchinella primitiva Cooper & Grant, 1975	West Texas, USA	Gaptank Fm.	Gzhelian	Cooper & Grant, 1975
Scacchinella sp.	West Texas, USA	Cathedral Mountain Fm.	Kungurian	Cooper & Grant, 1975
Scacchinella titan Cooper & Grant, 1975	West Texas, USA	Skinner Ranch, Hess and Cibolo Fm.	Kungurian	Cooper & Grant, 1975
Scacchinella triangulata Cooper & Grant, 1975	West Texas, USA	Gaptank Fm.	Gzhelian	Cooper & Grant, 1975

Systematic descriptions

Order Productida Sarytcheva and Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily Aulostegoidea Muir-Wood and Cooper, 1960

Family Scacchinellidae Licharew, 1928

Subfamily Scacchinellinae Licharew, 1928

Genus *Scacchinella* Gemmellaro, 1891

Type-species.—*Scacchinella variabilis* Gemmellaro, 1897, p.114, designated by Schuchert and LeVene, 1929, p. 110.

Diagnosis.—Shell large; ventral valve conical, cemented by apex and anchored by rhizoid

spines, completely spinose except for interarea; interarea extremely high, occupying nearly entire length and full width of ventral valve, with irregular longitudinal striations, no pseudodeltidium; dorsal valve lidlike. Ventral valve interior with a long median septum, not reaching valve floor except for at apex; vesicular plates present in apical cavity of ventral valve; dorsal valve interior with a strong, bilobed cardinal process.

Discussion.—Muir-Wood and Cooper (1960) and Cooper and Grant (1975) gave a detailed comparison and discussion on *Scacchinella* and its related genera. *Scacchinella* is somewhat similar to richthofeniids in view of its conical form. However, the dorsal valve of richthofeniids is always located well within the conical ventral valve, whereas the dorsal valve of *Scacchinella* forms an external lid to the cone and has a strong, bilobed cardinal process. *Scacchinella* is apparently related to Productidina rather than Orthotetida (Williams, 1953) in terms of the presence of spines on both valves (Muir-Wood and Cooper, 1960, pl. 26, figs. 3-5), although it has high interarea and strong bilobed cardinal process similar to those of Orthotetida. It may be related to *Tschernyschewia* Stoyanov, 1910 in terms of their similar strong median septum in ventral valve, but the latter has a typical concavo-convex productoid lateral profile. *Derbyella* Grabau (1931) from the Permian of Mongolia somewhat resembles *Scacchinella* in terms of its high conical ventral valve and lidlike dorsal valve. However, the figured specimens (Grabau, 1931, pl. 26, figs. 2a, 3a, b) suggest that the median septum in ventral valve meets the valve floor. In addition, the narrow delthyrium shown in figure 2b of plate 26 suggests that it is covered by a faint convex pseudodeltidium (Grabau, 1931, p. 270) which is absent in *Scacchinella*. Therefore, *Derbyella* is most likely unrelated to *Scacchinella*. *Scacchinella* is also similar to the members of Gemmellaroiinae in view of its conical shape, but gemmellaroiids possesses a convex pseudodeltidium forming a steep-sided externally flat-faced ridge and a blade-like cardinal process.

Scacchinella gigantea Schellwien, 1900
Figs. 3, 4

1900 *Scacchinella gigantea* Schellwien, p. 35, pl. 4, figs. 1-3; pl. 5, figs. 1-8; text-figs. 5, 6, 8.
1925 *Scacchinella* sp. Hayasaka, p. 144.
1928 *Scacchinella gigantea* Schellwien: Licharew, p. 267, figs. 9-10.
1932 *Scacchinella* cf. *gigantea* Gemmellaro: Hayasaka, p. 1, text-fig. 1.
1938 *Scacchinella gigantea* Schellwien: Heritsch, p. 101, pl. 5, figs. 1, 2, 9.
1939 *Scacchinella gigantea* Schellwien: Licharew, p. 96, pl. 23; figs. 2a-c.
1965 *Scacchinella gigantea* Schellwien: Ramovs, p. 357, pl. 13. figs. 3-6.
1986 *Scacchinella* sp. Ando, p. 216, figs. 4-10, 13.
1990a *Scacchinella* sp. Ando, p. 8, figs. 1, 2.
1990b *Scacchinella* sp. Ando, p. 15, figs. 2-6.
1995 *Scacchinella gigantea* Schellwien: Ando, p. 55, 2 figs.

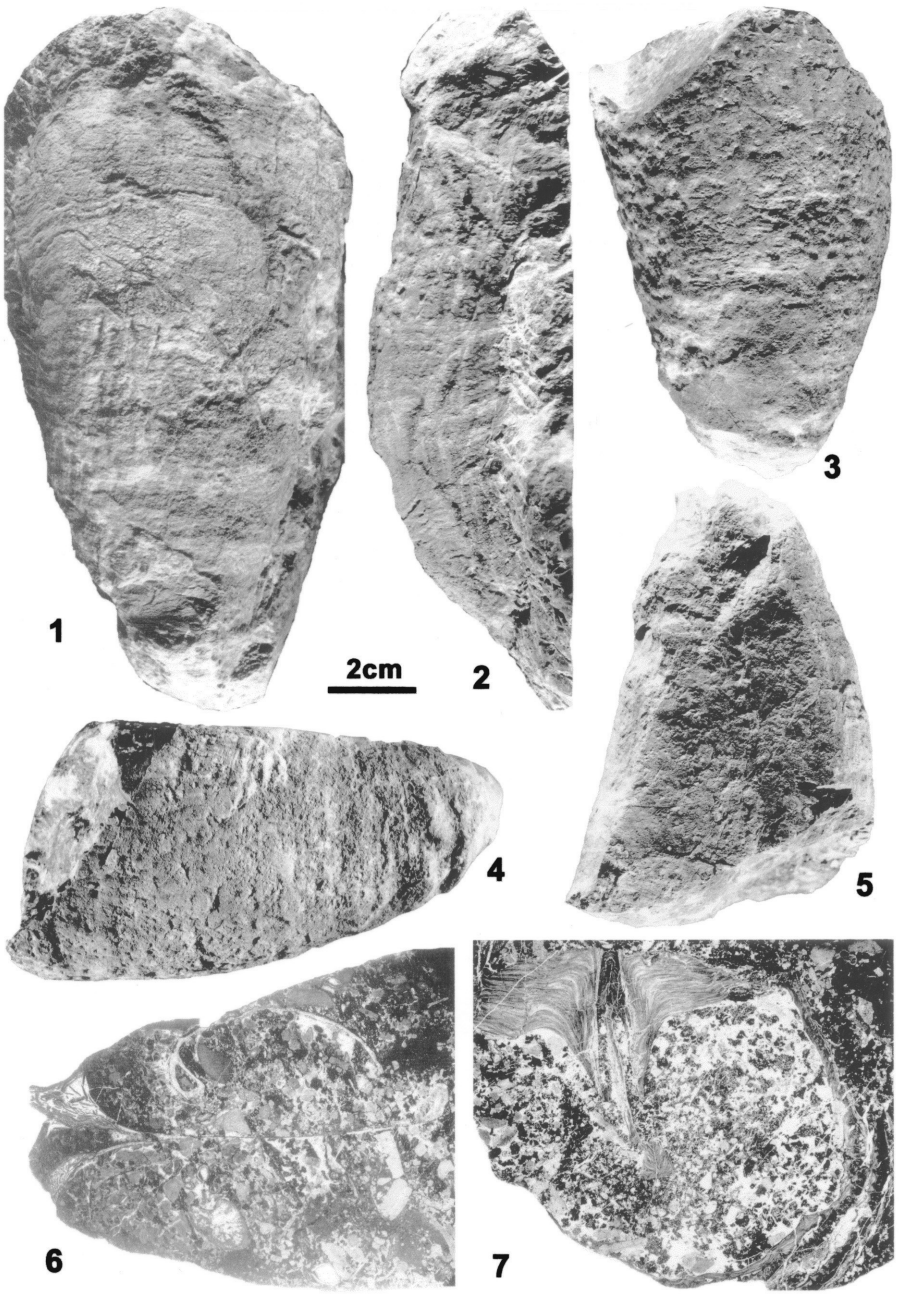

Fig. 3. *Scacchinella gigantea* Schellwien from the lower part (*Parafusulina* Zone) of the Akasaka Limestone at Kinshozan, Akasaka. 1, 2, 7, anterior and lateral views of a conjoined shell, and a cross section at 135.7 mm from the top of the ventral valve showing the shell structure and median septum, NU-B700. 3-6, anterior, lateral and posterior views of an incomplete shell, and a longitudinal section of the same specimen showing the median septum and vesicular plates, NU-B701.

1999 *Scacchinella gigantea* Schellwien: Tazawa and Araki, p. 453, fig. 2.
2000 *Scacchinella* sp. Okumura and Tomida, p. 196, fig. 2.

Material.—A conjoined shell (NU-B700) and an incomplete ventral valve (NU-B701), from the lower part (*Parafusulina* Zone) of the Akasaka Limestone in Mt. Kinshozan in the Akasaka area, Mino Belt, central Japan.

Description.—Shell large, 59 mm long, 73 mm wide and 153 mm thick, widest at hinge; hinge straight. Ventral valve highly conical; interarea extremely high, flat, with irregular longitudinal striations, no pseudodeltidium; beak ridges obtusely angular, clearly demarked from flanks; anterior side moderately convex. Dorsal valve slightly convex; interarea absent. Ventral valve interior with strong teeth; median septum (Figs. 4.1, 4.2) long, extending from interarea to valve floor in most stages, becoming free to floor in later stages; fitting between two prongs of dorsal cardinal process, thin in the middle, thickened near the valve floor and interarea; vesicular plates (Figs. 3.6, 4.3) developed inside cone of ventral valve; occupying about one-fifth of ventral height. Dorsal valve lidlike; with a strong bilobed cardinal process (Figs. 4.1, 4.2); forming two widely separated prongs extending ventrally; other characters not observed. Shell pseudopunctate (Figs. 4.4-4.6).

Comparison.—These specimens are characterized by their large size and highly conical outline. The Akasaka specimens are slightly larger than, but generally comparable with shells of *Scacchinella gigantea* Schellwien, described by Schellwien (1900, p. 35, pl. 4, figs. 1-3; pl. 5, figs. 1-8) from the Lower Permian (Sakmarian to Artinskian) Trogkofel Limestone in the Carnic Alps in view of their size and outline of the ventral cone. *Scacchinella titan* Cooper and Grant (1975, p. 923, pl. 270, figs. 12-16; pl. 272, figs. 1-6; pl. 273, figs. 1-25; pl. 274, figs. 1-6; pl. 275, figs. 1-4; pl. 276, figs. 1-3, etc.) from the Lower Permian (Upper Wolfcampian) Skinner Ranch, Hess and Cibolo Formations of West Texas is closest to the present species in view of its size. But it can be readily distinguished by its more slender ventral valve with at least two-thirds to four-fifths filled by vesicular plates. Some specimens described as *Scacchinella gigantea* Schellwien by King (1931, p. 91, pl. 23, figs. 20-25; pl. 24, figs. 1-5; pl. 25, figs. 16-18) from the Lower Permian (Lower Leonardian) Bone Spring Formation in the Glass Mountains, West Texas differs from the Carnic Alps species by its lower ventral valve and smaller size. These specimens were assigned to *Scacchinella americana* by Stehli (1954) and Muir-Wood and Cooper (1960). The specimens described as *Scacchinella gigantea* by Tazawa and Araki (1999, p. 453, figs. 2.1-2.4) from the Middle Permian Kanokura Formation of the southern Kitakami Mountains, northeast Japan have a lower ventral valve, and they are somewhat smaller than the Akasaka specimens. The present species differs from the type species, *Scacchinella variabilis* (Gemmellaro, 1897) from the Wordian Sosio Limestone in Sicily by its larger size and highly conical ventral valve.

Distribution.—Lower Permian (Sakmarian-Artinskian) of the Carnic Alps, Urals and southern Fergana; Lower Permian (Kungurian) of Akasaka, Mino Belt, central Japan; Middle

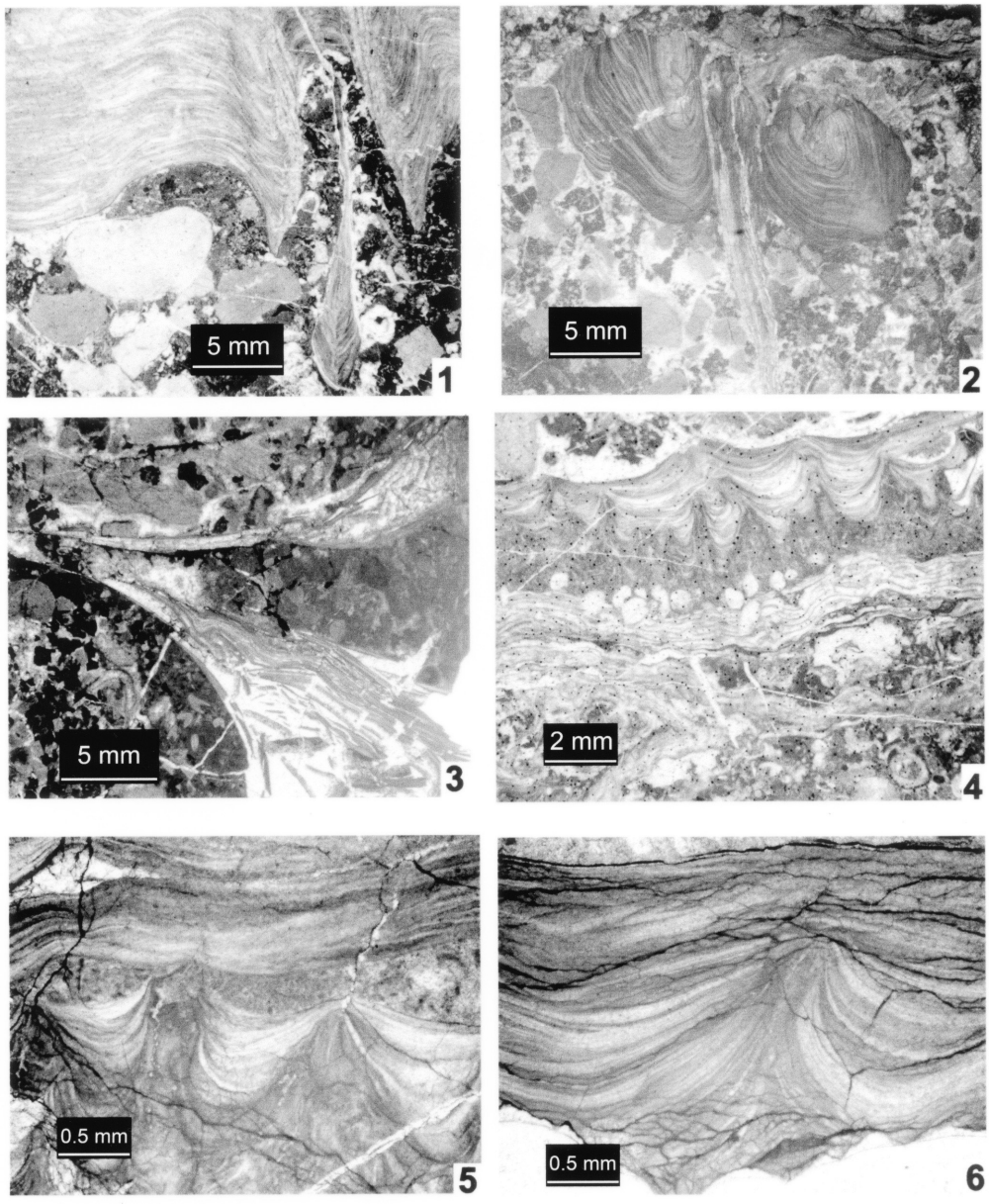

Fig. 4. *Scacchinella gigantea* Schellwien from the lower part (*Parafusulina* Zone) of the Akasaka Limestone at Kinshozan, Akasaka. 1, cross section at 126 mm from the top of the ventral valve showing the median septum between bilobes of the cardinal process, NU-B700. 2, cross section at 121.3 mm from the top of the ventral valve, showing the median septum and the bilobed cardinal process, NU-B700. 3, longitudinal section showing the vesicular plates in the top of the ventral valve, NU-B701. 4, cross section showing the shell structure from outside (bottom of the photo) to inside (top of the photo), NU-B700. 5, 6, showing pseudopunctae in the inner layer of the shell, NU-B700.

Permian (Capitanian) of Omotematsukawa, Kesennuma area, South Kitakami Belt, northeast Japan.

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