Memoir of the Fukui Prefectural Dinosaur Museum 22: 13–141 (2023)

ARTICLE

MIDDLE PERMIAN (GUADALUPIAN) BRACHIOPODS FROM SETAMAI, KAMIYASSE–IMO AND MATSUKAWA IN THE SOUTH KITAKAMI BELT, JAPAN

Jun-ichi TAZAWA[1] and Yousuke IBARAKI[2]

[1]Hamaura-cho 1-260-1, Chuo-ku, Niigata 951-8151, Japan
[2]Fossa Magna Museum, Itoigawa 941-0056, Japan

ABSTRACT

This study describes 83 species of middle Permian (Guadalupian) brachiopods in 64 genera (including three new species, *Paramesolobus kitakamiensis* sp. nov., *Callispirina sheni* sp. nov. and *Whitspakia nipponica* sp. nov.) from the Kanokura, Hosoo and Kamiyasse Formations in the central part (Setamai, Kamiyasse–Imo and Matsukawa areas) of the South Kitakami Belt (southern Kitakami Mountains), northeastern Japan. Most of the brachiopod species, excluding two species *Poikilosakos kamiyassensis* and *Martinia semiplana* from the Hosoo Formation, occur in the Wordian beds of the Kanokura and Kamiyasse Formations. The Wordian brachiopod fauna is characterised by a mixture of Boreal and Tethyan elements, and has a close affinity with those of northern China (Inner Mongolia), eastern Russia (South Primorye) and central Japan (the Hida Gaien Belt). Thus, the South Kitakami region belonged to the Sino-Mongolian–Japanese Province between the Boreal and Tethyan realms in the Northern Hemisphere. This region was probably a shallow sea bordering a microcontinent (the Proto-Japan Block) that was located near and to the east of the North China Block at the eastern end of the Central Asian Orogenic Belt during the Wordian.

Key words: Brachiopoda, Japan, middle Permian, South Kitakami Belt, Wordian

田沢純一・茨木洋介 (2023) 南部北上帯世田米，上八瀬–飯森，松川から産出する中期ペルム紀（グアダループ世）腕足類．福井県立恐竜博物館紀要 22：13–141.

南部北上帯（南部北上山地）中央部の世田米・上八瀬–飯森・松川地域に分布する叶倉層，細尾層，上八瀬層から産出する 64 属 83 種 (3 新種，*Paramesolobus kitakamiensis* sp. nov.*, Callispirina sheni* sp. nov., *Whitspakia nipponica* sp. nov. を含む) の中期ペルム紀（グアダループ世）腕足類を記載した．これらの腕足類は，細尾層から産出する *Poikilosakos kamiyassensis* と *Martinia semiplana* の 2 種を除いてほかはすべて，叶倉層と上八瀬層の Wordian 相当層から産出する．古生物地理学的に，世田米・上八瀬–飯森・松川地域の Wordian の腕足類フォーナはボレアル区とテチス区の要素が混在するボレアル型–テチス型混合フォーナで，中国北部（内蒙古），ロシア東部（プリモリエ），中部日本（飛騨外縁帯）の同時代の腕足類フォーナに類似する．以上のことから，南部北上地域は中期ペルム紀（Wordian）に北半球中緯度地域のシノモンゴル–日本区に属し，おそらく中央アジア造山帯の東端，北中国地塊の東方に位置したマイクロコンチネント（原日本地塊）の縁辺浅海域であったと推定される．

INTRODUCTION

Permian marine sedimentary rocks are widely distributed in the South Kitakami Belt (southern Kitakami Mountains), northeastern Japan. The Setamai area (i.e., Setamai, Sumita-cho, Kesen-gun, Iwate Prefecture; Figs. 1, 3A and 11) in the central part of the belt is a classical and important area for the middle Permian stratigraphy of Japan as well as the South Kitakami Belt. Since the work of Endo (1924), many studies have investigated the stratigraphy of the middle Permian Kanokura Formation (named by Onuki, 1956) in the Setamai area (e.g., Minato et al., 1954; Onuki, 1956; Saito, 1966; Choi, 1973; Tazawa and Ibaraki, 2001). In addition, the Kamiyasse–Imo (i.e., Kamiyasse, Kesennuma City, Miyagi Prefecture, and Imo, Yahagi-cho, Rikuzentakata City, Iwate Prefecture; Figs. 1, 2, 3B and 12) and Matsukawa (i.e., Matsukawa, Kesennuma City, Miyagi Prefecture; Figs. 1 and 13) areas, both of which are located in the central part of the South Kitakami Belt, are classical and renowned fossil localities for middle Permian (Wordian) marine invertebrates. The Wordian brachiopod fauna of the Kamiyasse–Imo area is

Received June 8, 2023. Accepted November 25, 2023.
Corresponding author—Jun-ichi Tazawa
E-mail: j1025-tazawa*memoad.jp

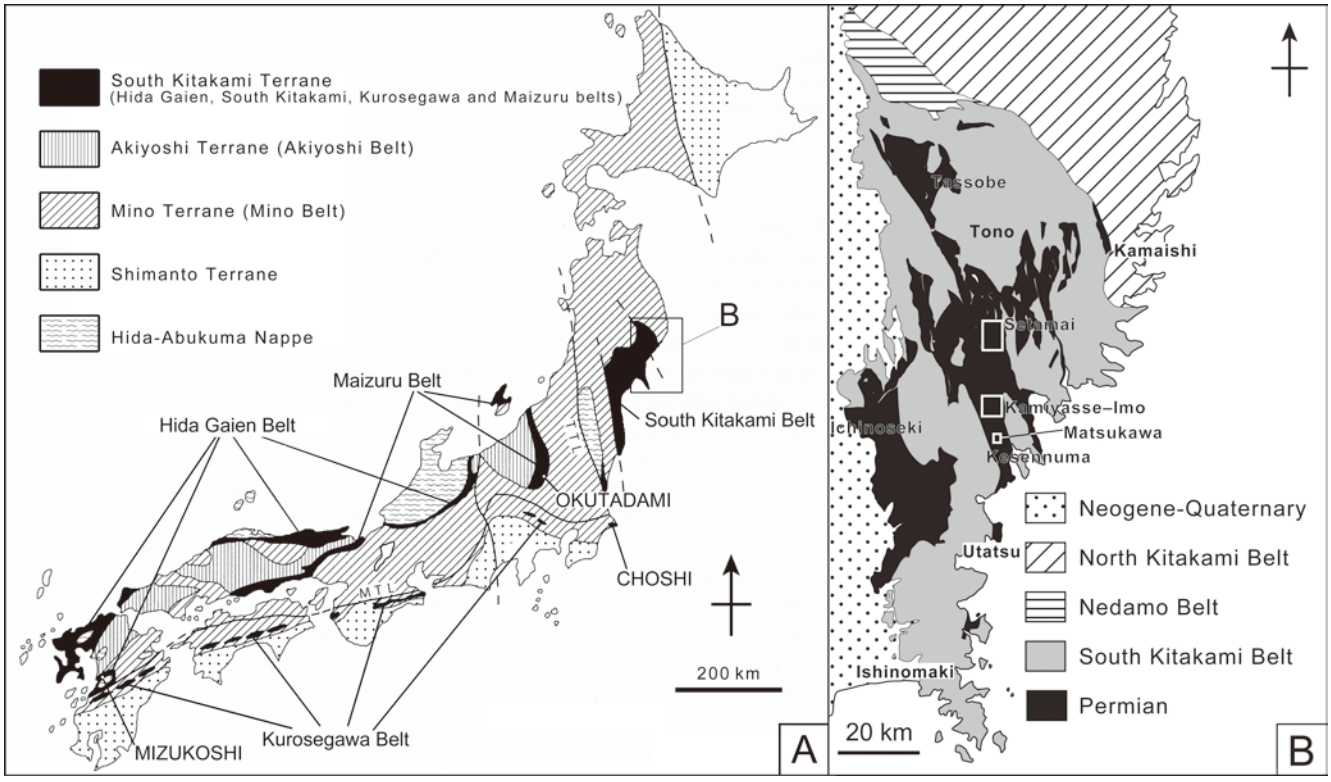

FIGURE 1. Maps showing the location and geology of the Setamai, Kamiyasse–Imo and Matsukawa areas, South Kitakami Belt, northeastern Japan. **A**, Geotectonic map of the Japanese Islands, showing the distribution of the South Kitakami Belt (based on Tazawa, 2018); **B**, geotectonic map of the northeastern Honshu, Japan, showing the distribution of the Permian rocks in the South Kitakami Belt (based on Kawamura et al., 2013).

the most diverse Japanese Permian brachiopod fauna. Since Yabe (1900), many studies have investigated the taxonomy of the brachiopod fauna (e.g., Hayasaka, 1922a, 1925a; Hayasaka and Minato, 1956; Nakamura, 1959b, 1972; Tazawa, 1974b, 2016b).

In this study, we describe middle Permian (Guadalupian; Roadian–Capitanian, mostly Wordian) brachiopods from the Kanokura Formation in the Setamai area and from the Hosoo and Kamiyasse Formations in the Kamiyasse–Imo and Matsukawa areas and discuss the age and palaeobiogeography of the Wordian brachiopod fauna. Most of the materials were collected by the present authors: J. Tazawa collected the brachiopod specimens from the Kamiyasse–Imo and Matsukawa areas in 1970–1975 during the course of graduate study at the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, under the supervision of M. Minato; and Y. Ibaraki collected brachiopod specimens from the Setamai area in 1996 during the course of graduate study at the Department of Geology, Faculty of Science, Niigata University, under the supervision of J. Tazawa.

PREVIOUS WORK

Stratigraphy

Previous studies on the stratigraphy of the middle Permian rocks in the Setamai area are summarized in Fig. 4. In the early studies, Endo (1924) named the lower part of the sandstone–limestone unit "the Alternation of Slate and Sandstone" and the upper part "the Fusulina Limestone". Onuki (1938) named the middle Permian rocks the Kanokura Stage (= upper part of the Yukizawa Series). Modern stratigraphical studies on the Permian rocks of the Setamai area began in the early 1940s. Minato (1942) and Minato et al. (1954) established the Permian stratigraphy in the Setamai area. According to those studies, the Permian rocks in the Setamai area can be divided into three series: the Sakamotozawa Series (Sakmarian; *Pseudoschwagerina* and *Pseudofusulina* zones), the Kanokura Series (Artinskian–Wordian; *Lyttonia* and *Lepidolina* zones) and the Toyoma Series (upper Permian?), in ascending stratigraphic order. Moreover, the middle Permian Kanokura Series was subdivided into two stages: the lower part was named the Kattisawa Stage and the upper part the Iwaizaki Stage. This stratigraphic division was accepted and subsequently

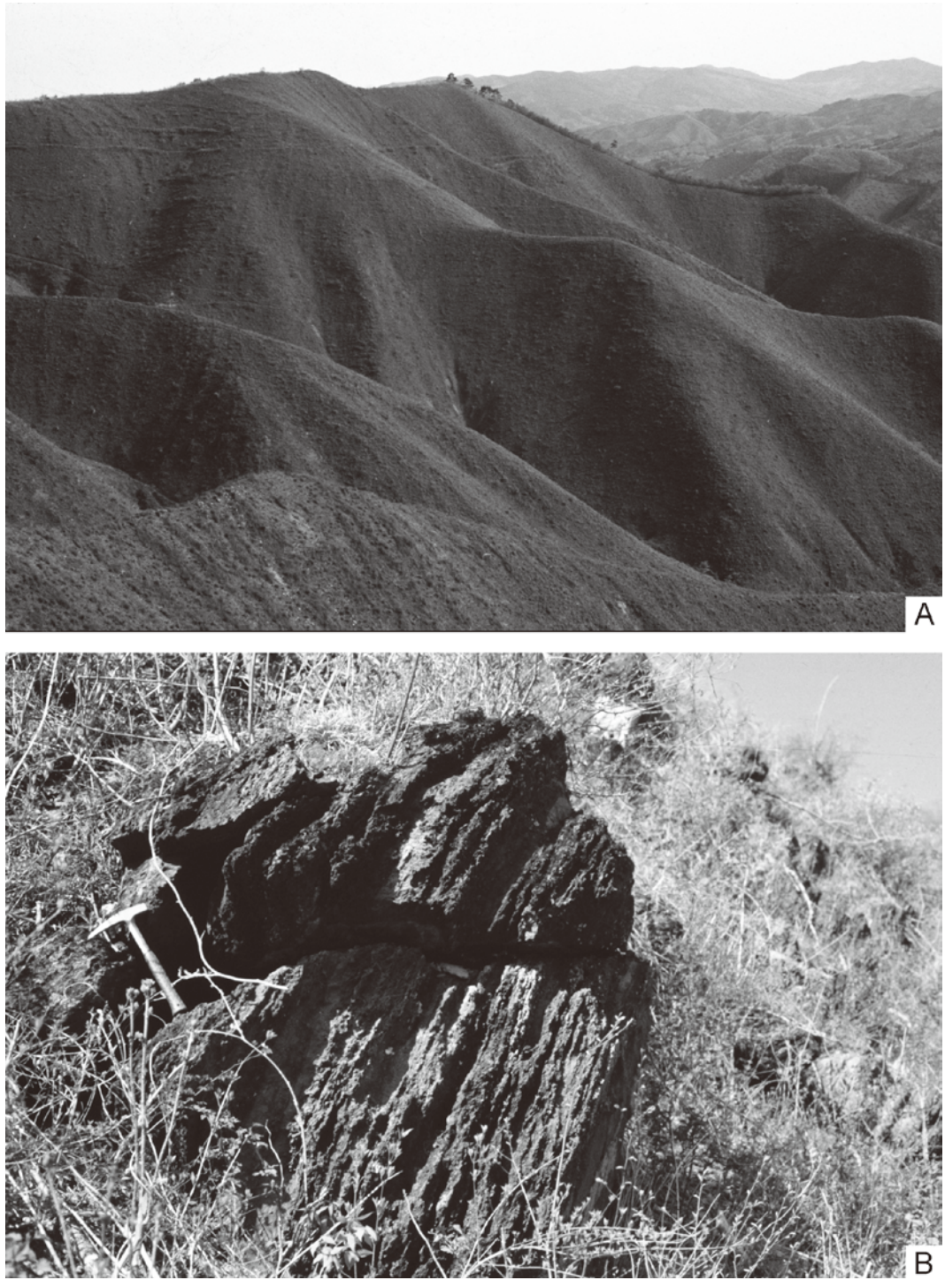

FIGURE 2. A view of central part of the Kamiyasse – Imo area, around the Kokitamukaisawa and Matashirosawa valleys (**A**), and outcrop of argillaceous limestone of the KY1 Unit of the Kamiyasse Formation at locality KF67, upper Shigejisawa Valley (**B**).

FIGURE 3. Outcrop of sandstone of the KN2 Unit, Kanokura Formation at locality KS9 in the middle Kanokurasawa Valley, Setamai (**A**), and outcrop of limestone of the KY2 Unit, Kamiyasse Formation at upper Minamizawa Valley, Kamiyasse (**B**).

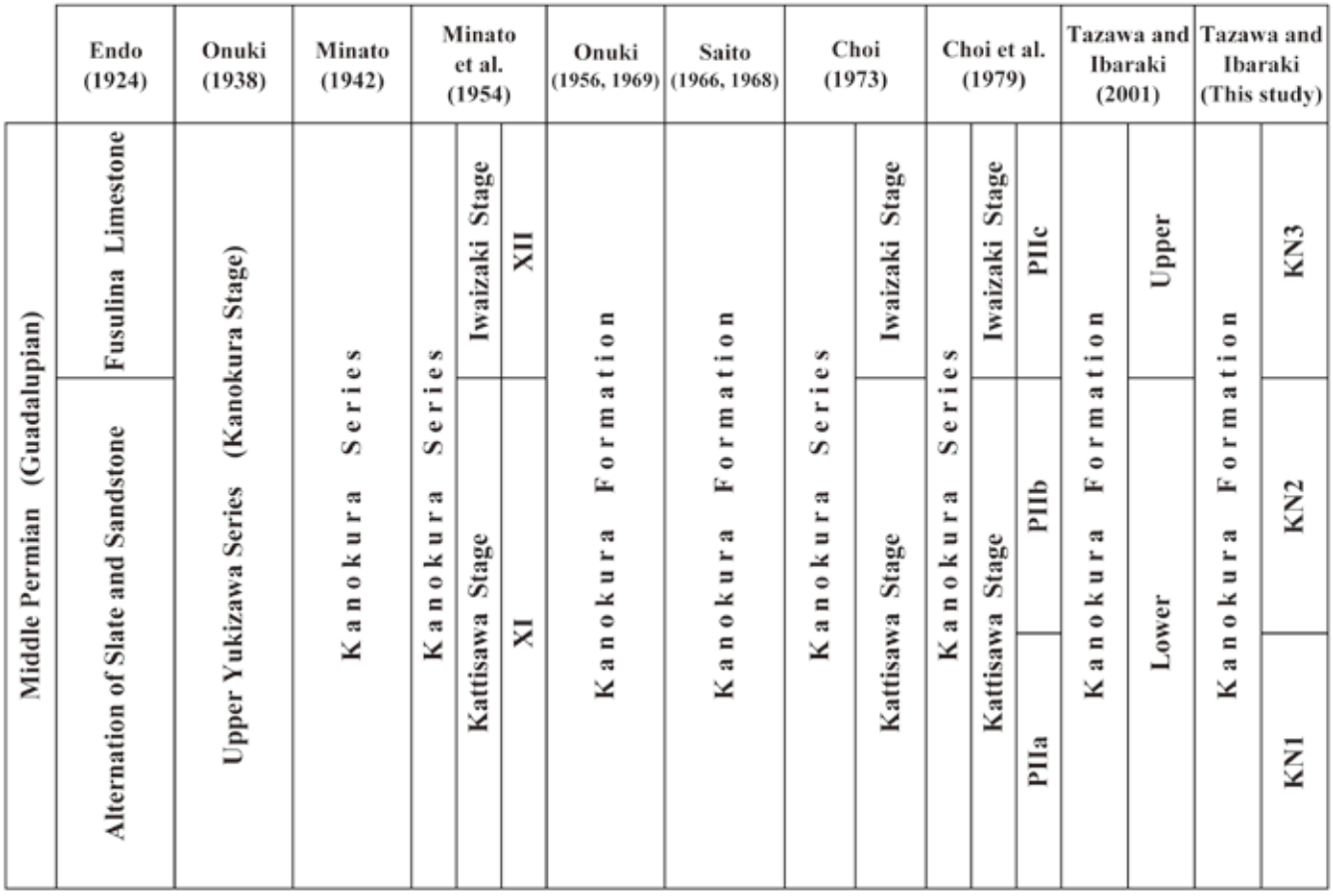

FIGURE 4. Comparison of stratigraphic schemes proposed for the middle Permian (Guadalupian) formations in the Setamai area, South Kitakami Belt.

followed by Onuki (1956, 1969), Saito (1966, 1968), Choi (1973), Choi et al. (1979) and Tazawa and Ibaraki (2001).

In contrast, there have been few previous studies on the Permian stratigraphy of the Kamiyasse–Imo and Matsukawa areas (Fig. 5). Shiida (1940) named the Permian rocks the Kesennuma Series. The lower part of the series was called the Kamiyasse Formation; the upper part was named the Futatsumori Formation. In that study, the upper part of the Kamiyasse Formation was assigned to the middle Permian. Subsequently, Onuki (1956), Kambe and Shimazu (1961) and Tazawa (1973, 1976) classified the Permian rocks into the same three formations (or groups, series) as those of the Setamai area; i.e., the lower Permian Sakamotozawa Formation, the middle Permian Kanokura Formation and the upper Permian Toyoma Formation (Onuki, 1956). However, Misaki and Ehiro (2004) divided the Permian rocks into four formations: the Nakadaira Formation, the Hosoo Formation, the Kamiyasse Formation and the Kurosawa Formation, in ascending stratigraphic order. In that study, both the Hosoo and Kamiyasse Formations were assigned to the middle Permian.

Palaeontology

Many taxonomic studies have been published on the middle Permian biota of the Setamai, Kamiyasse–Imo and Matsukawa areas: fusulines (Morikawa, 1953; Fujimoto, 1956; Kanomata and Chisaka, 1967; Kanomata and Miyawaki, 1967; Choi, 1970, 1973; Kobayashi et al., 2009); conulariids (Hayasaka, 1920, 1923, 1963a; Sugiyama, 1942; Murata, 1967); bryozoans (Sakagami, 1961); brachiopods (Yabe, 1900; Hayasaka, 1917, 1922a, 1925a, 1937, 1953, 1960, 1963b, 1963d, 1966, 1967; Hayasaka and Minato, 1956; Minato, 1955; Minato and Nakamura, 1956; Nakamura, 1959b, 1960, 1970, 1972; Nakamura et al., 1970; Tazawa, 1974a, 1974b, 1979, 1999c, 2008c, 2014, 2016a, 2016b, 2017; Tazawa and Araki, 1984a, 1984b, 1999, 2013, 2016, 2017, 2018; Tazawa and Ibaraki, 2001; Tazawa and Kaneko, 2016; Tazawa and Takaizumi, 1987; Shen and Tazawa, 1997, 2014; Afanasjeva and Tazawa, 2007, 2010; Afanasjeva et al., 2015; Shiino, 2009; Shiino and Suzuki, 2007; Masunaga and Shiino, 2021); bivalves (Hayasaka, 1925b; Murata, 1964; Nakazawa and Newell, 1968); cephalopods (Hayasaka, 1940; 1963c; Ehiro and Araki, 1997;

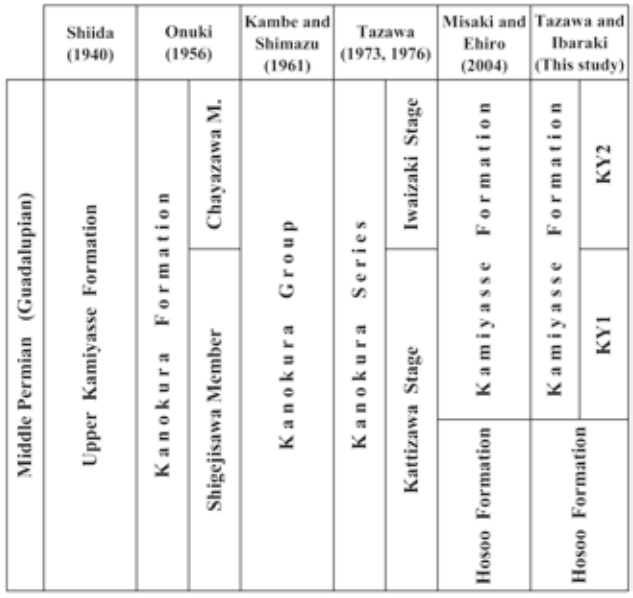

FIGURE 5. Comparison of stratigraphic schemes proposed for the middle Permian (Guadalupian) formations in the Kamiyasse–Imo area, South Kitakami Belt.

Ehiro and Misaki, 2005; Ehiro, 2015); trilobites (Araki, 1961; Jimbo, 1966; Araki and Koizumi, 1968; Koizumi and Sasaki, 1978; Kobayashi and Hamada, 1984) and cartilaginous fish (Araki, 1980). The brachiopods of the area have been studied extensively. Yabe (1900) described two species (*Lyttonia* sp. and *Lyttonia* cf. *nobilis*) from Matsukawa: this was the first study of Palaeozoic brachiopods in Japan. Subsequently, Hayasaka (1917, 1922a, 1925a, 1937, 1953, 1960, 1963b, 1966, 1967) and Hayasaka and Minato (1956) described 40 species in 24 genera; Minato (1955) and Minato and Nakamura (1956) described five species in five genera; Nakamura (1959b, 1960, 1970, 1972) and Nakamura et al. (1970) described 25 species in nine genera; Tazawa and colleagues (Tazawa, 1974a, 1974b, 1979, 1999c, 2008c, 2014, 2016a, 2016b, 2017; Tazawa and Araki, 1984a, 1984b, 1999, 2013, 2016, 2017, 2018; Tazawa and Ibaraki, 2001; Tazawa and Kaneko, 2016; Tazawa and Takaizumi, 1987) described 51 species in 41 genera; Shen and Tazawa (1997, 2014) described four species in four genera; Afanasjeva and colleagues (Afanasjeva and Tazawa, 2007, 2010; Afanasjeva et al., 2015) described three species in three genera; Shiino (2009) and Shiino and Suzuki (2007) described three species in two genera; and Masunaga and Shiino (2021) described three species in two genera.

In terms of biostratigraphy, Choi (1973) proposed three fusuline zones in the Kanokura Series of the Setamai area: the *Monodiexodina matsubaishi* and *Colania kotsuboensis* zones in the Kattisawa Stage and the *Lepidolina multiseptata* Zone in the Iwaizaki Stage. In addition, Choi (1973) assigned the Kattisawa Stage to the Kubergandian–Murgabian and the Iwaizaki Stage to the lower Lopingian. Subsequently, Minato et al. (1978) proposed the *Monodiexodina kofuganensis*, *Leptodus nobilis* and *Lepidolina multiseptata–L. minatoi* zones, assigning the Kattisawa Stage to the Kungurian–Kazanian and the Iwaizaki Stage to the lower Tatarian. Ehiro and Misaki (2005), on the basis of the ammonoid fauna, assigned the middle part of the Hosoo Formation to the Roadian and both the upper part of the Hosoo Formation and the Kamiyasse Formatio to the Wordian–Capitanian. Kobayashi et al. (2009) proposed three fusuline zones in the Kamiyasse Formation of the Kamiyasse–Imo area (the *Monodiexodina sutchanica*, *Parafusulina motoyoshiensis* and *Lepidolina shiraiwensis* zones) and correlated all three zones with the Midian (latest Wordian–Capitanian). Tazawa (2016b, 2017, 2018) assigned the lower part of the Kamiyasse Formation in the Kamiyasse–Imo and Matsukawa areas to the Wordian, based on the brachiopods.

In terms of palaeobiogeography, Tazawa (1987) and Nakamura and Tazawa (1990) recognized middle Permian mixed Boreal–Tethyan brachiopod faunas in northeastern Japan (the South Kitakami Belt), central Japan (the Hida Gaien Belt), eastern Russia (South Primorye), northeastern China (Jilin) and northern China (Inner Mongololia). Subsequently, Tazawa (1991, 1992, 1998) proposed the middle Permian geography of the South Kitakami region and adjacent areas in eastern Asia to have been as follows: the South Kitakami region was probably located at a middle latitude of the Northern Hemisphere, near and to the east of the North China Block, during the middle Permian. This hypothesis was confirmed by Tazawa (2003, 2007, 2016b, 2017) and Tazawa and Araki (2017). In contrast, Ehiro (1997, 1998, 2001, 2010) and Ehiro and Misaki (2005) emphasised that the middle Permian ammonoid faunas of the South Kitakami Belt consisted of Tethyan (tropical) and cosmopolitan genera and completely lacked Boreal (antitropical) genera; and suggested that the South Kitakami region was probably located in equatorial Panthalassa near the South China Block during the middle Permian.

STRATIGRAPHY

Permian rocks are exposed in the Setamai, Kamiyasse–Imo and Matsukawa areas in the form of two subparallel synclines that trend N–S to NNW–SSE and plunge gently towards the south (Figs. 1B, 6 and 8). The two synclines are separated by the left-lateral strike-slip Hizume–Kesennuma Fault (Hirokawa and Yoshida, 1954; Ehiro, 1977), which trends NNW–SSE. The Permian successions of the areas consist mostly of sandstone and shale with subordinate limestone and conglomerate. Both sandstone and limestone are predominant in the eastern syncline (Setamai area), but shale is dominant in the western syncline (Kamiyasse–Imo and Matsukawa areas).

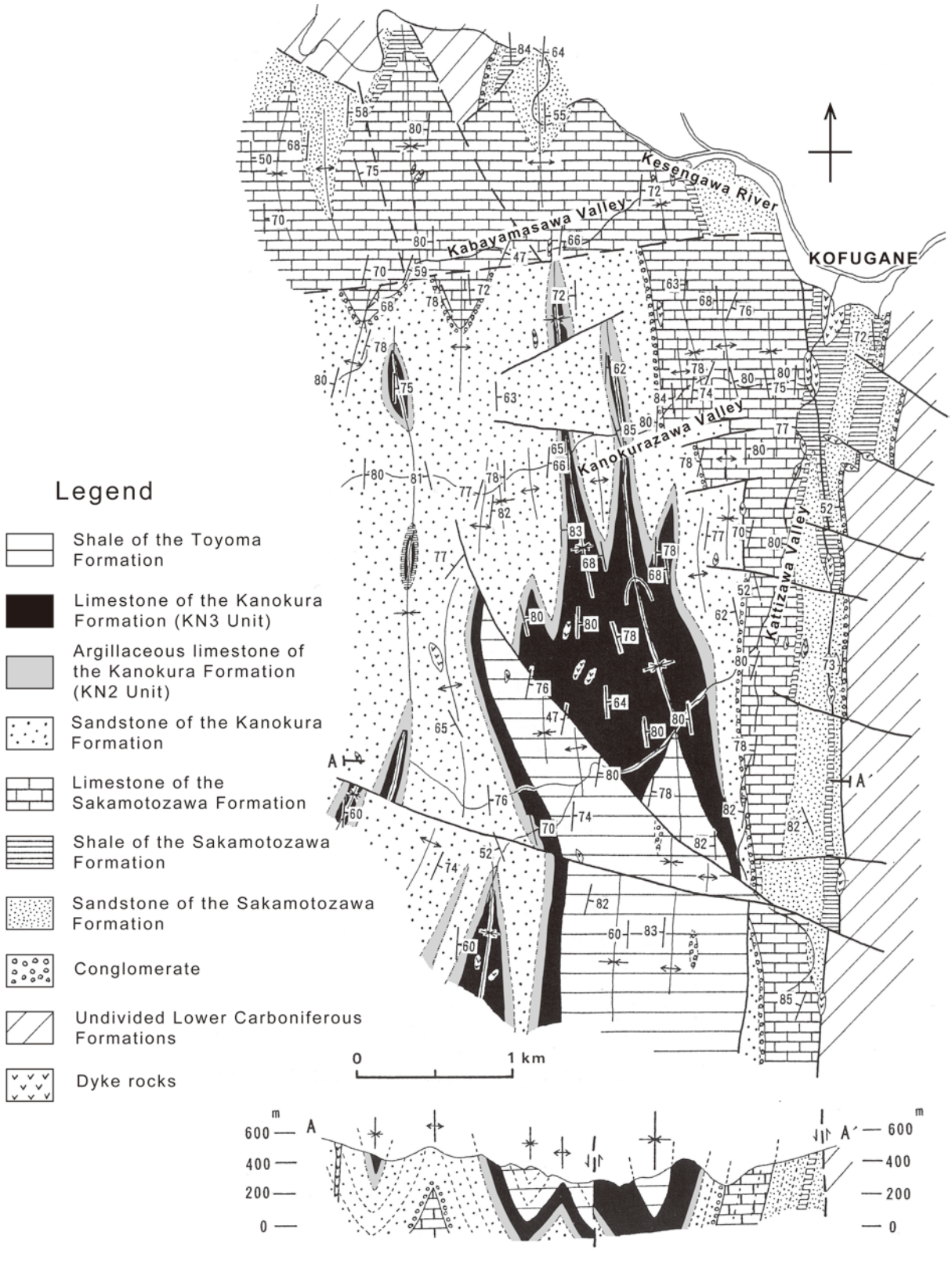

FIGURE 6. Geologic map of the Setamai area (after Tazawa and Ibaraki, 2001).

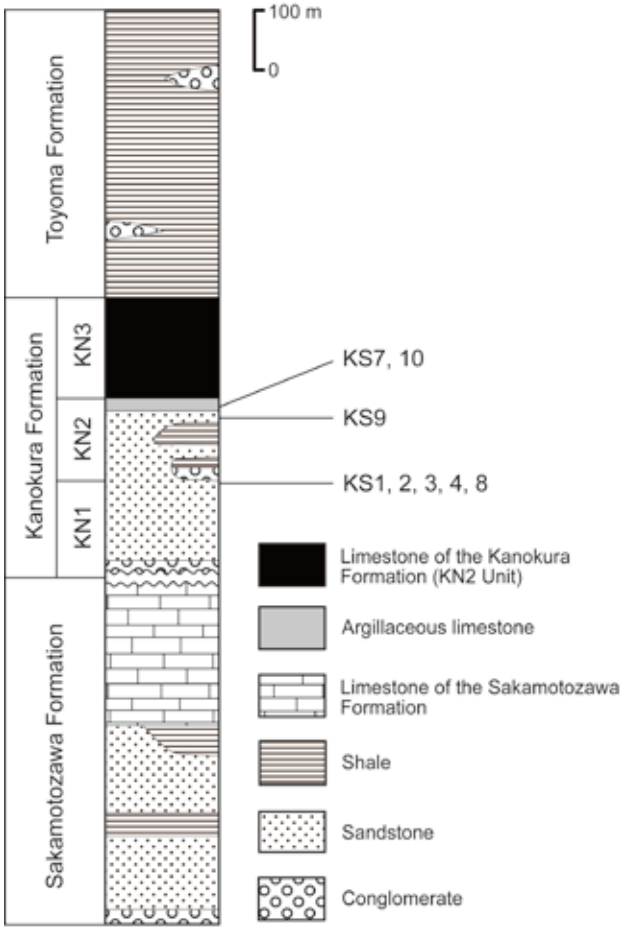

FIGURE 7. Generalized columnar section of the Permian formations in the Setamai area, showing the fossil horizons in the KN1 and KN2 units in the Kanokura Formation (modified and adapted from Tazawa and Ibaraki, 2001).

Setamai

According to Tazawa and Ibaraki (2001), the Permian rocks in the Setamai area are divided into three formations: the Sakamotozawa, Kanokura and Toyoma Formations, in ascending stratigraphic order. The middle Permian Kanokura Formation (470 m thick) is subdivided into a lower part (mainly grey to greenish-grey sandstone, with subordinate dark grey argillaceous limestone and conglomerate, 300 m thick) and an upper part (light grey limestone, 170 m thick). The boundary between the Kanokura Formation and the underlying Sakamotozawa Formation is an unconformity.

In the present study, the Kanokura Formation is subdivided into three units: the KN1 Unit (sandstone with a basal conglomerate, 160 m thick), the KN2 Unit (mainly sandstone, with subordinate conglomerate and argillaceous limestone, 140 m thick); and the KN3 Unit (limestone, 170 m thick), in ascending stratigraphic order (Fig. 7). Brachiopods occur in three horizons: sandstone of the uppermost part of the KN1 Unit; sandstone of the upper part of the KN2 Unit; and argillaceous limestone of the uppermost part of the KN2 Unit.

Kamiyasse–Imo

The middle Permian rocks in the Kamiyasse–Imo area are divided into two formations: the Hosoo Formation in the lower, and the Kamiyasse Formation in the upper (Tazawa, 2016b). The Hosoo Formation (400–500 m thick) consists mainly of dark grey sandy shale with thin layers of sandstone, conglomerate and limestone; the Kamiyasse Formation (150–250 m thick) consists mainly of grey to greenish-grey sandstone with subordinate shale, conglomerate and limestone (dark grey argillaceous limestone in its lower part and light grey limestone in its upper part). In this study, the Kamiyasse Formation is subdivided into two units, the KY1 Unit (mainly sandstone and argillaceous limestone with subordinate shale, 160 m thick) and the KY2 Unit (mainly sandstone and limestone with subordinate shale and conglomerate, 130 m thick), in ascending stratigraphic order (Fig. 9). Brachiopods occur mostly in the KY1 Unit but have also been found in the upper part of the Hosoo Formation and the lower part of the KY2 Unit.

Matsukawa

According to Tazawa and Araki (2017), the lower part of the Kamiyasse Formation (mainly grey to greenish-grey sandstone with subordinate dark grey argillaceous limestone and dark grey shale, 215 m thick) is locally exposed in the western wing of the syncline in the Matsukawa area (Fig. 8). Brachiopods occur in three horizons—two in the lower part and one in the middle part—of the lower Kamiyasse Formation (KY1 Unit; Fig. 10).

MATERIALS

The brachiopods described herein were collected from 62 localities (stations) in the Setamai, Kamiyasse–Imo and Matsukawa areas of the South Kitakami Belt. The topographic and stratigraphic locations, lithologies and brachiopod species of the 62 fossil localities are indicated in Figs. 7 and 9–13, and summarized in Table 1 and appendix. These specimens are now registered and stored in the Department of Geology, Niigata University, Niigata (NU-B prefix); the Hokkaido University Museum. Sapporo (UHR prefix); the Tohoku University Museum, Sendai (IGPS prefix); the Kesennuma Board of Education, Kesennuma, Miyagi Prefecture (KCG prefix); the Rikuzentakata City Museum, Rikuzentakata, Iwate Prefecture (RCM-F prefix); and the Palaeontological Institute, Russian Academy of

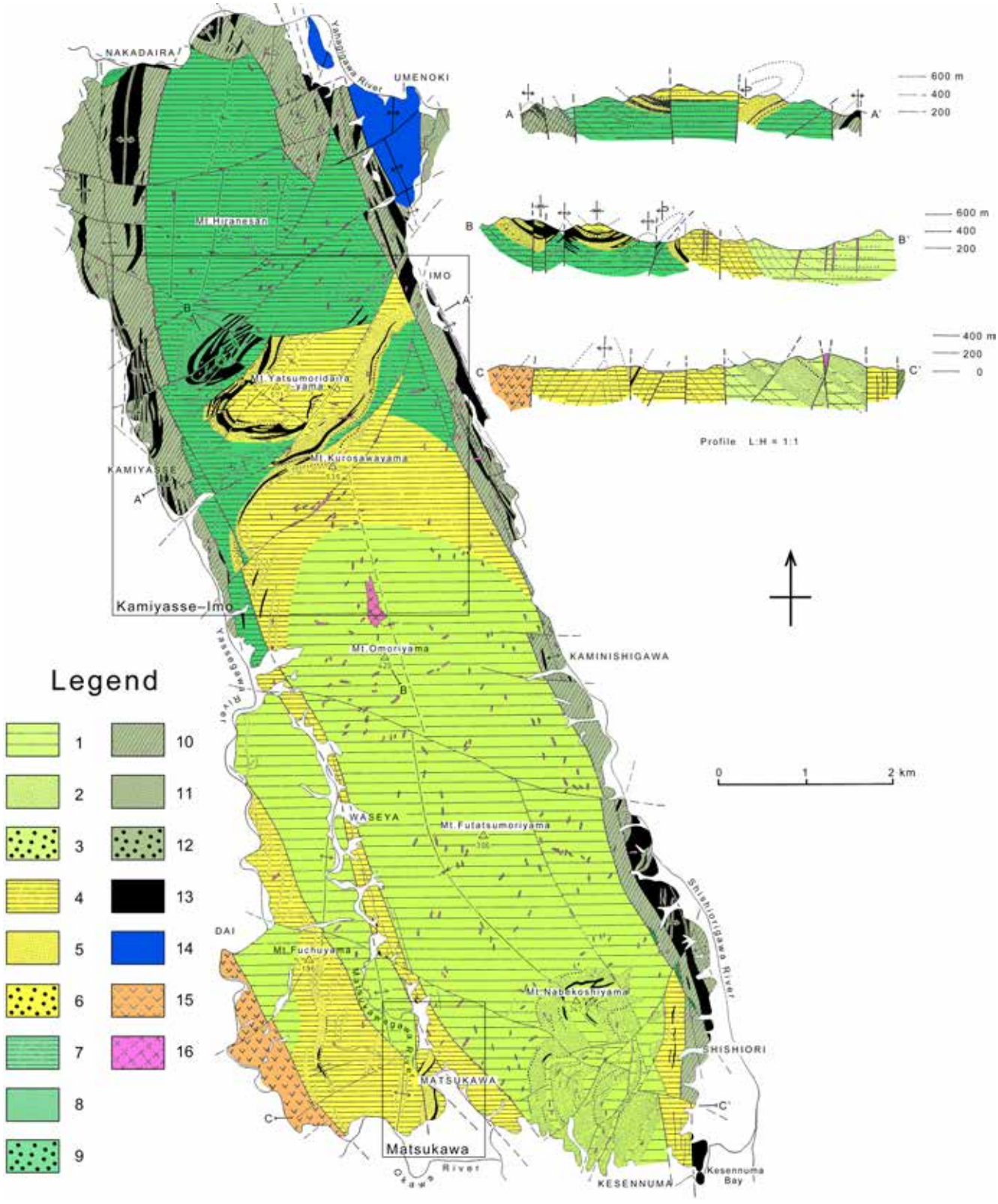

FIGURE 8. Geological map of the Kamiyasse–Imo and Matsukawa areas (modified from Tazawa, 1976). Legend 1 – 3, Toyoma Formation (1, Shale; 2, Sandstone; 3, Conglomerate); 4–6, Kamiyasse Formation (4, Shale; 5, Sandstone; 6, Conglomerate); 7–9, Hosoo Formation (7, Shale; 8, Sandstone; 9, Conglomerate); 10–12, Nakadaira Formation (10, Shale; 11, Sandstone; 12, Conglomerate); 13, Limestone of the Nakadaira, Hosoo, Kamiyasse and Toyoma Formations; 14, Carboniferous Nagaiwa Formation; 15, Cretaceous andesite; 16, Dyke rock.

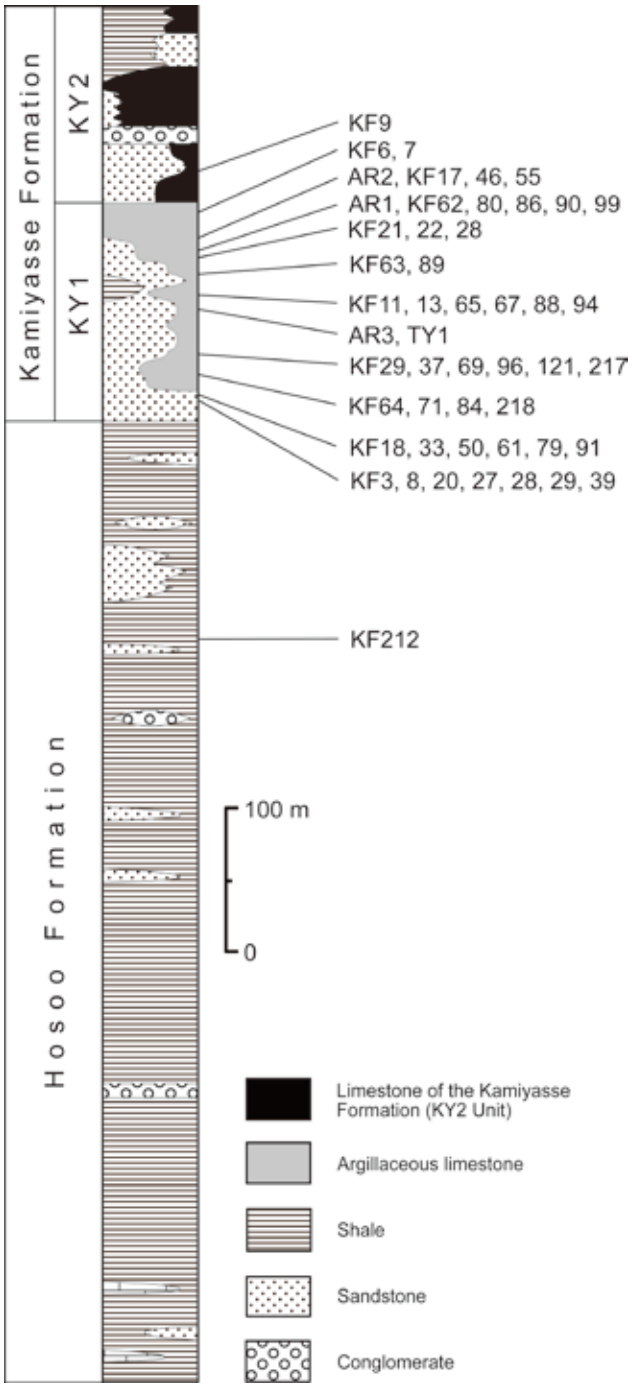

FIGURE 9. Generalized columnar section of the middle Permian (Guadalupian) rocks in the Kamiyasse–Imo area, showing the fossil horizons in the upper part of the Hosoo Formation and KY1 and KY2 units in the Kamiyasse Formation (modified and adapted from Tazawa, 2017).

Sciences, Moscow (PIN prefix).

BRACHIOPOD FAUNA

The brachiopods described herein are the following 83 species in 64 genera, including three new species (*Paramesolobus kitakamiensis* sp. nov., *Callispirina sheni* sp. nov. and *Whitspakia nippponica* sp. nov.): *Orbiculoidea verum* Masunaga and Shiino, 2021, *Isogramma heritschi* Nakamura, 1970, *I. nakamurai* Tazawa, 2016a, *Neochonetes* (*Huangichonetes*) *matsukawensis* Tazawa and Araki, 2018, *Paramesolobus kitakamiensis* Tazawa, sp. nov., *Kanokurachonetes kanokurensis* Afanasjava and Tazawa, 2010, *Capillomesolobus heritschi* Pečar, 1986, *Chonetinetes elongatus* Afanasjeva, Tazawa and Shintani, 2015, *Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, 2007, *Transennatia gratiosa* (Waagen, 1884), *Spinomarginifera lopingensis* (Kayser, 1883), *S. kueichowensis* Huang, 1932, *S. alpha* Huang, 1932, *Paramarginifera* sp., *Hexiproductus echidniformis* (Chao, 1925), *Kunlunia* sp., *Costiferina spiralis* (Waagen, 1884), *Tyloplecta yangtzeensis* (Chao, 1927), *Bathymyonia neimongolica* (Wang and Zhang, 2003), *Vediproductus punctatiformis* (Chao, 1927), *Waagenoconcha humboldti* (d'Orbigny, 1842), *W. irginae* (Stuckenberg, 1898), *Edriosteges multispinosus* Muir-Wood and Cooper, 1960, *Limbella* sp., *Chonosteges* sp., *Urushtenoidea crenulata* (Ding in Yang et al., 1962), *Scacchinella gigantea* Schellwien, 1900b, *Linoproductus hayasakai* Tazawa, 1979, *Globiella tschernyschewi* (Netschajew, 1911), *Asperlinus japonicus* (Tazawa, 2008c), *Lamiproductus kamiyassensis* (Tazawa, 2016a), *Anidanthus mizukoshiensis* Tazawa, 2008b, *Costatumulus cancriniformis* (Tschernyschew, 1889), *Permundaria asiatica* Nakamura, Kato and Choi, 1970, *P. tenuistriata* Tazawa, 1974a, *Grandaurispina kozlowskiana* (Fredericks, 1925), *Yakovlevia mammata* (Keyserling, 1846), *Y. kaluzinensis* Fredericks, 1925, *Neorichthofenia mabutii* (Tazawa and Araki, 1984b), *Leptodus nobilis* (Waagen, 1883), *Keyserlingina* sp., *Petasmaia expansa* Cooper and Grant, 1969, *Pararigbyella doulingensis* Shen and Zhang, 2008, *Poikilosakos kamiyassensis* Tazawa and Takaizumi, 1987, *Paralyttonia kesennumensis* Tazawa and Araki, 1984a, *Permianella typica* He and Zhu, 1979, *Dicystoconcha lapparenti* Termier and Termier in Termier et al., 1974, *Laterispina parallela* Shen, Fan, Zhang and Zhang, 1994, *Derbyia grandis* Waagen, 1884, *D. nipponica* Nakamura, 1972, *Meekella eximia* (de Verneuil, 1845), *M. nodosa* Nakamura, 1972, *Orthothetina polita* (Fliegel, 1901), *O. kayseri* (Fliegel, 1901), *O. kitakamiensis* (Hayasaka, 1953), *O. hayasakai* Nakamura, 1972, *O. transversa* Nakamura, 1972, *Streptorhynchus pelargonatus* (von Schlotheim, 1816), *S. cataclinus* Zhang in Yang et al., 1962, *Rhipidomella magna* Tazawa, 2016a, *Acosarina dorsisulcata* Cooper and Grant, 1969, *A. rectimarginata* Cooper and Grant, 1976b, *Orthotichia* sp., *Stenoscisma margaritovi* (Tschernyschew,

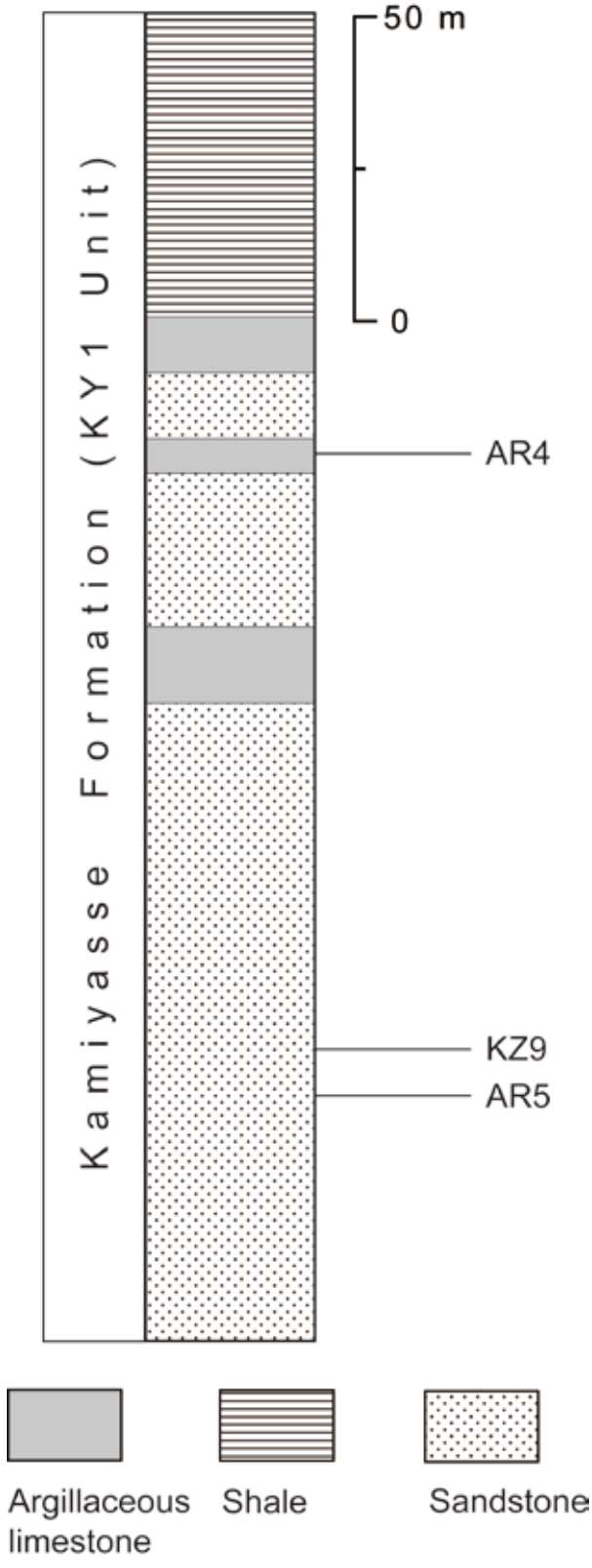

FIGURE 10. Generalized columnar section of the middle Permian (Guadalupian) rocks in the Matsukawa area, showing the fossil horizons in the Hosoo Formation and the KY1 Unit in the Kamiyasse Formation (modified and adapted from Tazawa and Araki, 2017).

1888), *S. mutabilis* (Tschernyschew, 1902), *S. sokolskajae* Koczyrkevicz, 1979b, *Rhynchopora tchernyshae* Koczyrkevicz, 1979a, *Permocryptospirifer omeishanensis* (Huang, 1933), *Hustedia remota* (Eichwald, 1860), *H. ratburiensis* Waterhouse and Piyasin, 1970, *Martinia semiplana* Waagen, 1883, *M. triquetra* Gemmellaro, 1899, *Neospirifer moosakhailensis* (Davidson, 1862), *Gypospirifer kobiyamai* Tazawa and Araki, 2013, *Alispiriferella lita* (Fredericks, 1924b), *Phricodothyris catatona* (Cooper and Grant, 1976a), *Permophricodothyris grandis* (Chao, 1929), *P. squamularioides* (Huang, 1933), *Licharewina arakii* (Hayasaka, 1963b), *Callispirina sheni* Tazawa, sp. nov., *Spiriferellina fredericksi* Tazawa, 2014, *Dielasma* sp. and *Whitspakia nipponica* Tazawa, sp. nov.

The above-listed brachiopods are classified into three faunas: the Kanokura fauna from the Kanokura Formation in the Setamai area; the Kamiyasse–Imo fauna from the Kamiyasse Formation in the Kamiyasse–Imo area; and the Matsukawa fauna from the Kamiyasse Formation in the Matsukawa area. Moreover, the three faunas are subdivided into five assemblages: the KN1 assemblage from the KN1 Unit of the Kanokura Formation; the KN2 assemblage from the KN2 Unit of the Kanokura Formation; the HO assemblage from the upper part of the Hosoo Formation; the KY1 (KI) assemblage from the KY1 Unit of the Kamiyasse Formation in the Kamiyasse–Imo area; and the KY1 (MK) assemblage from the KY1 Unit of the Kamiyasse Formation in the Matsukawa area.

Kanokura fauna

KN1 assemblage

The KN1 assemblage, from the uppermost part of the KN1 Unit of the Kanokura Formation in the Setamai area (localities KS1, KS2, KS3, KS4 and KS8), includes six species in five genera: *Transennatia gratiosa*, *Tyloplecta yangtzeensis*, *Linoproductus hayasakai*, *Leptodus nobilis*, *Derbyia grandis* and *D. nipponica*. Of these species, *Linoproductus hayasakai* and *Leptodus nobilis* are abundant; and the other species are rare (Table 1).

KN2 assemblage

The KN2 assemblage, from the upper part of the KN2 Unit of the Kanokura Formation in the Setamai area (localities KS7, KS9 and KS10), includes 11 species in 10 genera: *Transennatia gratiosa*, *Waagenoconcha irginae*, *Urushtenoidea crenulata*, *Permundaria asiatica*, *Grandaurispina kozlowskiana*, *Leptodus nobilis*, *Laterispina parallela*, *Derbyia grandis*, *D. nipponica*, *Orthothetina kitakamiensis* and *Alispiriferella lita*. Of these species, *Leptodus nobilis* and *Alispiriferella lita* are abundant; *Transennatia gratiosa* is common; and the other species are rare (Table 1).

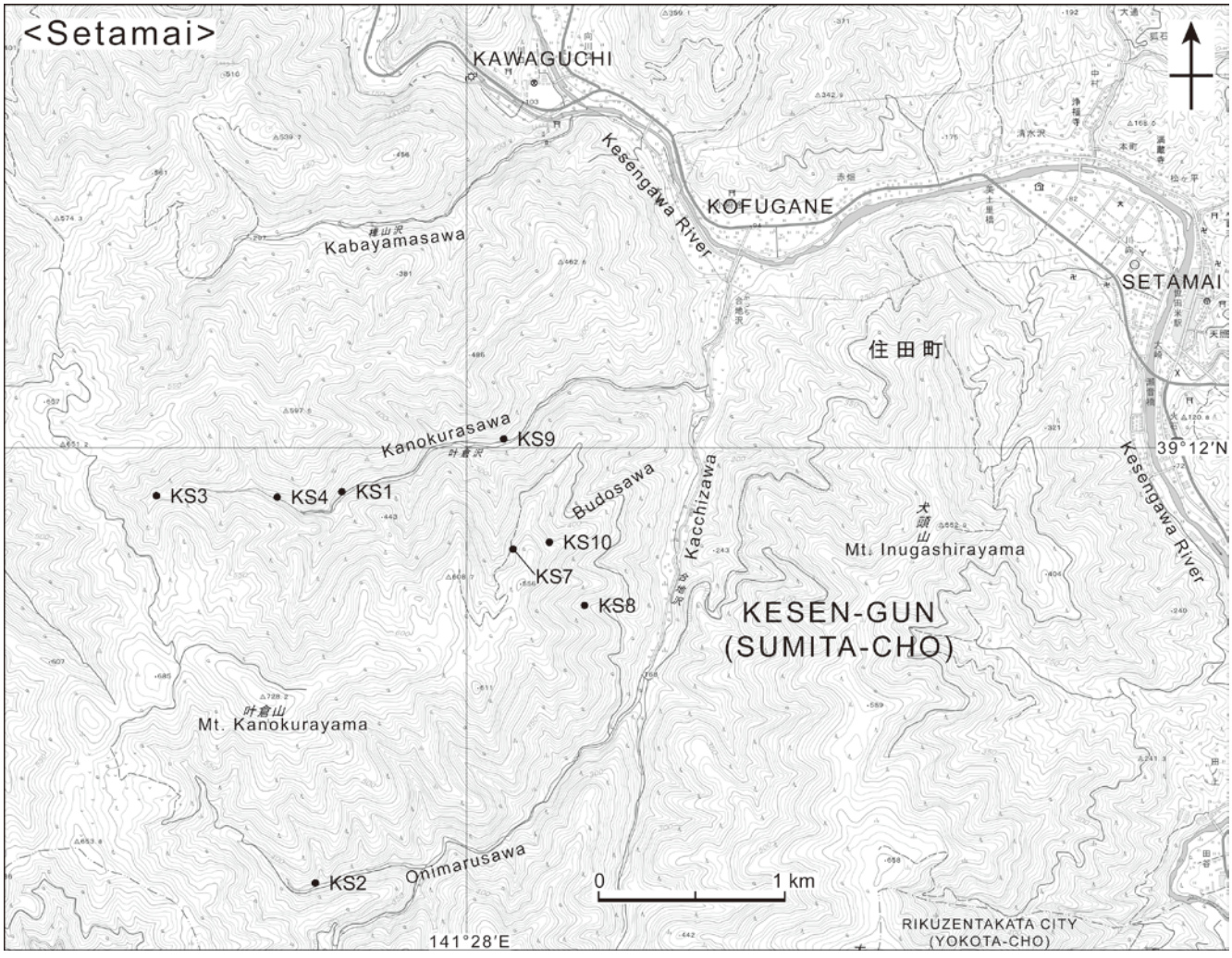

FIGURE 11. Map showing the fossil localities KS1, KS2, KS3, KS4, KS5, KS7, KS8, KS9 and KS10 in the Setamai area (using the electronic topographical map of GSI).

Kamiyasse–Imo fauna

HO assemblage

The HO assemblage, from the upper part of the Hosoo Formation in the Kamiyasse–Imo area (locality KF212), includes two species: *Poikilosakos kamiyassensis* and *Martinia semiplana*. Of these species, *Poikilosakos kamiyassensis* is abundant; and *Martinia semiplana* is common (Table 1).

KY1 (KI) assemblage

The KY1 (KI) assemblage, from the KY1 Unit of the Kamiyasse Formation in the Kamiyasse–Imo area (localities AR1, AR2, AR3, KF3, KF6, KF7, KF8, KF11, KF13, KF17, KF18, KF20, KF21, KF22, KF27, KF28, KF29, KF33, KF37, KF39, KF46, KF50, KF55, KF61, KF62, KF63, KF64, KF65, KF67, KF69, KF71, KF79, KF80, KF84, KF86, KF88, KF89, KF90, KF91, KF94, KF96, KF99, KF121, KF217, KF218 and TY1), includes 64 species in 49 genera: *Orbiculoidea verum*, *Isogramma heritschi*, *I. nakamurai*, *Paramesolobus kitakamiensis* sp. nov., *Kanokurachonetes kanokurensis*, *Chonetinetes elongatus*, *Kitakamichonetes multicapillatus*, *Transennatia gratiosa*, *Spinomarginifera lopingensis*, *S. kueichowensis*, *S. alpha*, *Paramarginifera* sp., *Costiferina spiralis*, *Tyloplecta yangtzeensis*, *Bathymyonia neimongolica*, *Vediproductus punctatiformis*, *Waagenoconcha humboldti*, *W. irginae*, *Edriosteges multispinosus*, *Limbella* sp., *Chonosteges* sp., *Urushtenoidea crenulata*, *Globiella tschernyschewi*, *Asperlinus japonicus*, *Lamiproductus kamiyassensis*, *Anidanthus mizukoshiensis*, *Permundaria asiatica*, *P. tenuistriata*, *Grandaurispina kozlowskiana*, *Leptodus nobilis*, *Pararigbyella doulingensis*, *Permianella typica*, *Dicystoconcha lapparenti*, *Derbyia nipponica*,

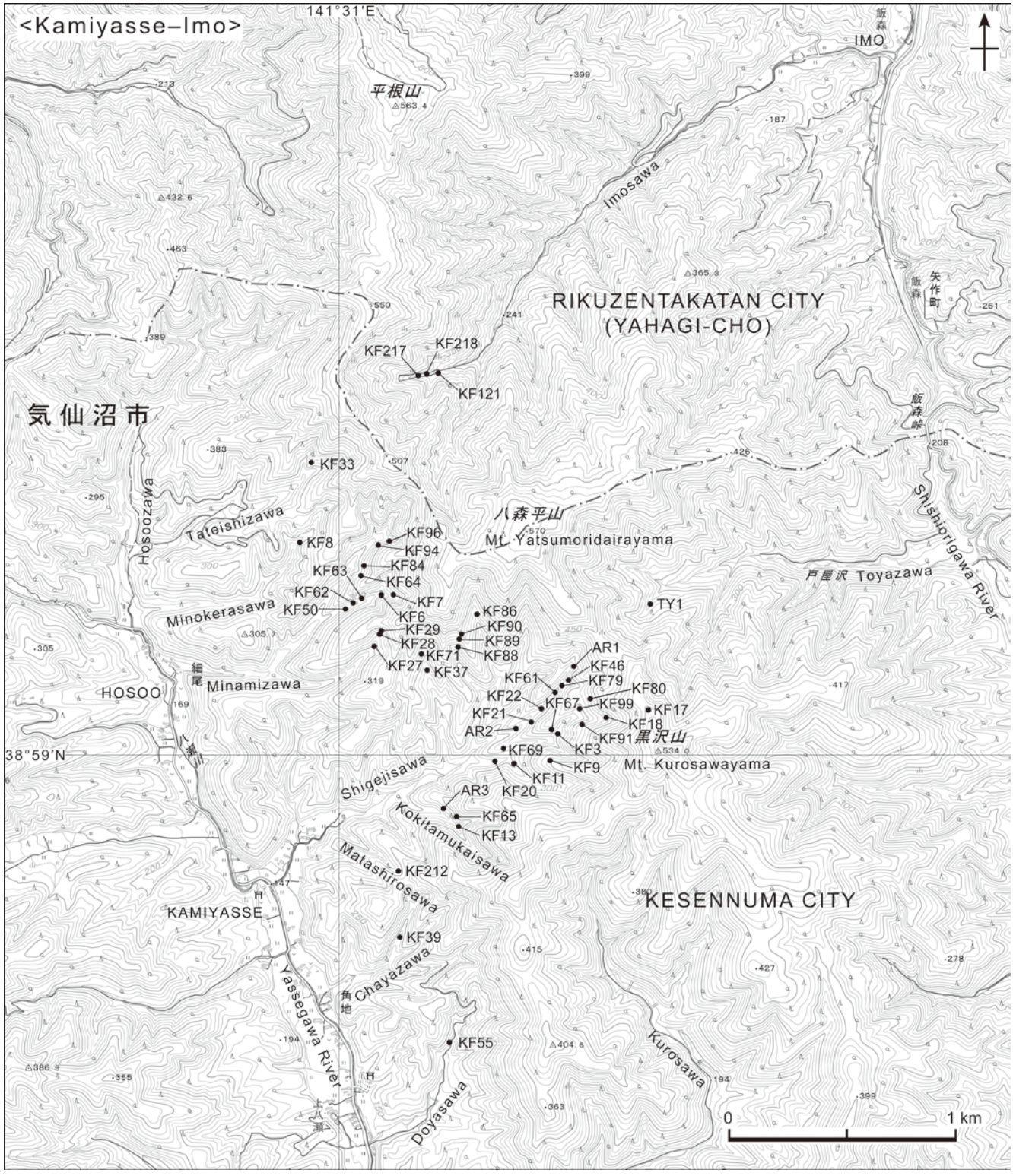

FIGURE 12. Map showing the fossil localities AR1, AR2, AR3, KF3, KF6, KF7, KF8, KF9, KF11, KF13, KF17, KF18, KF20, KF21, KF22, KF27, KF28, KF29, KF33, KF37, KF39, KF46, KF50, KF55, KF61, KF62, KF63, KF64, KF65, KF67, KF69, KF71, KF79, KF80, KF84, KF86, KF88, KF89, KF91, KF94, KF96, KF99, KF121, KF212, KF217, KF218 and TY1 in the Kamiyasse–Imo area (using the electronic topographical map of GSI).

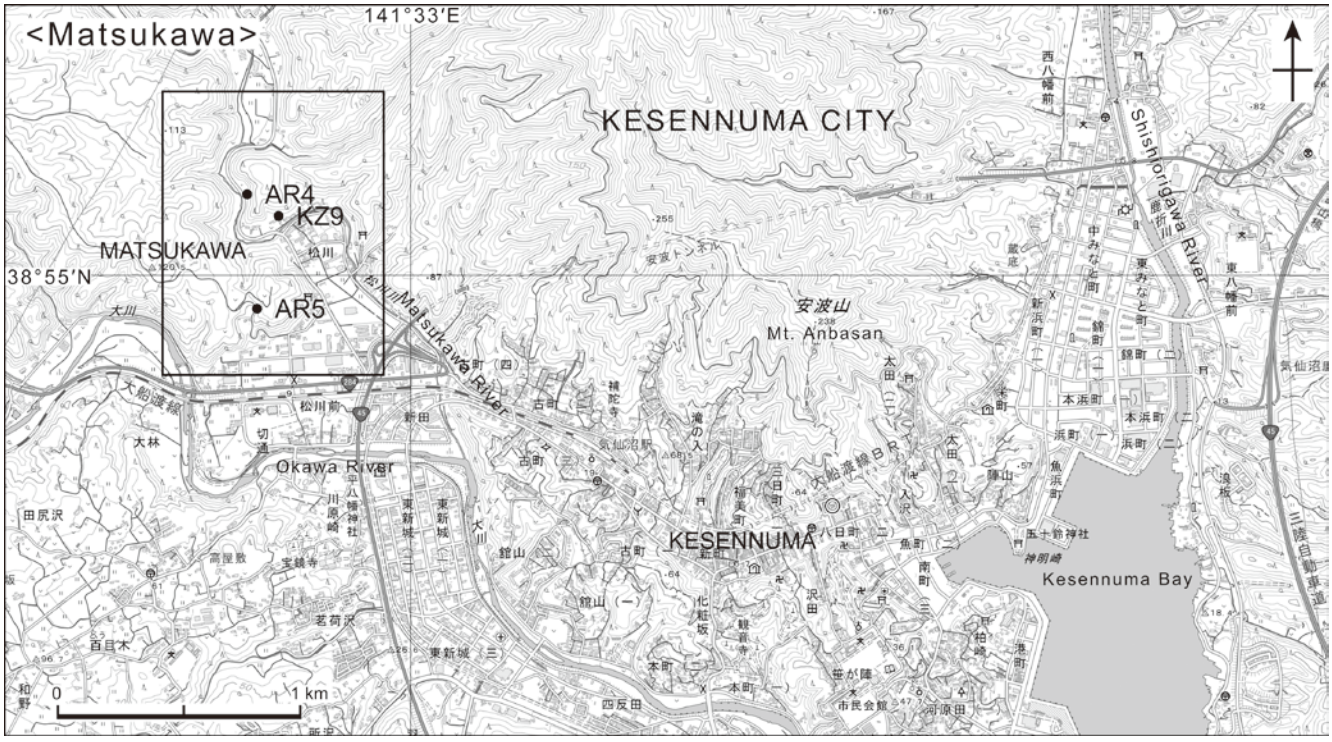

FIGURE 13. Map showing the fossil localities AR4, AR5 and KZ9 in the Matsukawa area (using the electronic topographical map of GSI).

Meekella eximia, *M. nodosa*, *Orthothetina polita*, *O. kayseri*, *O. hayasakai*, *O. transversa*, *Streptorhynchus pelargonatus*, *S. cataclinus*, *Rhipidomella magna*, *Acosarina dorsisulcata*, *A. rectimarginata*, *Orthotichia* sp., *Stenoscisma margaritovi*, *S. mutabilis*, *S. sokolskajae*, *Rhynchopora tchernyshae*, *Permocryptospirifer omeishanensis*, *Hustedia remota*, *H. ratburiensis*, *Martinia triquetra*, *Neospirifer moosakhailensis*, *Gypospirifer kobiyamai*, *Alispiriferella lita*, *Phricodothyris catatona*, *Permophricodothyris grandis*, *P. squamularioides*, *Licharewina arakii*, *Callispirina sheni* sp. nov., *Spiriferellina fredericksi* and *Whitspakia nipponica* sp. nov.

Of these species, *Kitakamichonetes multicapillatus*, *Spinomarginifera kueichowensis*, *Waagenoconcha irginae*, *Urushtenoidea crenulata*, *Leptodus nobilis*, *Permianella typica*, *Stenoscisma margaritovi* and *Spiriferellina fredericksi* are abundant; *Paramesolobus kitakamiensis* sp. nov., *Transennatia gratiosa*, *Spinomarginifera lopingensis*, *Tyloplecta yangtzeensis*, *Vediproductus punctatiformis*, *Waagenoconcha humboldti*, *Edriosteges multispinosus*, *Grandaurispina kozlowskiana*, *Dicystoconcha lapparenti*, *Derbyia nipponica*, *Orthothetina kayseri*, *Rhipidomella magna*, *Stenoscisma mutabilis*, *Permocryptospirifer omeishanensis*, *Martinia triquetra*, *Permophricodothyris grandis*, *P. squamularioides* and *Whitspakia nipponica* sp. nov. are common; and the other species are rare (Table 1).

Matsukawa fauna

KY1 (MT) assemblage

The KY1 (MT) assemblage, from the KY1 Unit of the Kamiyasse Formation in the Matsukawa area (localities AR4, AR5 and KZ9), includes 26 species in 24 genera: *Neochonetes* (*Huangichonetes*) *matsukawensis*, *Capillomesolobus heritschi*, *Transennatia gratiosa*, *Hexiproductus echidniformis*, *Kunlunia* sp., *Urushtenoidea crenulata*, *Scacchinella gigantea*, *Linoproductus hayasakai*, *Costatumulus cancriniformis*, *Permundaria asiatica*, *P. tenuistriata*, *Yakovlevia mammata*, *Y. kaluzinensis*, *Neorichthofenia mabutii*, *Leptodus nobilis*, *Keyserlingina* sp., *Petasmaia expansa*, *Paralyttonia kesennumensis*, *Dicystoconcha lapparenti*, *Meekella nodosa*, *Orthothetina kayseri*, *Stenoscisma margaritovi*, *Martinia triquetra*, *Alispiriferella lita*, *Licharewina arakii* and *Dielasma* sp. Of these species, *Alispiriferella lita* is abundant; *Scacchinella gigantea* and *Neorichthofenia mabutii* are common; and the other species are rare (Table 1).

AGE AND CORRELATION

Kanokura Formation

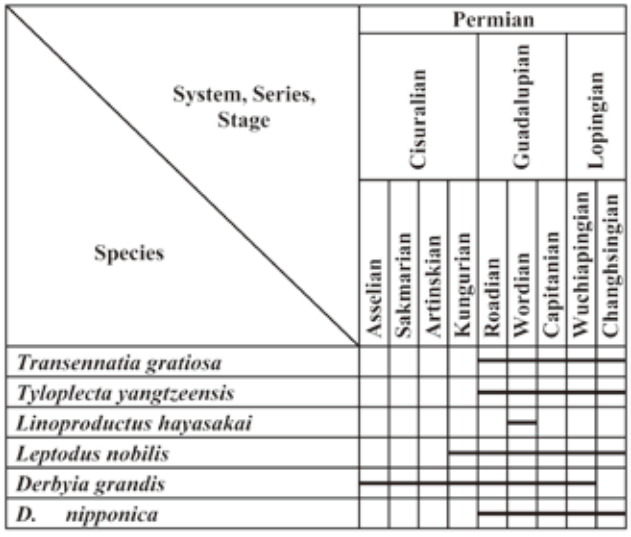

FIGURE 14. Stratigraphic distributions of brachiopod species of the KN1 assemblage in the Setamai area.

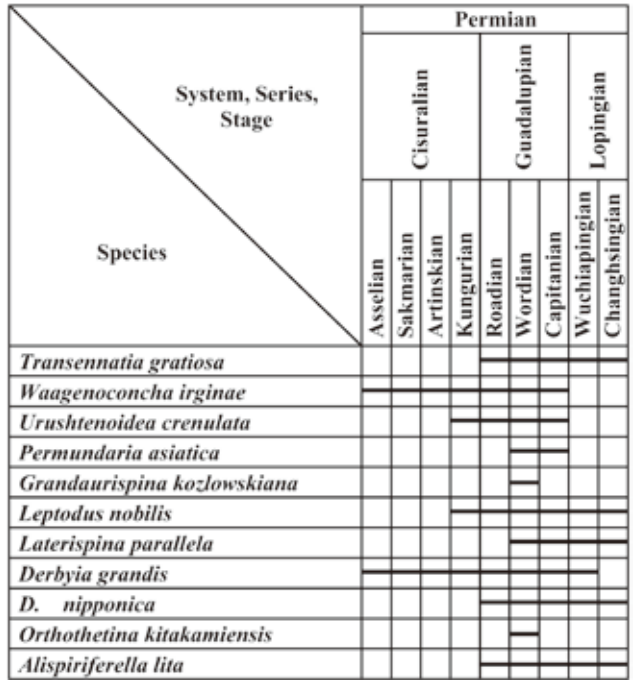

FIGURE 15. Stratigraphic distributions of brachiopod species of the KN2 assemblage in the Setamai fauna.

Lower part of the Kanokura Formation (KN1 Unit)

The stratigraphic distributions of the brachiopod species of the KN1 assemblage are described in the "Systematic descriptions" section of the present paper and summarised in Fig. 14. Of the brachiopods listed above, *Linoproductus hayasakai* is known only from the Wordian; *Transennatia gratiosa*, *Tyloplecta yangtzeensis* and *Derbyia nipponica* have a stratigraphic range of Roadian–Changhsingian; *Leptodus nobilis* is known from the Kungurian–Changhsingian; and *Derbyia grandis* ranges from the Asselian to the Wuchiapingian. To summarise, the age of the KN1 assemblage is identified as Wordian; thus, the uppermost part of the KN1 Unit is correlated with the Wordian. The age of the lower part of the KN1 Unit is unknown due to a lack of fossil evidence in the Setamai area. However, Tazawa and Shintani (2021) determined the age to be Kungurian on the basis of a brachiopod fauna called "the Tashiroyama fauna" (which includes *Transennatia insculpta*, *Dicystoconcha lapparenti* and *Crenispirifer sagus*), collected from near the base of the KN1 Unit of the Kanokura Formation in the Nagaiwa–Sakamotozawa area, about 10 km east of Setamai. Therefore, the age of the lower part of the Kanokura Formation (KN1 Unit) can be identified as Kungurian–Wordian.

Middle part of the Kanokura Formation (KN2 Unit)

The stratigraphic distributions of the brachiopod species of the KN2 assemblage are described in the "Systematic descriptions" section of the present paper and summarised in Fig. 15. Of the brachiopods listed above, *Grandaurispina kozlowskiana* and *Orthothetina kitakamiensis* are known only from the Wordian; *Permundaria asiatica* is known from the Wordian–Capitanian; *Urushtenoidea crenulata* has a stratigraphic range of Kungurian–Capitanian; *Transennatia gratiosa* is known from the Roadian–Changhsingian; *Laterispina parallela* is known from the Wordian–Changhsingian; and *Transennatia gratiosa*, *Derbyia nipponica* and *Alispiriferella lita* have a stratigraphic range of Roadian–Changhsingian. *Waagenoconcha irginae*, *Leptodus nobilis* and *Derbyia grandis* are long-ranging species. In summary, the age of the KN2 assemblage is identified as Wordian; thus, the middle part (KN2 Unit) of the Kanokura Formation is correlated with the Wordian.

Upper part of the Kanokura Formation (KN3 Unit)

In this study, no brachiopods are described from the upper part of the Kanokura Formation (KN3 Unit) in the Setamai area. However, Minato et al. (1978) correlated the Iwaizaki Stage (= upper Kanokura Formation) to the upper Maokou Limestone of South China based on fusulines *(Lepidolina multiseptata* and *L. minatoi*) described by Choi (1973). The upper Maokouan is correlated with the Capitanian (Jin et al., 1997); thus, the upper part of the Kanokura Formation (KN3 Unit) can be correlated with the Capitanian.

Hosoo Formation

The HO assemblage, from the upper part of the Hosoo Formation, consists of only two species (*Poikilosakos kamiyassensis* and *Martinia semiplana*) and is inadequate for age determination. Instead, Tazawa and Nakamura (2015)

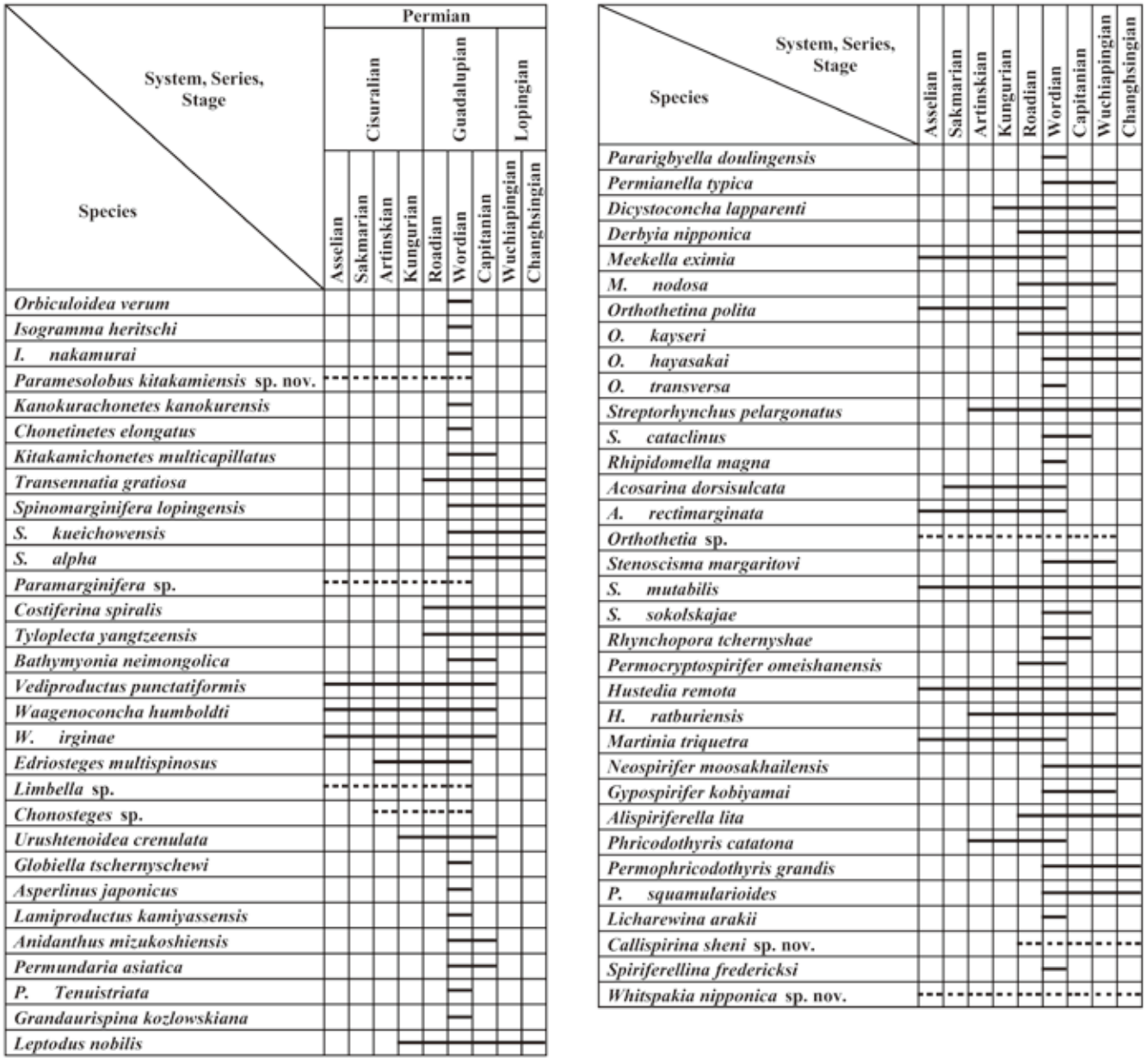

FIGURE 16. Stratigraphic distributions of brachiopod species of the KY1 (KI) assemblage in the Kamiyasse–Imo area. Broken lines show those of genera.

determined the age of the lower part of the Hosoo Formation as Kungurian on the basis of a brachiopod fauna, the "Nakadaira Fauna" (including *Kunlunia grabaui*, *Chaoiella taiyuanfuensis*, *Juresania juresanensis*, *Orthothetina curvata* and *Orthotichia jiangxiensis*) from Nakadaira, about 4 km north of Kamiyasse. Ehiro and Misaki (2005) correlated the middle and upper parts of the Hosoo Formation with the Roadian and Wordian, respectively, on the basis of ammonoids. The Roadian–Wordian boundary lies slightly above the brachiopod fossil horizon (KF212). According to Ehiro and Misaki (2005), the middle part of the Hosoo Formation yields *Agathiceras* sp., *Agathiceras*? sp., *Adrianites* sp., *Demarezites* sp. and *Demarezites*? sp., and the upper part of the Hosoo Formation yields *Agathiceras* sp., *Cardiella* sp., *Tauroceras*? sp., *Parastacheoceras bidentatus*, *Waagenoceras* sp. and *Paraceltites elegans*. To summarise, the Hosoo Formation can be correlated with the Kungurian–Wordian; and the fossil horizon (KF212) is assigned to the Roadian.

Kamiyasse Formation

Lower part of the Kamiyasse Formation

The stratigraphic distributions of the brachiopod species of the KY1 (KI) and KY1 (MT) assemblages are described in the "Systematic descriptions" section of the present paper and summarised in Fig. 16. Of the brachiopods listed above, *Orbiculoidea verum*, *Isogramma heritschi*, *I. nakamurai*, *Kanokurachonetes kanokurensis*, *Chonetinetes elongatus*, *Globiella tschernyschewi*, *Asperlinus japonicus*, *Lamiproductus kamiyassensis*, *Permundaria tenuistriata*, *Grandaurispina kozlowskiana*, *Pararigbyella doulingensis*, *Orthothetina transversa*, *Rhipidomella magna*, *Licharewina arakii* and *Spiriferellina fredericksi* are known only from the Wordian; *Kitakamichonetes multicapillatus*, *Bathymyonia neimongolica*, *Anidanthus mizukoshiensis*, *Permundaria asiatica*, *Streptorhynchus cataclinus*, *Stenoscisma sokolskajae* and *Rhynchopora tchernyshae* have a stratigraphic range of Wordian–Capitanian; *Permianella typica*, *Stenoscisma margaritovi* and *Gypospirifer kobiyamai* are known from the Wordian–Wuchiapingian; and *Spinomarginifera lopingensis*, *S. kueichowensis*, *S. alpha*, *Orthothetina hayasakai*, *Neospirifer moosakhailensis*, *Permophricodothyris grandis* and *P. squamularioides* range from the Wordian to the Changhsingian. In contrast, *Permocryptospirifer omeishanensis* is known from the Roadian–Wordian; *Edriosteges multispinosus* and *Phricodothyris catatona* have a stratigraphic range of Artinskian–Wordian; *Acosarina dorsisulcata* is known from the Sakmarian–Wordian; and *Meekella eximia*, *Orthothetina polita*, *Acosarina rectimarginata* and *Martinia triquetra* have been reported from Asselian–Wordian strata. In summary, the age of the KY1 (KI) assemblage is identified as Wordian; thus, the lower part of the Kamiyasse Formation (KY2 Unit) in the Kamiyasse–Imo area is correlated with the Wordian. This conclusion is consistent with that of Tazawa (2016b).

The stratigraphic distributions of the brachiopod species of the KY1 (MT) assemblage are described in the "Systematic descriptions" section of the present paper and summarised in Fig. 17. Of the brachiopods listed above, *Neochonetes* (*Huangichonetes*) *matsukawensis*, *Linoproductus hayasakai*, *Paralyttonia kesennumensis* and *Licharewina arakii* are known only from the Wordian; *Permundaria asiatica* and *P. tenuistriata* are known from the Wordian–Capitanian; and *Stenoscisma margaritovi* ranges from the Wordian to the Wuchiapingian. In contrast, *Petasmaia expansa* is known from the Artinskian–Wordian; *Capillomesolobus heritschi* has a stratigraphic range of Sakmarian–Wordian; and *Hexiproductus echidniformis*, *Costatumulus cancriniformis* and *Martinia triquetra* are known from the Kasimovian–Wordian. *Urushtenoidea crenulata* is known from the Kungurian–Capitanian; and two speecies (*Yakovlevia kaluzinensis* and *Dicystoconcha lapparenti*) are known from the Kungurian–Wuchiapingian. To summarise, the KY1 (MT) assemblage is identified as Wordian in age, so, the lower part of the Kamiyasse Formation (KY2 Unit) in the Matsukawa area is also correlated with the Wordian. This conclusion is consistent with the findings of Tazawa and Araki (2017, 2018).

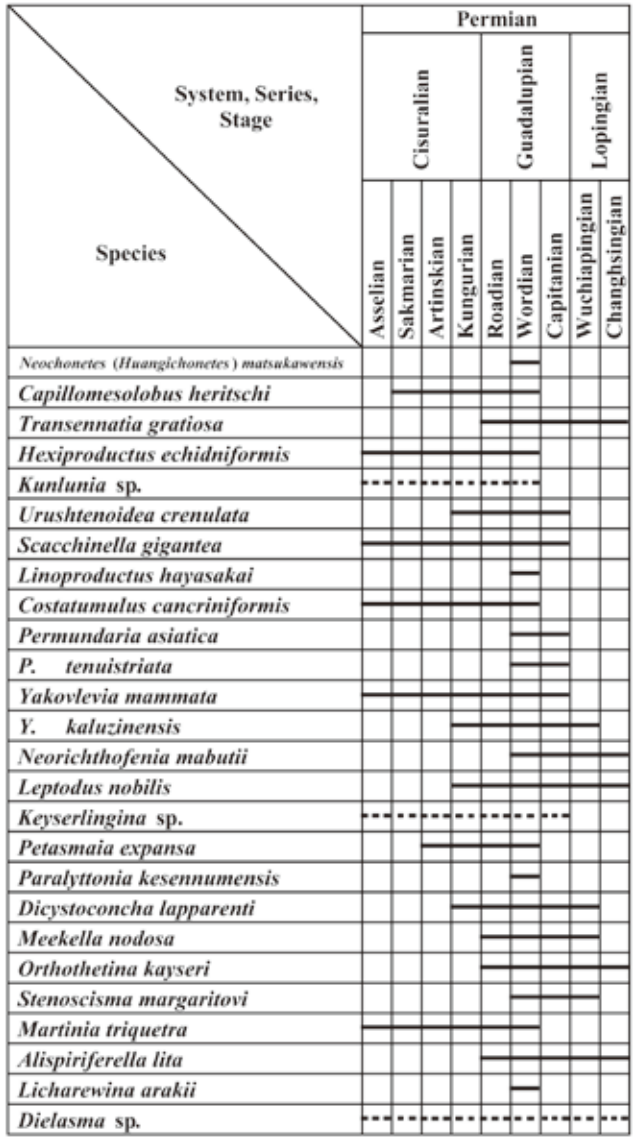

FIGURE 17. Stratigraphic distributions of brachiopod species of the KY1 (MT) assemblage in the Matsukawa area. Broken lines show those of genera.

Upper part of the Kamiyasse Formation

Only one species, *Waagenoconcha irginae*, a long-ranging (Asselian–Capitanian) species, was collected from the upper part of the Kamiyasse Formation (KY2 Unit) of the Kamiyasse–Imo and Matsukawa areas; thus, age determination of the upper part of the Kamiyasse Formation (KY2 Unit) is difficult on the basis of brachiopods. However, Tazawa (1976) correlated the upper part of the Kamiyasse

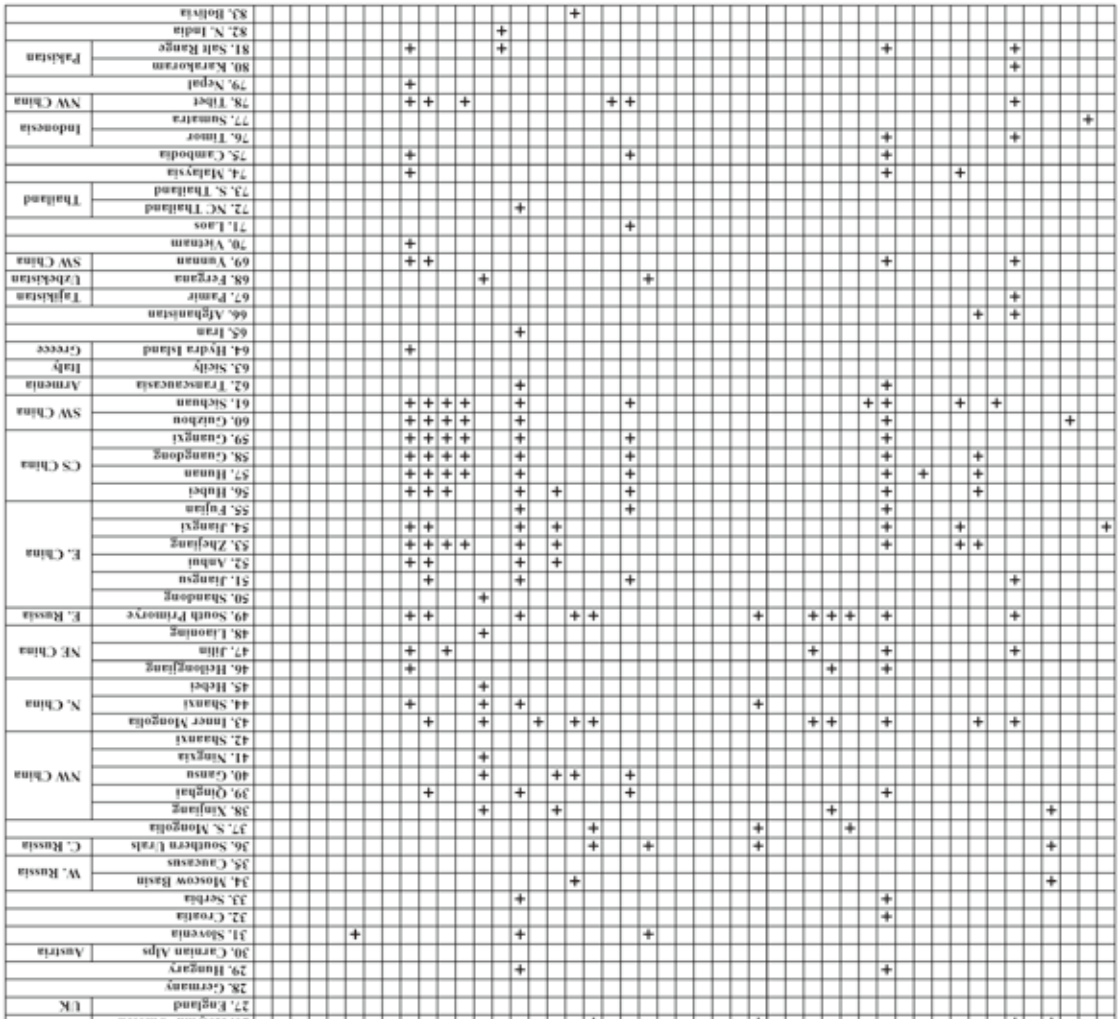

FIGURE 18 (1). Geographic distributions of brachiopod species of the KY1 (KI) and KY1 (MT) assemblages excluding three new species (*Paramesolobus kitakamiensis* sp. nov., *Callispirina sheni* sp. nov. and *Whitspakia nipponica* sp. nov.) and seven uncertain species (*Paramarginifera* sp., *Kunlunia* sp., *Limbella* sp., *Chonosteges* sp., *Keyserlingina* sp. *Orthothetina* sp. and *Dielasma* sp.).

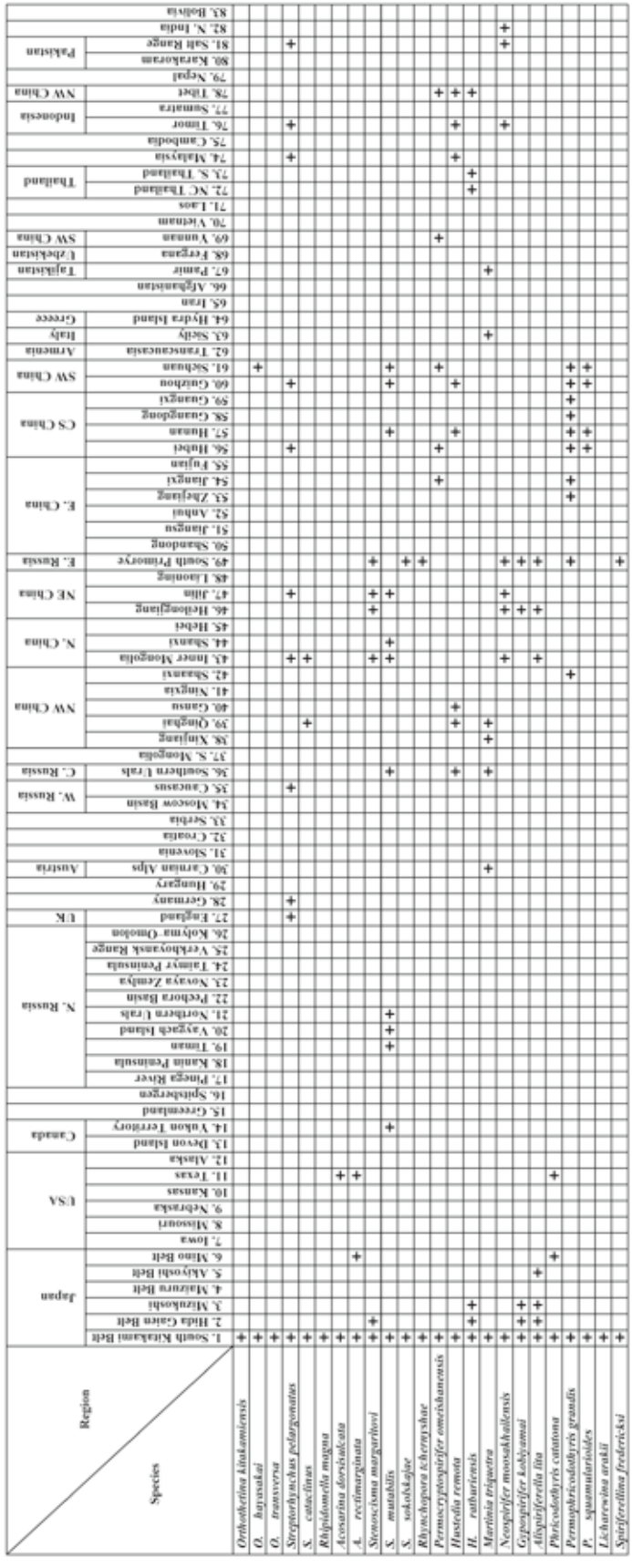

FIGURE 18 (2). Continue

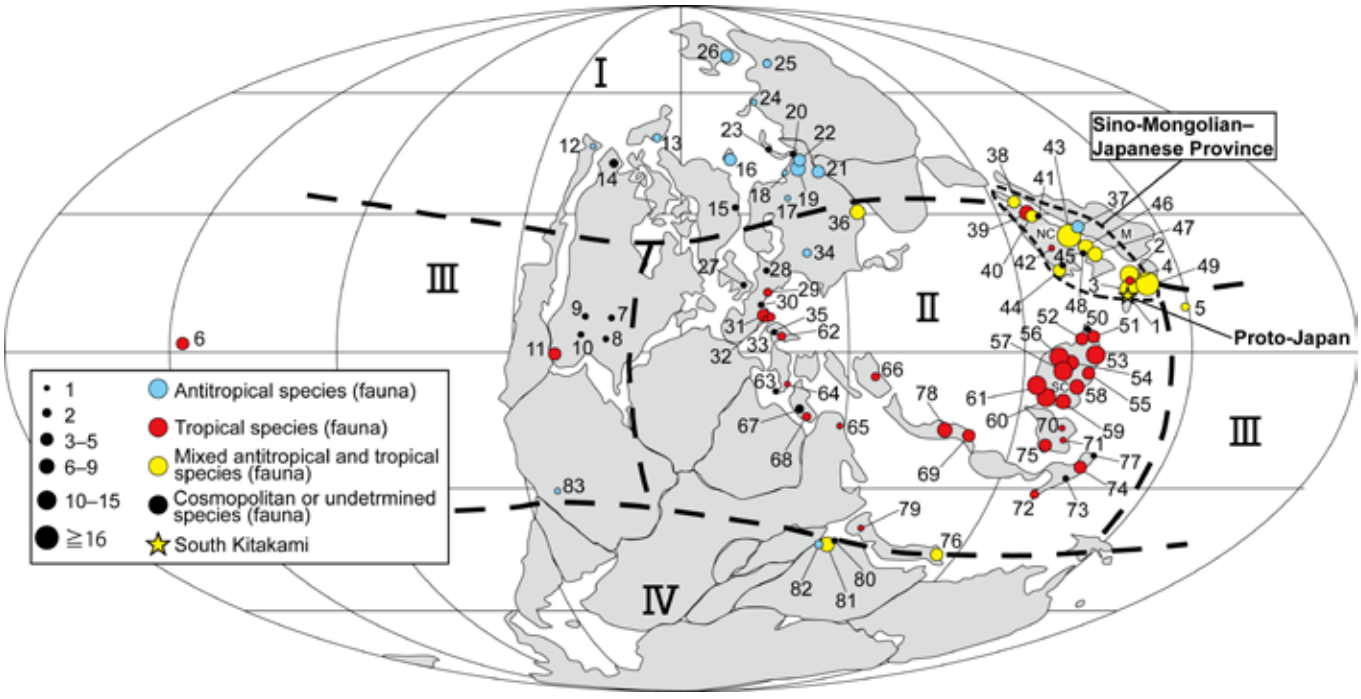

FIGURE 19. Middle Permian (Wordian) reconstruction map of the world (adapted from Scotese, 2004), showing the geographic distribution of brachiopod species of the KY1 (KI) and KY1 (MT) assemblages excluding three new species (*Paramesolobus kitakamiensis* sp. nov., *Callispirina sheni* sp. nov. and *Whitspakia nipponica* sp. nov.) and seven uncertain species (*Paramarginifera* sp., *Kunlunia* sp., *Limbella* sp., *Chonosteges* sp., *Keyserlingina* sp. *Orthothetina* sp. and *Dielasma* sp.). Location numbers are same in Fig.18, and the numbers appended to the circles in the legend indicate the species numbers, M: Mongolia, NC: North China, SC: South China, I: Boreal Realm, II : Tethyan Realm, III : Panthalassa Realm, IV : Gondwanan Realm.

Formation with the *Lepidolina multiseptata* Zone (= *Lepidolina multiseptata–L. minatoi* Zone of Minato et al., 1979) from the presence of *Lepidolina multiseptata*, *Verbeekina verbeeki* and *Codonofusiella explicata*. Ehiro and Araki (1997) considered the uppermost Kamiyasse Formation and the lowest Toyoma Formation (= Kurosawa Formation of Misaki and Ehiro, 2004) to be late Capitanian in age because of the occurrence of *Tainoceras carinatum*, *Tainoceras* sp., *Pleuronautilus* sp., *Stearoceras* sp., *Jilingites kesennumensis*, *Stacheoceras* sp., *Timorites takaizumii* and *Pseudagathiceras ornatum*. To summarise, the upper part of the Kamiyasse Formation can be correlated with the Capitanian.

PALAEOBIOGEOGRAPHY

The geographic distributions of the Wordian brachiopod species of the KN1, KN2, KY1 (KI) and KY1 (MT) assemblages are documented in the "Systematic descriptions" section and are summarised in Figs. 18 and 19. Of the 72 species (excluding three new species and six uncertain species) of the Wordian brachiopods, 19 species also occur in eastern Russia (South Primorye); 16 species also occur in northern China (Inner Mongolia); 15 species also occur in southwestern China (Sichuan); 13 species are found in central-southern China (Hunan); and 12 species are found in central Japan (Hida Gaien Belt), central-southern China (Hubei) and southwestern China (Guizhou). The Wordian brachiopod faunas of the South Kitakami Belt, South Primorye, Inner Mongolia and the Hida Gaien Belt include both antitropical (*Waagenoconcha*, *Costatumulus*, *Grandaurispina*, *Yakovlevia*, *Rhynchopora*, *Neospirifer*, *Gypospirifer* and *Alispiriferella*) and tropical (*Transennatia*, *Spinomarginifera*, *Tyloplecta*, *Leptodus*, *Pararigbyella*, *Permianella*, *Dicystoconcha*, *Permocryptospirifer* and *Permophricodothyris*) genera; in contrast, the Wordian brachiopod faunas of Hubei, Hunan, Guizhou and Sichuan lack antitropical genera. To summarise, the Wordian brachiopod fauna, consisting of the KN1, KN2, KY1 (KI) and KY1 (MT assemblages, is a mixed Boreal–Tethyan fauna and exhibits affinities with those of northern China (Inner Mongolia), eastern Russia (South Primorye) and central Japan (Hida Gaien Belt). This conclusion is consistent with the previous works on the Wordian brachiopod faunas of Setamai (Tazawa and Ibaraki, 2001), Kamiyasse–Imo (Tazawa, 2016b), Matsukawa (Tazawa and Araki, 2017, 2018), Obama (Tazawa, 2003) and Yakejima (Tazawa et al., 2000) in the South Kitakami Belt.

From the information provided above, we can conclude

that the Wordian brachiopod fauna of the South Kitakami Belt is characterised by a mixture of both Boreal and Tethyan elements and belonged to the Sino-Mongolian–Japanese Province (Shi and Tazawa, 2001; Shen et al., 2009) between the Boreal and Tethyan realms in mid-latitudes of the Northern Hemisphere (Fig. 19). The South Kitakami region was probably located near and to the east of the North China Block at the eastern end of the Central Asian Orogenic Belt during the Wordian. This conclusion is consistent with earlier studies of the Wordian brachiopod biogeography of eastern Asia (Tazawa, 1991, 1992, 1998, 2002, 2007; Shi, 2006) and globally (Shen et al., 2009), and with the bipolar distribution of the Wordian antitropical fusulinoidean genus *Monodiexodina* (Ueno, 2006). Excluding the Permian brachiopod and fusuline palaeobiogeography, Li and Takeuchi (2022) supported the above-mentioned Permian reconstruction of the South Kitakami region and east Asia, including the North China Block, based on U-Pb dating of detrital zircon from Permian successions of the South Kitakami Belt.

CONCLUSIONS

In this study, middle Permian (Guadalupian; Roadian–Capitanian, mostly Wordian) brachiopods are described from the Kanokura, Hosoo and Kamiyasse Formations in the Setamai, Kamiyasse–Imo and Matsukawa areas of the central part of the South Kitakami Belt (southern Kitakami Mountains), northerastern Japan. A total of 83 species in 64 genera are described, of which three are new (*Paramesolobus kitakamiensis* sp. nov., *Callispirina sheni* sp. nov. and *Whitspakia nippponica* sp. nov.). In terms of biostratigraphy, the lower (KN1 Unit) and middle (KN2 Unit) parts of the Kanokura Formation and the lower part (KY1 Unit) of the Kamiyasse Formation are correlated with the Wordian. Palaeobiogeographically, the Wordian brachiopod fauna, including the KN1, KN2, KY1 (KI) and KY1 (MK) assemblages, is a mixed Boreal–Tethyan fauna and exhibits affinities with those of northern China (Inner Mongolia), eastern Russia (South Primorye) and central Japan (the Hida Gaien Belt). Thus, the South Kitakami region belonged to the Sino-Mongolian–Japanese Province (Shi and Tazawa, 2001; Shen et al., 2009) between the Boreal and Tethyan realms in the Northern Hemisphere. This region was probably a shallow sea bordering the Proto-Japan Block (microcontinent), which was located near and to the east of the North China Block at the eastern end of the Central Asian Orogenic Belt during the Wordian.

SYSTEMATIC DESCRIPTIONS
(by J. Tazawa)

The suprageneric classification given herein mainly follows that of "Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volumes 2–6", edited by Kaesler (2000a, 2000b, 2002, 2006) and Selden (2007), with exception that classification of the suborder Productidina follows Waterhouse (2002).

Order LINGULIDA Waagen, 1885
Superfamily DISCINOIDEA Gray, 1840
Family DISCINIDAE Gray, 1840
Genus *ORBICULOIDEA* d'Orbigny, 1847

Type species.—*Orbicula forbessi* Davidson, 1848.

Orbiculoidea verum Masunaga and Shiino, 2021
(Fig. 20A)

Orbiculoidea sp. Hayasaka, 1963b, p. 479, fig. 1.
Orbiculoidea jangarensis Ustritsky. Tazawa and Araki, 2013, p. 4, fig. 2.1.
Orbiculoidea verum Masunaga and Shiino, 2021, p. 262, figs. 4–8.

Material.— One specimen from locality AR3, external mould of a ventral valve, KCG7.

Remarks.—This specimen was previously described by Tazawa and Araki (2013, p. 4, fig. 2.1) as *Orbiculoidea jangarensis* Ustritsky, 1960 from the lower part of the Kanokura Formation (= Kamiyasse Formation) of Kamiyasse in the Kamiyasse–Imo area. Subsequently, Masunaga and Shiino (2021, p. 262, figs. 4–8) redescribed the specimen, together with newly added 95 specimens from the upper part of the Hosoo Formation at Minamizawa and Shigejisawa valleys in Kamiyasse, as *Orbiculoidea verum* Masunaga and Shiino, 2021. This species resembles well *Orbiculoidea jangarensis* Ustritsky, 1960 in size, shape and external ornament of ventral valve, but differs in having a posterior-sited apex in dorsal valve.

Occurrence.—KY1 Unit in Kamiyasse (locality AR3).

Distribution.— Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Order DICTYONELLIDA Cooper, 1956
Superfamily EICHWALDIOIDEA Schuchert, 1893
Family ISOGRAMMIDAE Schuchert, 1929
Genus *ISOGRAMMA* Meek and Worthen, 1870

Type species.—*Chonetes*? *millepunctatus* Meek and Worthen, 1870.

Isogramma heritschi Nakamura, 1970
(Fig. 20B–D)

Isogramma heritschi Nakamura, 1970, p. 308, pl. 4, figs. 3–7; Minato et al., 1979, pl. 57, figs. 2–4, 6; Tazawa et al., 2014, p. 378, fig. 2.4; Tazawa, 2015, p. 63, fig. 6.4.

Material.—Five specimens from locality KF217: (1)

external moulds of two ventral valves, UHR19043, 19044; (2) external and internal moulds of a dorsal valve, UHR19045 (holotype); (3) external mould of a dorsal valve, UHR19047; and (4) internal mould of a dorsal valve, UHR19046.

Remarks.—These specimens were described by Nakamura (1970, p. 308, pl. 4, figs. 3–7) as *Isogramma heritschi* Nakamura, 1970. This species is a middle-sized *Isogramma* (length 25 mm, width 53 mm in the holotype), with external ornament consisting of numerous fine concentric growth lines (numbering 5–7 in 1 mm in dorsal valve) and some rugae parallel to postero-lateral margins of shell. *Isogramma manchoukuoensis* Hatai and Omura (1941, p. 7, pl. 2, figs. 5–11, text-fig. 1), from the Penchi Formation of Liaoning, northeastern China, differs from *I. heritschi* in its smaller size and less-transverse outline. *Isogramma paotechowensis* (Grabau and Chao in Chao, 1928), originally described by Chao (1928, p. 33, pl. 1, fig. 27; pl. 4, figs. 1–5) as *Aulacorhynchus paotechowensis* Grabau and Chao in Chao, 1928 from the Taiyuan Formation of Shanxi, northern China, differs from the present species by its much larger dimensions. *Isogramma concavum* Cooper and Grant (1974, p. 252, pl. 25, figs. 16, 17), from the Neal Ranch Formation of Texas in the USA, resembles the present species in size and outline, but differs in having deeply concave dorsal valve.

Occurrence.—KY1 Unit in Imo (locality KF217).

Distriburion.—Wordian: northeastern Japan (Kamiyasse–Imo and Hitachi in the South Kitakami Belt).

Isogramma nakamurai Tazawa, 2016a
(Fig. 21A–C)

Isogramma paotechowensis (Grabau and Chao). Minato, 1955, p. 29, text-fig. 1; Nakamura, 1970, p. 306, pl. 3, figs. 1, 2; pl. 4, figs. 1, 2; Minato et al., 1979, pl. 57, figs. 1, 5.

Isogramma aff. *paotechowensis* (Grabau and Chao). Chen and Shi, 2006b, p. 416, fig. 3.

Isogramma nakamurai Tazawa, 2016a, p. 82, figs. 3, 4.

Material.—Four specimens from locality KF217: (1) external and internal moulds of a dorsal valve, UHR19040 (holotype); (2) external and internal moulds of two dorsal valves, UHR19041, 19042; and (3) external mould of a dorsal valve, NU-B1657.

Remarks.—These specimens were previously described by Tazawa (2016a, p. 82, figs. 3, 4) as *Isogramma nakamurai* Tazawa, 2016a. This species is characterized by its large size (length 58 mm, width about 130 mm in the holotype, UHR19040) and external ornament consisting of numerous fine elevated and slightly undulated concentric growth lines. *Isogramma paotechowensis* (Grabau and Chao in Chao, 1928), from the Taiyuan Formation of Shanxi, northern China, differs from *I. nakamurai* by its smaller size and in having more regular concentric growth lines on both ventral and dorsal valves. *Isogramma renfrarum* Cooper (1952, p. 114, pl. 21, figs. 1–3; pl. 22, fig 1; pl. 23, fig. 1), from the Pennsylvanian Gonzales Shale of north-central Texas, is also a large-sized species of *Isogramma*, but the Texan species differs from *I. nakamurai* in its more transverse outline and in having more regular and coarser growth lines on dorsal valve. The type species, *Isogramma millepunctata* (Meek and Worthen, 1870, p. 566, pl. 25, fig. 3), from the Pennsylvanian of Illinois, is readily distinguished from the present species by its much smaller size and more regular and coarser growth lines on both valves.

Occurrence.—KY1 Unit in Imo (locality KF217).

Distribution.—Wordian: northeastern Japan (Kamiyasse-Imo in the South Kitakami Belt).

Order PRODUCTIDA Sarytcheva and Sokolskaya, 1959
Suborder CHONETIDINA Muir-Wood, 1955
Superfamily CHONETOIDEA Bronn, 1862
Family RUGOSOCHONETIDAE Muir-Wood, 1962
Subfamily RUGOSOCHONETINAE Muir-Wood, 1962
Genus *NEOCHONETES* Muir-Wood, 1962
Subgenus *NEOCHONETES* (*HUANANGICHONETES*) Shen and Archbold, 2002

Type species.—*Chonetes substrophomenoides* Huang, 1932.

Neochonetes (*Huangichonetes*) *matsukawensis* Tazawa and Araki, 2018
(Fig. 22A)

Neochonetes (*Huangichonetes*) *matsukawensis* Tazawa and Araki, 2018, p. 12, fig. 4.1.

Material.—One specimen from locality AR4, external and internal moulds of a ventral valve, KCG61 (holotype).

Remarks.—This specimen was described by Tazawa and Araki (2018, p. 12, fig. 4.1) as *Neochonetes* (*Huangichonetes*) *matsukawensis* Tazawa and Araki, 2018. The specimen from the lower Kamiyasse Formation of Matsukawa is large in size for genus, transverse in outline (length 8 mm, width 13 mm), and having numerous costellae on ventral valve, numbering 56 near anterior margin of ventral valve. *Neochonetes* (*Huangichonetes*) *matsukawensis* is most similar to the type species, *Neochonetes* (*Hunagichonetes*) *substrophomenoides* (Huang, 1932), redescribed by Shen and Archbold (2002, p. 337, fig. 5E–M) from the Lopingian of Hunan and Guizhou, southern China, in shape and external ornament of ventral valve, but differs from the Chinese species in its larger size and much transverse outline.

Occurrence.—KY1 Unit in Matsukawa (locality AR4).

Distribution.—Wordian: northeastern Japan (Matsukawa in the South Kitakami Belt).

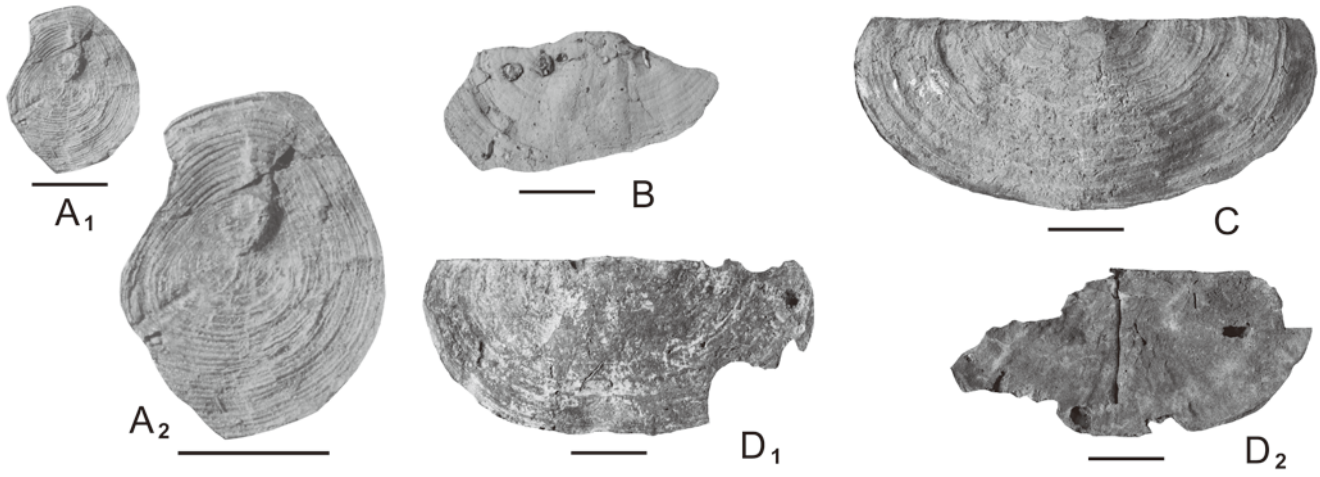

FIGURE 20. **A**, *Orbiculoidea verum* Masunaga and Shiino, external mould (A_1, A_2) of ventral valve, KCG7; **B**–**D**, *Isogramma heritschi* Nakamura; B, external cast of ventral valve, UHR19043; C, external mould of dorsal valve, UHR19047; D, external mould (D_1) and internal mould (D_2) of dorsal valve, UHR19045 (holotype). Scale bars are 1 cm.

Genus *PARAMESOLOBUS* Afanasjeva, 1975

Type species.—*Paramesolobus ivanovae* Afanasjeva, 1975.

Paramesolobus kitakamiensis Tazawa, sp. nov.
(Fig. 22E–H)

Chonetes sinuosa Schellwien. Hayasaka, 1925a, p. 93, pl. 5, figs. 5, 6.
Mesolobus sinuosa (Schellwien). Tazawa, 1976, pl. 2, fig. 12; Minato et al., 1979, pl. 61, figs. 4–6.

Etymology.—Named after the fossil locality, Kitakami Mountains.

Material.—Eight specimens from localities KF79 and KF217: (1) external and internal moulds of a ventral valve, NU-B2457; (2) external mould of a ventral valve, NU-B2458; (3) internal moulds of two ventral valves, NU-B2459, 2460; (4) external and internal moulds of three dorsal valves, NU-B2461, 2462 (holotype), 2463; and (5) external mould of a dorsal valve, NU-B2464.

Diagnosis.—Large-sized *Paramesolobus* with relatively fine capillae on both ventral and dorsal valves.

Description.—Shell large in size for genus, transversely subrectangular in outline, with greatest width at slightly anterior to hinge; length 16 mm, width 28 mm in the largest dorsal valve specimen (NU-B2464). Ventral valve moderately convex in lateral profile; hinge straight, with two spines preserved on one side; umbo small; ears small, flat to slightly convex, not clearly demarcated from visceral region; sulcus wide and shallow, with a narrow rounded median lobe. Dorsal valve moderately concave in lateral profile; fold broad and low, having a narrow median sulcus, External surface of ventral valve ornamented with numerous bifurcating capillae, numbering 8 –9 in 2 mm at about midlenth of valve. External ornament of dorsal valve similar to those of ventral valve. Internally, ventral valve with short median septum posteriorly one fourth valve length. Dorsal valve with short diverging lateral septa and a long median septum, extending to two-thirds valve length; cardinal process ill preserved. Internal shell surface with radial rows of papillae; anterior margin capillate.

Remarks.—Of these specimens from Kamiyasse–Imo, the largest one (NUB2464) was previously figured by Tazawa (1976, pl. 2, fig. 12) and Minato et al. (1979, pl. 61, fig. 4) as *Mesolobus sinuosa* (Schellwien). However, the genus *Mesolobus* Dunbar and Condra, 1932 differs from the genus *Paramesolobus* Afanasjeva, 1975 in having lamellose external ornament; and *Capillomesolobus sinuosa* (Schellwien, 1900b), from the Trogkofel Limestone of the Carnian Alps, differs from the Kitakami species in being much smaller size and in having finer capillae on both valves. All the specimens including the largest one can be safely assigned to the genus *Paramesolobus* by large size, external ornament consisting of numerous bifurcating and relatively coarse capillae, and in having a ventral sulcus with a median lobe and a dorsal fold with a median sulcus. *Paramesolobus kitakamiensis* sp. nov. is distinguished from the type species, *Paramesolobus ivanovae* Afanasjeva (1975, p. 102, fig. 4), from the upper Carboniferous (Kasimovian) of the Russian Platform, by its larger size and in having finer capillae on ventral valve. Shells, described by Chao (1928, p. 22, pl. 1,

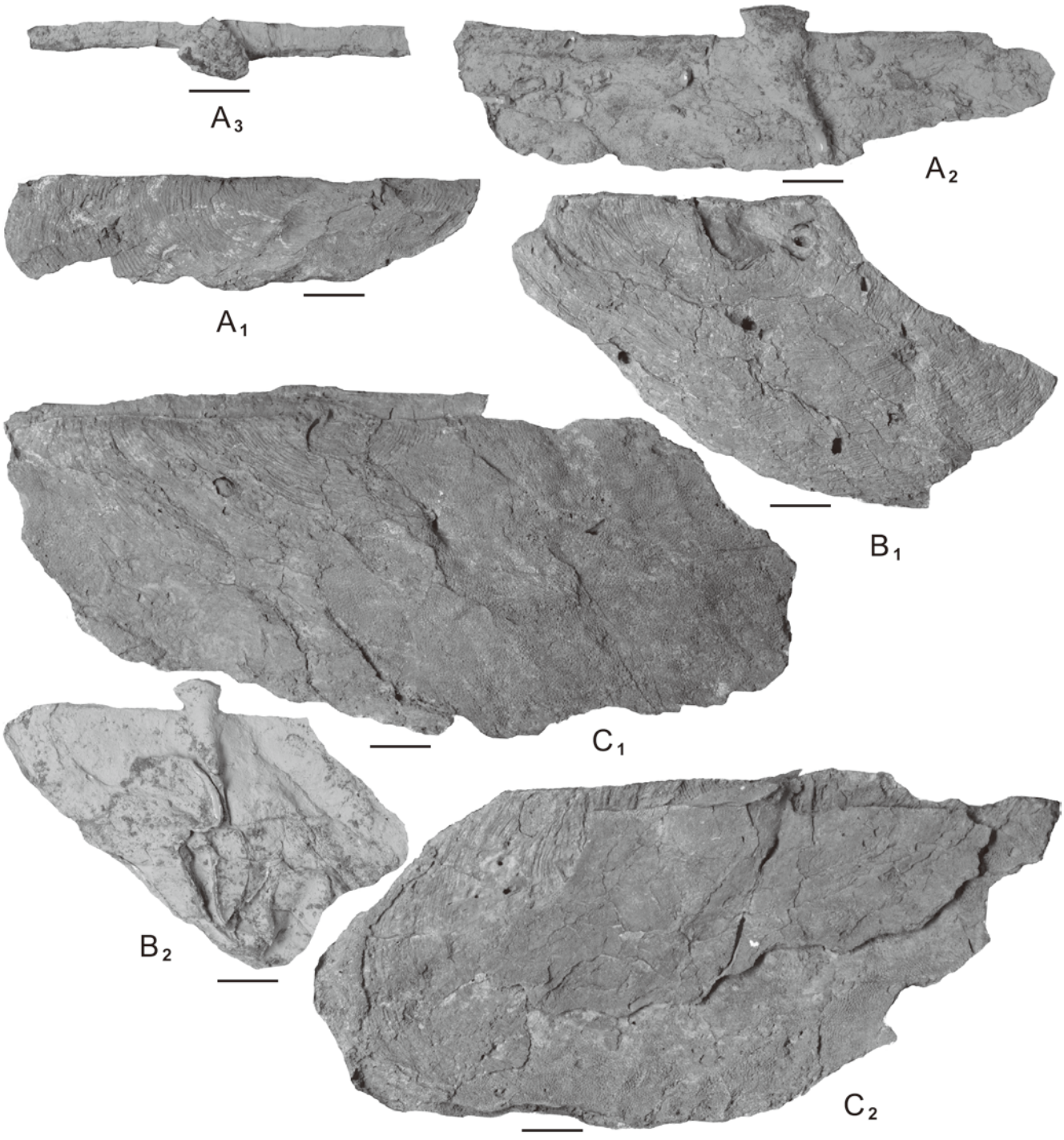

FIGURE 21. **A–C**, *Isogramma nakamurai* Tazawa; A, external mould (A_1), internal latex cast (A_2) and posterior view (A_3) of internal latex cast of dorsal valve, UHR19041; B, external mould (B_1) and internal latex cast (B_2) of dorsal valve, UHR19042; C, external mould (C_1) and internal Mould (C_2) of dorsal valve, UHR19040 (holotype). Scale bars are 1 cm.

figs. 23–25; pl. 2, figs. 3–12; pl. 4, fig. 7) as *Chonetes latesinuata* Schellwien, 1892, from the Taiyuan Series of northern China, differs from *Paramesolobus kitakamiensis* in having coarser capillae on both ventral and dorsal valves.

Occurrence.—KY1 Unit in Kamiyasse (locality KF79) and Imo (locality KF217).

Genus *KANOKURACHONETES* Afanasjeva and Tazawa, 2010

Type species.—*Kanokurachonetes kanokurensis* Afanasjava and Tazawa, 2010.

Kanokurachonetes kanokurensis Afanasjava and Tazawa, 2010
(Fig. 22B–D)

Kanokurachonetes kanokurensis Afanasjava and Tazawa, 2010, p. 19, pl. 2, figs. 1–10.

Material.—Five specimens from localities KF39 and KF55: (1) internal mould of a ventral valve, PIN5213/1 (holotype); and (2) external moulds of four dorsal valves, PIN5213/10, 5213/11, NU-B2455, 2456.

Remarks.—Of the specimens listed above, three (PIN5213/1, PIN5213/10 and PIN5213/11) from the locality KF55 were previously described by Afanasjeva and Tazawa (2010, p. 19, pl. 2, figs. 1–10) as *Kanokurachonetes kanokurensis* Afanasjava and Tazawa, 2010. The two (NU-B2455 and NU-B2456) from the locality KF39 are also referred to this species in size, shape and external ornament of dorsal valves. The diagnosis of the genus *Kanokurachonetes* is as follows (after Afanasjeva and Tazawa, 2010, p. 18–19): Shell medium in size, semicircular in outline and relatively concavoconvex; sulcus and fold well developed; cardinal spines inclined to cardinal margins at angle of 45–50°; Ventral interarea apsacline and dorsal area orthocline; external radial ornamentation composed of a few bifurcated costellae on entire surface of valves; microornamentation represented by concentric rows of densely spaced ovate papillae. Inside ventral valve, median septum spanning one-third of valve length; diductor scars large, bifid; inside dorsal valve, cardinal process relatively low, with basal alveolus; socket ridges massive; weak median septum only developed in middle of valve; lateral septa hardly visible; brachial ridges absent; thin accessory septa extending from alveolus to anterior margin; beyond these structures, internal structures of both valves covered with small, rounded, irregularly arranged papillae. No other species has been known besides the type species.

Occurrence.—KY1 Unit in Kamiyasse (localities KF39 and KF55).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Subfamily CAPILLOMESOLOBINAE Pečar, 1986
Genus *CAPILLOMESOLOBUS* Pečar, 1986

Type species.—*Capillomesolobus karavankensis* Pečar, 1986.

Capillomesolobus heritschi Pečar, 1986
(Fig. 22I)

Chonetes sinuosa Schellwien, 1900b, p. 38, pl. 9, figs. 17, 18; Hayasaka, 1925a, p. 93, pl. 5, figs. 5, 6.
Chonetes sp. Heritsch, 1938, p. 103, pl. 7, figs. 6, 7.
Mesolobus mesolobus (Norwood and Pratten). Nakamura, 1959a, p. 205, pl. 2, figs. 2, 3; Minato et al., 1979, pl. 46, fig. 11.
Mesolobus sp. Tazawa, 1979, p. 25, pl. 4, fig. 2.
Mesolobus sinuosus (Schellwien). Minato et al., 1979, pl. 61, figs. 4–6.
Capillomesolobus heritschi Pečar, 1986, p. 28, pl. 3, figs. 1–9, text-fig. 11; Tazawa and Nakamura, 2015, p. 159, fig. 4.1–4.3; Tazawa and Araki, 2017, p. 269, fig. 6.1.

Material.—One specimen from locality AR5, external and internal moulds of a ventral valve, IGPS96237.

Remarks.—This specimen was previously described by Tazawa (1979, p. 25, pl. 4, fig. 2) as *Mesolobus* sp. Tazawa, 1979, and subsequently redescribed by Tazawa and Araki (2017, p. 269, fig. 6.1) as *Capillomesolobus heritschi* Pečar, 1986. The Matsukawa species can be referred to *Capillomesolobus heritschi* Pečar (1986, p. 28, pl. 3, figs. 1–9, text-fig. 11), from the Trogkofel Limestone of the Karavanke Mountains, Slovenia, in its small size (length about 10 mm, width about 12 mm) and in having deep ventral sulcus with a median lobe and numerous capillae (numbering 13–14 in 2 mm at midlength) on external surface of ventral valve. Comparison with the other species of *Capillomesolobus* has been discussed by Tazawa and Nakamura (2015, p. 161).

Occurrence.—KY1 Unit in Matsukawa (locality AR5).

Distribution. — Sakmarian–Wordian: northeastern Japan (Nakadaira and Matsukawa in the South Kitakami Belt) and Slovenia (Karavanke Mountains).

Subfamily SVALBARDIINAE Archbold, 1982
Genus *CHONETINETES* Cooper and Grant, 1969

Type species.—*Chonetinetes reversus* Cooper and Grant, 1969.

Chonetinetes elongatus Afanasjeva, Tazawa and Shintani, 2015
(Fig. 22J)

Chonetinetes elongatus Afanasjeva, Tazawa and Shintani, 2015, p. 24, pl. 4, figs. 1–3.

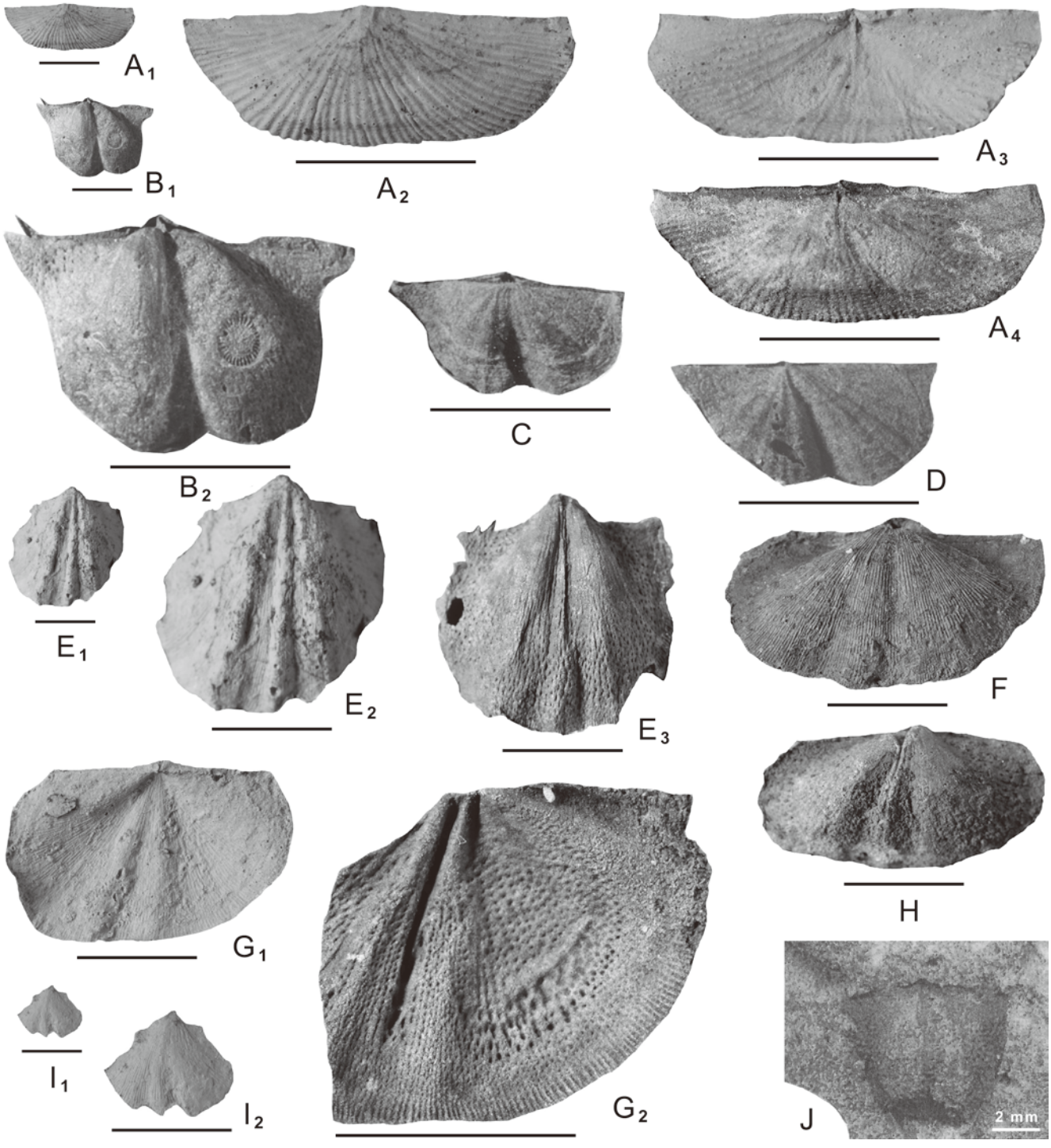

FIGURE 22. **A**, *Neochonetes* (*Huangichonetes*) *matsukawensis* Tazawa and Araki, external latex cast (A_1, A_2), internal latex cast (A_3) and internal mould (A_4) of ventral valve, KCG61 (holotype); **B–D**, *Kanokurachonetes kanokurensis* Afanasjeva and Tazawa; B, internal mould (B_1, B_2) of ventral valve, PIN5313/1 (holotype); C, external mould of dorsal valve, PIN5313/10; D, external mould of dorsal valve, PIN5313/11: **E–H**, *Paramesolobus kitakamiensis* sp. nov.; E, external latex cast (E_1, E_2) and internal mould (E_3) of ventral valve, NU-B2457; F, external mould of dorsal valve, NU-B2464; G, external latex cast (G_1) and internal mould (G_2) of dorsal valve, NU-B2462 (holotype); H, internal mould of ventral valve, NU-B2460; **I**, *Capillomesolobus heritschi* Pečar, external latex cast (I_1, I_2) of ventral valve, IGPS96237; **J**, *Chonetinetes elongatus* Afanasjeva, Tazawa and Shintani, internal mould of ventral valve, NU-B1834 (holotype). Scale bars are 1 cm, except for that of J.

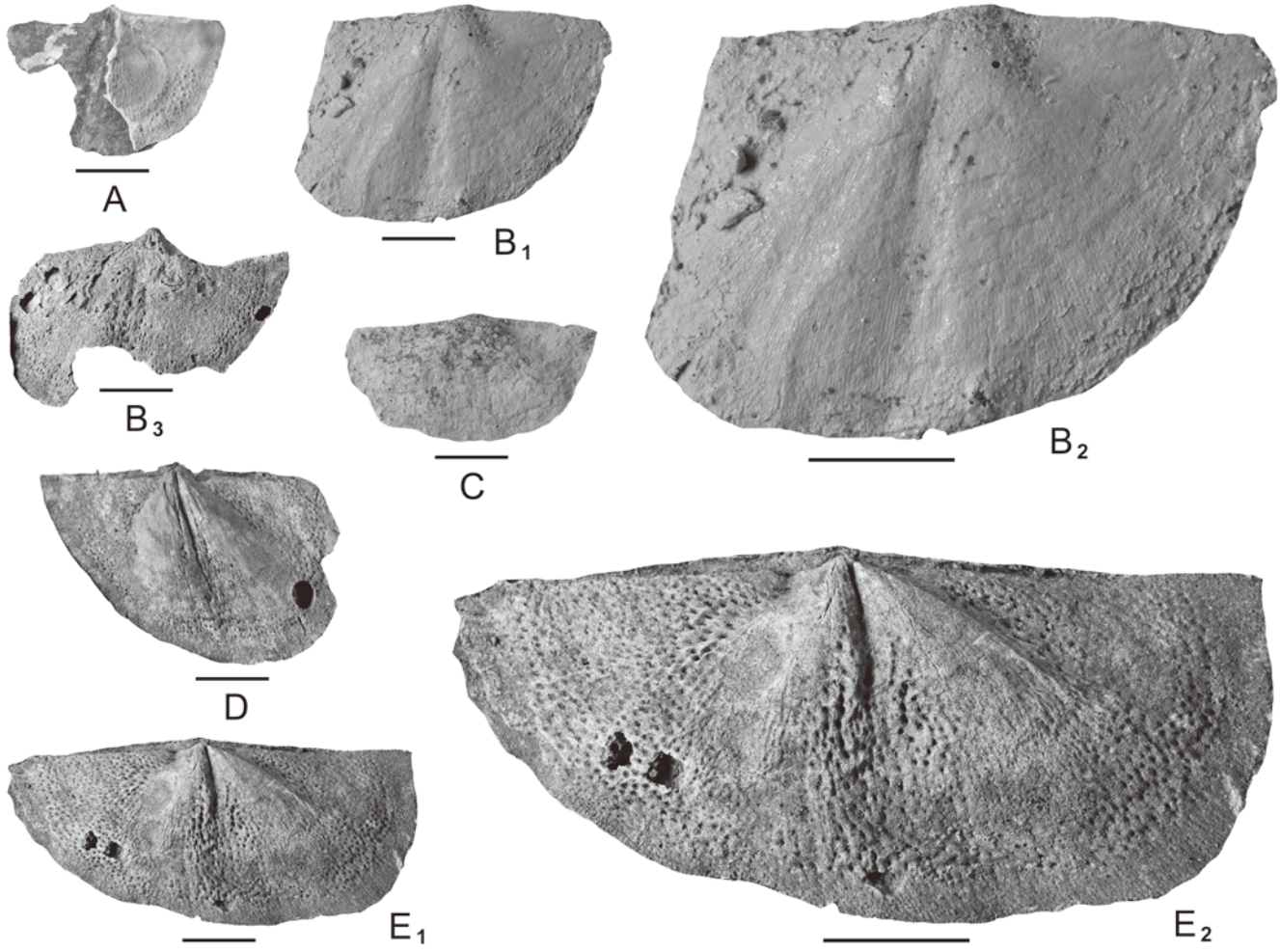

FIGURE 23. **A–E**, *Kitakamichonetes multicapillatus* Afanasjeva and Tazawa; A, internal mould of dorsal valve, with partly preserved interior of ventral valve, NU-B2438; B, external latex cast (B_1, B_2) and internal mould (B_3) of ventral valve, NU-B2439; C, external latex cast of ventral valve, NU-B2442; D, internal mould of ventral valve, NU-B2445; E, internal mould (E_1, E_2) of ventral valve, NU-B2444. Scale bars are 1 cm.

Material.—One specimen from locality KF39, external and internal moulds of a ventral valve, NU-B1827.

Remarks.—This specimen was described by Afanasjeva et al. (2015, p. 24, pl. 4, figs. 1–3) as *Chonetinetes elongatus* Afanasjeva, Tazawa and Shintani, 2015. The Kitakami species is characterized by its longer outline (length 10 mm, width 8 mm), and in having a narrow and deep sulcus and a pair of flat and triangular ears, clearly demarcated from visceral portion by bend. *Chonetinetes elongatus* is mostly similar to *Chonetinetes angustisulcatus* Cooper and Grant (1975, p. 1282, pl. 477, figs. 1–28), from the Road Canyon Formation of Texas, in having a narrow sulcus and a pair of flattened, triangular ears well demarcated from the visceral portion of ventral valve, but differs from the Texan species in its longer outline. The type species, *Chonetinetes reversus* Cooper and Grant, 1969, redescribed by Cooper and Grant (1975, p. 1284, pl. 477, figs. 29–48) from the Road Canyon Formation of Texas, is readily distinguished from the present species in having fold and sulcus not reaching anterior margin of shell.

Occurrence.—KY1 Unit in Kamiyasse (locality KF39).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Subfamily CHALIMOCHONETINAE Afanasjeva, 1988

Genus *KITAKAMICHONETES* Afanasjeva and Tazawa, 2007

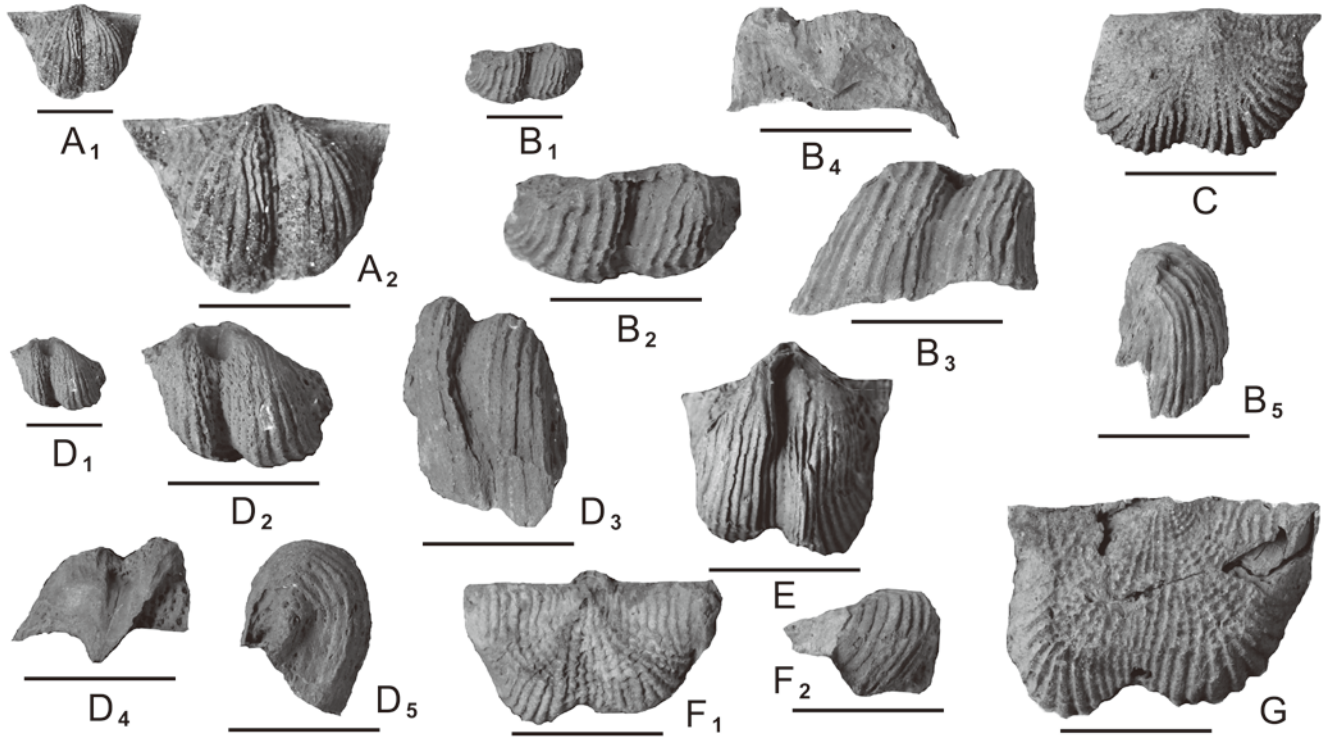

FIGURE 24. **A–G**, *Transennatia gratiosa* (Waagen); A, internal mould (A_1, A_2) of ventral valve, NU-B1736; B, ventral (B_1, B_2), anterior (B_3), posterior (B_4) and lateral (B_5) views of internal mould of ventral valve, NU-B1735; C, external mould of dorsal valve, UHR17113; D, ventral (D_1, D_2), anterior (D_3), posterior (D_4) and lateral (D_5) views of ventral valve, UHR30097; E, internal mould of ventral valve, NU-B2472; F, dorsal (F_1) and lateral (F_2) views of external mould of dorsal valve, NU-B1737; G, external mould of dorsal valve, UHR12126. Scale bars are 1 cm.

Type species.—*Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, 2007.

Kitakamichonetes multicapillatus Afanasjeva and Tazawa, 2007
(Fig. 23A–E)

Chonetes blanfordi var. *lita* Hayasaka, 1925a, p. 92, pl. 5, figs. 3, 4.
Neochonetes sp. Tazawa, 1979, p. 25, pl. 4, fig. 1.
Kitakamichonetes multicapillatus Afanasjeva and Tazawa, 2007, p. 73, pl. 11, figs. 1–12; Tazawa, 2008b, p. 42, fig. 6.3, 6.4; Tazawa et al., 2014, p. 378, fig. 2.1; Tazawa, 2015, p. 64, fig. 6.1.
Dyoros (*Dyoros*) sp. Tazawa and Araki, 2017, p. 269, fig. 6.2.

Material.—Seventeen specimens from localities KF61, KF71, KF79, KF94 and KF218: (1) external mould of a dorsal valve, with partly preserved interior of ventral valve, NU-B2438: (2) external and internal moulds of two ventral valves, NU-B2439, 2440; (3) external moulds of three ventral valves, NU-B2441–2443; (4) internal moulds of eight ventral valves, NU-B2444–2452; and (5) external mould of two dorsal valves, NU-B2453, 2454.

Remarks.—The specimens from the lower Kamiyasse Formation in Kamiyase are referred to *Kitakamichonetes multicapillatus* Afanasjeva and Tazawa, 2007. This species is characterized by its large, transverse shell (length 31 mm, width about 60 mm in the largest dorsal valve specimen, NU-B2444) and external ornament consisting of numerous and very fine capillae (numbering 8–9 in 2 mm at near anterior margin of ventral valve). *Kitakamichonetes multicapillatus* somewhat resembles *Eolissochonetes maximus* Afanasjeva (1977, p. 17, pl. 2, figs. 1–6, 11–14), from the middle and upper Carboniferous of the Kolyma–Omolon Massif, northern Russia, but differs primarily in its more prominent beak and longer median septum on ventral valve, presence of brachial ridges, and absence of an alveolus inside dorsal valve.

Occurrence.—KY1 Unit in Kamiyasse (localities KF61, KF71, KF79, KF94) and Imo (locality KF218).

Distribution.—Wordian–Capitanian: northeastern Japan (Kamiyasse–Imo, Matsukawa and Hitachi in the South Kitakam Belt) and southwestern Japan (Mizukoshi in Kyushu Island).

Suborder PRODUCTIDINA Waagen, 1883
Superfamily MARGINIFEROIDEA Stehli, 1954
Family MARGINIFERIDAE Stehli, 1954
Subfamily MARGINIFERINAE Stehli, 1954
Genus *TRANSENNATIA* Waterhouse, 1975

Type species.—*Productus gratiosus* Waagen, 1884.

Transennatia gratiosa (Waagen, 1884)
(Fig. 24A–G)

Productus gratiosus Waagen, 1884, p. 691, pl. 72, figs. 3–7; Diener, 1897a, p. 23, pl. 3, figs. 3–7; Mansuy, 1913, p. 115, pl. 13, fig. 1; Diener, 1915, p. 70, pl. 7, fig. 4; Colani, 1919, p. 10, pl. 1, fig. 2; Chao, 1927, p. 44, pl. 4, figs. 6–10; Chi-Thuan, 1962, p. 491, pl. 2, figs. 5–7.

Productus (*Dictyoclostus*) *gratiosus* Waagen. Huang, 1933, p. 88, pl. 11, fig. 14; Hayasaka, 1960, p. 49, pl. 1, fig. 8.

Marginifera gratiosa (Waagen). Reed, 1944, p. 98, pl. 19, figs. 6, 7.

Dictyoclostus gratiosus (Waagen). Zhang and Ching (Jin), 1961, p. 411, pl. 4, figs. 12–18; Wang et al., 1964, p. 291, pl. 45, figs. 14–19; Leman, 1994, pl. 1, figs. 11–13.

Gratiosina gratiosa (Waagen). Grant, 1976, pl. 33, figs. 19–26; Licharew and Kotlyar, 1978, pl. 12, figs. 5, 6; pl. 20, fig. 1; Minato et al., 1979, pl. 61, figs. 11–13.

Asioproductus gratiosus (Waagen). Yang et al., 1977, p. 350, pl. 140, fig. 5; Feng and Jiang, 1978, p. 254, pl. 90, figs. 1, 2; Tong, 1978, p. 228, pl. 80, fig. 7; Lee et al., 1980, p. 373, pl. 164, fig. 14; pl. 166, figs. 5, 6.

Asioproductus bellus Chan (Zhan), 1979, p. 85, pl. 6, figs. 7–13; pl. 9, figs. 8–10, text-fig. 18.

Gratiosina sp. Minato et al., 1979, pl. 61, fig. 14.

Dictyoclostus minor Lee and Gu in Lee et al., 1980, p. 372, pl. 166, figs. 1–4.

Transennatia gratiosus (Waagen). Wang et al., 1982, p. 214, pl. 92, figs. 6–8; pl. 102, figs. 4–9; Liu et al., 1982, p. 185, pl. 132, fig. 9; Ding and Qi, 1983, p. 280, pl. 95, fig. 14; Zeng et al., 1995, pl. 5, figs. 14, 15.

Transennatia gratiosa (Waagen). Yang, 1984, p. 219, pl. 33, fig. 7; Jin, 1985, pl. 4, figs. 33, 34, 45, 46; Tazawa and Matsumoto, 1998, p. 6, pl. 1, figs. 4–8; Tazawa, 2000, fig. 3.6, 3.7; Tazawa et al., 2000, p. 7, pl. 1, figs. 3–5; Tazawa, 2001, p. 289, fig. 6.1–6.7; Tazawa and Ibaraki, 2001, p. 7, pl. 1, figs. 1–3; Shen et al., 2002, p. 676, fig. 4.27–4.31; Tazawa, 2002, fig. 10.2; Chen et al., 2005, p. 354, figs. 10E–H, 11; Tazawa, 2008b, p. 43, fig. 6.6, 6.7; Shen and Zhang, 2008, fig. 4.20–4.22; Shen and Clapham, 2009, p. 718, pl. 1, figs. 13–22; Shen and Shi, 2009, p. 157, fig. 3K–O; Tazawa et al., 2014, p. 378, fig. 2.2, 2.3; Tazawa, 2015, p. 65, fig. 6.2, 6.3; Tazawa, 2016b, p. 14, fig. 5.1–5.5; Tazawa and Araki, 2017, p. 209, fig. 6.3.

Material.—Nineteen specimens from localities KF217, KF218, KS2, KS9 and KZ9: (1) external moulds of three ventral valves, NU-B302, 303, UHR17098; (2) internal moulds of seven ventral valves, NU-B304, 305, 1735, 1736, 1738, 2472, UHR30097; and (3) external moulds of ten dorsal valves, NU-B306, 1737, 1739, 1740, UHR12126, 17099. 17112, 17113, 17115.

Remarks.—Most of the specimens from Setamiai, Kamiyasse–Imo and Matsukawa were described by Tazawa and Ibaraki (2001, p. 7, pl. 1, figs. 1–3), Tazawa (2016b, p. 14, fig. 5.1–5.5) and Tazawa and Araki (2017, p. 209, fig. 6.3) as *Transennatia gratiosa* (Waagen, 1884). These specimens can be referred to *Transennatia gratiosa* (Waagen, 1884, p. 691, pl. 72, figs. 3–7), from the Wargal and Chhidru Formations of the Salt Range, Pakistan, on the basis of small size (length 15 mm, width 21 mm in the largest dorsal valve specimen, UHR12126), large triangular ears, strongly geniculated dorsal valve with nearly flat visceral disc and moderately long trail, and sharply reticulate ornament on visceral discs of both ventral and dorsal valves, although the Kitakami specimens are smaller than the type specimens from the Salt Range. *Dictyoclostus minor* Lee and Gu (in Lee et al., 1980, p. 372, pl. 166, figs. 1–4.), from the Miaoling Formation of Jilin, northeastern China, is probably a junior synonym of the present species. *Transennatia insculpta* (Grant, 1976, p. 135, pl. 32, figs. 1–37; pl. 33, figs. 1–6), from the Rat Buri Formation of Ko Muk, southern Thailand, differs from *T. gratiosa* in being smaller size and in having more extended ears.

Occurrence.— KN1 Unit (Locality KS2) and KN2 Unit (locality KS9) in Setamai; KY1 Unit in Imo (localities KF217 and KF218) and Matsukawa (locality KZ9) .

Distribution. — Roadian−Changhsingian: northeastern Japan (Setamai, Kamiyasse–Imo, Matsukawa, Ogatsu, Takakurayama and Hitachi in the South Kitakami Belt), central Japan (Moribu and Oguradani in the Hida Gaien Belt), southwestern Japan (Mizukoshi in Kyushu Island), northern China (Shanxi), northeastern China (Heilongjiang and Jilin), eastern Russia (South Primorye), eastern China (Anhui, Zhejiang and Jiangxi), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Guizhou, Sichuan), Greece (Hydra Island), southwestern China (Yunnan), Vietnam, Malaysia, Cambodia (Sisophon), northwestern China (Tibet), Nepal (Kumaon Himalayas) and Pakistan (Salt Range).

Superfamily PRODUCTOIDEA Gray, 1840
Superfamily MARGINIFEROIDEA Stehli, 1954
Family COSTISPINIFERIDAE Muir-Wood and Cooper, 1960

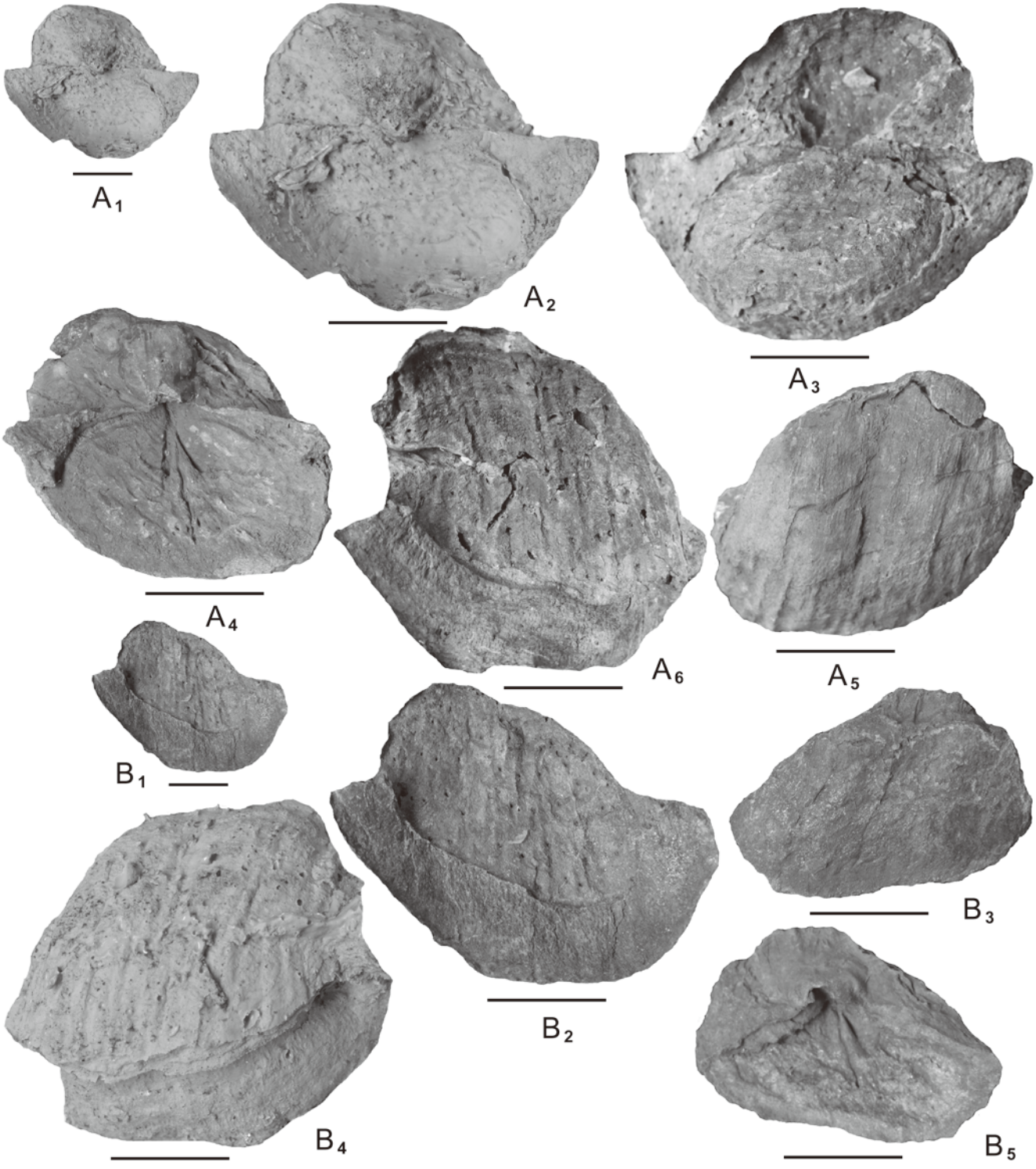

FIGURE 25. **A**, **B**, *Spinomarginifera lopingensis* (Kayser); A, dorsal view of external latex cast (A_1, A_2), dorsal view of external mould (A_3), dorsal (A_4) and ventral view (A_5) of internal mould, and ventral view (A_6) of ventral external mould of conjoined shell, UHR12642; B, ventral view of external mould (B_1, B_2), ventral view of internal mould (B_3), ventral view of external latex cast (B_4), and dorsal view of internal mould (B_5) of conjoined shell, NU-B2021. Scale bars are 1 cm.

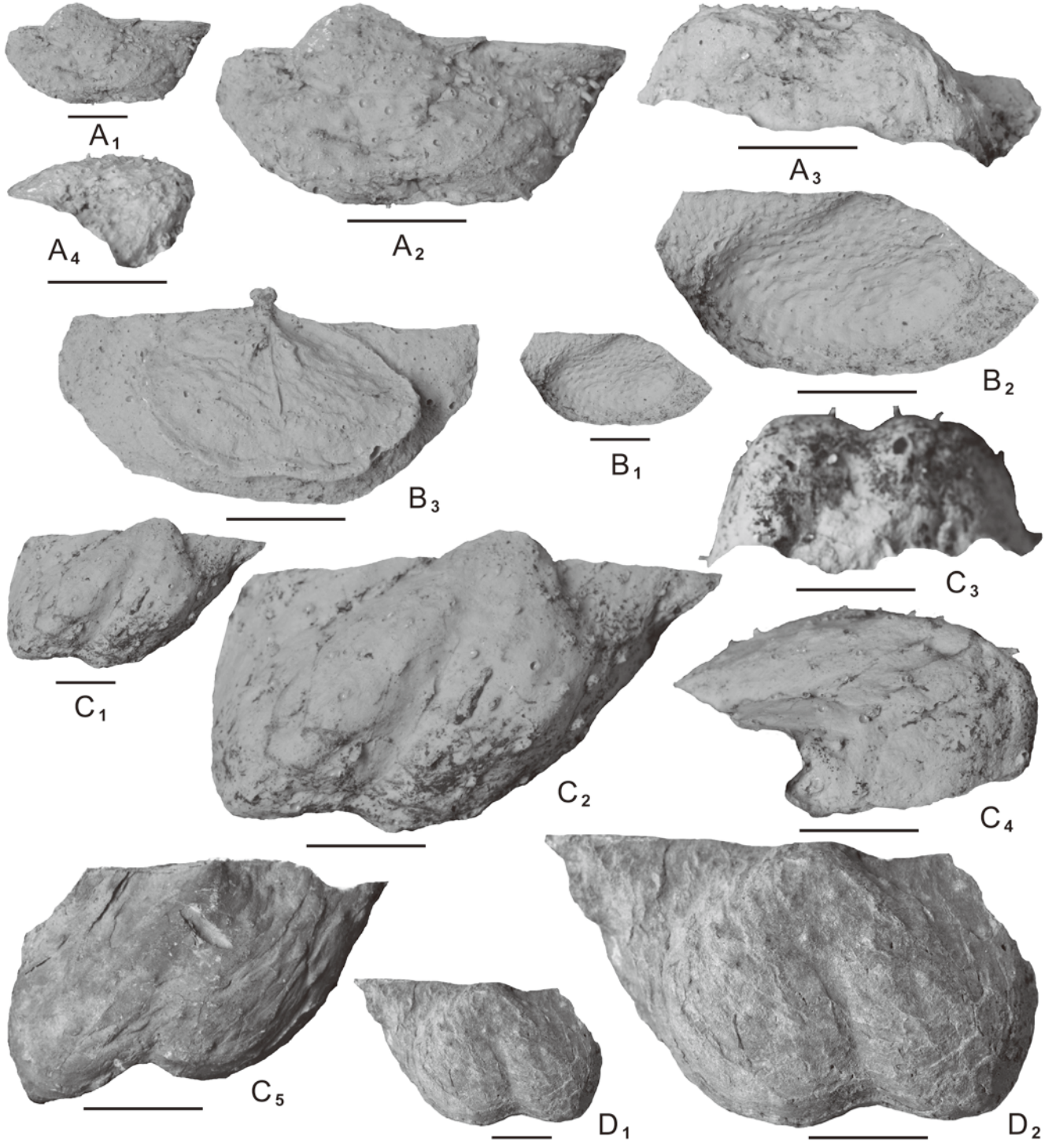

FIGURE 26. **A**, **B**, *Spinomarginifera kueichowensis* Huang; A, ventral (A_1, A_2), anterior (A_3) and lateral (A_4) views of external latex cast of ventral valve, UHR30074; B, external latex cast (B_1, B_2) and internal latex cast (B_3) of dorsal valve, UHR30071; **C**, **D**, *Spinomarginifera alpha* Huang; C, ventral (C_1, C_2), anterior (C_3) and lateral (C_4) views of external latex cast of ventral valve, and external mould (C_5) of dorsal valve, UHR30086; D, external mould (D_1, D_2) of dorsal valve, UHR12369. Scale bars are 1 cm.

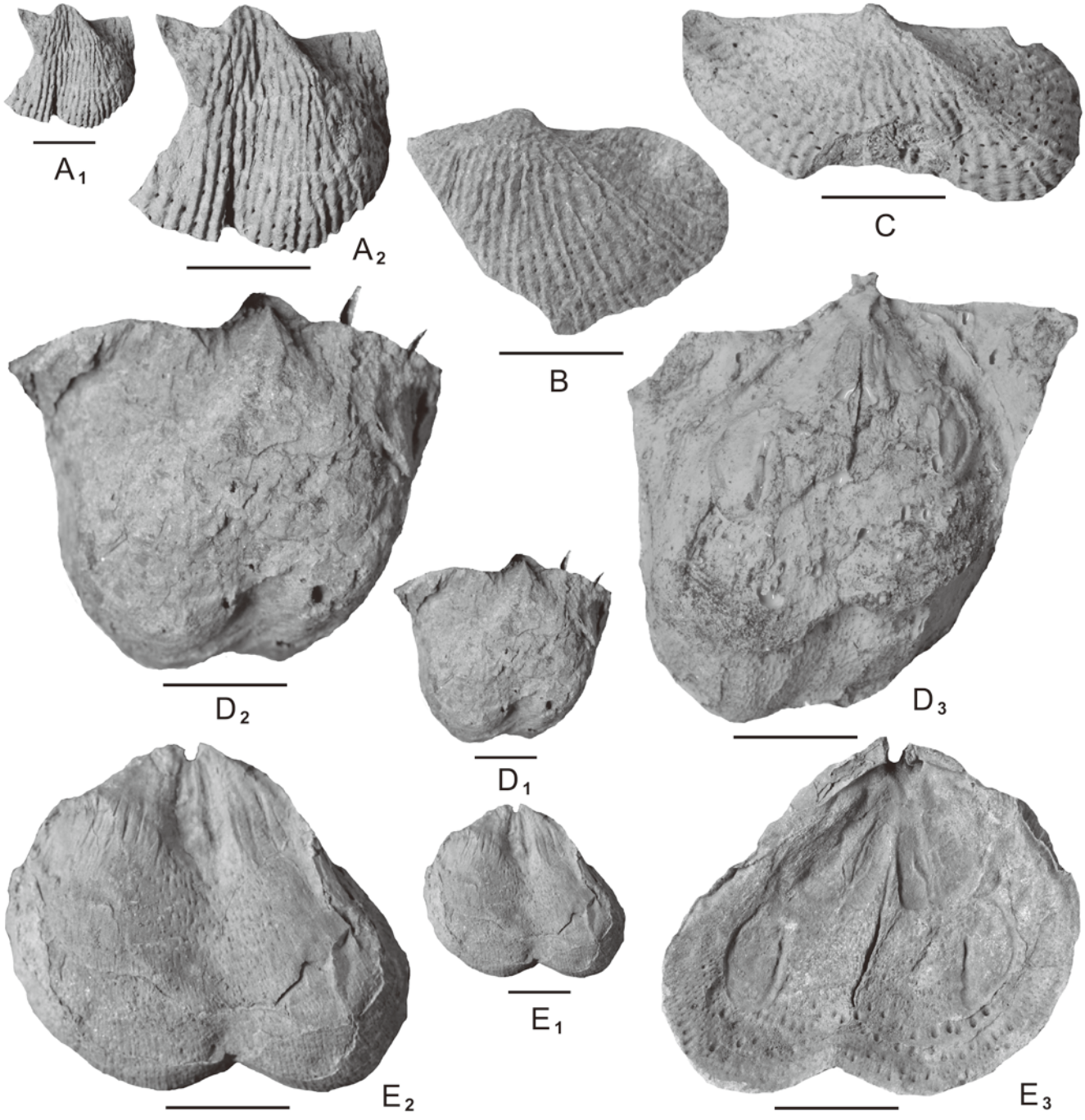

FIGURE 27. **A**–**C**, *Hexiproductus echidniformis* (Chao); A, internal mould (A_1, A_2) of ventral valve, KCG50; B, external mould of dorsal valve, KCG53; C, external mould of dorsal valve, KCG51; **D**, **E**, *Spinomarginifera alpha* Huang; D, external mould (D_1, D_2) and internal latex cast (D_3) of dorsal valve, UHR12371; E, ventral (E_1, E_2) and dorsal (E_3) views of internal mould of conjoined shell, NU-B2474. Scale bars are 1 cm.

Subfamily SPINOMARGINIFERINAE Waterhouse, 2002
Genus *SPINOMARGINIFERA* Huang, 1932

Type species.—*Spinomarginifera kueichowensis* Huang, 1932.

Spinomarginifera lopingensis (Kayser, 1883)
(Fig. 25A, B)

Productus nystianus var. *lopingensis* Kayser, 1883, p. 187, pl. 28, figs. 1–5.
Productus (*Marginifera*) *helicus* var. Frech, 1911, p. 130, pl. 19, figs. 1–3.
Marginifera lopingensis (Kayser). Chao, 1927, p. 153, pl. 16, figs. 8–12.
Spinomarginifera kueichowensis Huang. Nakamura, 1959b, p. 143, pl. 15, fig. 1 only; Minato et al., 1979, pl. 63, fig. 1 only.
Spinomarginifera lopingensis (Kayser). Zhang and Ching (Jin), 1961, p. 412, pl. 4, figs. 26–33; Wang et al., 1964, p. 312, pl. 49, figs. 21–23; Yang et al., 1977, p. 349, pl. 139, fig. 5; Tong, 1978, p. 222, pl. 79, fig. 6; Licharew and Kotlyar, 1978, pl. 15, figs. 9, 10; Zhan, 1979, p. 80, pl. 5, figs. 17, 18; Liao, 1980, pl. 5, figs. 35–39; Wang et al., 1982, p. 219, pl. 92, figs. 1, 2; Wang, 1984, p. 187, pl. 80, fig. 16; Yang, 1984, p. 217, pl. 33, fig. 4; Liao, 1987, pl. 5, figs. 5, 7–18; Zeng et al., 1995, pl. 9, fig. 1; Shen et al., 2002, p. 677, figs. 4.32, 4.33, 5.1–5.4; He et al., 2008, p. 812, fig. 4.1–4.10; Li and Shen, 2008, p. 315, figs. 4.17–4.19, 6.1–6.7; Shen and Zhang, 2008, fig. 4.13–4.19; Shen and Shi, 2009, p. 157, fig. 3P–3X; Tazawa, 2012, p. 20, fig. 4.1–4.3; Tazawa, 2017, p. 41,fig. 6.1–6.3.
Spinomarginifera lopingensis (Chao). Jin et al., 1985, p. 194, pl. 9, figs. 3–9; Jin, 1985, pl. 7, figs. 5, 16, 18, 20.
Spinomarginifera lopingensis Huang. Liao and Xu, 2002, pl. 1, figs. 28–33.
Spinomarginifera huangi Wang and Zhang, 2003, p. 73, pl. 21, fig. 12 only.

Material.—Seven specimens from localities KF7, KF90 and KF217: (1) external and internal moulds of two conjoined shells, UHR12642, 30077; (2) internal moulds of two conjoined shells, with external moulds of the ventral valves, NU-B2021, 2022; and (3) external moulds of three dorsal valves, NU-B2023, 2024, 2473.

Remarks.—Most of the specimens were previously described by Tazawa (2017, p. 41, figs. 6.1–6.3) as *Spinomarginifera lopingensis* (Kayser, 1883). The specimens from Kamiyasse–Imo can be referred to *Spinomarginifera lopingensis* (Kayser, 1883), from the upper Permian of Loping, Jiangxi Province, eastern China, in medium size (length about 19 mm, width about 32 mm in the best-preserved conjoined shell, UHR12642) and in having prominent costae on trails of both valves. *Spinomarginifera kueichowensis* Huang (1932, p. 56, pl. 5, figs. 1–11), from the upper Permian (Wuchiapingian) of Guizhou, southwestern China, differs from *S. lopingensis* in lacking radial costae on trails of both valves.

Occurrence.—KY1 Unit in Kamiyasse (localities KF7 and KF90) and Imo (KF217).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo and Nabekoshiyama in the South Kitakami Belt), northwestern China (Qinghai), northern China (Inner Mongolia), eastern Russia (South Primorye), eastern China (Jiangsu, Anhui, Zhejiang and Jiangxi), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Guizhou, Sichuan and Yunnan) and northwestern China (Tibet).

Spinomarginifera kueichowensis Huang, 1932
(Fig. 26A, B)

Spinomarginifera kueichowensis Huang, 1932, p. 56, pl. 5, figs. 1–11; Nakamura, 1959b, p. 143, pl. 15, figs. 2–4 only; Muir-Wood and Cooper, 1960, p. 65, figs. 15–22, 24; Wang et al., 1964, p. 316, pl. 51, figs. 9–11; Jin et al., 1974, p. 312, pl. 164, fig. 13; Tazawa, 1976, pl. 2, fig. 1; Feng and Jiang, 1978, p. 252, pl. 89, figs. 5, 6; Minato et al., 1979, pl. 63, fig. 2 only; Zhan, 1979, p. 80, pl. 11, figs. 14–17, 20; Liao, 1980, pl. 4, fig. 29; Liu et al., 1982, p. 184, pl. 131, figs. 8–10; Wang, 1984, p. 187, pl. 74, fig. 16; pl. 76, fig. 3; Zeng et al., 1995, pl. 5, fig. 10; Tazawa, 2002, fig. 10.11; Chen in Chen et al., 2006, p. 314, fig. 8, table 2; Shen and Shi, 2009, p. 158, figs. 3DD, 3EE, 4I; Tazawa et al., 2014, p. 381, fig. 2.10; Tazawa, 2015, p. 67, fig. 6.10; Tazawa, 2017, p. 43, fig. 7.1, 7.2.
Spinomarginifera nipponica Shimizu, 1961, p. 244, pl. 8, figs. 1–20; pl. 9, figs. 14–16.
Spinomarginifera cf. kueichowensis Huang. Lee et al., 1980, p. 357, pl. 165, fig. 11; pl. 166, fig. 25; Gu, 1992, p. 224, pl. 69, fig. 6.

Material.—Twelve specimens from localities KF63, KF71, KF84, KF88, KF90 and KF217: (1) external and internal moulds of a conjoined shell, NU-B2017; (2) internal moulds of two conjoined shells, with external mould of the ventral valves, UHR12584, 30074; (3) external and internal moulds of four dorsal valves, NU-B2018, 2019, 2020, UHR30071; and (4) external moulds of five dorsal valves, UHR11554, 12368, 30068, 30080, 30082.

Remarks.—These specimens were described by Tazawa (2017, p. 43, fig. 7.1, 7.2) as *Spinomarginifera kueichowensis* Huang, 1932. The specimens from Kamiyasse–Imo can be referred to *Spinomarginifera kueichowensis* Huang, 1932, from the upper Permian (Wuchiapingian) of Guizhou, southwestern China, in medium size (length 18 mm, width about 38 mm in the largest specimen, UHR30074), transverse outline, numerous spine bases on ventral valve and strongly developed marginal ridge in dorsal valve. *Spinomarginifera nipponica* Shimizu, 1961, from the Gujo Formation of Kawahigashi in the Maizuru Belt, southwestern Japan, is

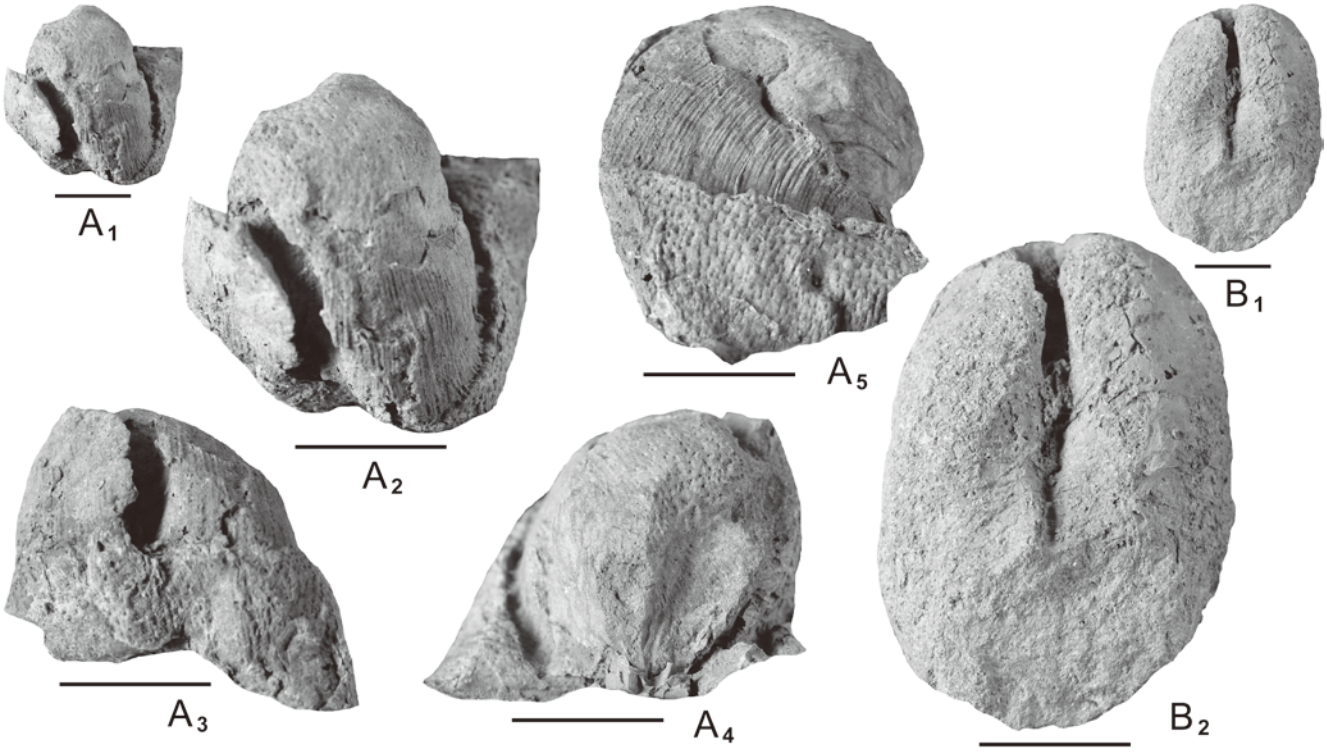

FIGURE 28. **A**, **B**, *Paramarginifera* sp.; A, ventral (A_1, A_2), anterior (A_3), posterior (A_4) and lateral (A_5) views of internal mould of ventral valve, NU-B2589; B, ventral view (B_1, B_2) of internal mould of ventral valve, NU-B2590. Scale bars are 1 cm.

regarded as a junior synonym of *S. kueichowensis*. The preceding species, *Spinomarginifera lopingensis* (Kayser, 1883), is distinguished from *S. kueichowensis* in having costae on trails of both ventral and dorsal valves. *Spinomarginifera alpha* Huang, 1932, originally described by Huang (1932, p. 60, pl. 5, figs. 12, 13) as *Spinomarginifera kueichowensis* mut. *alpha* Huang, 1932, from the upper Permian of Guizhou, southwestern China, differs from the present species in its larger size and in having coarser and sparser spine bases on ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (localities KF63, KF71, KF84, KF88 and KF90) and Imo (locality KF217).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo and Hitachi in the South Kitakami Belt), southwestern Japan (Kawahigashi in the Maizuru Belt), northeastern China (Jilin), eastern China (Zhejiang), central-southern China (Hubei, Hunan, Guangdong and Guangxi) and southwestern China (Guizhou and Sichuan).

Spinomarginifera alpha Huang, 1932
(Figs. 26C, D; 27D, E)

Spinomarginifera kueichowensis mut. *alpha* Huang, 1932, p. 60, pl. 5, figs. 12, 13; Wang et al., 1964, p. 316, pl. 49, figs. 31–33; Jin et al., 1974, p. 313, pl. 164, figs. 11, 12; Yang et al., 1977, p. 349, pl. 139, fig. 9.

Spinomarginifera huangi Nakamura, 1959b, p. 145, pl. 15, figs. 5–7; Minato et al., 1979, pl. 63, figs. 3–5.

Spinomarginifera alpha Huang. Liao, 1980, p. 259, pl. 5, figs. 44–47; Zhao et al., 1981, pl. 8, figs. 28, 29; Wang et al., 1982, p. 219, pl. 96, fig. 26; Shen et al., 2003a, p. 231, pl. 1, figs. 6–9; Chen et al., 2005, p. 355, fig. 10C, D; Tazawa, 2017, fig. 8.1–8.4.

Material. — Eight specimens from localities KF89, KF90 and KF217: (1) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B2025; (2) internal moulds of two conjoined shells, with external moulds of the dorsal valves, NU-B2026, UHR12370; (3) internal mould of a conjoined shell, NU-B2474; (3) external moulds of a conjoined shell, UHR30086; (4) external and internal moulds of a dorsal valve, UHR12371; and (5) external mould of two dorsal valves, UHR12369, NU-B2475.

Remarks. — The specimens from Kamiyasse–Imo can be referred to *Spinomarginifera alpha* Huang, 1932, from the Lopingian of Guizhou, southwestern China, in being large

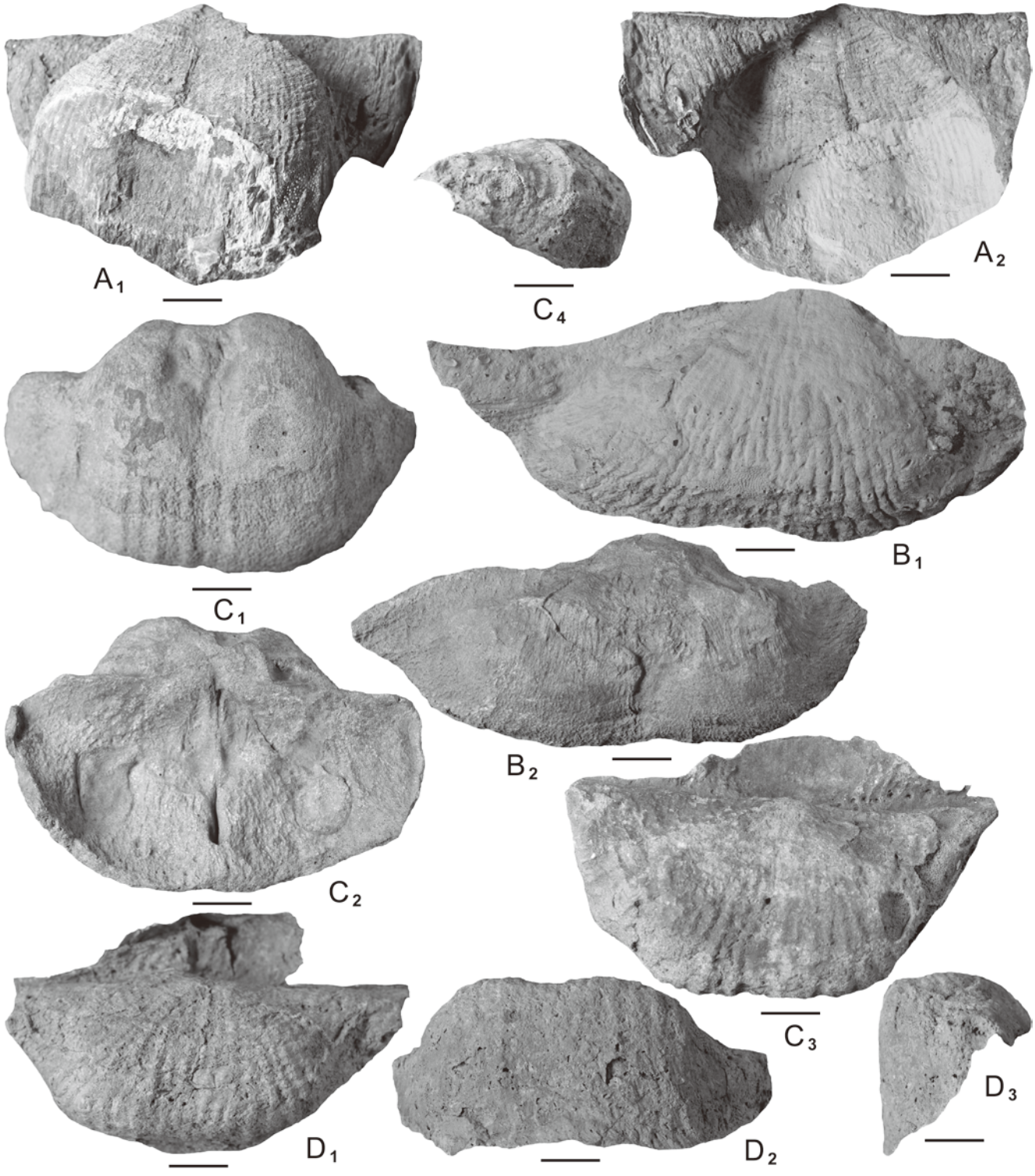

FIGURE 29. **A**, *Kunlunia* sp., external mould (A_1) and external latex cast (A_2) of dorsal valve, KCG59; **B**–**D**, *Costiferina spiralis* (Waagen); B, external latex cast (B_1) and internal mould (B_2) of ventral valve, UHR16004; C, ventral (C_1) and dorsal (C_2) views of internal mould, and dorsal (C_3) and lateral (C_4) views of external mould of conjoined shell, UHR12373; D, dorsal (D_1), anterior (D_2) and lateral (D_3) views of external mould of dorsal valve, UHR13555. Scale bars are 1 cm.

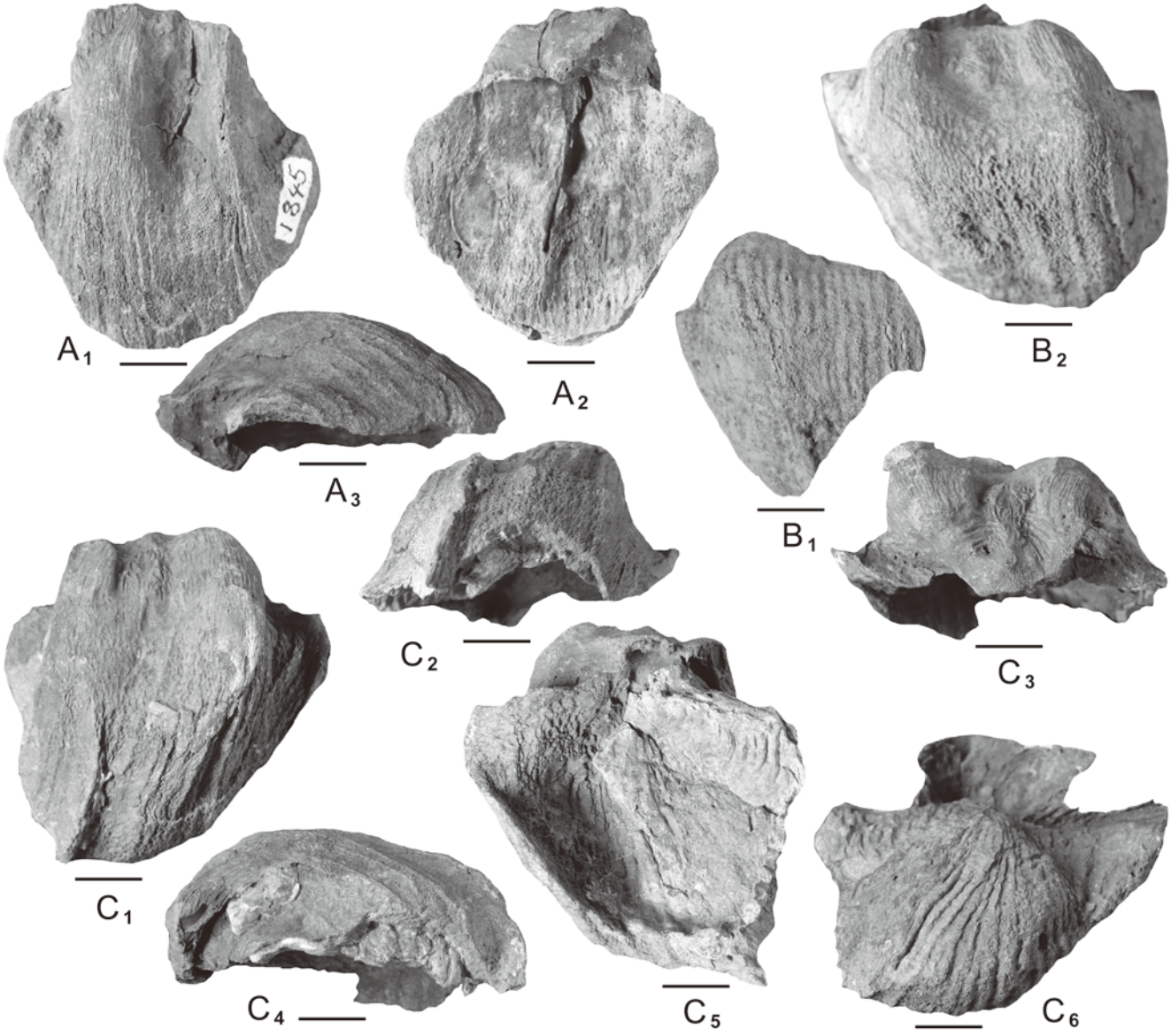

FIGURE 30. **A–C**, *Tyloplecta yangtzeensis* (Chao); A, ventral (A_1), dorsal (A_2) and lateral (A_3) views of internal mould of conjoined shell, NU-B1845; B, external latex cast (B_1) and internal mould (B_2) of ventral valve, UHR13553; C, ventral (C_1), anterior (C_2), posterior (C_3), lateral (C_4) and dorsal (C_5) views of internal mould, and dorsal view (C_6) of external mould of conjoined shell, UHR12602. Scale bars are 1 cm.

size (length 29 mm, width 35 mm in the best preserved ventral valve specimen, UHR30086; length 30 mm, width 36 mm in the best-preserved dorsal valve specimen, UHR12371) and in having coarse, widely-spaced spine bases on both ventral and dorsal valves. *Spinomarginifera huangi* Nakamura (1959b, p. 145, pl. 15, figs. 5–7), from the lower Kamiyasse Formation of Kamiyasse, is regarded as a junior synonym of the present species. The preceding species, *Spinomarginifera kueichowensis* Huang, 1932, is readily distinguished from *S. alpha* by its smaller size, much transverse outline and more numerous and finer spine bases on both ventral and dorsal valves.

Occurrence.—KY1 Unit in Kamiyasse (localities KF89 and KF90) and Imo (locality KF217).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), eastern

China (Zhejiang), central-southern China (Hunan, Guangdong and Guangxi), southwestern China (Guizhou and Sichuan) and northwestern China (Tibet).

Family PAUCISPINIFERIDAE Muir-Wood and Cooper, 1960
Subfamily PAUCISPINIFERINAE Muir-Wood and Cooper, 1960
Genus *PARAMARGINIFERA* Fredericks, 1916

Type species.—*Marginifera clarkei* Tschernyschew, 1902.

Paramarginifera sp.
(Fig. 28A, B)

Material.—Three specimens from localities KF121 and KF217, internal moulds of three ventral valves, NU-B2589–2591.

Remarks.—These specimens are safely assigned to the genus *Paramarginifera* Fredericks, 1916 by its medium-sized (length about 25 mm, width about 30 mm in the best preserved specimen, NU-B2589) and highly inflated ventral valve with large trigonal-shaped ears, a narrow and deep sulcus on trail and a conspicuous cincture around anterolateral margins of corpse. The external ornament of ventral valve, which is faintly preserved, is consisted of numerous fine costellae. Internal structures of ventral valve are not well preserved, except for a highly raised adductor muscle scars in central part of the valve. The Kitakami species somewhat resembles *Paramarginifera gobiensis* (Chao, 1927), redescribed by Wang and Zhang (2003, p. 69, pl. 1, figs. 38–42; pl. 12, figs. 1, 2; pl. 21, figs. 17–21) from the Zhesi Formation (Wordian–Capitanian) of Zhesi, Inner Mongolia, northern China, but accurate comparison is difficult owing to ill-preservation of the present material.

Occurrence.—KY1 Unit in Imo (localities KF121 and KF217).

Genus *HEXIPRODUCTUS* Shi, Chen and Tong, 2008

Type species.—*Productus echidniformis* Chao, 1925.

Hexiproductus echidniformis (Chao, 1925)
(Fig. 27A–C)

Productus echidniformis Grabau em. Chao, 1925, p. 239, pl. 2, figs. 7–9.
Avonia echidniformis (Grabau em. Chao). Chao, 1927, p. 120, pl. 14, figs. 17–27; Chao, 1928, p. 55, pl. 6, fig. 7; Ozaki, 1931, p. 108, pl. 10, figs. 6–9; Nakamura, 1959a, p. 201, pl. 1, figs. 2–8; Volgin, 1960, p. 47, pl. 4, fig. 4; Sergunkova and Zhizhilo, 1975, p. 60, pl. 9, fig. 7; Lee and Gu, 1976, p. 240, pl. 141, fig. 1; Minato et al., 1979, pl. 46, figs. 15–17; Lee et al., 1980, p. 350, pl. 145, fig. 25; Lee and Duan, 1985, p. 227, pl. 66, figs. 16–21; Zhan and Wu, 1987, p. 203, pl. 47, figs. 23–25; He et al., 1995, pl. 56, figs. 51, 52, 61–64; Wang, 1995, pl. 1, fig. 4; Wang and Yang, 1998, p. 67, pl. 3, figs. 21–25.
Productus (*Avonia*) *echidniformis* Grabau and Chao. Licharew, 1939, p. 86, pl. 17, figs. 9, 10.
Avonia sp. Minato et al., 1979, pl. 46, figs. 13, 14.
"*Avonia*" *echidniformis* (Grabau em. Chao). Zhang et al., 1983, p. 286, pl. 131, fig. 1.
"*Avonia*"? *echidniformis* (Grabau em. Chao). Chen and Shi, 2002, p. 299, fig. 4J.
Breileenia echidniformis (Grabau in Chao). Chen and Shi, 2006a, p. 137, pl. 1, figs. 13, 14; text-fig. 10.
Hexiproductus echidniformis (Grabau in Chao). Shi et al., 2008, p. 290, fig. 6A–D.
Hexiproductus echidniformis (Chao). Tazawa and Nakamura, 2015, p. 161, fig. 4.4–4.10; Tazawa and Araki, 2017, p. 271, fig. 6.4–6.6.

Material.—Four specimens from localities AR4 and KZ9: (1) internal mould of a ventral valve, KCG50; and (2) external moulds of three dorsal valves, KCG51–53.

Remarks.—These specimens were previously described by Tazawa and Araki (2017, p. 271, fig. 6.4–6.6) as *Hexiproductus echidniformis* (Chao, 1925). The Matsukawa specimens can be referred to *Hexiproductus echidniformis* (Chao, 1925), originally described from the upper Carboniferous–lower Permian of Gansu, northwestern China and Shanxi, northern China, in transversely subrectangular outline and external ornament of both ventral and dorsal valves, consisting of irregular fine concentric rugae and strong costae with numerous elongate spine bases.

Occurrence.—KY1 Unit in Matsukawa (localities AR4 and KZ9).

Distribution.—Kasimovian–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), northwestern China (Xinjiang, Gansu and Ningxia), northern China (Inner Mongolia, Shanxi and Hebei), northeastern China (Liaoning), eastern China (Shandong) and Uzbekistan (Fergana).

Family DICTYOCLOSTIDAE Stehli, 1954
Subfamily DICTYOCLOSTINAE Stehli, 1954
Genus *KUNLUNIA* Wang in Zhang et al., 1983

Type species.—*Kunlunia aspera* Wang in Zhang et al., 1983.

Kunlunia sp.
(Fig. 29A)

Kunlunia sp. Tazawa and Araki, 2018, p. 13, fig. 4.4.

Material. — One specimen from locality AR4, external mould of a dorsal valve, KCG59.

Remarks. — This specimen was previously described by Tazawa and Araki (2018, p. 13, fig. 4.4) as *Kunlunia* sp. on

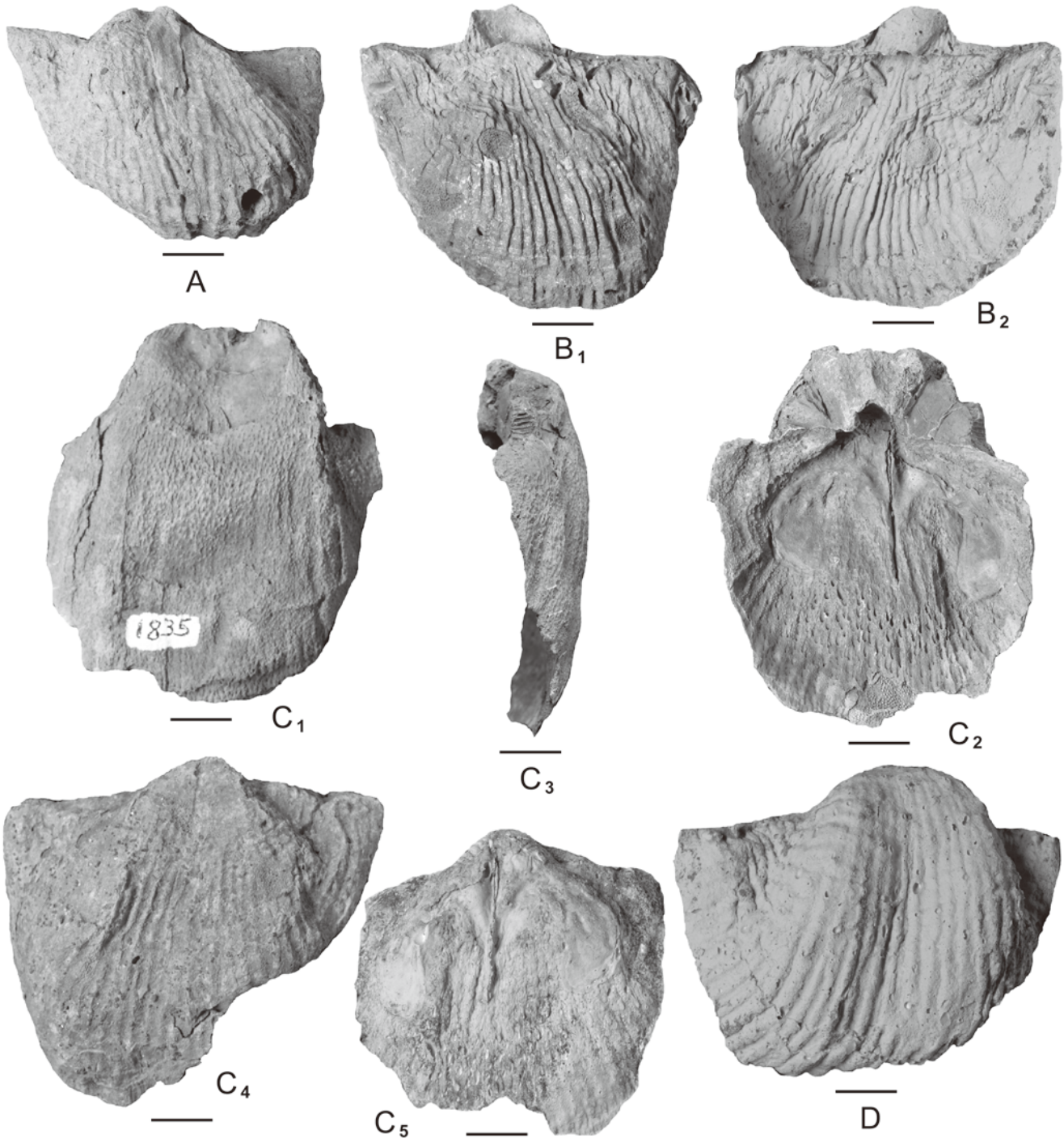

FIGURE 31. **A–D**, *Tyloplecta yangtzeensis* (Chao); A, external mould of dorsal valve, NU-B1841; B, external mould (B_1) and external latex cast (B_2) of dorsal valve, NU-B1839; C, ventral (C_1), dorsal (C_2) and lateral (C_3) views of internal mould, external mould (C_4) and internal latex cast (C_5) of dorsal valve of conjoined shell, NU-B1835; D, external latex cast of ventral valve, NU-B1837. Scale bars are 1 cm.

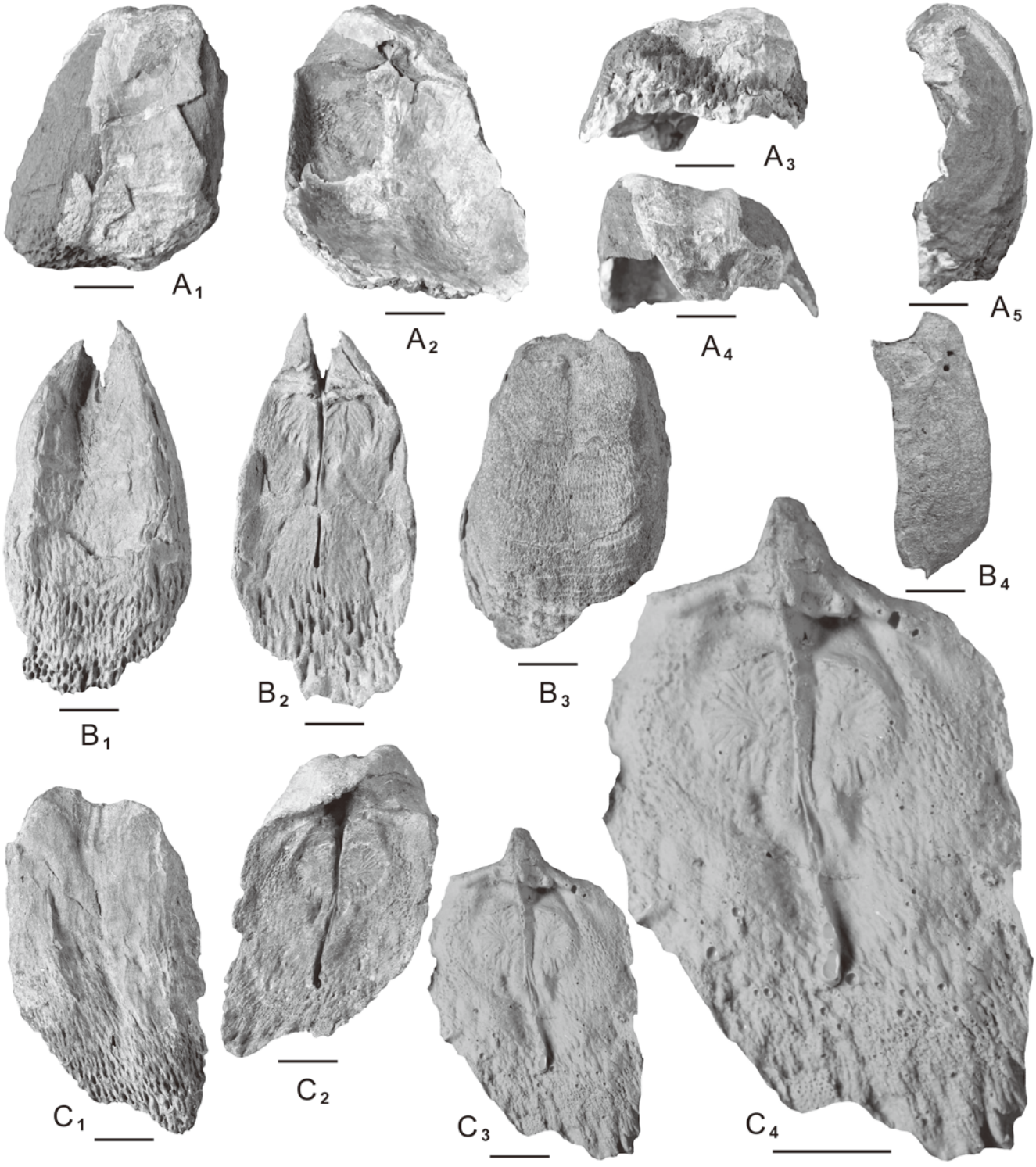

FIGURE 32. **A–C**, *Bathymyonia neimongolica* (Wang and Zhang); A, ventral (A_1), dorsal (A_2), anterior (A_3), posterior (A_4) and lateral (A_5) views of internal mould of conjoined shell, NU-B19810; B, ventral (B_1) and dorsal (B_2) views of internal mould, and dorsal (B_3) and lateral (B_4) views of external mould of conjoined shell, UHR13131; C, ventral (C_1) and dorsal (C_2) views of internal mould, and internal latex cast (C_3, C_4) of dorsal valve of conjoined shell, UHR13132. Scale bars are 1 cm.

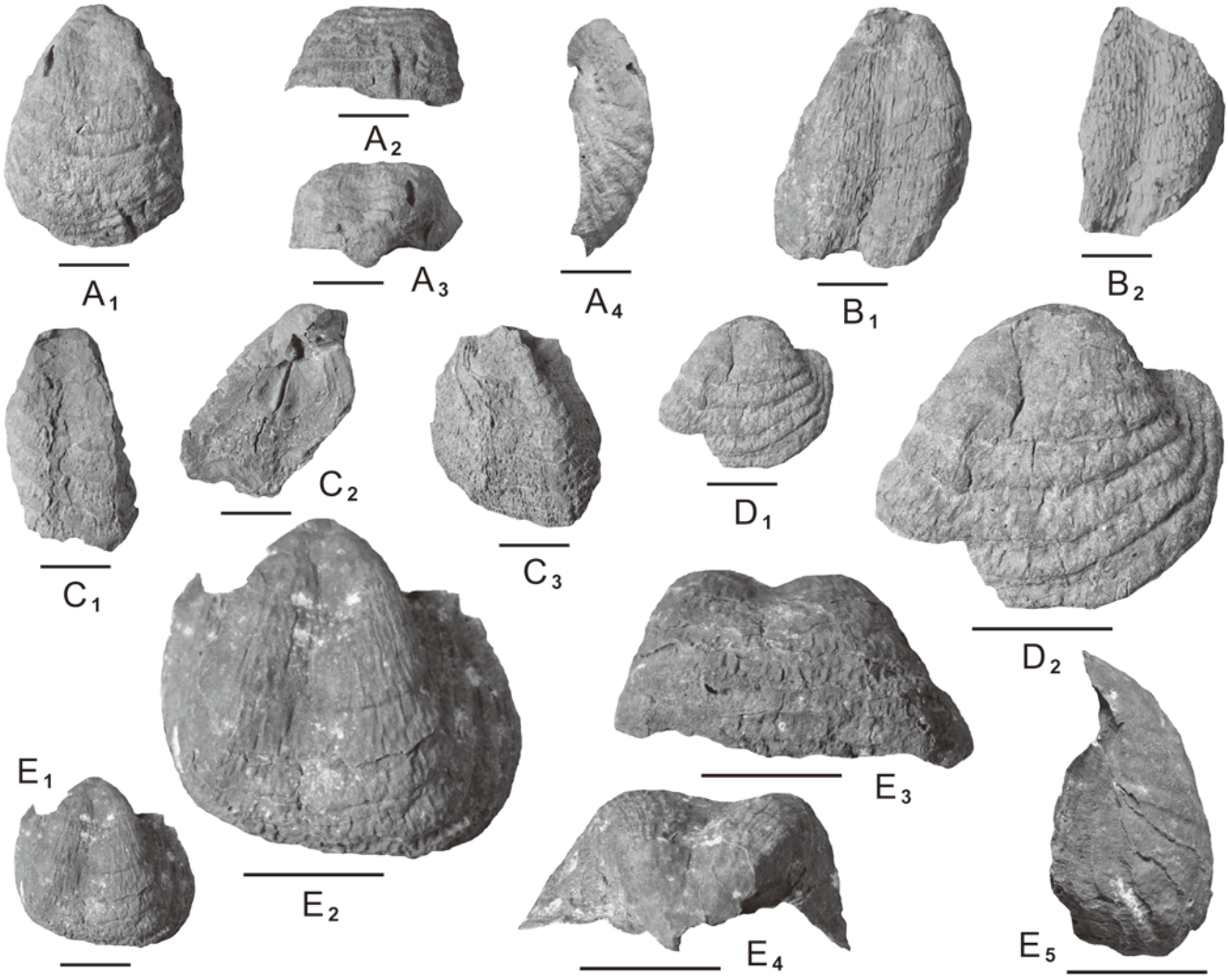

FIGURE 33. **A–E**, *Vediproductus punctatiformis* (Chao); A, ventral (A_1), anterior (A_2), posterior (A_3) and lateral (A_4) views of internal mould of ventral valve, UHR12472; B, internal mould (B_1) and external latex cast (B_2) of ventral valve, NU-B1660; C, ventral (C_1) and dorsal (C_2) views of internal mould, and dorsal external mould (C_3) of conjoined shell, NU-B1662; D, external mould (D_1, D_2) of dorsal valve, NU-B1666; E, ventral (E_1, E_2), anterior (E_3), posterior (E_4) and lateral (E_5) views of internal mould of ventral valve, NU-B1664. Scale bars are 1 cm.

the basis of a dictyoclostid shell with large extended ears on dorsal valve. The Matsukawa species somewhat resembles *Kunlunia grabaui* (Nakamura, 1960), redescribed by Tazawa and Nakamura (2015, p. 162, fig. 5.1–5.3) from the lower part of the Hosoo Formation (Kungurian) of Nakadaira, South Kitakami Belt, in shape and external ornament of dorsal valve, but differs in its larger size (length 54 mm, width 76 mm in the dorsal valve specimen, KCG59). Specific identification is, however, difficult for the poorly preserved specimen.

Occurrence.—KY1 Unit in Matsukawa (locality AR4).

Subfamily CALLYTHARRELLINAE Waterhouse, 2002
Genus *COSTIFERINA* Muir-Wood and Cooper, 1960

Type species.—*Productus indicus* Waagen, 1884.

Costiferina spiralis (Waagen, 1884)
(Fig. 29B–D)

Productus spiralis Waagen, 1884, p. 681, pl. 67, fig. 6; pl. 68, fig. 3; pl. 69, figs. 1–3; Diener, 1915, p. 67, pl. 6, fig.

16; pl. 7, figs. 1, 2.
Productus vishnu Waagen. Hayasaka, 1922a, p. 60, pl. 10, figs. 3–8.
Dictyoclostus aff. *spiralis* (Waagen). Nakamura, 1960, p. 497, pl. 1, figs. 1, 2; pl. 2, figs. 1, 2.
Costiferina aff. *spiralis* (Waagen). Minato et al., 1979, pl. 64, fig. 2.

Material. — Four specimens from localities KF217 and Kanokurazawa (exact location unclear): (1) external and internal moulds of a conjoined shell, UHR12373; (2) internal mould of a conjoined shell, with external mould of the ventral valve, UHR16004; and (3) external moulds of two dorsal valves, UHR13555, 13556.

Remarks. — Most of the specimens, except for the largest one (UHR16004), were previously described by Nakamura (1960, p. 497, pl. 1, figs. 1, 2; pl. 2, figs. 1, 2) as *Dictyoclostus* aff. *spiralis* Waagen (1884). All the specimens are, however, referred to *Costiferina spiralis* (Waagen, 1884, p. 681, pl. 67, fig. 6; pl. 68, fig. 3; pl. 69, figs. 1–3), from the Amb Formation of the Salt Range, Pakistan, by large, transverse shell (length about 55 mm, width about 115 mm in the largest specimen, UHR16004), ornamented with coarse costae (numbering 3–4 in 10 mm at about midlength of ventral valve) on both ventral and dorsal valves and strongly geniculated dorsal valve. The type species, *Costiferina indica* (Waagen, 1884, p. 687, pl. 70, figs. 1–6; pl. 71, fig. 1), from the Wargal and Chhidru Formations of the Salt Range, differs from *C. spiralis* in its smaller size and less transverse outline.

Occurrence. — Lower Kanokura Formation in Setamai (exact location unclear); and KY1 Unit in Imo (locality KF217).

Distribution. — Roadian–Changhsingian: northeastern Japan (Setamai and Kamiyasse–Imo in the South Kitakami Belt), Pakistan (Salt Range) and India (Kashmir).

Family BUXTONIIDAE Muir-Wood and Cooper, 1960
Subfamily TYLOPLECTINAE Termier and Termier, 1970
Genus *TYLOPLECTA* Muir-Wood and Cooper, 1960

Type species. — *Productus scabriculus* mut. *nankingensis* Frech, 1911.

Tyloplecta yangtzeensis (Chao, 1927)
(Figs. 30A–C, 31A–D)

Productus semireticulatus Martin. Kayser, 1883, p. 181, pl. 25, figs. 1–4.
Productus costatus Sowerby. Kayser, 1883, p. 182, pl. 25, figs. 5–7.
Productus sumatrensis Roemer. Fliegel, 1901, p. 128, pl. 6, fig. 1.
Productus yangtzeensis Chao, 1927, p. 50, pl. 5, figs. 1–3; pl. 8, fig. 9; Simić, 1933, p. 31, 92, pl. 1, figs. 11–14.
Productus (*Dictyoclostus*) *yangtzeensis* Chao. Huang, 1932, p. 26, pl. 1, figs. 18–21.
Dictyoclostus yangtzeensis (Chao). Ramovs, 1958, p. 506, pl. 3, fig. 1.
Dictyoclostus sino-indicus (Frech). Nakamura, 1960, p. 499, pl. 2, figs. 2–4; pl. 3, fig. 1; Minato et al., 1979, pl. 63, fig. 6; pl. 64, fig. 1.
Tyloplecta yangtzeensis (Chao). Schréter, 1963, p. 124, pl. 6, figs. 1–7; Yanagida, 1964, p. 3, pl. 1, figs. 1, 3, text-fig. 2; Ting, 1965, p. 268, pl. 3, figs. 1, 2; Sarytcheva in Ruzhentsev and Sarytcheva, 1965, pl. 37, fig. 1; Fantini Sestini and Glaus, 1966, p. 909, pl. 64, figs. 1, 4; pl. 65, fig. 1; Pitakpaivan et al., 1969, p. 10, pl. 17, figs. 13–15; Termier and Termier, 1970, p. 458, pl. 31, fig. 4; Yang et al., 1977, p. 361, pl. 143, fig. 4; Feng and Jiang, 1978, p. 258, pl. 92, figs. 5–8; Licharew and Kotlyar, 1978, p. 12, figs. 11, 12; pl. 19, figs. 8, 9; Tong, 1978, p. 230, pl. 81, fig. 4; Zhan, 1979, p. 88, pl. 6, figs. 20–22; Liao, 1980, pl. 4, figs. 21, 22; Nakamura et al., 1981, p. 44, pl. 1, figs. 1–3; pl. 3, figs. 1, 2; Liu et al., 1982, p. 186, pl. 133, figs. 4, 5; Wang et al., 1982, p. 212, pl. 89, figs. 5, 6; pl. 92, figs. 10, 11; Ding and Qi, 1983, p. 286, pl. 98, fig. 4; Liao, 1987, p. 104, pl. 5, figs. 23, 24; Liang, 1990, p. 192, pl. 33, figs. 1–9; Zhu, 1990, p. 70, pl. 13, figs. 1–9; pl. 14, fig. 28; Zeng et al., 1995, pl. 7, figs. 2, 3, 7; He et al., 2008, p. 815, fig. 3.14, 3.15; Shen and Zhang, 2008, fig. 5.1, 5.2; Shen and Shi, 2009, p. 159, fig. 4A–H; Tazawa, 2016b, p. 16, figs. 5.6, 6.1–6.3.
Tyloplecta sino-indicus (Frech). Tazawa, 1976, pl. 2, fig. 13.
Tyloplecta cf. *yangtzeensis* (Chao). Tazawa and Ibaraki, 2001, p. 8, pl. 1, fig. 5.
Tyloplecta sp. Tazawa, 2002, fig. 10.6.

Material. — Twenty-one specimens from localities KF96, KF121, KF217 and KS8: (1) external and internal moulds of two conjoined shells, UHR12602, NU-B1842; (2) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B1893; (3) internal mould of a conjoined shell, with external mould of the dorsal valve, NU-B1835, UHR12603; (4) internal moulds of three conjoined shells, NU-B1845–1847; (5) external cast of a ventral valve, NU-B1836; (6) external mould of a ventral valve NU-B1837; (7) internal mould of two ventral valves, NU-B1838, UHR13554; and (8) external moulds of eight dorsal valves, NU-B335, 1839–1841, 1849, 1848–1850.

Remarks. — Most of the specimens were previously described by Tazawa (2016b, p. 16, figs. 5.6, 6.1–6.3) as *Tyloplecta yangtzeensis* (Chao, 1927). The specimens from Setamai and Kamiyasse–Imo can be referred to *Tyloplecta yangtzeensis* (Chao, 1927, p. 50, pl. 5, figs. 1–3; pl. 8, fig. 9), from the Lungtan Formation of Zhejiang, eastern China, by large size (length 55 mm, width 66 mm in the largest specimen, NU-B1837), subquadrate to subglobose outline and external ornament of both ventral and dorsal valves. The preceding species, *Tyloplecta sinoindica* (Frech, 1911), is

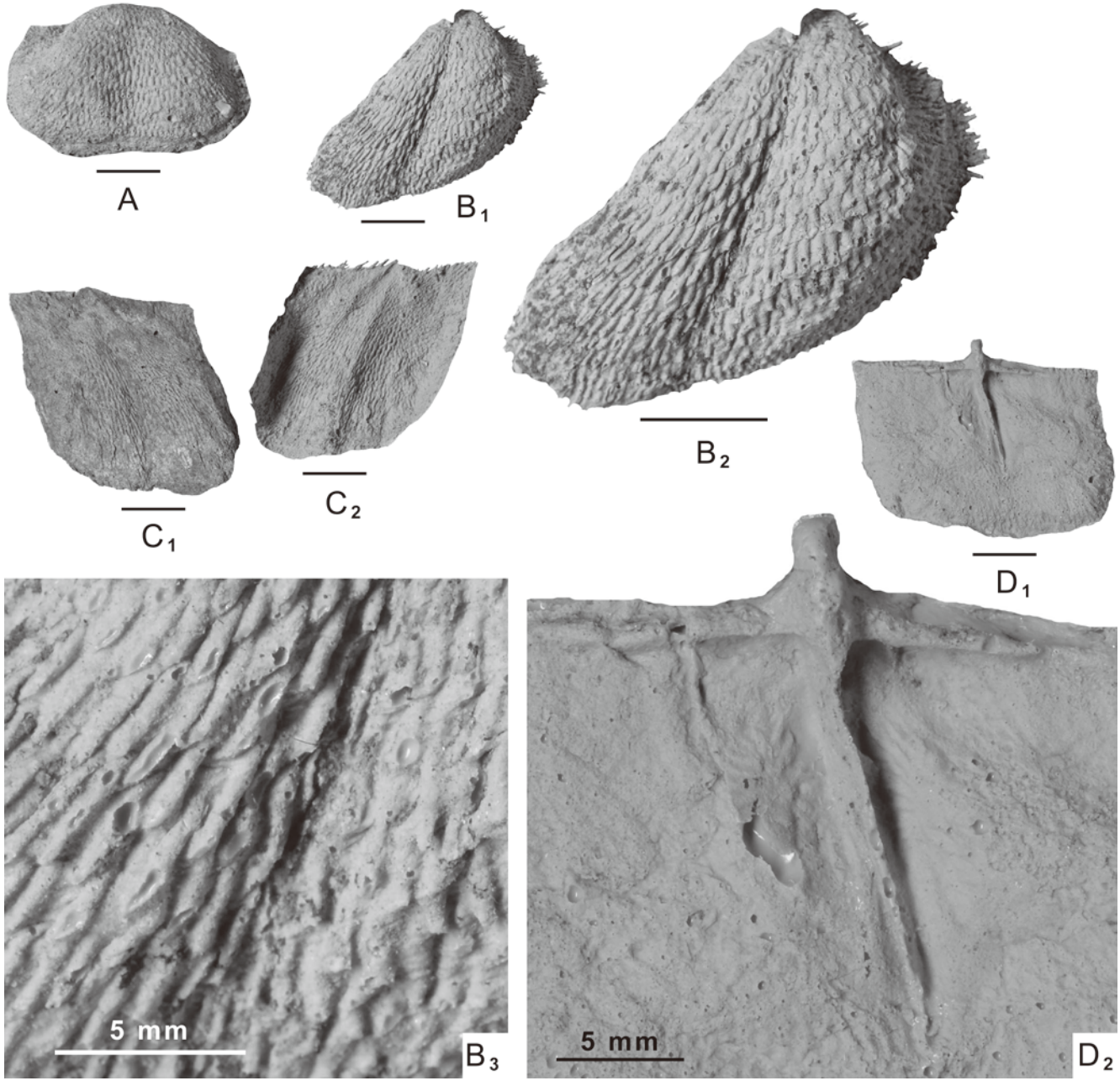

FIGURE 34. **A**–**D**, *Waagenoconcha humboldti* (d'Orbigny); A, external latex cast of ventral valve, UHR12596; B, external latex cast (B_1, B_2) and enlarged external ornament (B_3) of ventral valve, UHR14847; C, external mould (C_1) and external latex cast (C_2) of dorsal valve, UHR19846; D, internal latex cast (D_1) and enlarged posterior portion showing internal structures (D_2) of dorsal valve, UHR19842. Scale bars are 1 cm, except for B_3 and D_2.

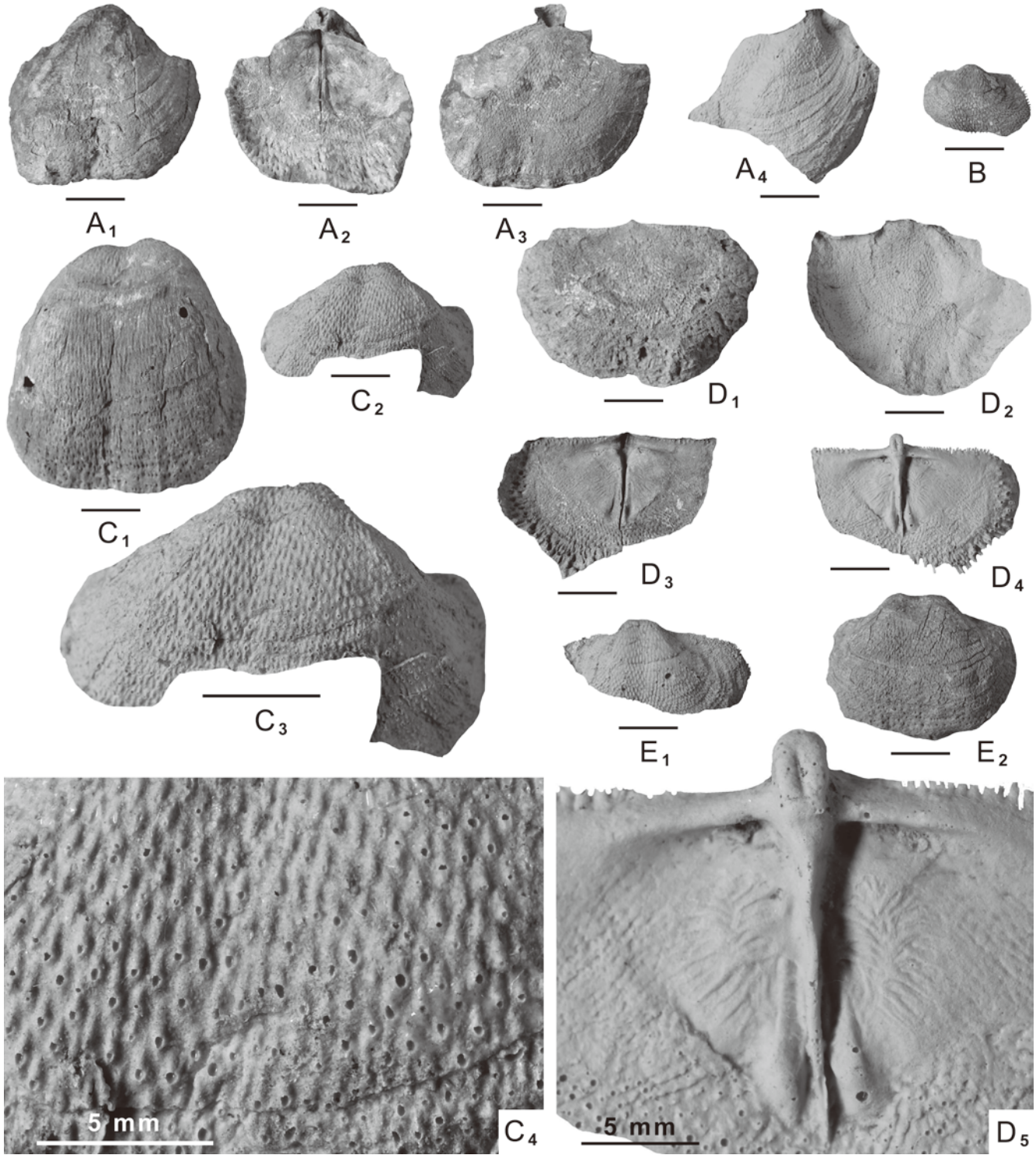

FIGURE 35. **A–E**, *Waagenoconcha irginae* (Stuckenberg); A, ventral (A_1) and dorsal (A_2) views of internal mould, dorsal external mould (A_3) and ventral external latex cast (A_4) of conjoined shell, UHR19841; B, internal mould of ventral valve, UHR19828; C, internal mould (C_1), external latex cast (C_2, C_3) and enlarged external latex cast, showing spine bases on external surface (C_4) of ventral valve, UHR19818; D, external mould (D_1), external latex cast (D_2), internal mould (D_3), internal latex cast (D_4) and enlarged posterior portion, showing cardinal process, median septum, lateral septa and muscle scars (D_5) of dorsal valve, UHR19821; E, external cast (E_1) and internal mould (E_2) of ventral valve, UHR19822. Scale bars are 1 cm, except for C_4 and D_5.

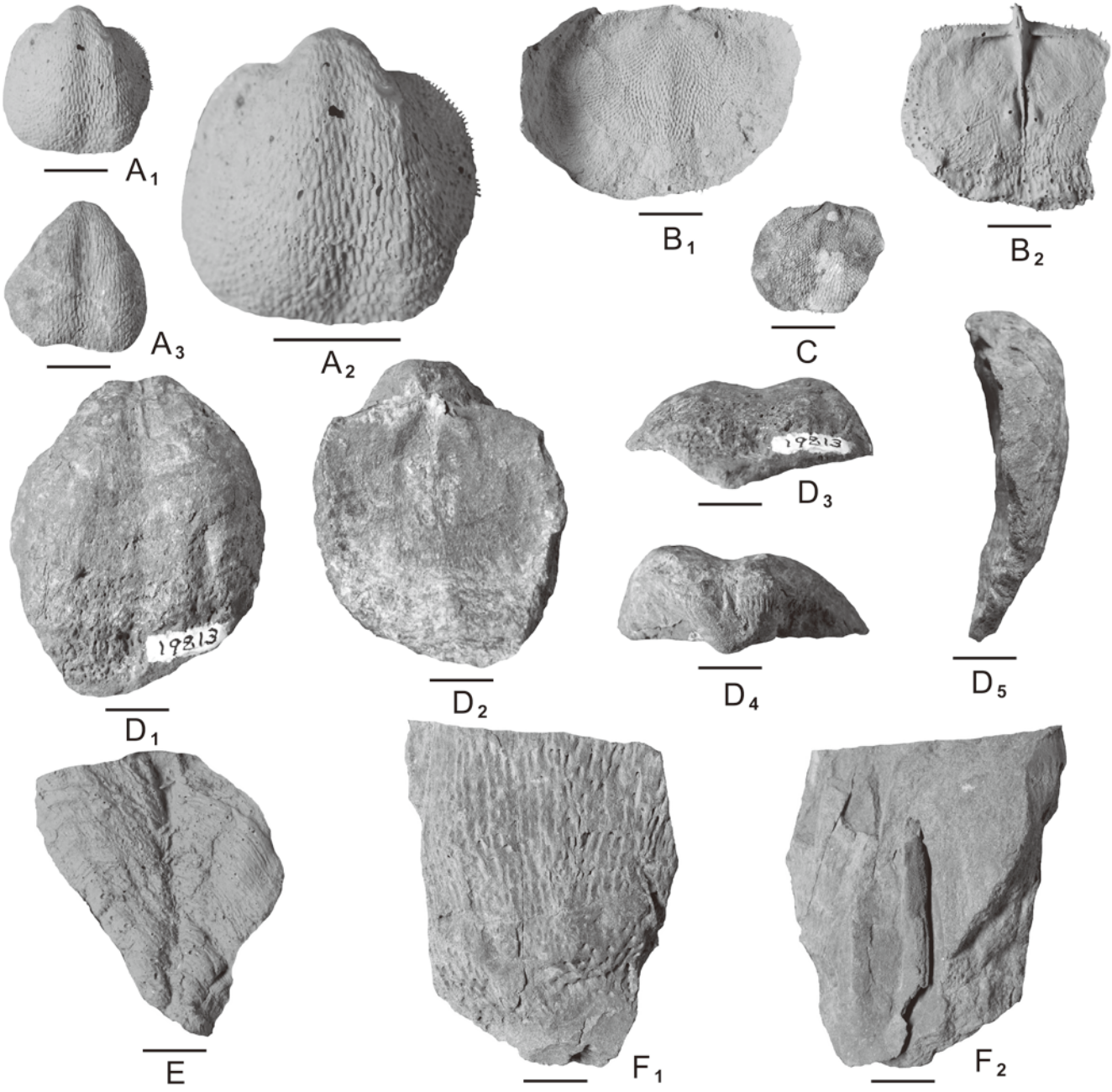

FIGURE 36. **A**–**D**, *Waagenoconcha irginae* (Stuckenberg); A, external latex cast (A_1, A_2) and internal mould (A_3) of ventral valve, UHR19838; B, external latex cast (B_1) and internal latex cast (B_2) of dorsal valve, UHR19826; C, external mould of dorsal valve, UHR19831; D, ventral (D_1), dorsal (D_2), anterior (D_3), posterior (D_4) and lateral (D_5) views of internal mould of conjoined shell, UHR19813; **E**, **F**, *Scacchinella gigantea* Schellwien; E, anterior view of internal mould of ventral valve, NU-B197; F, anterior (F_1) and posterior (F_2) views of internal mould of ventral valve, NU-B198. Scale bars are 1 cm.

readily distinguished from *T. yangtzeensis* by its more elongate and strongly inflated ventral valve and trapezoidal dorsal valve. *Tyloplecta nankingensis* (Frech, 1911, p. 163, pl. 22, fig. 3), from the Lungtan Formation of Jiangsu, eastern China, differs from the present species by its much smaller size and in having more strongly convex ventral valve. The specimens, described by Nakamura (1960, p. 499, pl. 2, figs. 2–4; pl. 3, fig. 1) and figured by Minato et al. (1979, pl. 63, fig. 6; pl. 64, fig. 1) as *Dictyoclostus sinoindicus* (Frech, 1911) from the lower Kanokura Series (= lower Kamiyasse Formation) of Imo in the South Kitakami Belt, are referred to *Tyloplecta yangtzeensis*.

Occurrence. — KN1 Unit in Setamai (locality KS8); and KY1 Unit in Kamiyasse (locality KF96) and Imo (localities KF121 and KF217).

Distribution. — Roadian–Changhsingian: northeastern Japan (Setamai and Kamiyasse–Imo in the South Kitakami Belt), Hungary, Slovenia, Serbia, northwestern China (Qinghai), northern China (Shanxi), eastern Russia (South Primorye), eastern China (Jiangsu, Anhui, Zhejiang, Jiangxi and Fujian), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Guizhou and Sichuan), Armenia, Iran and north-central Thailand.

Superfamily ECHINOCONCHOIDEA Stehli, 1954
Family ECHINOCONCHIDAE Stehli, 1954
Subfamily JURESANIINAE Muir-Wood and Cooper, 1960
Genus *BATHYMYONIA* Muir-Wood and Cooper, 1960

Type species.—*Productus nevadensis* Meek, 1877.

Bathymyonia neimongolica (Wang and Zhang, 2003)
(Fig. 32A–C)

Waagenoconcha imperfecta Prensergast. Tazawa, 1974b, p. 127, pl. 3, fig. 2 only; Minato et al., 1979, pl. 65, figs. 1, 2; Shiino and Suzuki, 2007, figs. 3–6.
Waagenoconcha (*Yazengoconcha*) *neimongolica* Wang and Zhang, 2003, p. 97, pl. 8, figs. 1–8; pl. 9, figs. 1–4; pl. 14, figs. 4–7.
Bathymyonia neimongolica (Wang and Zhang, 2003). Tazawa, 2014, p. 17, fig. 3.1–3.4; Tazawa et al., 2014, p. 381, fig. 3.1, 3.2; Tazawa, 2015, p. 69, fig. 7.1, 7.2 .

Material.—Six specimens from localities KF46, KF217 and KF218; (1) internal moulds of two conjoined shells, with external moulds of the dorsal valves, UHR13131, 13132; (2) internal mould of a conjoined shell, with partly preserved shell substance, UHR19810; (3) internal moulds of two ventral valves, UHR12137, 19811; and (4) external mould of a dorsal valve, NU-B1658.

Remarks. — The specimens from the lower Kamiyasse Formation in the Kamiyasse–Imo area were first described by Tazawa (1974b, p. 127, pl. 3, fig. 2 only) as *Waagenoconcha imperfecta* Prendergast, 1935, and subsequently redescribed by Tazawa (2014, p. 17, fig. 3.1–3.4) as *Bathymyonia neimongolica* (Wang and Zhang, 2003). These specimens can be referred to *Bathymyonia neimongolica* (Wang and Zhang, 2003), originally described by Wang and Zhang (2003, p. 97, pl. 8, figs. 1–8; pl. 9, figs. 1–4; pl. 14, figs. 4–7) from the Zhesi Formation of Inner Mongolia, northern China, on account of elongate subrectangular outline, flattened visceral disc , steep lateral slopes of ventral valve and enormously large cardinal process in dorsal valve. *Bathymyonia barabaschensis* Kotlyar in Licharew and Kotlyar (1978, p. 67, pl. 16, fig. 1), from the upper Barabashevka Formation of South Primorye, eastern Russia, differs from *B. neimongolica* by its less elongate, more strongly and evenly convex ventral valve. The type species, *Bathymyonia nevadensis* (Meek, 1877), refigured by Muir-Wood and Cooper (1960, pl. 82, figs 1–7; pl. 109, fig. 1) on the specimens from the Phosphoria Formation of Wyoming, Utah and Nevada in the USA, is distinguished from *B. neimongolica* by its smaller, less elongate and more evenly convex ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (locality KF46) and Imo (localities KF217 and KF218).

Distribution.— Wordian–Capitanian: northeastern Japan (Kamiyasse–Imo and Hitachi in the South Kitakami Belt) and northern China (Inner Mongolia).

Genus *VEDIPRODUCTUS* Sarytcheva in Sarytcheva and Sokolskaya, 1965

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

Vediproductus punctatiformis (Chao, 1927)
(Fig. 33A–E)

Echinoconchus punctatiformis Chao, 1927, p. 72, pl. 6, figs. 9–12; Zhan and Lee, 1962, p. 477, pl. 2, fig. 9.
Echinoconchus cf. *fasciatus* (Kutorga). Minato et al., 1979, pl. 65, figs. 5–7.
Vediproductus punctatiformis (Chao). Wang et al., 1982, p. 208, pl. 80, figs. 10, 11; pl. 84, fig. 4; Ding and Qi, 1983, p. 282, pl. 96, fig. 3; Wang, 1984, p. 190, pl. 76, fig. 7; Chang, 1987, p. 759, pl. 2, fig. 4; Liang, 1990, p. 187, pl. 27, fig. 5; Shiino, 2009, p. 255, fig. 4A–H; Tazawa, 2016b, p. 19, fig. 7.1–7.5.
Vediproductus mugenjin Shiino, 2009, p. 252, fig. 3.

Material.—Fourteen specimens from localities KF64, KF217 and KF218: (1) external and internal moulds of two conjoined shells, NU-B1660, 1661; (2) internal moulds of two conjoined shells, with external moulds of the dorsal valves, NU-B1662, 1663; (3) external and internal moulds of a ventral valve, NU-B1664; (4) internal moulds of six ventral valves, NU-B1666, 1667, UHR12022, 12472, 12612, 12641; and (5) external moulds of three dorsal valves, NU-B1665, 1668, UHR17083.

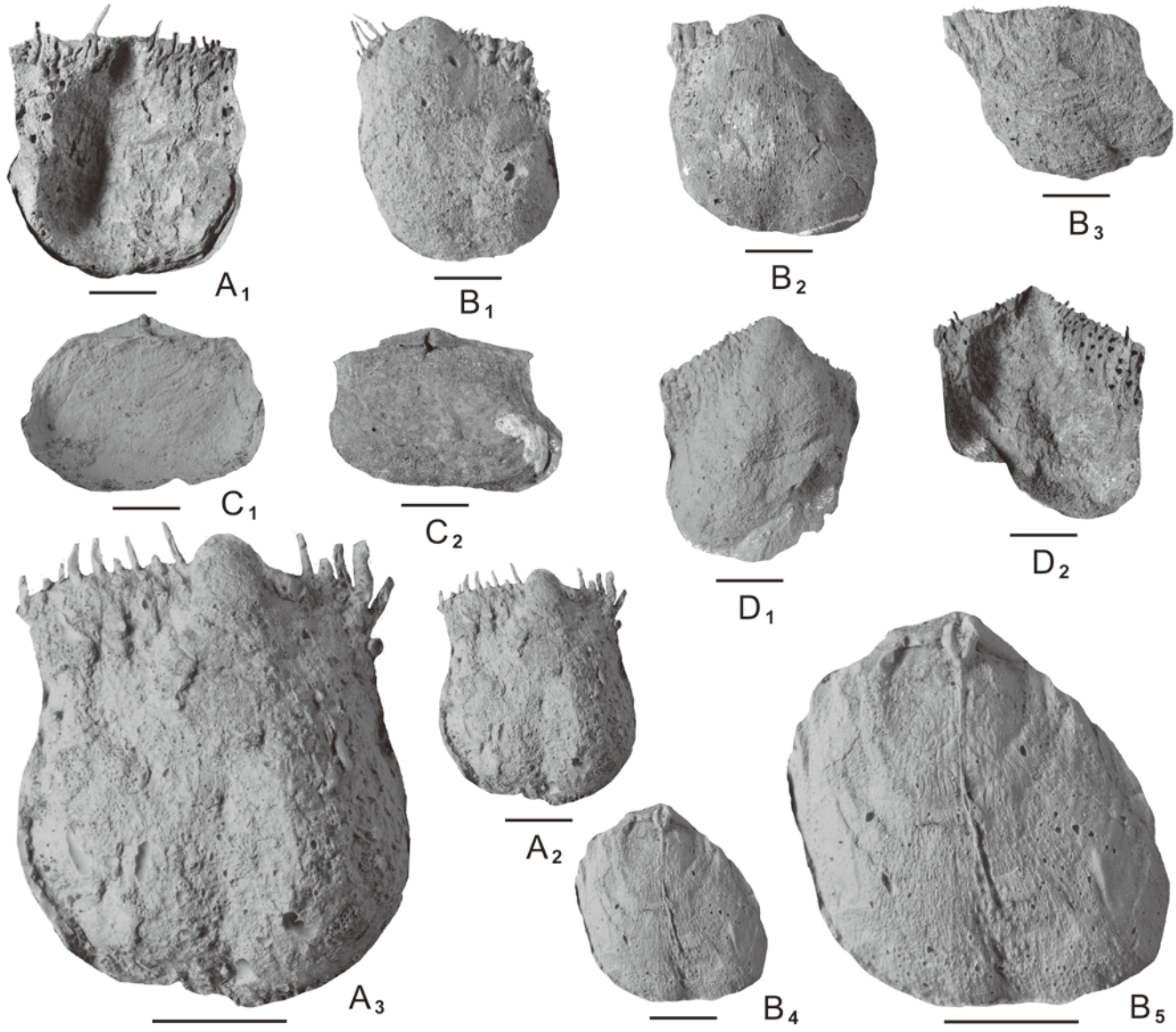

FIGURE 37. **A– D**, *Edriosteges multispinosus* Muir-Wood and Cooper; A, external mould (A_1) and external latex cast (A_2, A_3) of ventral valve, UHR12634; B, ventral external latex cast (B_1), ventral internal mould (B_2), dorsal external mould (B_3) and dorsal internal latex cast (B_4, B_5) of conjoined shell, UHR12631; C, external latex cast (C_1) and external mould (C_2) of dorsal valve, UHR12633; D, external latex cast (D_1) and external mould (D_2) of ventral valve, UHR12665. Scale bars are 1 cm.

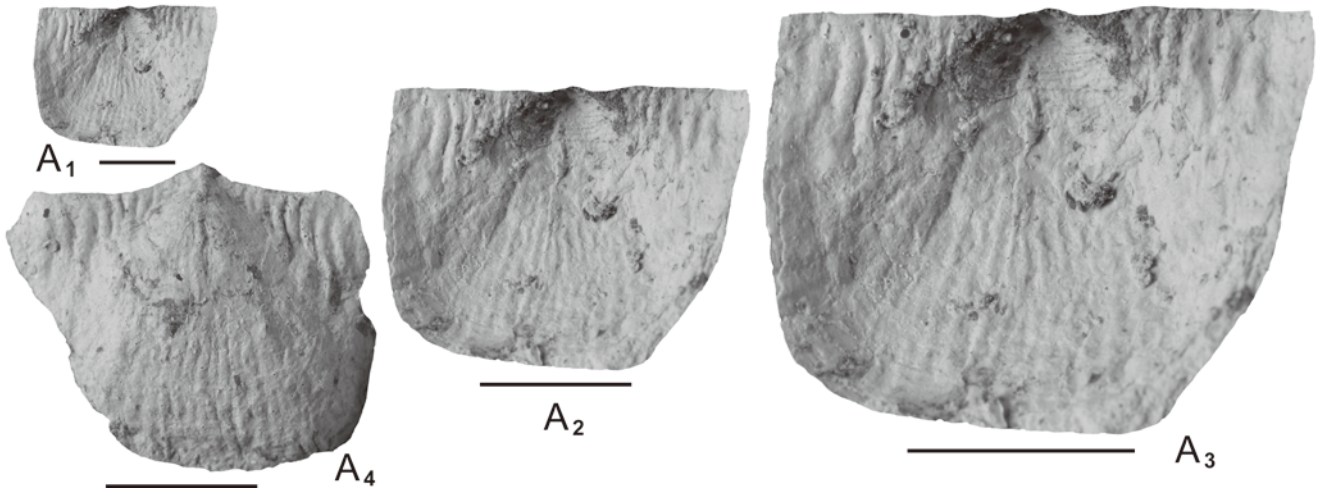

FIGURE 38. **A**, *Limbella* sp., external latex cast (A_1, A_2, A_3) and internal latex cast (A_4) of dorsal valve, NU-B2572. Scale bars are 1 cm.

Remarks.—These specimens were described by Tazawa (2016b, p. 19, fig. 7.1–7.5) as *Vediproductus punctatiformis* (Chao, 1927). The specimens from Kamiyasse–Imo are referred to *Vediproductus punctatiformis* (Chao, 1927, p. 72, pl. 6, figs. 9–12), from the Ksiaokiang Limestone of Jiangxi, eastern China, in medium size (length 34 mm, width 26 mm in the best-preserved specimen, NU-B1660), elongate oval and strongly convex ventral valve and numerous regular spinose bands on both ventral and dorsal valves. *Vediproductus mugenjin* Shiino (2009, p. 252, fig. 3), from the lower Kamiyasse Formation of Kamiyasse, may be a synonym of the present species. 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 the Transcaucasus, differs from *V. punctatiformis* in its less convex and wider ventral valve and broader concentric bands on both ventral and dorsal valves.

Occurrence.—KY1 Unit in Kamiyasse (locality KF64) and Imo (localities KF217 and KF218).

Distribution.—Asselian–Capitanian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), northwestern China (Xinjiang and Gansu), eastern China (Anhui, Zhejiang and Jiangxi) and central-southern China (Hubei).

Family WAAGENOCONCHIDAE Muir-Wood and Cooper, 1960

Subfamily WAAGENOCONCHINAE Muir-Wood and Cooper, 1960

Genus *WAAGENOCONCHA* Chao, 1927

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

Waagenoconcha humboldti (d'Orbigny, 1842)
(Fig. 34A–D)

Productus humboldti d'Orbigny, 1842, p. 54, pl. 5, figs. 4–7; Tschernyschew, 1902, p. 275, 620, pl. 53, figs. 1–3; Kozlowski, 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 in Sarytcheva and Sokolskaya, 1952, p. 98, pl. 15, fig. 109; Chronic, 1953, p. 86, pl. 15, figs. 4–7; Muir-Wood and Cooper, 1960, pl. 89, figs. 6–10: Samtleben, 1971, p. 60, pl. 2, figs. 17–19; Ifanova, 1972, p. 102, pl. 3, figs. 11–13; Tazawa, 1974b, p. 125, pl. 1, figs. 2, 3; pl. 2, fig. 1; pl. 4, fig. 6; Ding and Qi, 1983, p. 283, pl. 96, fig. 9; 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, fig. 4.1–4.5; Tazawa and Shintani. 2015, p. 45, fig. 4.1 ; Tazawa, 2017, p. 47, fig. 9.1–9.4; Tazawa and Shintani, 2022, p. 24, fig. 20C, D.

Waagenoconcha imperfecta Prendergast. Tazawa, 1974b, p. 127, pl. 2, fig. 6 only.

Material.—Eight specimens from localities KF121 and KF217: (1) internal mould of a conjoined shell, UHR19819; (2) external and internal moulds of two ventral valves, UHR12133, 19847; (3) external moulds of two ventral valves, UHR12595, 12596; (4) external mould of a dorsal valve, UHR19846; and (5) internal moulds of two dorsal

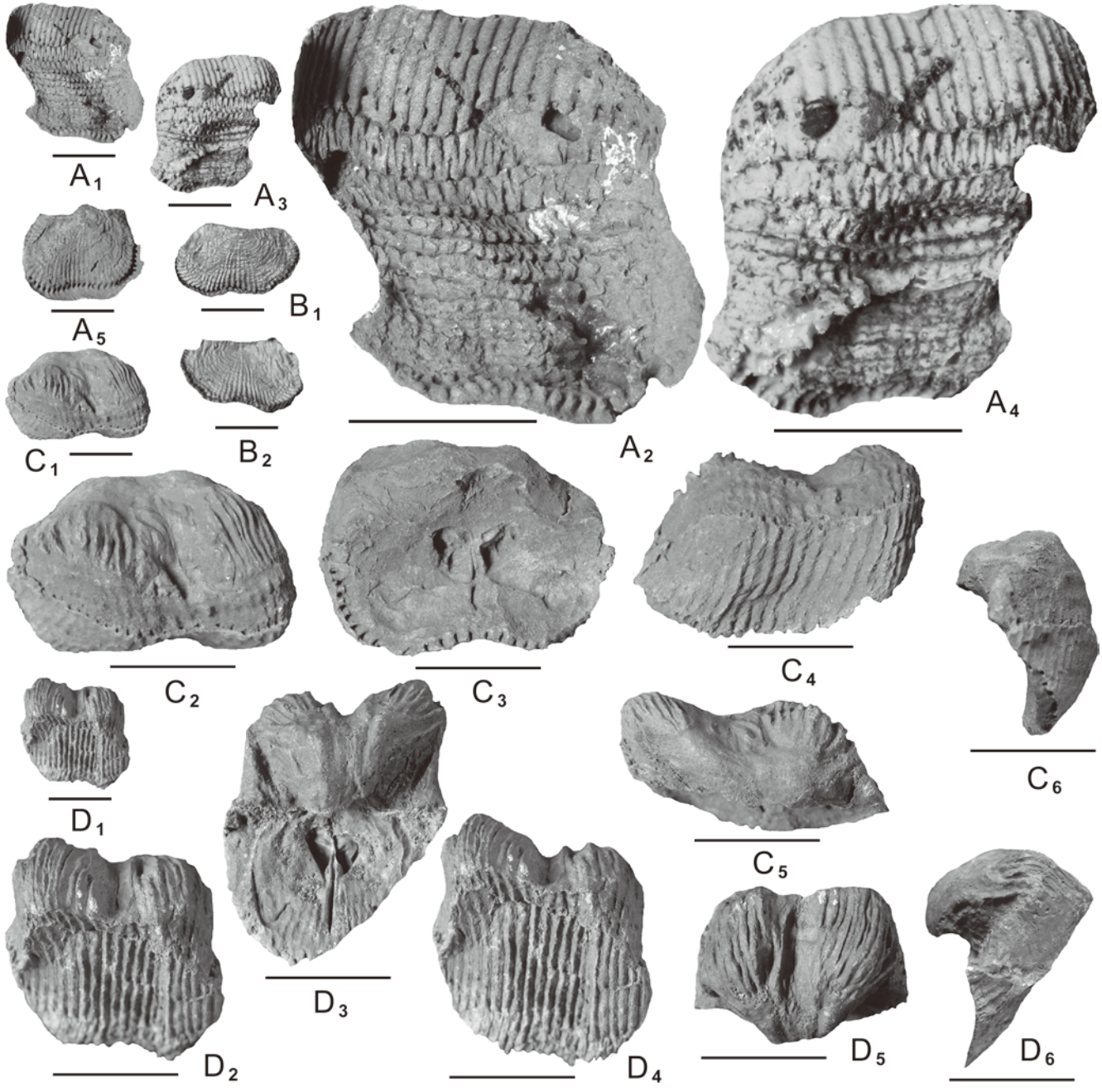

FIGURE 39. **A–D**, *Urushtenoidea crenulata* (Ding); A, anterior view of internal mould (A_1, A_2) and internal latex cast (A_3, A_4) and dorsal view of external mould (A_5) of conjoined shell, UHR30386; B, external mould (B_1) and external latex cast (B_2) of dorsal valve, NU-B2150; C, ventral (C_1, C_2), dorsal (C_3), anterior (C_4), posterior (C_5) and lateral (C_6) views of internal mould of conjoined shell, NU-B2148; D, ventral (D_1, D_2), dorsal (D_3), anterior (D_4), posterior (D_5) and lateral (D_6) views of internal mould of conjoined shell, NU-B2479. Scale bars are 1 cm.

valves, UHR19842, 19843.

Remarks.—These specimens were previously described by Tazawa (1974b, p. 125, pl. 1, figs. 2, 3; pl. 2, fig. 1; pl. 4, fig. 6) and Tazawa (2017, p. 47, fig. 9.1–9.4) as *Waagenoconcha humboldti* (d'Orbigny, 1842). The specimens from Kamiyasse–Imo are referred to *Waagenoconcha humboldti* (d'Orbigny, 1842), originally described from the lower Permian (Asselian) of Yarbichambi, Bolivia, on account of medium size (length about 33 mm, width about 45 mm in the largest specimen, UHR12596), transversely subrectangular outline and external ornament of both valves, particularly, in having elongate, relatively coarse spine bases (numbering 4–5 spine bases in 5 mm width at midlength) and strong rugae on ventral valve. *Waagenoconcha abichi* (Waagen, 1884, p. 697, pl. 74, figs. 1–7), from the Wargal and Chhidru Formations of the Salt Range, Pakistan, is also a medium-sized species, but the Pakistani species differs from *W. humboldti* in having coarser and sparser spine bases on ventral valve.

Occurrence.—KY1 Unit in Imo (localities KF121 and KF217).

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

Waagenoconcha irginae (Stuckenberg, 1898)
(Figs. 35A–E, 36A–D)

Productus irginae Stuckenberg, 1898, p. 220, pl. 2, fig. 16; Tschernyschew, 1902, p. 273, 618, pl. 30, figs. 3, 4; pl. 52, figs. 1–4; Miloradovich, 1935, p. 67, 133, pl. 5, figs. 1, 2.

Productus cf. *humboldti irginae* Stuckenberg. Fredericks, 1925, p. 19, pl. 4, fig. 117.

Waagenoconcha humboldti var. *irginae* (Stuckenberg). Solomina, 1960, p. 31, pl. 2, figs. 1–4.

Waagenoconcha irginae (Stuckenberg). Muir-Wood and Cooper, 1960, pl. 89, figs. 15, 16; Gobbett, 1963, p. 76, pl. 5, fig. 7; pl. 6, figs. 1–5; Zavodowsky and Stepanov, 1970, p. 89, pl. 3, figs. 3, 4; Ifanova, 1972, p. 103, pl. 3, figs. 14–16; Lee and Gu, 1976, p. 252, pl. 155, figs. 3, 4; pl. 170, fig. 3; Kalashnikov, 1986, pl. 118, figs. 2, 3; Kalashnikov, 1993, p. 70, pl. 36, figs. 3–5; Tazawa and Araki, 2016, p. 157, fig. 4.1–4.6; Tazawa, 2016b, p. 22, fig. 7.6–7.11; Tazawa, 2017, p. 49, fig. 10.1–10.4.

Waagenoconcha imperfecta Prendergast. Tazawa, 1974b, p. 127, pl. 1, figs. 4–6; pl. 2, figs. 2–7; pl. 3, figs. 1–3; pl. 4, figs. 1–4, 7 (excluding pl. 2, fig. 6; pl. 3, fig. 2); Tazawa, 1976, pl. 2, fig. 6; Minato et al., 1979, pl. 65, figs. 1, 2; Manankov, 1991, p. 112, pl. 23, figs. 4–7; Tazawa. 2002, figs. 10.12; Tazawa, 2007, fig. 4.12.

Waagenoconcha sp. Tazawa and Ibaraki, 2001, p. 9, pl. 1, fig. 4.

Waagenoconcha cf. *imperfecta* Prendergast. Tazawa, 2001, p. 293, fig. 7.24.

Material.—Fifty-six specimens from localities KF9, KF11, KF39, KS9 and TY1: (1) external and internal moulds of two conjoined shells, UHR19813, 19841; (2) internal moulds of three conjoined shells, with external moulds of the dorsal valves, UHR19816, 19817, 19827; (3) internal moulds of eleven conjoined shells, KCG24–29, UHR19834, 19839; (4) external and internal moulds of six ventral valves, UHR19812, 19818, 19822, 19828, 19838, 19840; (5) external mould of a ventral valve, UHR19823; (6) internal moulds of twenty-three ventral valves, KCG30–44, NU-B1659, UHR19815, 19825, 19830, 19832, 19835; (7) external and internal moulds of eight dorsal valves, UHR19814, 19821, 19824, 19826, 19829, 19831, 19836, 19837; and (8) external moulds of seven dorsal valves, KCG45–49, NU-B336, UHR19820.

Remarks.—Most of the specimens were described by Tazawa and Araki (2016, p. 157, fig. 4.1–4.6) and Tazawa (2016b, p. 22, fig. 7.6 7.11; 2017, p. 49, fig. 10.1–10.4.) as *Waagenoconcha irginae* (Stuckenberg, 1898). These specimens can be referred to *Waagenoconcha irginae* (Stuckenberg, 1898), redescribed and refigured by Tschernyschew (1902, p. 273, 618, pl. 30, figs. 3, 4; pl. 52, figs. 1–4) from the lower Permian (*Cora–Schwagerina* horizons) of Ufa, southern Urals, central Russia, in being medium size (length 47 mm, width 40 mm in the largest specimen, UHR19813; length 34 mm, width 34 mm in average-sized specimen, UHR19835), equidimensional to slightly longer subrectangular in outline and external ornament of both ventral and dorsal valves, in particular, fine quincunxially arranged spine bases becoming finer anteriorly (numbering 8 spine bases in 5 mm width at midlength, 8–9 spine bases in 5 mm width near anterior margin). *Waagenoconcha imperfecta* Prendergast, 1935, redescribed by Archbold (1993, p. 20, figs. 11–13) from the upper Permian (Wuchiapingian) of the Canning and Bonaparte Gulf basins of western Australia, differs from the present species in its much larger size and in having finer spine bases on ventral valve. The preceding species, *Waagenoconcha humboldti* (d'Orbigny, 1842), is readily distinguished from *W. irginae* by coarser spine bases on ventral valve.

Occurrence.—NK2 Unit in Setamai (locality KS9); KY1 Unit in Kamiyasse (localities KF11 and KF39) and Imo (locality TY1); and KY2 Unit in Kamiyasse (locality KF9).

Distribution. — Asselian–Capitanian: northeastern Japan (Setamai and Kamiyasse–Imo in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), Spitsbergen, northern Russia (Kanin Peninsula, Timan, northern Urals, Pechora Basin and Kolyma Massif), central Russia (southern Urals), southern Mongolia, northern China (Inner Mongolia) and eastern Russia (South Primorye).

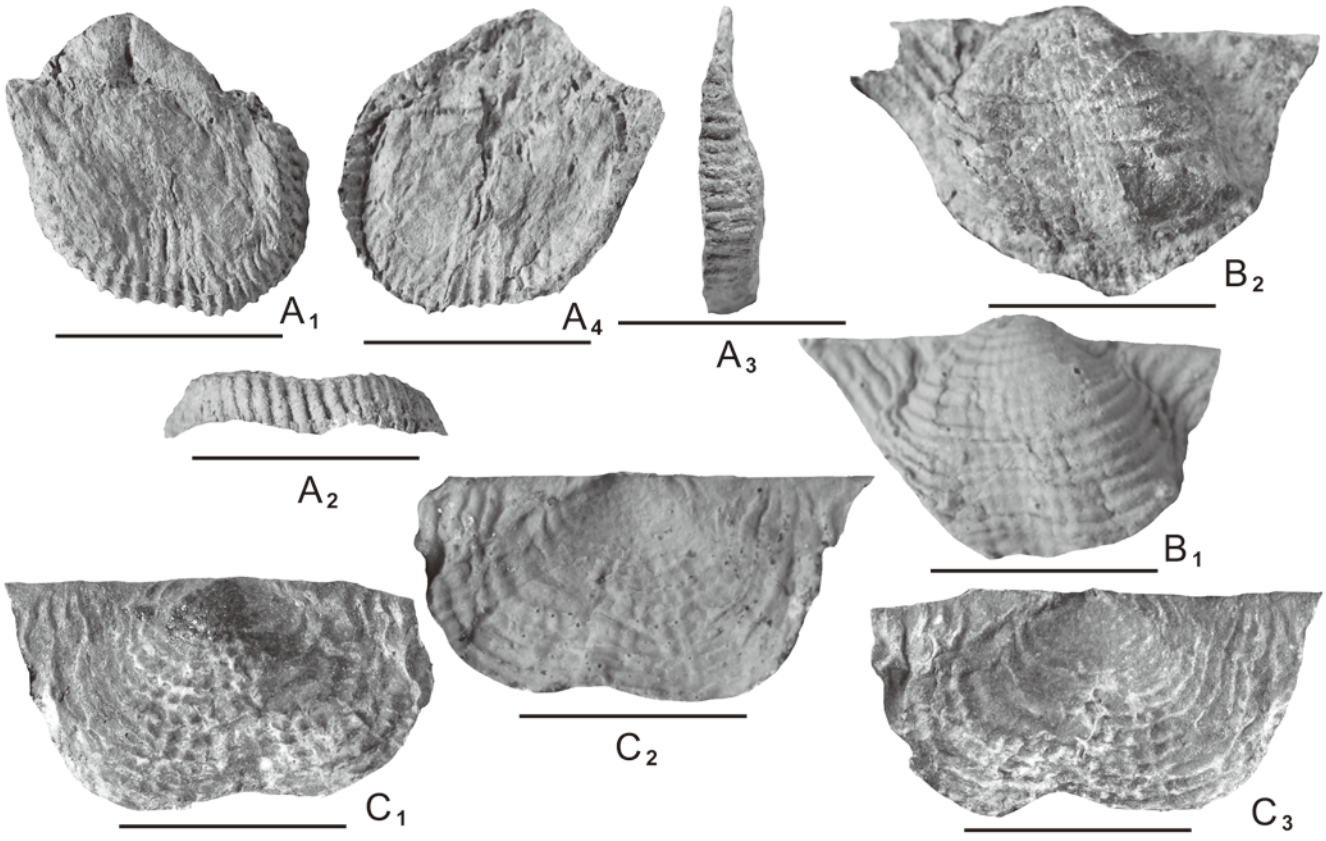

FIGURE 40. **A**, *Chonosteges* sp., dorsal (A_1), anterior (A_2) and lateral (A_3) views of external mould, and internal mould (A_4) of dorsal valve, NU-B2519; **B**, **C**, *Anidanthus mizukoshiensis* Tazawa; B, external latex cast (B_1) and internal mould (B_2) of ventral valve, NU-B2543; C, external mould (C_1), external latex cast (C_2) and internal mould (C_3) of dorsal valve, NU-B2542. Scale bars are 1 cm.

Superfamily AULOSTEGOIDEA Muir-Wood and Cooper, 1960

Family ECHINOSTEGIDAE Muir-Wood and Cooper, 1960

Subfamily ECHINOSTEGINAE Muir-Wood and Cooper, 1960

Genus *EDRIOSTEGES* Muir-Wood and Cooper, 1960

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

Edriosteges multispinosus Muir-Wood and Cooper, 1960
(Fig. 37A–D)

Aulosteges medlicottianus (Waagen). King, 1931, p. 93, pl. 26, figs. 7–11; pl. 27, figs. 8, 9.

Edriosteges multispinosus Muir-Wood and Cooper, 1960, p. 104, pl. 17, figs. 1–10; Cooper and Grant, 1975, p. 840, pl. 218, figs. 1–11; pl. 219, figs. 1–27; pl. 220, figs. 1–32; pl. 221, figs. 1–23; pl. 222, figs. 6–13; pl. 223, figs. 17, 18; Sun, 1991, p. 226, pl. 5, fig. 17.

Edriosteges poyangensis (Kayser). Minato et al., 1979, pl. 61, figs. 7–10.

Material.—Eight specimens from localities KF89 and KF218: (1) external and internal moulds of a conjoined shell, UHR12631; (2) external mould of a conjoined shell, UHR12632; (3) external and internal moulds of two ventral valves, NU-B1276, UHR12634; (4) external mould of a ventral valve, UHR12665; (5) internal mould of a ventral valve, UHR12635; (6) external and internal moulds of a dorsal valve, NU-B2569; and (7) external mould of a dorsal valve, UHR12633, 12635.

Description.—Shell medium in size for genus, slightly longer subquadrate in outline, with greatest width at hinge; length 37 mm, width 34 mm in the largest specimen, UHR12634. Ventral valve strongly and unevenly convex in

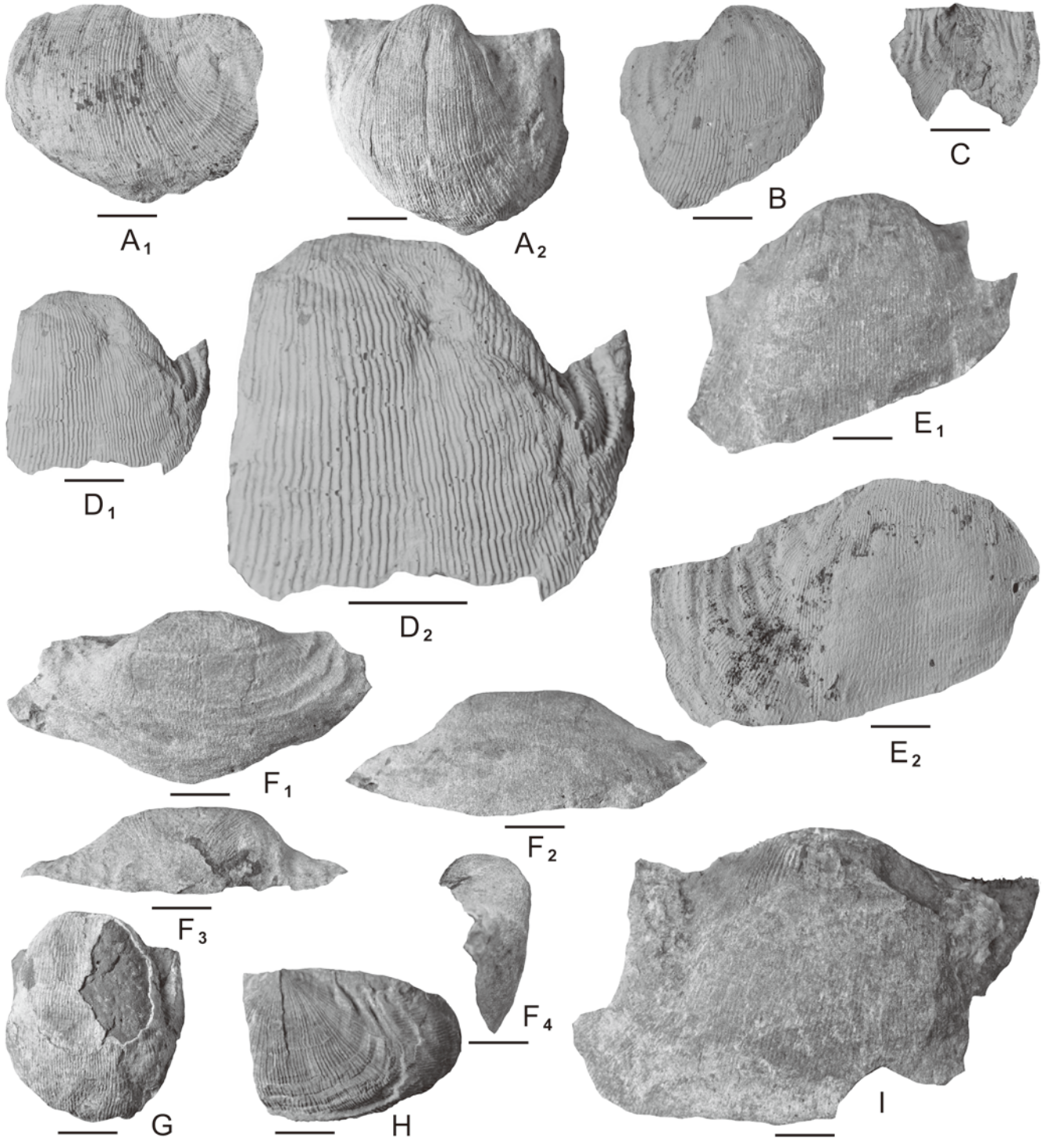

FIGURE 41. **A**–**I**, *Linoproductus hayasakai* Tazawa; A, external latex cast (A_1) and internal mould (A_2) of ventral valve, IGPS96239; B, external latex cast of ventral valve, IGPS96241; C, external latex cast of dorsal valve, IGPS96249; D, external latex cast (D_1, D_2) of ventral valve, IGPS96240; E, internal mould (E_1) and external latex cast (E_2) of ventral valve, NU-B337; F, ventral (F_1), anterior (F_2), posterior (F_3) and lateral (F_4) views of internal mould of ventral vale, NU-B344; G, exterior of ventral valve, NUB2482; H, external mould of dorsal valve, NU-B2483; I, internal mould of dorsal valve, NU-B341. Scale bars are 1 cm.

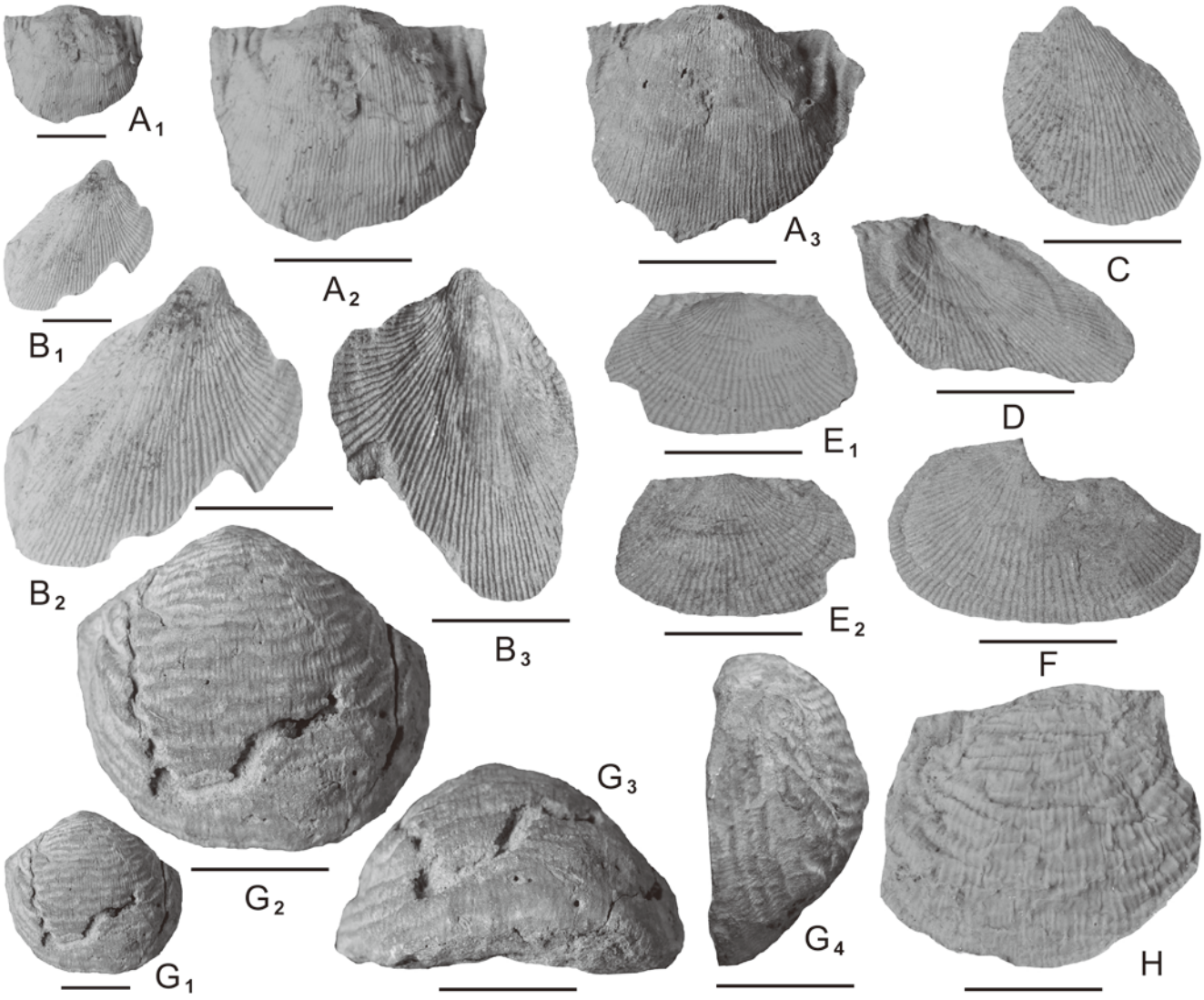

FIGURE 42. **A**, *Globiella tschernyschewi* (Netschajew), external latex cast (A_1, A_2) and internal mould (A_3) of ventral valve, NU-B6197; **B–F**, *Lamiproductus kamiyassensis* (Tazawa); B, external latex cast (B_1, B_2) and external mould (B_3) of ventral valve, NU-B1978 (holotype); C, external latex cast of ventral valve, NU-B1983; D, external mould of ventral valve, NU-B1979; E, external latex cast (E_1) and external mould (E_2) of dorsal valve, NU-B1990; F, external mould of dorsal valve, NU-B1991; **G**, **H**, *Costatumulus cancriniformis* (Tschernyschew); G, ventral (G_1, G_2), anterior (G_3) and lateral (G_4) views of internal mould of ventral valve, IGPS96217; H, external latex cast of ventral valve, IGPS96218. Scale bars are 1 cm.

lateral profile, most convex at posterior portion, flattened medially; ears large, triangular; sulcus shallow on anterior two-thirds. Dorsal valve slightly concave, geniculated with short trail. External surface of ventral valve ornamented with numerous spines, dense on ears and sporadically on venter; dorsal valve ornamented with irregular fine concentric rugae. Interior of ventral valve not well preserved. Interior of dorsal valve with prominent trilobate cardinal process on shaft; thin, long median breviseptum extending to two-thirds valve length; strong, short lateral ridges; a pair of large dendritic adductor scars on posterior of valve. .

Remarks.—These specimens are referred to *Edriosteges multispinosus* MuirWood and Cooper (1960, p. 104, pl. 17, figs. 1–10), from the upper Leonardian of the Glass Mountains, Texas, by medium size and slightly longer subquadrate outline. Minato et al. (1979, pl. 61, figs. 7–10)

figured some of the present specimens (UHR12631–12633) as *Edriosteges poyangensis* (Kayser). But *Edriosteges poyangensis* (Kayser, 1883, p. 190, pl. 28. figs. 8–10), from the upper Permian of Loping, Jiangxi, eastern China, differs from *E. multispinosus* in its smaller size, transverse outline, and in having numerous fine concentric lines on both ventral and dorsal valves.

Occurrence. — KY1 Unit in Kamiyasse (locality KF89) and Imo (locality KF218).

Distribution.—Artinskian–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), USA (Texas) and northwestern China (Tibet).

Genus *LIMBELLA* Stehli, 1954

Type species.—*Aulosteges wolfcampensis* King, 1931.

Limbella sp.
(Fig. 38A)

Material.—One specimen from locality KF37, external and internal moulds of a dorsal valve, NU-B2572.

Remarks.—The single specimen from Imo can be assigned to the genus *Limbella* Stehli, 1954 by medium size (length 20 mm, width 23 mm), subquadrate outline, moderately concave dorsal valve with flattened ears, external ornament consisting of numerous capillae, fine costellae and dimples scattered over valve, and in having bilobed cardinal process and short median septum in dorsal valve. The Imo species most resembles *Limbella wolfcampensis* (King, 1931), redescribed and refigured by Cooper and Grant (1975, p. 834, pl. 213, figs. 1–29; pl. 214, figs. 1–21; pl. 215, figs. 1–3; pl. 216, figs. 11–13, 15) from the lower Wolfcamian of Texas, in size, shape and external ornament of dorsal valve, but, exact comparison is difficult for the poor material.

Occurrence.—KY1 Unit in Kamiyasse (locality KF37).

Subfamily CHONOSTEGINAE Muir-Wood and Cooper, 1960

Genus *CHONOSTEGES* Muir-Wood and Cooper, 1960

Type species.—*Aulosteges magnicostatus* Girty, 1909.

Chonosteges sp.
(Fig. 40A)

Material.—One specimen from locality KF62, external and internal moulds of a dorsal valve, NU-B2519.

Remarks.—The single specimen from Kamiyasse can be assigned to the genus *Chonosteges* Muir-Wood and Cooper, 1960 by its small size (length 14 mm, width 14 mm), flat and smooth visceral disc which is strongly geniculated with a short trail, and numerous strong costae on dorsal trail. But the specific identification is difficult for the poorly preserved specimen.

Occurrence.—KY1 Unit in Kamiyase (locality KF62).

Genus *URUSHTENOIDEA* Jin and Hu, 1978

Type species.—*Urushtenia chaoi* Jin, 1963.

Urushtenoidea crenulata (Ding in Yang et al., 1962)
(Fig. 39A–D)

Eomarginifera crenulata Ding in Yang et al., 1962, p. 85, pl. 37, figs. 6–8.

Urushtenia crenulata (Ding). Jin, 1963, p. 20, 29, pl. 1, figs. 17–24; pl. 2, figs. 9, 10, 18–20, text-fig. 5; Jin et al., 1974, p. 309, pl. 162, figs. 1–3; Yang et al., 1977, p. 335, pl. 136, fig. 11; Tong, 1978, p. 218, pl. 78, fig. 17; Yang and Gao, 1996, pl. 34, figs. 7, 8.

Urushtenoidea crenulata (Ding). Nakamura, 1979, p. 228, pl. 1, figs. 5–9; pl. 3, figs. 1, 2; Yang, 1984, p. 213, pl. 31, fig. 19; Jin, 1985, pl. 6, fig. 41; Tazawa, 2000, fig. 3.10, 3.11; Tazawa, 2001, p. 296, fig. 7.1–7.9; Shen et al., 2003c, p. 1131, fig. 4.11–4.13; Tazawa, 2008b, p. 50, fig. 7.15, 7.16; Shen and Shi, 2009, p. 155, fig. 3B–I; Tazawa, 2016b, p. 24, fig. 8.1–8.4; Tazawa and Araki, 2017, p. 272, fig. 6.8, 6.9.

Urushtenoidea maceus (Jin). Nakamura, 1979, p. 227, pl. 1, figs. 1–4; pl. 2, figs. 1–3; Minato et al., 1979, pl. 65, figs. 8–11; Tazawa, 2002, fig. 10.8.

Uncisteges crenulata (Ding). Liu et al., 1982, p. 178, pl. 129, fig. 1; Zhu, 1990, p. 74, pl. 14, figs. 4–14; pl. 17, fig. 12.

Material. —Twenty specimens from localities AR4, KF39, KF90, KF217, KF218, KS9 and KZ9: (1) external mould of a conjoined shell, UHR30386; (2) internal moulds of two conjoined shells, with external moulds of the ventral valves, NU-B2476, 2477; (3) internal moulds of two conjoined shells, with external moulds of the dorsal valves, NU-B2142, 2143; (4) internal moulds of six conjoined shells, NU-B2144–2148, 2478; (5) internal moulds of four ventral valves, NU-B2149, 2479, UHR30387, 30388; (6) external and internal moulds of a dorsal valve, NU-B2480; (7) external moulds of three dorsal valves, NU-B2150, 2151, 2481; and (8) internal mould of a dorsal valve, UHR17068.

Remarks.—These specimens were previously described by Tazawa (2016b, p. 24, fig. 8.1–8.4) and Tazawa and Araki (2017, p. 272, fig. 6.8, 6.9) as *Urushtenoidea crenulata* (Ding in Yang et al., 1962). The specimens from Kamiyasse–Imo and Matsukawa are referred to *Urushtenoidea crenulata* (Ding in Yang et al., 1962), from the Maokouan of Qinghai, northwestern China, in size (length about 17 mm, width about 25 mm in the largest specimen, NU-B2148), transversely subquadrate outline, and external ornament of both ventral and dorsal valves, especially in having relatively fine costae (6–7 in 5 mm) on ventral trail. *Urushtenoidea maceus* Jin (1963, p. 19, pl. 2, figs. 1–6), from the Chihsian–Maokouan of eastern China (Jiangsu, Anhui and

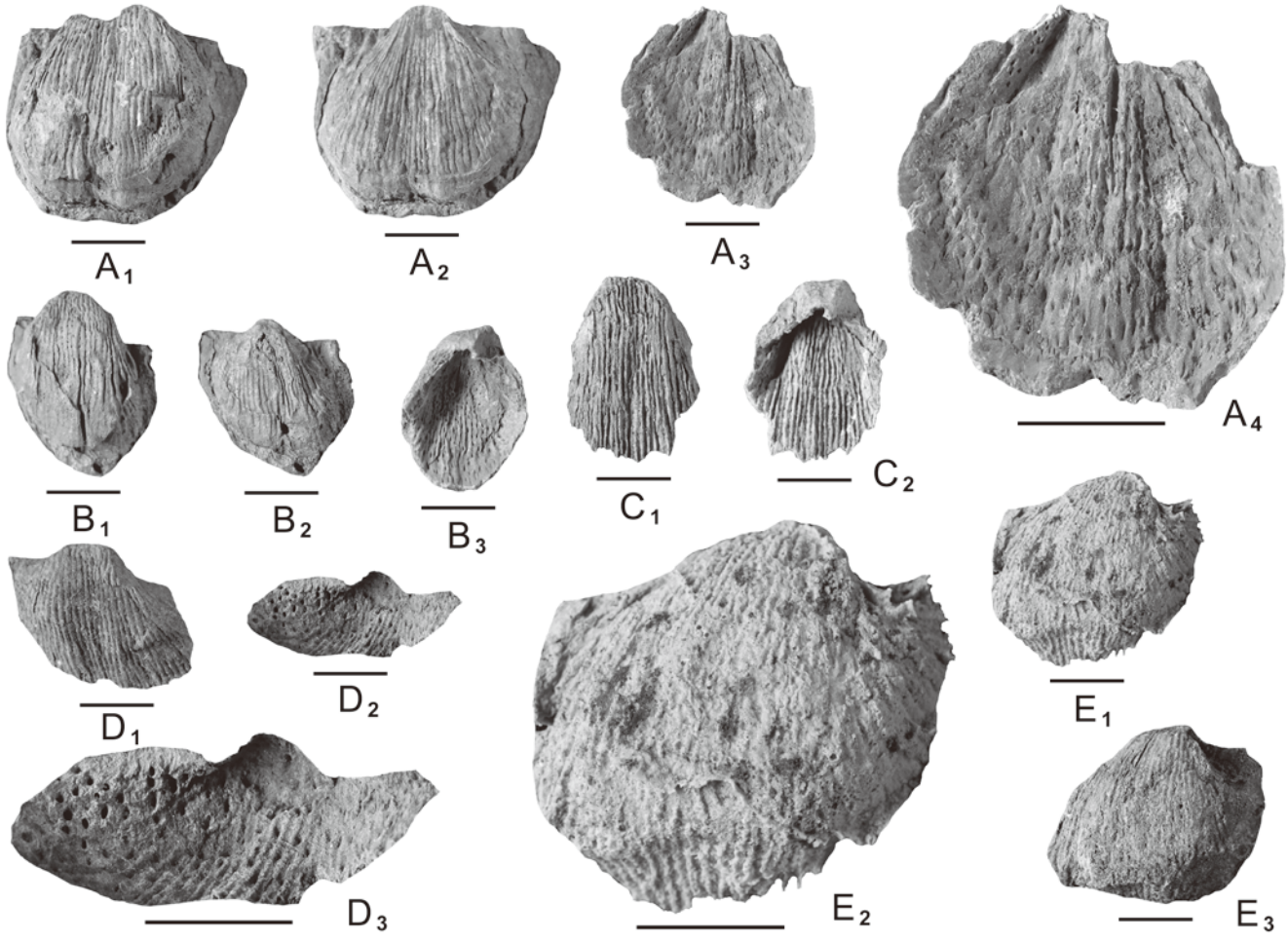

FIGURE 43. **A–E**, *Asperlinus japonicus* (Tazawa); A, ventral internal mould (A_1), dorsal internal mould (A_2) and dorsal external mould (A_3, A_4) of conjoined shell, NU-B702 (holotype); B, ventral internal mould (B_1), dorsal external mould (B_2) and dorsal internal mould (B_3) of conjoined shell, NU-B704; C, ventral internal mould (C_1) and dorsal internal mould (C_2) of conjoined shell, NU-B705; D, internal mould (D_1) and external mould (D_2, D_3) of ventral valve, NU-B703; E, external latex cast (E_1, E_2) and internal mould (E_3) of ventral valve, NU-B2526. Scale bars are 1 cm.

Zhejiang) and central-southern China (Hubei), differs from *U. crenulata* in having finer costae (8–9 in 5 mm) on ventral valve. *Urushtenoidea chaoi* Jin (1963, p. 15, 28, pl. 1, figs. 1–4, 9–12; pl. 2, figs. 7, 8, 13–17), from the upper Chihsian–lower Maokouan of Jiangxi and Anhui, eastern China, is readily distinguished from the present species in having coarser costae (3–4 in 5 mm) on ventral valve.

Occurrence. — KN2 Unit in Setamai (locality KS9); and KY1 Unit in Kamiyasse (localities KF39 and KF90), Imo (localities KF217 and KF218) and Matsukawa (locality AR4).

Distribution. — Kungurian–Capitanian: northeastern Japan (Kamiyasse–Imo and Matukawa in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), southwestern Japan (Mizukoshi in Kyushu Island), northwestern China (Qinghai and Gansu), eastern China (Jiangsu and Fujian), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Sichuan), Laos, Cambodia and northwestern China (Tibet).

Family SCACCHINELLIDAE Licharew, 1928
Subfamily SCACCHINELLINAE Licharew, 1928
Genus *SCACCHINELLA* Gemmellaro, 1891

Type species.—*Scacchinella variabilis* Gemmelaro, 1891.

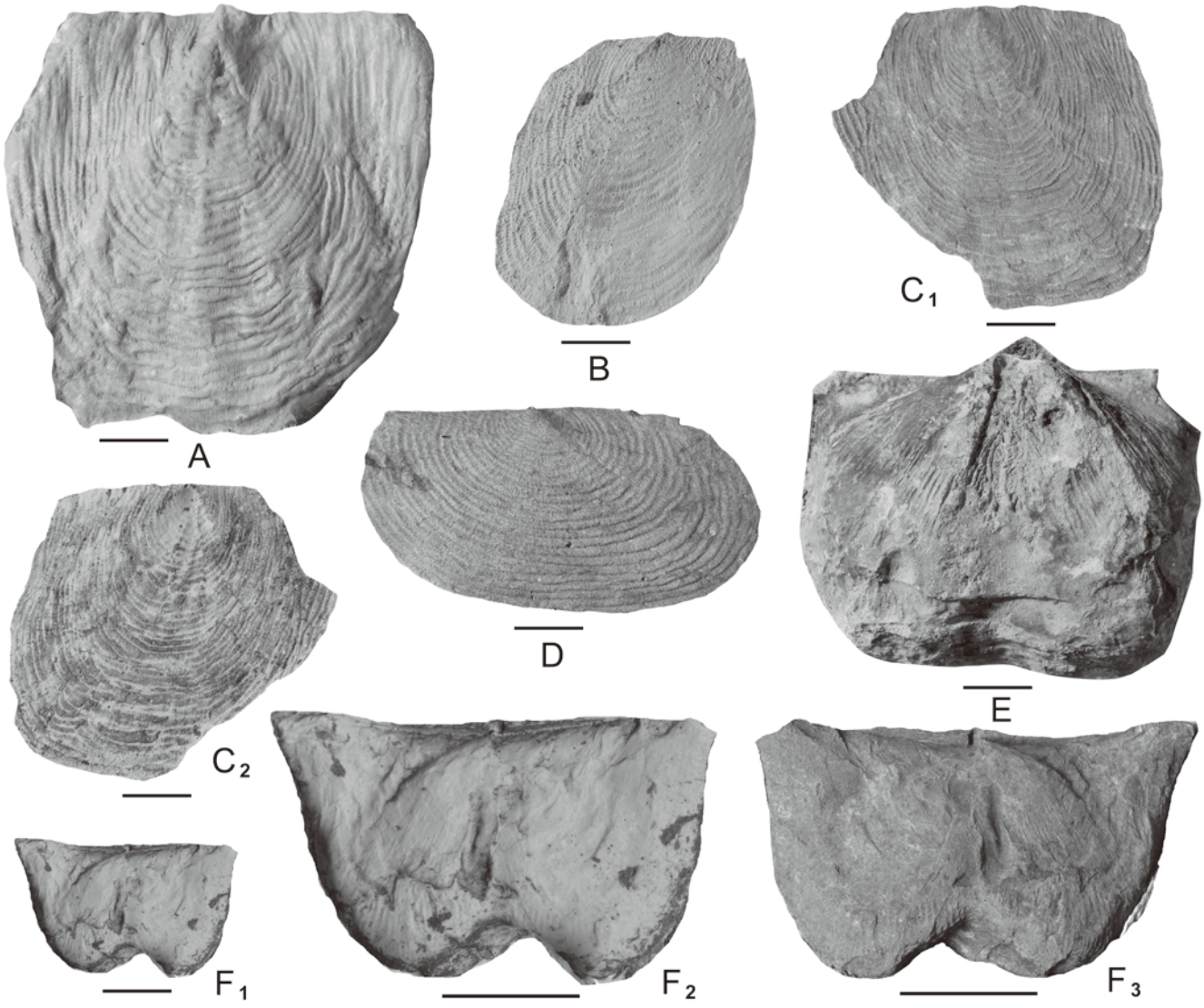

FIGURE 44. **A**, **B**, *Permundaria asiatica* Nakamura, Kato and Choi; A, external latex cast of ventral valve, KCG54; B, external latex cast of ventral valve, UHR19015 (holotype); **C**, **D**, *Permundaria tenuistriata* Tazawa; C, external mould (C_1) and external latex cast (C_2) of dorsal valve, KCG14; D, internal mould of ventral valve, UHR19700 (holotype); **E**, *Yakovlevia kaluzinensis* Fredericks, internal mould of ventral valve, KCG8; **F**, *Yakovlevia mammata* (Keyserling), internal latex cast (F_1, F_2) and internal mould (F_3) of ventral valve, KCG15. Scale bars are 1 cm.

Scacchinella gigantea Schellwien, 1900b
(Fig. 36E, F)

Scacchinella gigantea Schellwien, 1900b, p. 35, pl. 4, figs. 1–3; pl. 5, figs. 1–8, text-figs. 5, 6, 8; Heritsch, 1938, p. 101, pl. 5, figs. 1, 2, 9: Licharew, 1939, p. 96, pl. 23, fig. 2; Ramovs, 1965, p. 357, pl. 13, figs. 3–6; Tazawa and Araki, 1999, p. 453, fig. 2.1–2.4; Tazawa and Araki, 2017, p. 272, fig. 7.8, 7.9.

Material.—Five specimens from locality KZ9: (1) external mould of a ventral valve, NU-B197; and (2) internal moulds of four ventral valves, NU-B198–201.

Remarks.—These specimens were previously described by Tazawa and Araki (1999, 2017) as *Scacchinella gigantea* Schellwien, 1900b. The Matsukawa specimens are strongly

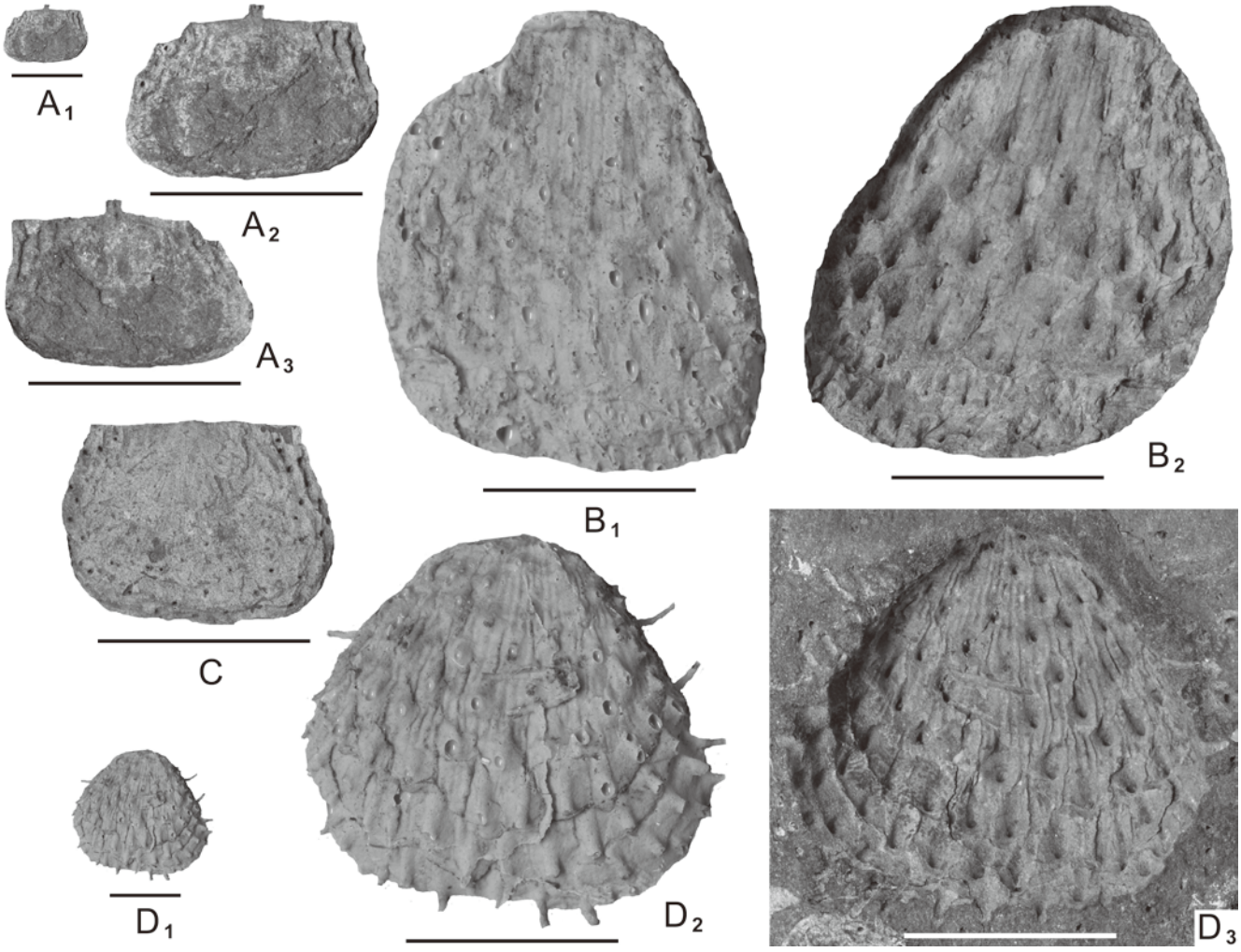

FIGURE 45. **A**–**D**, *Grandaurispina kozlowskiana* (Fredericks); A, external mould (A_1, A_2) and internal mould (A_3) of dorsal valve, NU-B2001; B, external latex cast (B_1) and external mould (B_2) of ventral valve, NU-B2006; C, external mould of dorsal valve, NU-B2002; D, external latex cast (D_1, D_2) and external mould (D_3) of ventral valve, NU-B1997. Scale bars are 1 cm.

deformed and imperfect, but they can be referred to *Scacchinella gigantea* Schellwien (1900b), from the Trogkofel Formation of the Carnian Alps, by medium to large, transversely subelliptical ventral valve with a broad and very shallow depression on the middle of the anterior side of the valve. *Scacchinella exasperata* Cooper and Grant (1975, p. 921, pl. 271, figs. 14–24; pl. 273, figs. 26–28), from the lower Wolfcampian of Texas in the USA, differs from *S. gigantea* in its more rounded and cyrindrical outline and in having a broader ventral interarea. *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; pl. 277, figs. 1–4; pl. 278, figs. 1–19; pl. 279, figs. 1–9; pl. 280, figs. 1–8; pl. 281, figs. 1–18; pl. 282, figs. 1–19; pl. 283, figs. 1–22; pl. 284, figs. 16–30), from the upper Wolfcampian of Texas, differs from the present species in its larger dimensions, more rounded, nearly circular anterior profile and much broader ventral interarea.

Occurrence.—KY1 Unit in Matsukawa (locality KZ9).

Distribution.— Asselian–Capitanian: northeastern Japan (Matsukawa in the South Kitakami Belt), Slovenia (Carnian Alps), central Russia (southern Urals) and Uzbekistan (Fergana).

Superfamily LINOPRODUCTOIDEA Stehli, 1954
Family LINOPRODUCTIDAE Stehli, 1954
Subfamily LINOPRODUCTINAE Stehli, 1954
Genus *LINOPRODUCTUS* Chao, 1927

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

Linoproductus hayasakai Tazawa, 1979
(Fig. 41A–I)

Productus cora d'Orbigny. Hayasaka, 1925a, p. 94, pl. 5, figs. 7–9.
Linoproductus cora (d'Orbigny). Hayasaka and Minato, 1956, p. 145, pl. 23, figs. 9, 10; Tazawa, 1976, pl. 2, fig. 11; Minato et al., 1979, pl. 62, figs. 1, 2; Tazawa and Ibaraki, 2001, p. 10, pl. 1, figs. 11–13; pl. 2, figs. 1–8.
Linoproductus sp. Minato et al., 1979, pl. 62, figs. 3, 4.
Linoproductus hayasakai Tazawa, 1979, p. 26, pl. 4, figs. 5–11; Tazawa and Araki, 2017, p. 274, fig. 7.2–7.4.

Material.— Forty specimens from localities AR5, KS1, KS3 and KS4: (1) external and internal moulds of eight ventral valves, IGPS96239, 96240–96242, NU-B337–340; (2) exterior of a ventral valve, NU-B2482; (3) external mould of a ventral valve, IGPS96243 (holotype); (4) internal moulds of twenty-seven ventral valves, IGPS96244–96248, NU-B341–359; and (5) external mould of six dorsal valves, IGPS17042, 96249, NU-B360–362, 2483.

Remarks.—Part of the specimens were previously described by Tazawa (1979, p. 26, pl. 4, figs. 5–11) as *Linoproductus hayasakai* Tazawa, 1979; and the others were described by Tazawa and Ibaraki (2001, p. 10, pl. 1, figs. 11–13; pl. 2, figs. 1–8) as *Linoproductus cora* (d'Orbigny, 1842). All the specimens are, however, referred to *Linoproductus hayasakai* Tazawa, 1979, which is characterized by its medium size (length 41 mm, width 42 mm in the holotype, IGPS96243), fine costellae (numbering 15–18 in 10 mm at midlength of ventral valve) and no spines on ventral valve. The type species, *Linoproductus cora* (d'Orbigny, 1842), redescribed by Tschernyschew (1902, p. 279, 621, pl. 33, figs. 2, 3; pl. 35, fig. 1; pl. 54, figs. 1–5, text-figs. 69–71), from the lower Permian of Timan, northern Russia, differs from *L. hayasakai* in its larger size and in having coarser costellae and sporadically distributed spines on ventral valve. *Linoproductus kaseti* Grant (1976, p. 154, pl. 41, figs. 8–28), from the Rat Buri Formation of Phangnga, southern Thailand, is also a medium-sized *Linoproductus* species, but the Thailand species differs from the present species in its elongate outline and in having coarser costellae and some spines on ventral valve.

Occurrence.—KN1 Unit in Setamai (localities KS1, KS3 and KS4) and KY1 Unit in Matsukawa (locality AR5).

Distribution. —Wordian: northeastern Japan (Setamai, Kamiyasse–Imo and Matsukawa in the South Kitakami Belt).

Genus *GLOBIELLA* Muir-Wood and Cooper, 1960

Type species.—*Productus hemispharium* Kutorga, 1844.

Globiella tschernyschewi (Netschajew, 1911)
(Fig. 42A)

Productus tschernyschewi Netschajew, 1911, p. 31, 141, pl. 1, figs. 5, 7; pl. 2, figs. 5–11, 16.
Stepanoviella tschernyschewi (Netschajew). Grigorjewa, 1962, p. 45, pl. 10, figs. 1–3; pl. 13, fig. 5; pl. 14, fig. 3.
Globiella tschernyschewi (Netschajew). Grigorjewa et al. in Sarytcheva, 1977, p. 164, pl. 27, figs. 10, 11; Tazawa, 2016b, p. 26, fig. 9.1.

Material.—One specimen from locality KF21, external and internal moulds of a ventral valve, NU-B1977.

Remarks.—This specimen was previously described by Tazawa (2016b, p. 26, fig. 9.1) as *Globiella tschernyschewi* (Netschajew, 1911). The specimen from Kamiyasse can be referred to *Globiella tschernyschewi* (Netschajew, 1911), from the Kazanian beds of the Pinega River region, northern Russia, by its small (length 17 mm, width 22 mm), slightly transverse and hemisphaerical ventral valve ornamented with numerous capillae (numbering 16–17 in 5 mm at about midlength) and strong, irregular concentric rugae. The type species, *Globiella hemisphaerium* (Kutorga, 1844), redescribed by Grigorjewa (1962, p. 42, pl. 9, figs. 1–9; pl. 13, figs. 6–9; text-figs. 3, 5, 14, 15) from the Kazanian beds of the Pinega River and the Kama River regions, northern Russia, is distinguished from *G. tschernyschewi* by its longer ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (locality KF21).

Distribution.— Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and northern Russia (Pinega River).

Subfamily LAMIPRODUCTINAE Liang, 1990
Genus *ASPERLINUS* Waterhouse and Piyasin, 1970

Type species.—*Productus asperulus* Waagen, 1884.

Asperlinus japonicus (Tazawa, 2008c)
(Fig. 43A–E)

Terrakea japonica Tazawa, 2008c, p. 336, fig. 3A–J.

Material.—Thirty-three specimens from localities KF17, KF28, KF79, KF86, KF90, KF217 and KF218: (1) external and internal moulds of two conjoined shells, NU-B2520, 2521; (2) internal moulds of six conjoined shells, with external moulds of the dorsal valves, NU-B702 (holotype), 704, 2522–2525; (3) internal moulds of three conjoined shells, NU-B705, 706, 1786; (4) external and internal moulds of three ventral valves, NU-B703, 2526, 2527; (5) external

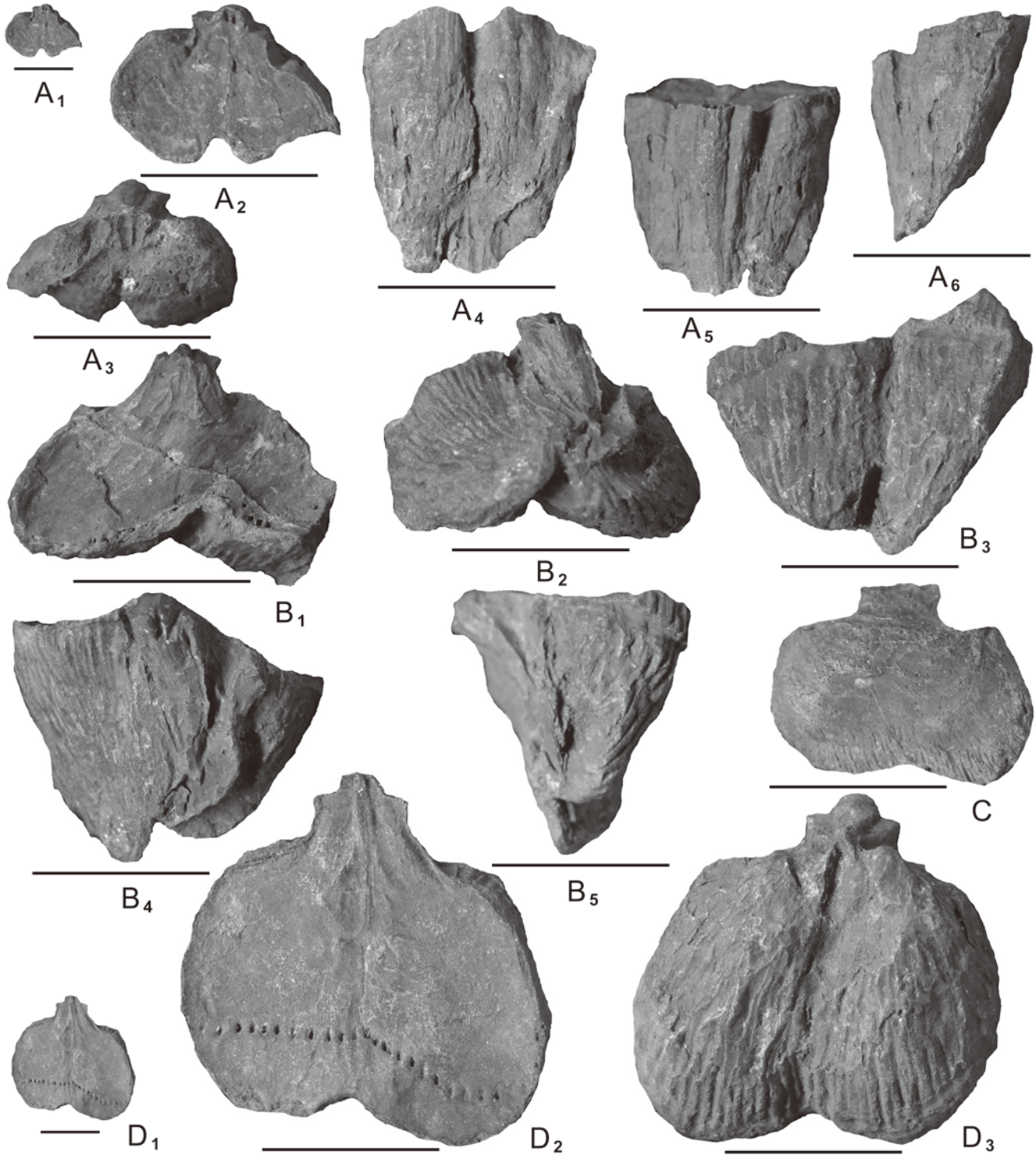

FIGURE 46. **A**–**D**, *Neorichthofenia mabutii* (Tazawa and Araki); A, dorsal (A_1, A_2), ventral (A_3), anterior (A_4), posterior (A_5) and lateral (A_6) views of internal mould of conjoined shell, IGPS98874; B, dorsal (B_1), ventral (B_2), anterior (B_3), posterior (B_4) and lateral (B_5) views of internal mould of conjoined shell, IGPS98870 (holotype); C, external mould of dorsal valve, IGPS98877; D, dorsal (D_1, D_2) and ventral (D_3) views of internal mould of conjoined shell, IGPS98872. Scale bars are 1 cm.

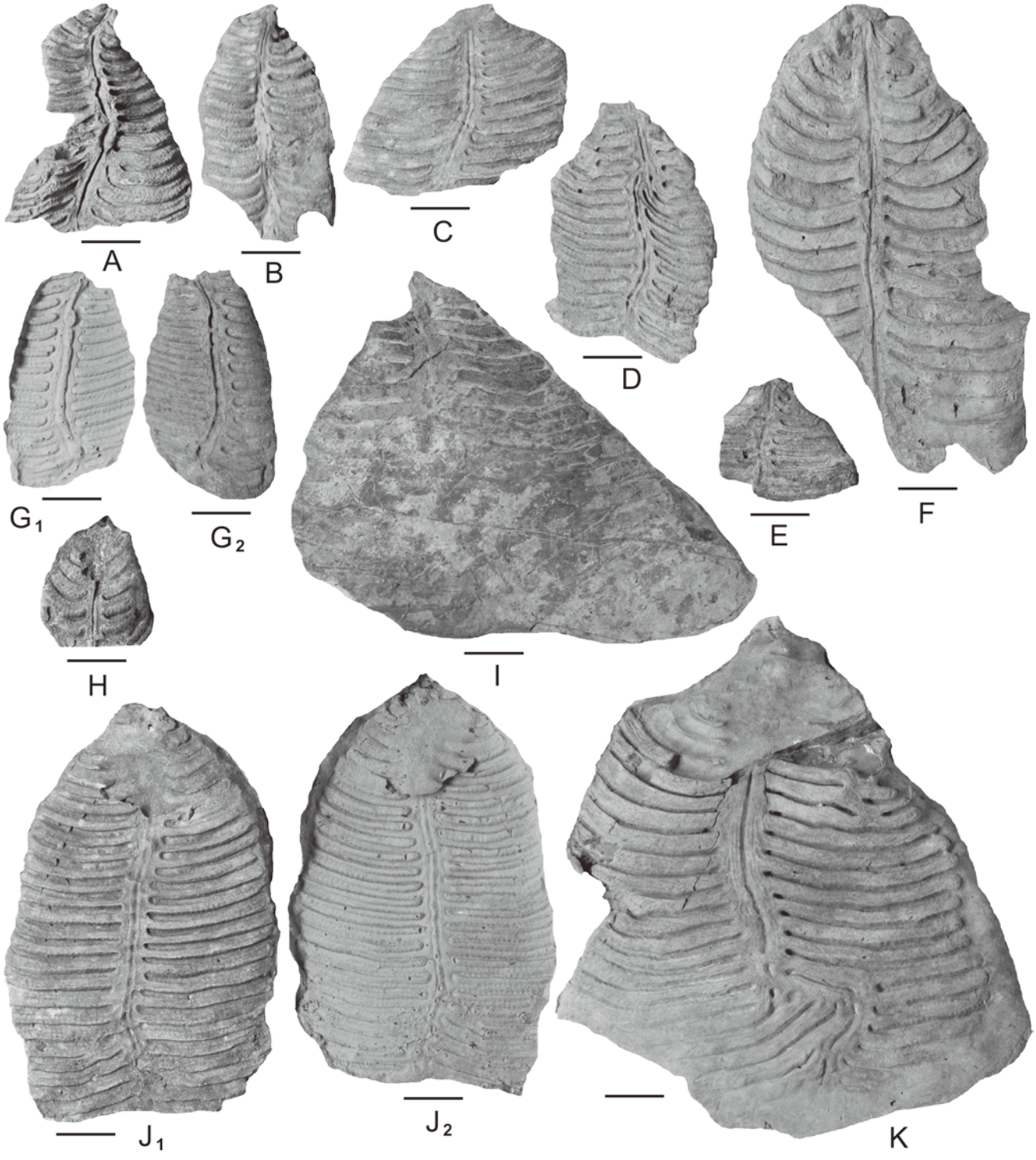

FIGURE 47. **A**–**K**, *Leptodus nobilis* (Waagen); A, internal mould of ventral valve, UHR12110; B, internal mould of ventral valve, UHR12114; C, internal mould of ventral valve, NU-B1691; D, internal mould of ventral valve, NU-B1701; E, internal mould of ventral valve, NU-B1697; F, internal mould of ventral valve, UHR12111; G, internal latex cast (G_1) and internal mould (G_2) of ventral valve, UHR12117; H, internal mould of ventral valve, NU-B1722; I, internal mould of ventral valve, UHR12109; J, internal mould (J_1) and internal latex cast (J_2) of ventral valve, NU-B1681; K, internal mould of ventral valve, NU-B1693.Scale bars are 1 cm.

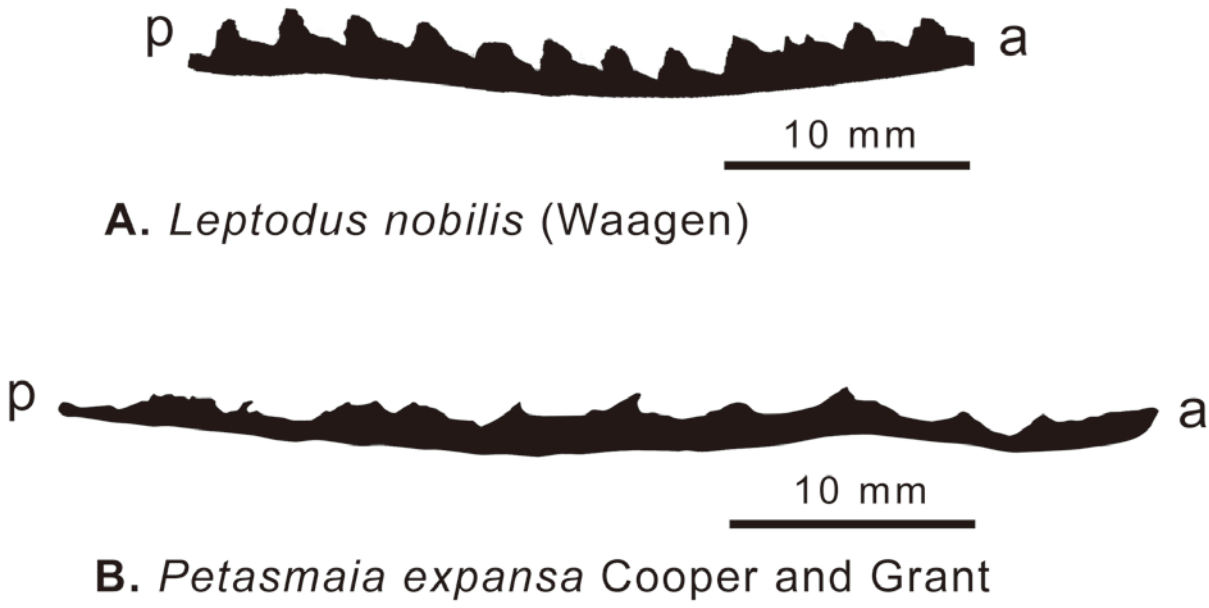

FIGURE 48. Longitudinal section of internal latex cast of ventral valve, showing lateral septa, a: anterior, p: posterior. **A**, *Leptodus nobilis* (Waagen), NU-B1681; **B**, *Petasmaia expansa* Cooper and Grant, KCG55.

moulds of two ventral valves, NU-B2528, 2529; and (6) internal moulds of seventeen ventral valves, NU-B707–710, 1785, 2530–2541.

Remarks.—Of the above-listed specimens, nine from Imo were previously described by Tazawa (2008c, p. 336, fig. 3A–J) as *Terrakea japonica* Tazawa, 2008c. This species is, however, assigned to the genus *Asperlinus* Waterhouse and Piyasin, 1970 in having somewhat irregular costellae (7–8 in 5 mm at about midvalve) and numerous spine bases on ventral valve. The type species, *Asperlinus asperulus* (Waagen, 1884), redescribed by Waterhouse and Piyasin (1970, p. 132, pl. 23, figs. 2–5) from the Wordian beds of Khao Phrik, southern Thailand, differs from the Kitakami species in its much smaller in size. The Kitakami species most resembles the shells, figured by Licharew and Kotlyar (1978, pl. 14, figs. 11–12) as *Asperlinus asperulus* (Waagen) from the upper Barabashevka Formation (Capitanian) of Primorye, eastern Russia, but accurate comparison is difficult owing to lack of description on the Russian specimens.

Occurrence.—KY1 Unit in Kamiyasse (localities KF17, KF28, KF79, KF86 and KF90) and Imo (localities KF217 and KF218).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Genus *LAMIPRODUCTUS* Liang, 1990

Type species.—*Lamiproductus typica* Liang, 1990.

Lamiproductus kamiyassensis (Tazawa, 2016a)
(Fig. 42B–F)

Globiella kamiyassensis Tazawa, 2016a, p. 84, fig. 5.

Material.—Nineteen specimens from locality KF99: (1) external moulds of six ventral valves, NU-B1978 (holotype), 1979–1983; (2) internal moulds of six ventral valves, NU-B1984–1989; and (3) external moulds of seven dorsal valves, NU-B1990–1996.

Remarks.—These specimens were previously described by Tazawa (2016a, p. 84, fig. 5) as *Globiella kamiyassensis* Tazawa, 2016a. However, the genus of this species is not *Globiella* but *Lamiproductus* Liang, 1990 in having strong costae on both ventral and dorsal valves. This species is characterized by its medium size (length 25 mm, width 21 mm in the holotype, NU-B1978), narrow, tapering umbo and external ornament of ventral valve consisting of numerous strong costae (numbering 10–11 in 5 mm at midlength of ventral valve). The type species, *Lamiproductus typica* Liang (1990, p. 205, pl. 35, figs. 1–12, 14–18, text-fig. 26), from the Lengwu Formation (Capitanian) of Zhejiang, eastern

China, is distinguished from the Kitakami species in having irregular costae on both valves.

Occurrence.—KY1 Unit in Kamiyasse (locality KF99).

Distribution.— Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Subfamily ANIDANTHINAE Waterhouse, 1968b

Genus *ANIDANTHUS* Hill, 1950

Type species.—*Linoproductus springsurensis* Booker, 1932.

Anidanthus mizukoshiensis Tazawa, 2008b
(Fig. 40B, C)

Anidanthus mizukoshiensis Tazawa, 2008b, fig. 7.6–7.8.

Material.—Three specimens from localities KF3 and KF39: (1) external and internal moulds of two ventral valves, NU-B2543, 2544; and (2) external and internal moulds of a dorsal valve, NU-B2542.

Remarks.—The specimens from Kamiyasse can be referred to *Anidanthus mizukoshiensis* Tazawa (2008b, p. 47, fig. 7.6–7.8), from the upper part of the Mizukoshi Formation (correlated with the Capitanian, by Ishida et al., 2010) of Mizukoshi, central Kyushu, southwestern Japan, in being small and transverse outline (length 12 mm, width 25 mm in the largest specimen, NU-B2543) and in having external ornament consisting of numerous strong lamellae and fine costellae on both ventral and dorsal valves. This species like *Anidanthus minor* Cooper (1957, p. 38, pl. 6A, figs. 1–17), from the Coyote Butte Formation of central Oregon, USA, in its small size, but the American species is less transverse in outline. The type species *Anidanthus springsurensis* (Booker, 1932), redescribed by Briggs (1998, p. 204, fig. 97A–K) from the Kungurian bed of the Sydney–Bowen Basin, eastern Australia, differs from *A. mizukoshiensis* in its larger size and less transverse outline.

Occurrence.—KY1 Unit in Kamiyasse (localities KF3 and KF39).

Distribution.—Wordian–Capitanian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and southwestern Japan (Mizukoshi in Kyushu Island).

Family KANSUELLIDAE Muir-Wood and Cooper, 1960
Subfamily AURICULISPININAE Waterhouse,1986
Genus *COSTATUMULUS* Waterhouse in Waterhouse and Briggs, 1986

Type species.—*Auriculispina tumida* Waterhouse in Waterhouse, Briggs and Parfrey, 1983.

Costatumulus cancriniformis (Tschernyschew, 1889)
(Fig. 42G, H)

Productus cancriniformis Tschernyschew, 1889, p. 283, 373, pl. 7, figs. 32, 33; Tschernyschew, 1902, p. 292, 629, pl. 52, figs. 5, 6; Fredericks, 1925, p. 27, pl. 4, figs. 115, 116.

Cancrinella cancriniformis (Tschernyschew). Kaschirzew, 1959, p. 39, pl. 15, figs. 4, 5; Solomina, 1960, p. 49, pl. 8, figs. 3–7; Ustritsky and Tschernjak, 1963, p. 84, pl. 13, figs. 6–8; pl. 14, figs. 1–5; Abramov, 1970, p. 124, pl. 5, figs. 9–12; Solomina, 1970, p. 85, pl. 5, fig. 9; Zavodowsky and Stepanov, 1970, p. 101, pl. 24, fig. 8; pl. 27, fig. 10; pl. 35, figs. 4–7; Grigorjeva et al. in Sarytcheva, 1977, p. 134, pl. 20, fig. 1; Alexandrov and Einor, 1979, pl. 24, fig. 5; Tazawa, 1979, p. 27, pl. 4, figs. 3, 4; Lee and Duan, 1985, p. 239, pl. 75, figs. 2–5; Pavlova and Lazarev in Tatarinov et al., 1991, p. 114, pl. 26, figs. 5, 6, 8, 14; Kalashnikov, 1993, p. 81, pl. 33, fig. 10.

Costatumulus cancriniformis (Tschernyschew). Tazawa and Araki, 2017, p. 274, figs. 6.10, 7.1.

Material.—Two specimens from locality AR5, external and internal moulds of two ventral valves, IGPS96217, 96218.

Remarks.—These specimens were first described by Tazawa (1979, p. 27, pl. 4, figs. 3, 4) as *Cancrinella cancriniformis* (Tschernyschew, 1889); and subsequently redescribed by Tazawa and Araki (2017, p. 274, figs. 6.20, 7.1) as *Costatumulus cancriniformis* (Tschernyschew, 1889). The specimens from Matsukawa can be referred to *Costatumulus cancriniformis* (Tschernyschew, 1889), from the lower Permian (Artinskian) of the northern Urals, by its strongly inflated ventral valve which is ornamented with numerous undulate concentric rugae. *Costatumulus tazawai* Shen, Archbold, Shi and Chen (2000, p. 743, figs. 12.1–12.8, 11–14), from the Selong Group (Wuchiapingian) of Xizang (Tibet), differs from *C. cancriniformis* in having more numerous, finer costellae on ventral valve. The type species, *Costatumulus tumida* (Waterhouse in Waterhouse *et al.*, 1983, p. 133, pl. 3, figs. 2–4, 6, 7), from the Tiverton Formation of the Bowen Basin in Queensland, eastern Australia, is readily distinguished from the present species in having less strong concentric rugae on ventral valve.

Occurrence.—KY1 Unit in Matsukawa (locality AR5).

Distribution.—Moscovian−Wordian; northeastern Japan (Matsukawa in the South Kitakami Belt), northern Russia (Timan, northern Urals, Pechora Basin, Taimyr Peninsula, Verkhoyansk Range and Kolyma Massif), central Russia (southern Urals), southern Mongolia, northern China (Shanxi) and eastern Russia (South Primorye).

Genus *PERMUNDARIA* Nakamura, Kato and Choi, 1970

Type species.—*Permundaria asiatica* Nakamura, Kato and Choi, 1970.

Permundaria asiatica Nakamura, Kato and Choi, 1970
(Fig. 44A, B)

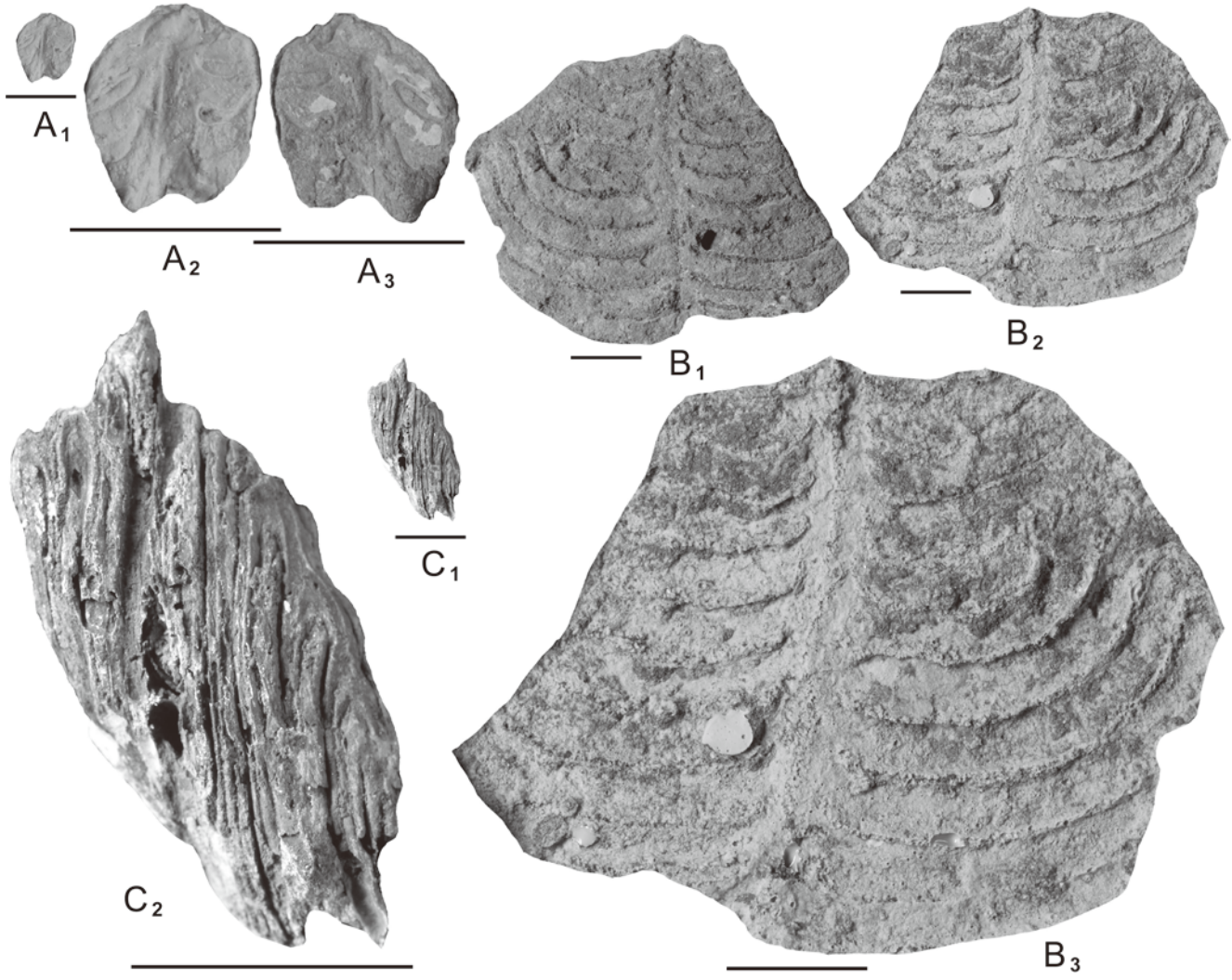

FIGURE 49. **A**, *Keyserlingina* sp., internal latex cast (A_1, A_2) and internal mould (A_3) of ventral valve, KCG19; **B**, *Petasmaia expansa* Cooper and Grant, internal mould (B_1) and internal latex cast (B_2, B_3) of ventral valve, KCG55; **C**, *Pararigbyella doulingensis* Shen and Zhang, internal mould (C_1, C_2) of ventral valve, NU-B1756. Scale bars are 1 cm.

Striatifera? sp. Hayasaka and Minato, 1956, p. 144, pl. 23, figs. 6, 7.

Permundaria asiatica Nakamura, Kato and Choi, 1970, p. 296, pl. 2, figs. 1, 2; Tazawa, 1976, pl. 2, fig. 7; Minato et al., 1979, pl. 62, figs. 12, 13; Tazawa, 2000, fig. 3.4; Tazawa, 2001, p. 296, fig. 7.17–7.19; Tazawa and Araki, 2018, p. 15, fig. 4.5.

Material. — Four specimens from localities AR4, KF80, KF99 and KS10: (1) external and internal mould of a ventral valve, UHR19015 (holotype); (2) external mould of a ventral valve, KCG54; (3) internal moulds of two ventral valves, UHR 19698, 19699.

Remarks. — These specimens were previously described by Nakamura et al. (1970, p. 296, pl. 2, figs. 1, 2), Tazawa (1974a, p. 315, pl. 43, figs. 3, 4) and Tazawa and Araki (2018, p. 15, fig. 4.5) as *Permundaria asiatica* Nakamura, Kato and Choi, 1970 on the basis of its large, subquadrate and flattened ventral valve (length 47 mm, width about 37

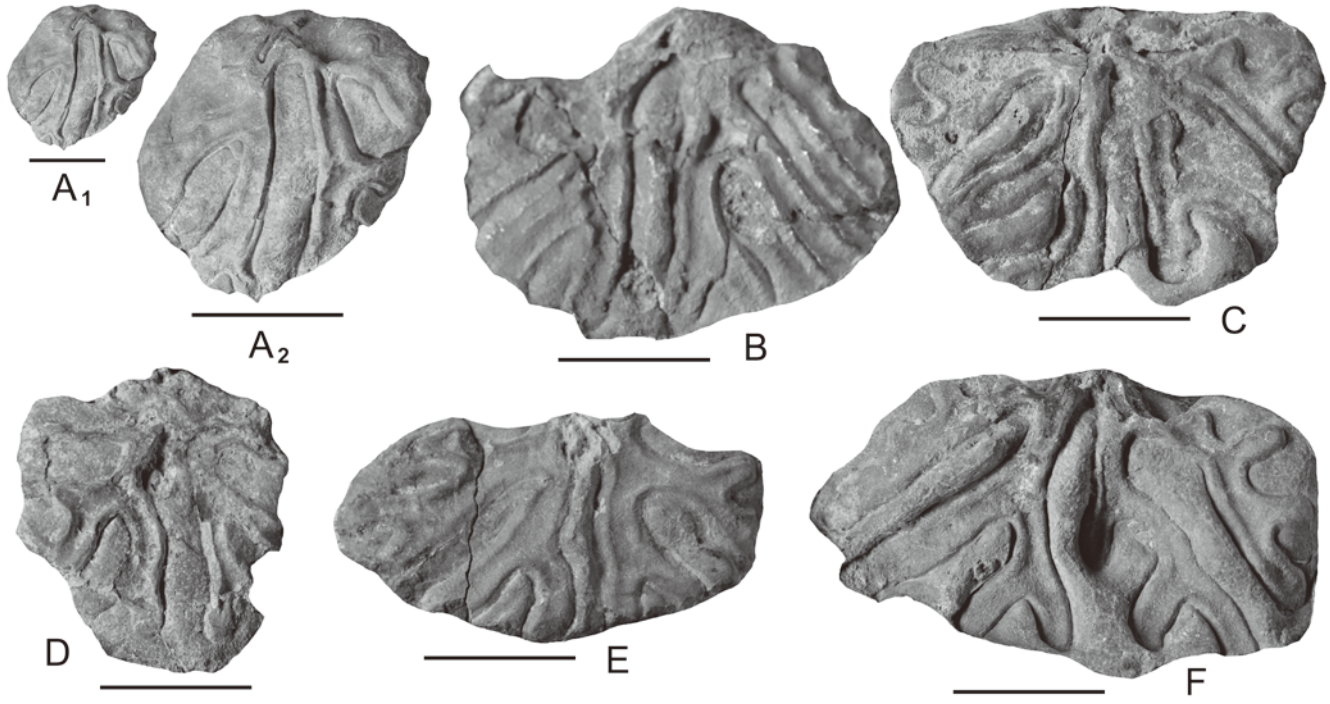

FIGURE 50. **A**–**F**, *Poikilosakos kamiyassensis* Tazawa and Takaizumi; A, internal mould (A_1, A_2) of ventral valve, IGPS99009; B, internal mould of ventral valve, IGPS99012; C, internal mould of ventral valve, IGPS99015; D, internal mould of ventral valve, IGPS99016; E, internal mould of ventral valve, IGPS99011; F, internal mould of ventral valve, IGPS99010 (holotype). Scale bars are 1 cm.

mm in the holotype; length more than 65 mm, width more than 64 mm in a ventral valve specimen, KCG54), ornamented with numerous fine costellae (numbering 5 in 2 mm at about midlength) and numerous regular but slightly undulate concentric rugae. As noted by Nakamura et al. (1970), *Striatifera*? sp. Hayasaka and Minato, 1956, from the lower part of the Kanokura Series (= Kamiyasse Formation) of Imo, South Kitakami Belt, is a synonym of the present species. *Permundaria tenuistriata* Tazawa (1974a, p. 317, pl. 43, figs. 1, 2), from the lower Kamiyasse Formation of Kamiyasse, South Kitakami Belt, is distinguished from *P. asiatica* in having finer capillae on both ventral and dorsal valves.

Occurrence.—KN2 Unit in Setamai (locality KS10); KY1 Unit in Kamiyasse (localities KF80 and KF99) and Matsukawa (AR4).

Distribution. — Wordian—Capitanian: northeastern Japan (Setamai, Kamiyase–Imo and Matsukawa in the South Kitakami Belt) and central Japan (Moribu in the Hida Gaien Belt).

Permundaria tenuistriata Tazawa, 1974a
(Fig. 44C, D)

Permundaria tenuistriata Tazawa, 1974a, p. 317, pl. 43, figs. 1, 2; Tazawa and Araki, 2017, p. 275, fig. 6.11.

Material.—Three specimens from localities AR4 and KF99: (1) internal mould of a ventral valve, UHR19700 (holotype); and (2) external moulds of two dorsal valves, KCG14 and UHR19701.

Remarks.—These specimens were described by Tazawa (1974a, p. 317, pl. 43, figs. 1, 2) and Tazawa and Araki (2017, p. 275, fig. 6.11) as *Permundaria tenuistriata* Tazawa, 1974a, on account of large (length about 30 mm, width 61 mm in the holotype, UHR19700; length 45 mm, width about 50 mm in a dorsal valve specimen, KCG14), semicircular and almost flat dorsal valve, ornamented by numerous regular concentric rugae and numerous capillae (11–12 capillae in 2 mm at about midlength). The preceding species, *Permundaria asiatica* Nakamura, Kato and Choim 1970, is readily distinguished from *Permundaria tenuistriata* in having coarser capillae (6–8 in 3 mm at 10 mm from umbo) on ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (locality KF99)

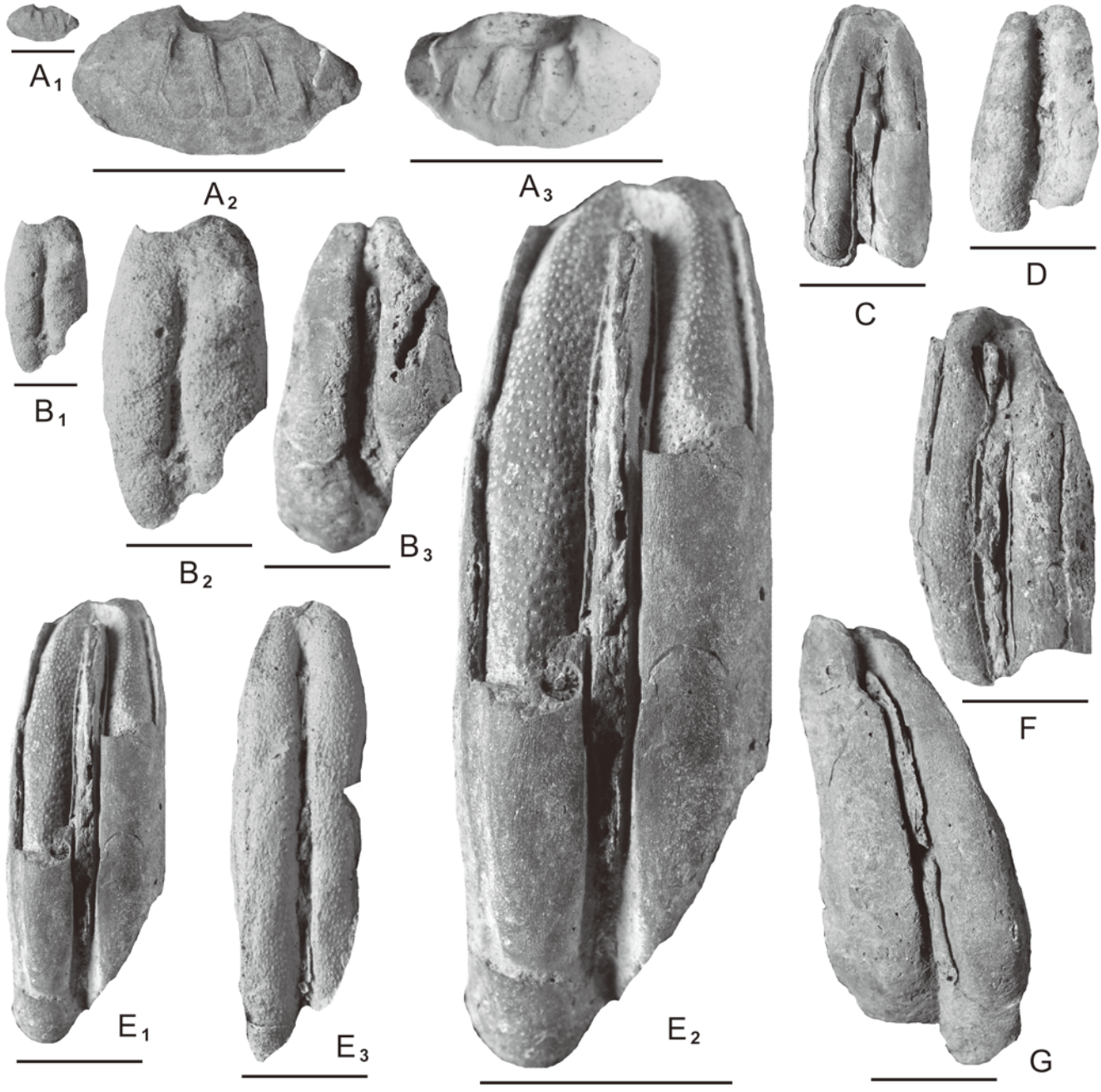

FIGURE 51. **A**, *Paralyttonia kesennumensis* Tazawa and Araki, internal mould (A_1, A_2) and internal latex cast (A_3) of ventral valve, IGPS98393; **B**–**G**, *Permianella typica* He and Zhu; B, external latex cast (B_1, B_2) and internal mould (B_3) of ventral valve, NU-B58; C, external mould of dorsal valve, NU-B60; D, internal mould of dorsal valve, NU-B55; E, internal mould (E_1, E_2) and external latex cast (E_3) of ventral valve, NU-B63; F, external mould of dorsal valve, NU-B57; G, internal mould of ventral valve, NU-B65. Scale bars are 1 cm.

and Matsukawa (locality AR4).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo and Matsukawa in the South Kitakami Belt).

Subfamily PAUCISPINAURIINAE Waterhouse, 1986
Genus *GRANDAURISPINA* Muir-Wood and Cooper, 1960

Type species.—*Grandaurispina kingorum* Muir-Wood and Cooper, 1960.

Grandaurispina kozlowskiana (Fredericks, 1925)
(Fig. 45A–D)

Productus villiersi kozlowskianus Fredericks, 1925, p. 18, pl. 1, figs. 36–40; pl. 2, figs. 86, 87; Hayasaka, 1925a, p. 96, pl. 5, figs. 10, 11.
Cancrinella villiersi kozlowskiana (Fredericks). Hayasaka and Minato, 1956, p. 144, pl. 23, fig. 5.
Cancrinella cancriniformis spinosa Hayasaka and Minato, 1956, p. 144, pl. 23, fig. 4.
Cancrinella spinosa Hayasaka and Minato. Minato et al., 1979, pl. 62, figs. 5–8, 11; Tazawa, 1976, pl. 2, fig. 5; Tazawa, 2002, fig. 10.3.
Cancrinella kozlowskiana (Fredericks). Minato et al., 1979, pl. 62, figs. 9, 10.
Cancrinella truncata (Chao). Lee et al., 1980, p. 380, pl. 165, figs. 13, 14, 24; Gu, 1992, p. 237, pl. 68, figs. 18, 20.
Cancrinella sp. Tazawa and Ibaraki, 2001, p. 11, pl. 1, fig. 6.
Cancrinella cf. *spinosa* Hayasaka and Minato. Tazawa, 2001, p. 295, fig. 6.17.
Grandaurispina kozlowskiana (Fredericks). Tazawa, 2016b, p. 27, fig. 9.2–9.5.

Material.— Eighteen specimens from localities KF21, KF22, KF46, KF50, KF218 and KS9: (1) external and internal moulds of nine ventral valves, NU-B1997–2000, 2003–2005, 2484, 2485; (2) external mould of two ventral valves, NU-B307, 2006; (3) internal moulds of three ventral valves, NU-B 2007–2009; (4) external and internal moulds of two dorsal valves, NU-B2001, 2002; and (5) external moulds of two dorsal valves, NU-B2010, 2011.

Remarks.—Most of the specimens listed above were previously described by Tazawa (2016b, p. 27, fig. 9.2–9.5) as *Grandaurispina kozlowskiana* (Fredericks, 1925). The specimens from the lower Kamiyasse Formation of Kamiyasse and Imo in the Kamiyasse–Imo area can be referred to *Grandaurispina kozlowskiana* (Fredericks, 1925), originally described by Fredericks (1925, p. 18, pl. 1, figs. 36–40; pl. 2, figs. 86, 87) from the Chandalaz Formation of South Primorye, eastern Russia, on account of small size (length 23 mm, width 22 mm in the largest specimen, NU-B2006) and in having numerous, quincunxially arranged, elongate spine bases on venter and dense strong spine bases on ears and adjacent lateral slopes of ventral valve . *Grandaurispina bella* Cooper and Grant (1975, p. 1162, pl. 442, figs. 1–38), from the Word Formation of Texas in the USA, is also a small-sized *Grandaurispina* with numerous spine bases on ventral valve, but differs from *G. kozlowskiana* in its more rounded outline. The type species, *Grandaurispina kingorum* Muir-Wood and Cooper (1960, p. 306, pl. 121, figs. 1–13), from the Word Formation of Texas, differs from the present species in its larger size and in having more distant spine bases on ventral valve.

Occurrence. —KN2 Unit in Setamai (locality KS9); and KY1 Unit in Kamiyasse (localities KF21, KF22 and KF46) and Imo (locality KF218).

Distribution.—Wordian: northeastern Japan (Setamai, Kamiyasse–Imo and Iwaizaki in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), northern China (Inner Mongolia), northeastern China (Jilin) and eastern Russia (South Primorye),.

Family YAKOVLEVIIDAE Waterhouse, 1975
Genus *YAKOVLEVIA* Fredericks, 1925

Type species.—*Yakovlevia kaluzinensis* Fredericks, 1925.

Yakovlevia mammata (Keyserling, 1846)
(Fig. 44F)

Productus mammatus Keyserling, 1846, p. 206, pl. 4, fig. 5; de Koninck, 1847, p. 49, pl. 7, fig. 4; Tschernyschew, 1902, p. 295, pl. 35, figs. 4–6; Keidel, 1906, p. 367, pl. 12, fig. 5.
Linoproductus? *mammatus* (Keyserling). Chao, 1927, p. 146, pl. 15, figs. 10–14.
Productus (*Linoproductus*?) *mammatus* Keyserling. Grabau, 1931, p. 288, pl. 29, figs. 10–14.
Productus (*Thomasina*) *mammatus* Keyserling. Stepanov, 1937a, p. 127, 177, pl. 2, figs. 5–7.
Muirwoodia mammata (Keyserling). Muir-Wood and Cooper, 1960, pl. 120, figs. 9–11; Harker, 1960, p. 58, pl. 16, figs. 1–5; Gobbett, 1963, p. 112, pl. 13, figs. 23–28; Lee and Gu, 1976, p. 263, pl. 159, figs. 7–9; pl. 163, fig. 2; pl. 164, figs. 3, 4; pl. 170, figs. 6, 7; Licharew and Kotlyar, 1978, pl. 14, figs. 3–5; Liu and Waterhouse, 1985, p. 17, pl. 4, figs. 4–6; Nakamura et al., 1992, pl. 1, fig. 4; Kalashnikov, 1993, p. 63, pl. 19, figs. 1–3.
Yakovlevia mammatus (Keyserling). Kotlyar, 1961, text-figs. 4–6.
Yakovlevia mammata (Keyserling). Brabb and Grant, 1971, p. 16, pl. 1, figs. 9–12, 33–36; Ifanova, 1972, p. 121, pl. 7, figs. 4, 5; Kalashnikov, 1986, pl. 121, figs. 5, 6; Malkowski, 1988, p. 40, pl. 5, fig. 6; Zhang, 1990, pl. 2, figs. 4, 7, 9; Tazawa, 1999b, fig. 2.1, 2.2; Tazawa, 1999c, p. 90, fig. 3.1–3.5; Wang and Zhang, 2003, p. 85, pl. 6, figs. 1–8; pl. 7, figs. 1–10; Klets, 2005, pl. 11, figs. 1–7 ; Tazawa and Araki, 2017, p. 275, fig. 6.7.
Yakovlevia paramammata Lee and Gu in Lee et al., 1980, p.

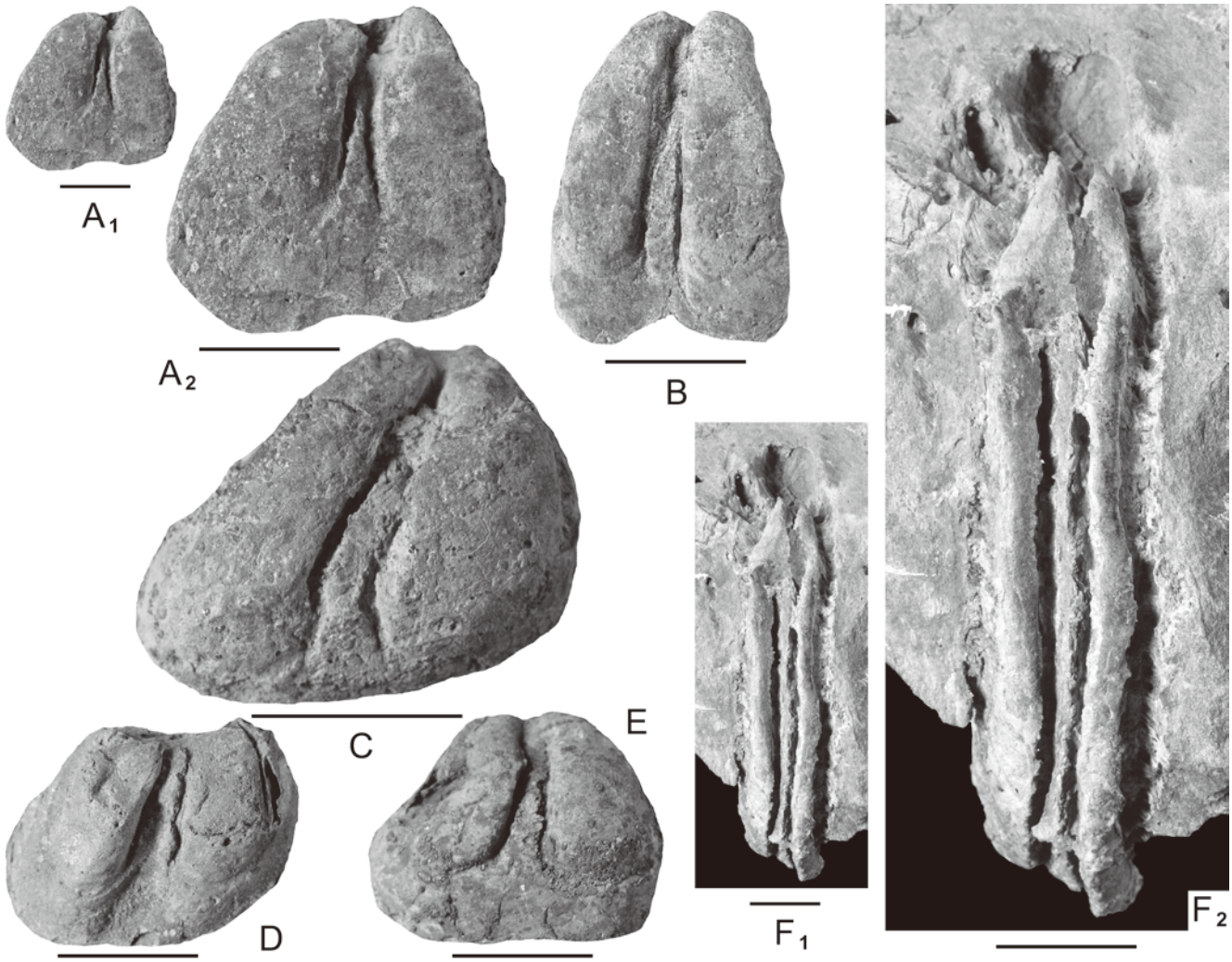

FIGURE 52. **A**–**E**, *Dicystoconcha lapparenti* Termier and Termier; A, internal mould (A_1, A_2) of ventral valve, NU-B2493; B, internal mould of ventral valve, NU-B2494; C, internal mould of ventral valve, NU-B2491; D, internal mould of ventral valve, NU-B2492; E, internal mould of ventral valve, NU-B1680; **F**, *Laterispina parallela* Shen, Fan, Zhang and Zhang, internal mould (F_1, F_2) of ventral valve, NU-B70. Scale bars are 1 cm.

382, pl. 171, figs. 4, 15.
Muirwoodia sp. Tazawa, 1987, fig. 1.6.

Material.—One specimen from locality AR4, internal mould of a ventral valve, KCG15.

Remarks.— This specimen was previously described by Tazawa and Araki (2017, p. 275, fig. 6.7) as *Yakovlevia mammata* (Keyserling, 1846). The Matsukawa specimen can be referred to *Yakovlevia mammata* (Keyserling, 1846), from the lower Permian (Sakmarian?) of the Pechora Basin, northern Russia, in its small size (length 19 mm, width 33 mm), and in having large, acute ears and a narrow, moderately deep sulcus on ventral trail. *Yakovlevia greenlandica* (Dunbar, 1955, p. 103, pl. 16, figs. 1–17), from the Guadalupian of eastern Greenland, is also a small-sized *Yakovlevia* species, but the Greenlandic species is distinguished from *Y. mammata* by its less transverse outline. *Yakovlevia mammatiformis* (Fredericks, 1926, p. 87, pl. 3, figs. 4–6), from the lower Permian (Artinskian) of the Pechora Basin, northern Russia, is clearly distinguished from

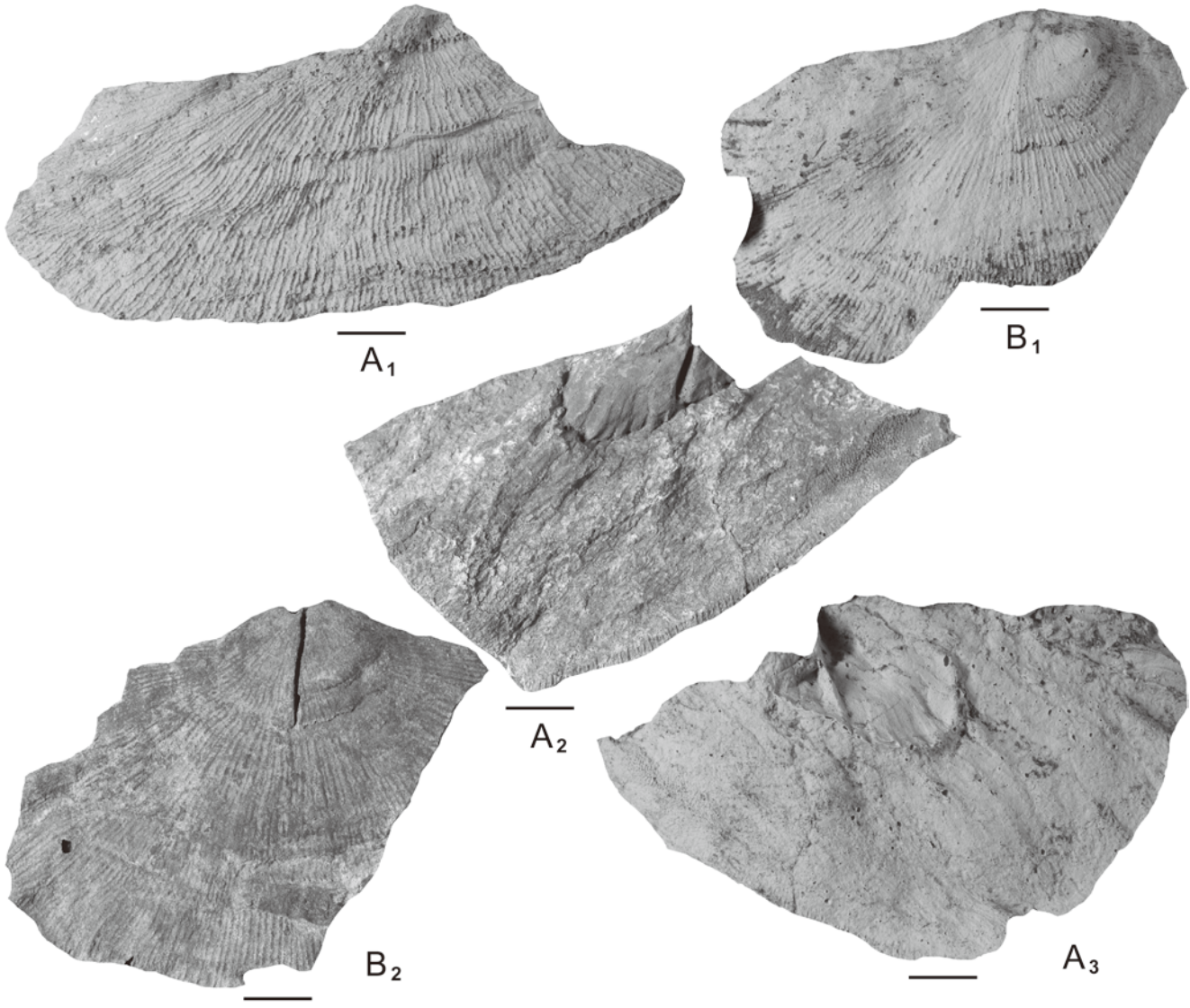

FIGURE 53. **A**, **B**, *Derbyia grandis* Waagen; A, external latex cast (A_1), internal mould (A_2) and internal latex cast (A_3) of ventral valve, NU-B363; B, external latex cast (B_1) and internal mould (B_2) of ventral valve, NU-B364. Scale bars are 1 cm.

the present species by its larger size and more transverse outline.

Occurrence.—KY1 Unit in Matsukawa (locality AR4).

Distribution.—Kasimovian–Capitanian: northeastern Japan (Kamiyasse–Imo and Matsukawa in the South Kitakami Belt), northern USA (Alaska), northern Canada (Devon Island), Spitsbergen, northern Russia (Timan, Pechora Basin and Verkhoyansk Range), northwestern China (Xinjiang), northern China (Inner Mongolia), northeastern China (Heilongjiang) and eastern Russia (South Primorye).

Yakovlevia kaluzinensis Fredericks, 1925
(Fig. 44E)

Chonetes (*Yakovlevia*) *kaluzinensis* Fredericks, 1925, p. 7, pl. 2, figs. 64–66.

Yakovlevia kaluzinensis Fredericks. Kotlyar, 1961, text-figs. 1–3; Licharew and Kotlyar, 1978, pl. 14, figs. 1, 2;

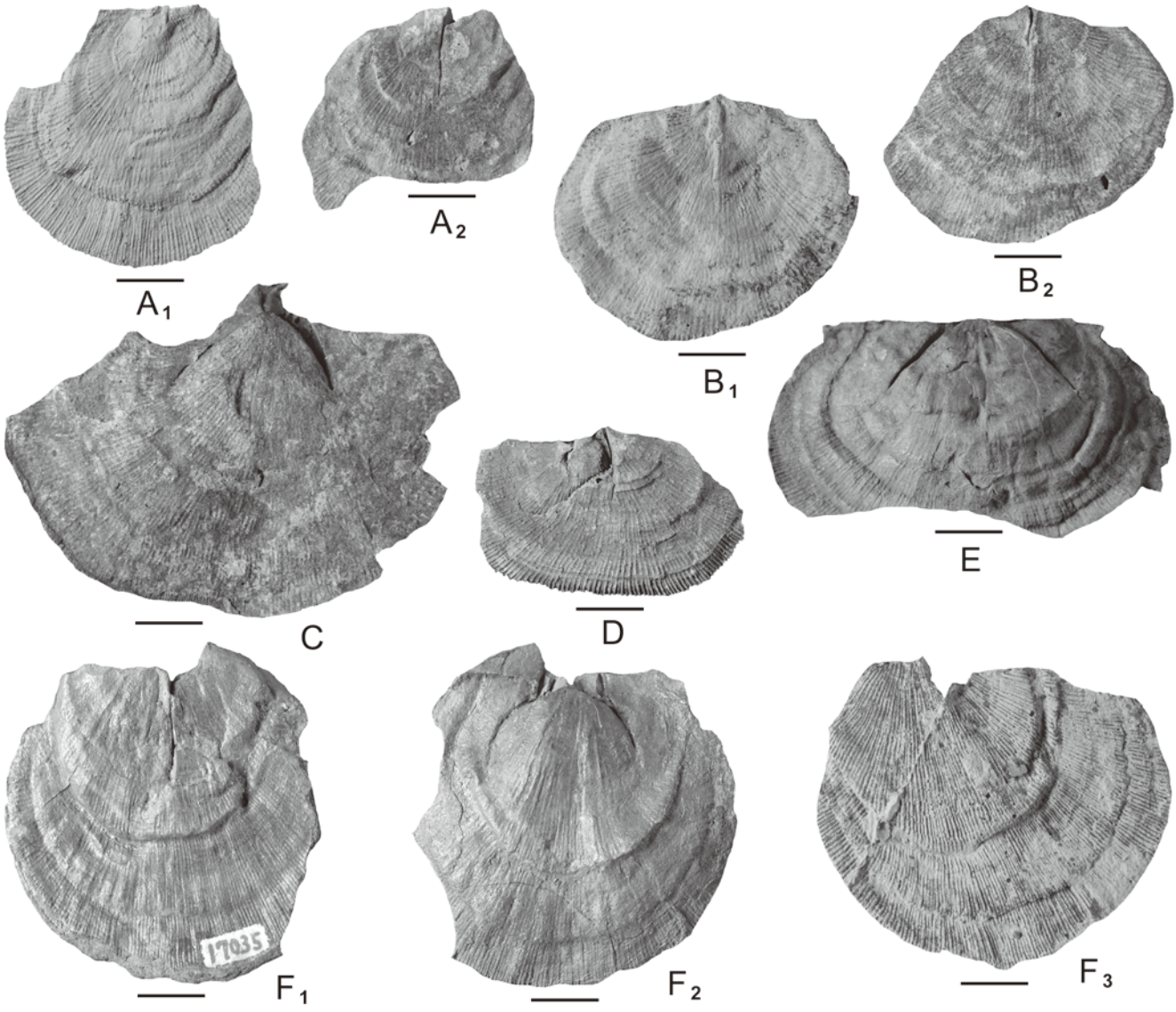

FIGURE 54. **A–F**, *Derbyia nipponica* Nakamura; A, external latex cast (A_1) and internal mould (A_2) of ventral valve, UHR12470: B, external latex cast (B_1) and internal mould (B_2) of ventral valve, NU-B365; C, internal mould of dorsal valve, NU-B369; D, internal mould of ventral valve, NU-B2485; E, internal mould of dorsal valve, NU-B2486; F, ventral internal mould (F_1), dorsal internal mould (F_2) and ventral external latex cast (F_3) of conjoined shell, UHR17035. Scale bars are 1 cm.

Manankov, 1998, pl. 8, figs. 18, 19; Tazawa, 1999b, fig 2.4–2.6; Tazawa, 1999c, p. 90, fig. 3.7–3.15; Tazawa, 2000, fig. 3.18; Tazawa, 2001, p. 291, fig. 6.20–6.25; Tazawa, 2008b, p. 49, fig. 7.14; Tazawa and Araki, 2013, p. 5, fig. 2.2; Tazawa and Araki, 2017, p. 276, fig. 6.12.

Material.—One specimen from locality AR5, internal mould of a ventral valve, KCG8.

Remarks.— This specimen was previously described by Tazawa and Araki (2013, p. 5, fig. 2.2) and Tazawa and Araki (2017, p. 276, fig. 6.12) as *Yakovlevia kaluzinensis* Fredericks, 1925. The Matsukawa specimen can be referred to *Yakovlevia kaluzinensis* Fredericks, 1925, originally described by Fredericks (1925, p. 7, pl. 2, figs. 64–66) from the Chandalaz Formation of Vladivostok, South Primorye, eastern Russia, by its large size (length 49 mm, width 58

mm), transversely rectangular outline and in having internal structures, consisting of a pair of small, elongate subtrigonal and dendritic adductor scars and two large, flabellate and radially striated diductor scars in ventral valve. *Yakovlevia impressa* (Toula, 1875, p. 236, pl. 5, fig. 11), from the middle Permian of Spitsbergen, differs from *Y. kaluzinensis* in having larger and more prominent ears. The preceding species, *Yakovlevia mammata* (Keyserling, 1846), is readily distinguished from the present species by its much smaller size and larger and more acute ears.

Occurrence.—KY1 Unit in Matsukawa (locality AR5).

Distribution.—Kungurian–Wuchiapingian: northeastern Japan (Matsukawa in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), southwestern Japan (Mizukoshi in Kyushu Island), southern Mongolia and eastern Russia (South Primorye).

Superfamily RICHTHOFENIOIDEA Waagen, 1885
Family HERCOSIIDAE Cooper and Grant, 1975
Genus *NEORICHTHOFENIA* Shen, He and Zhu, 1992

Type species.—*Richthofenia mabutii* Tazawa and Araki, 1984b.

Neorichthofenia mabutii (Tazawa and Araki, 1984b)
(Fig. 46A–D)

Richthofenia mabutii Tazawa and Araki, 1984b, p. 3, pl. 1, figs. 1–7.
Neorichthofenia mabutii (Tazawa and Araki). Shen et al., 1992, p. 180, pl. 3, figs. 13–22.

Material.—Eight specimens from locality AR4: (1) internal moulds of five conjoined shells, IGPS98870 (holotype), 98871–98874; (2) internal moulds of two ventral valves, IGPS98875. 98876; and (3) external mould of a dorsal valve, IGPS98877.

Remarks.—The specimens from Matsukawa were first described by Tazawa and Araki (1984b, p. 3, pl. 1, figs. 1–7) as *Richthofenia mabutii* Tazawa and Araki, 1984b. Subsequently, Shen et al. (1992, p. 180) proposed the genus *Neorichthofenia* with the Matsukawa species as type species. Wardlaw et al. (2000, p. 614) classified the Matsukawa species as the type species of *Neorichthofenia* Shen, He and Zhu, 1992, which belonged to the family Hercosiidae Cooper and Grant, 1975. The genus *Neorichthofenia* is characterized by having a median ridge in ventral valve. *Neorichthofenia mabutii* was described by Shen et al. (1992) from also the Changhsing Formation of Sichuan, southwestern China. No other species assigned to the genus has been known.

Occurrence.—KY1 Unit in Matsukawa (locality AR4).

Distribution.— Wordian–Changhsingian: northeastern Japan (Matsukawa in the South Kitakami Belt) and southwestern China (Sichuan).

Suborder LYTTONIIDINA Williams, Harper and Grant, 2000
Superfamily LYTTONIOIDEA Waagen, 1883
Family LYTTONIIDAE Waagen, 1883
Subfamily LYTTONIINAE Waagen, 1883
Genus *LEPTODUS* Kayser, 1883

Type species.—*Leptodus richthofeni* Kayser, 1883.

Leptodus nobilis (Waagen, 1883)
(Figs. 47A–K, 48A)

Lyttonia nobilis Waagen, 1883, p. 398, pl. 29, figs. 1–3; pl. 30, figs. 1, 2, 5, 6, 8, 10, 11; Noetling, 1904, p. 112, text-figs. 4–7; Noetling, 1905, p. 140, pl. 17, figs. 1, 2; pl. 18, figs. 1–11, text-fig. 2; Mansuy, 1913, p. 123, pl. 13, fig. 10; Mansuy, 1914, p. 32, pl. 6, fig. 7; pl. 7, fig. 1; Albrecht, 1924, p. 289, fig. 1; Huang, 1932, p. 89, pl. 7, figs. 9, 10; pl. 8, figs. 8, 9; pl. 9, figs. 1–8, text-figs. 8–11.
Lyttonia sp. Yabe, 1900, p. 2, text-figs. 1, 2.
Oldhamina (*Lyttonia*) *richthofeni* var. *nobilis* Waagen. Fredericks, 1916, p. 76, pl. 4, fig. 2, text-fig. 22.
Lyttonia richthofeni Kayser. Hayasaka, 1917, p. 43, pl. 18, figs. 1–8; Hayasaka, 1922a, p. 62, pl. 11, figs. 1–6; Hayasaka, 1922b, p. 103, pl. 4, figs. 12, 13; Mashiko, 1934, p. 182, text-fig. on p. 182.
Lyttonia (*Leptodus*) *richthofeni* Kayser. Hamlet, 1928, p. 31, pl. 6, figs. 1–4.
Lyttonia richthofeni forma *nobilis* Waagen: Licharew, 1932b, p. 69, 96, pl. 2, figs. 13, 14; pl. 5, figs. 1–4, 6, text-fig. 3.
Lyttonia cf. *nobilis* Waagen. Huang, 1936, p. 493, pl. 1, fig. 5.
Leptodus nobilis (Waagen). Termier and Termier, 1960, p. 241, text-pl. 3, figs. 1–10; Chi-Thuan, 1961, p. 274, pl. 1, fig. 1; Ding in Yang et al., 1962, p. 90, pl. 37, fig. 4; Schréter, 1963, p. 107, pl. 3, figs. 5–8; Cooper and Grant, 1974, pl. 191, figs. 8, 9; Grant, 1976, pl. 43, figs. 18, 19; Lee and Gu, 1976, p. 267, pl. 162, figs. 1, 2; Tazawa, 1976, pl. 2, fig. 8; Yang et al., 1977, p. 371, pl. 147, fig. 5; Feng and Jiang, 1978, p. 269, pl. 100, fig. 2; Licharew and Kotlyar, 1978, pl. 14, figs. 13–15; Jin et al., 1979, p. 82, pl. 23, fig. 15; Minato et al., 1979, pl. 66, figs. 1, 4, 5; Zhan, 1979, p. 93, pl. 9, fig. 12; Lee et al., 1980, p. 389, pl. 172, figs. 15, 16; Liao, 1980, pl. 6, figs. 42, 43; Wang et al., 1982, p. 229, pl. 95, fig. 20; Gu and Zhu, 1985, pl. 1, figs. 31, 33, 34; Liao and Meng, 1986, p. 81, pl. 2, figs. 24, 25; Sremac, 1986, p. 30, pl. 10, figs. 1, 2; Liang, 1990, p. 225, pl. 40, figs. 1, 5; Leman, 1994, pl. 1, figs. 3, 4; Zeng et al., 1995 , pl. 11, fig. 3; Tazawa et al., 1998, p. 241, figs. 2.1, 2.2, 4; Tazawa and Matsumoto, 1998, p. 7, pl. 2, figs. 7–12; Kato et al., 1999, p. 47, fig. 4; Tazawa, 2000, figs. 3.14, 3.15, 7.1; Tazawa, 2001, p. 297, fig. 7.13–7.16; Tazawa and Ibaraki, 2001, p. 11, pl. 1, figs. 7–10; Shen et al., 2002, p. 678, fig. 5.28; Tazawa, 2002, fig. 10.14; Tazawa, 2003, p. 31, fig. 4.1, 4.2; Wang and Zhang, 2003, p. 118, pl. 22, figs. 13–18; Tazawa, 2009, p. 71, fig. 4.7;

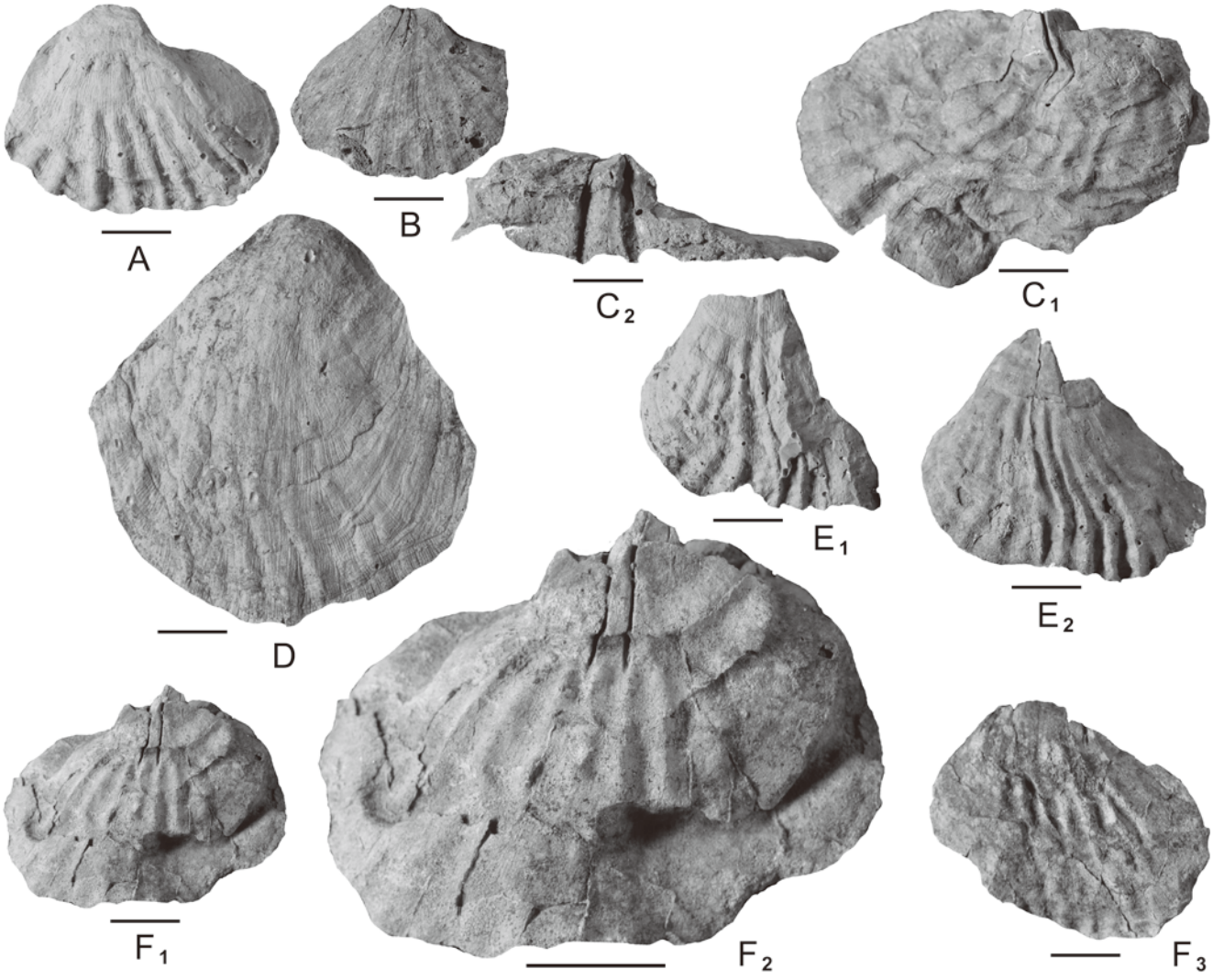

FIGURE 55. **A**, **B**, *Meekella eximia* (de Verneuil); A, external latex cast of dorsal valve, UHR12576: B, internal mould of ventral valve, UHR13574; **C–F**, *Meekella nodosa* Nakamura; C, ventral view (C_1) and posterior view (C_2) of internal mould of ventral valve, UHR12578 (holotype); D, external latex cast of ventral valve, KCG60; E, external latex cast (E_1) and internal mould (E_2) of ventral valve, UHR12577; ventral internal mould (F_1, F_2) and dorsal internal mould (F_3) of conjoined shell, UHR19533.Scale bars are 1 cm.

Tazawa, 2016b, p. 29, figs. 10.1–10.5, 11.5–11.7; Tazawa and Araki, 2017, p. 276, fig. 8.1, 8.2.

Gubleria armenica Sarytcheva, 1964, p. 68, pl. 8, figs. 1–3; Sarytcheva and Sokolskaya, 1965, p. 39, figs. 9, 10.

Gubleria sp. Licharew and Kotlyar, 1978, pl. 15, figs. 5, 6.

Leptodus ivanovi Fredericks. Minato et al., 1979, pl. 66, fig. 3.

Leptodus sp. Minato et al., 1979, pl. 66, fig. 2.

Leptodus elongatus Ching and Hu: Wang et al., 1982, p. 229, pl. 91, figs. 16, 17; pl. 93, fig. 4.

Gubleria sp. Zhu, 1990, p. 80, pl. 16, fig. 24.

Leptodus sp. Yanagida et al., 1993, p. 5, pl. 1, figs. 8, 9.

Leptodus sp. Yanagida, 1996, fig. 2.14.

Leptodus sp. Tazawa, 1999a, p. 5, pl. 1, fig. 1; Tazawa et al., 1999, fig. 2.1.

Gubleria sp. Sone et al., 2001, p. 185, fig. 6.9–6.12.

Leptodus sp. Shen and Zhang, 2008, fig. 5.4.

Material.—Twenty-three specimens from localities AR4,

KF13, KF67, KF84, KF217, KF218, KS1 and KS7: (1) internal mould of a ventral valve, with external and internal moulds of the dorsal valve (internal plate), UHR12111; (2) external and internal moulds of a ventral valve, NU-B1681; (3) external moulds of two ventral valves, NU-B1682, 1683; and (4) internal moulds of fifty-seven ventral valves, KCG16–18, NU-B308–314, 1684–1694, 1696–1704, 1706–1726, 2486, UHR11450, 12109, 12110, 12114, 12117.

Remarks.—These specimens were previously described by Tazawa and Ibaraki (2001, p. 11, pl. 1, figs. 7–10), Tazawa (2016b, p. 29, figs. 10.1–10.5, 11.5–11.7) and Tazawa and Araki (2017, p. 276, fig. 8.1, 8.2) as *Leptodus nobilis* (Waagen, 1883). The specimens from Setamai, Kamiyasse–Imo and Matsukawa are referred to *Leptodus nobilis* (Waagen, 1883), originally described from the Wargal and Chhidru Formations of the Salt Range, by flat ventral valve with numerous, regularly and symmetrically disposed broad and solid lateral septa on both sides of median septum. *Leptodus richthofeni* Kayser (1883 p. 161, pl. 21, figs. 9–11), from the upper Permian of Loping, Jiangxi Province, eastern China, and refigured by Cooper and Grant (1974, pl. 191, figs. 11–15) on the lectotype, is readily distinguished from *L. nobilis* by its more highly convex ventral valve, sharp lateral septa and wider interseptal spaces.

Occurrence. — KN1 Unit (locality KS1) and KN2 Unit (locality KS7) in Setamai; and KY1 Unit in Kamiyasse (localities KF13, KF67 and KF84), Imo (localities KF217 and KF218) and Matsukawa (locality AR4).

Distribution. — Kungurian–Changhsingian; northeastern Japan (Setamai, Kamiyasse–Imo, Matsukawa, Ogatsu and Ichinoseki in the South Kitakami Belt), central Japan (Moribu and Oguradani in the Hida Gaien Belt, and Akasaka in the Mino Belt), southwestern Japan (Yakuno and Yachiyo in the Maizuru Belt, and Tsunemori in the Akiyoshi Belt), Hungary, Croatia, Serbia, northwestern China (Qinghai), northern China (Inner Mongolia), northeastern China (Heilongjiang and Jilin), eastern Russia (South Primorye), eastern China (Zhejiang, Jiangxi and Fujian), central-southern China (Hubei, Hunan, Guangdong and Guangxi), southwestern China (Guizhou and Sichuan), Armenia (Transcaucasia), southwestern China (Yunnan), Malaysia, Cambodia, Indonesia (Timor) and Pakistan (Salt Range).

Genus *KEYSERLINGINA* Tschernyschew, 1902

Type species.—*Keyserlingina schellwieni* Tschernyschew, 1902.

Keyserlingina sp.
(Fig. 49A)

Keyserlingina sp. Tazawa and Araki, 2017, p. 277, fig. 8.3.

Material.—One specimen from locality KZ9, internal mould of a ventral valve, KCG19.

Remarks.— This specimen was previously described by Tazawa and Araki (2017, p. 277, fig. 8.3) as *Keyserlingina* sp. The specimen from Matsukawa is safely assigned to the genus *Keyserlingina* on the basis of its small (length 10 mm, width 8 mm), nearly flat internal plate, with a broad median ridge and symmetrically arranged, broad and deeply grooved lateral ridges numbering 2 on each side of median ridge. The Matsukawa species resembles *Keyserlngina filicis* (Keyserling, 1853), redescribed by Tschernyschew (1902, p. 56, 474, pl. 42, figs. 16, 17) from the lower Permian *Schwagerina* Limestone of the Urals, in having lateral ridges slightly inclined towards anterior. Accurate comparison of these two species is, however, difficult for the poorly preserved material of the Kitakami species.

Occurrence.—KY1 Unit in Matsukawa (locality KZ9).

Genus *PETASMAIA* Cooper and Grant, 1969

Type species.—*Petasmaia expansa* Cooper and Grant, 1969.

Petasmaia expansa Cooper and Grant, 1969
(Figs. 48B, 49B)

Petasmaia expansa Cooper and Grant, 1969, p. 10, pl. 2, figs. 15–18; Cooper and Grant, 1974, p. 430, pl. 163, figs. 1–8; pl. 164, figs. 1–16; pl. 165, figs. 1–23; pl. 169, figs. 11–16; Tazawa and Ono, 2013, p. 51, figs. 2, 3; Tazawa et al., 2016, p. 374, fig. 7.6; Tazawa and Araki, 2018, p. 15, figs. 5, 6.4.

Material.—One specimen from locality KZ9, internal mould of a ventral valve, KCG55.

Remarks.—This specimen was described by Tazawa and Araki (2018, p. 15, figs. 5, 6.4) as *Petasmaia expansa* Cooper and Grant, 1969 on account of transversely wider ventral valve (length about 45 mm, width about 58 mm) and regularly arranged thin lateral septa (numbering 11 pairs), being gently convex anteriorly and inclined posteriorly. The Matsukawa specimen, smaller than the type specimens of West Texas, may be a young individual. *Petasmaia ehiroi* Tazawa and Miyake (2011, p. 8, figs. 3.10, 3.11, 4), from the Toyoma Formation of Maeda, South Kitakami Belt, differs from *P. expansa* in having lateral septa with narrower interspaces.

Occurrence.—KY1 Unit in Matsukawa (locality KZ9).

Distribution.— Artinskian–Wordian: northeastern Japan (Matsukawa in the South Kitakami Belt), central Japan (Akasaka in the Mino Belt) and USA (Texas).

Genus *PARARIGBYELLA* Shen and Zhang, 2008

Type species.—*Pararigbyella quadrilobata* Shen and Zhang, 2008.

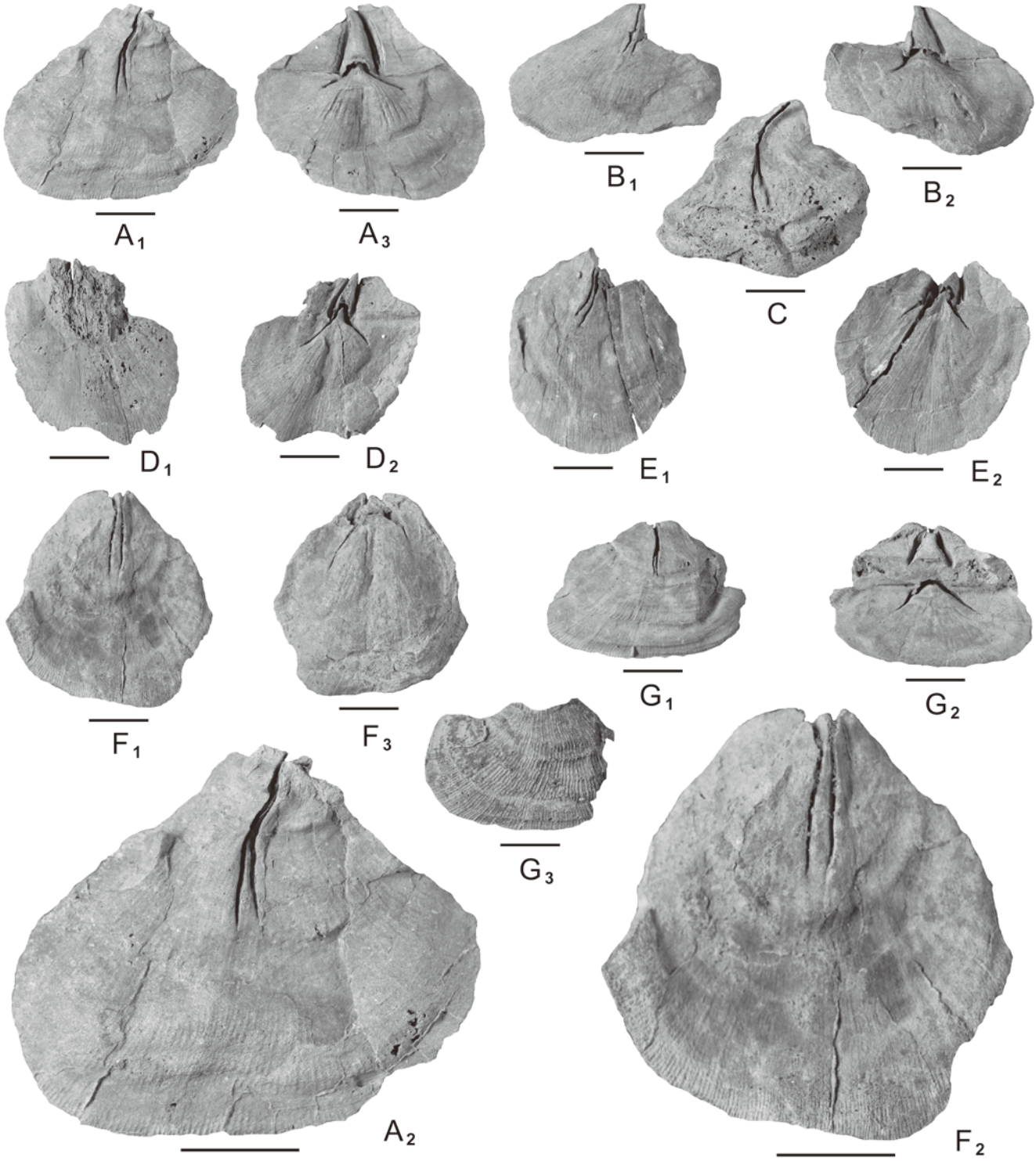

FIGURE 56. **A–C**, *Orthothetina polita* (Fliegel); A, ventral (A_1, A_2) and dorsal (A_3) views of internal mould of conjoined shell, UHR13663; B, ventral (B_1) and dorsal (B_2) views of internal mould of conjoined shell, UHR13664; C, internal mould of ventral valve, UHR13668; **D–G**, *Orthothetina kayseri* (Fliegel); D, ventral (D_1) and dorsal (D_2) views of internal mould of conjoined shell, UHR13693; E, ventral (E_1) and dorsal (E_2) views of internal mould of conjoined shell, UHR13686; F, ventral (F_1, F_2) and dorsal (F_3) views of internal mould of conjoined shell, NU-B2499; G, ventral internal mould (G_1), dorsal internal mould (G_2) and ventral external latex cast (G_3) of conjoined shell, NU-B2502. Scale bars are 1 cm.

Pararigbyella doulingensis Shen and Zhang, 2008
(Fig. 49C)

Pararigbyella doulingensis Shen and Zhang, 2008, p. 933, fig. 5.12–5.14; Shen and Tazawa, 2014, p. 247, fig. 3.6–3.8.

Material.—One specimen from locality KF218, internal mould of a ventral valve, NU-B1756.

Remarks.—This specimen was previously described by Shen and Tazawa (2014, p. 247, fig. 3.6–3.8) as *Pararigbyella doulingensis* Shen and Zhang, 2008. The specimen from Imo is not well preserved, but large size (length 25 mm, width about 16 mm), elongate triangular outline, bifurcated lobes and distinct median septum which is bounded by two sinuses in posterior one-third, are comparable with those of *Pararigbyella doulingensis* Shen and Zhang, 2008, from the uppermost Douling Formation (lower Wuchiapingian) in Chenxian, Hunan, central-southern China. The type species, *Pararigbyella quadrilobata* Shen and Zhang (2008, p. 933, fig. 5.5–5.11), from the Douling Formation of Hunan, is readily distinguished from the present species by its much smaller dimensions and fewer sinuses.

Occurrence.—KY1 Unit in Imo (locality KF218).

Distribution. —Wordian; northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and central-southern China (Hunan).

Subfamily POIKILOSAKINAE Williams, 1953
Genus *POIKILOSAKOS* Watson, 1917

Type species.—*Poikilosakos petaloides* Watson, 1917.

Poikilosakos kamiyassensis Tazawa and Takaizumi, 1987
(Fig. 50A–F)

Poikilosakos kamiyassensis Tazawa and Takaizumi, 1987, p. 12, fig. 3.1–3.7.

Material.—Eight specimens from locality KF212, internal moulds of eight ventral valves, IGPS99009, 99010 (holotype), 99011–99016.

Remarks.—These specimens were described by Tazawa and Takaizumi (1987, p. 12, fig. 3.1–3.7) as *Poikilosakos kamiyassensis* Tazawa and Takaizumi, 1987. The Kitakami species is large, transverse *Poikilosakos* (length about 21 mm, width about 34 mm in the holotype, IGPS99010), having a pair of long, narrow, often irregular brachial lobes. *Poikilosakos kamiyassensis* most resembles *Poikilosakos tschernyschewi* Fredericks (1926, p. 83, fig. 1), from the lower Permian (Sakmarian) of the central Ural Mountains, central Russia, in size, shape and in having long, narrow lobes, but the Russian species differs in having less frequently branched and more symmetrically developed lobes. The type species, *Poikilosakos petaloides* Watson (1917, p. 213, pl. 14, figs. 1–5), from the upper Pennsylvanian of north-central Texas, is readily distinguished from the Kitakami species by its smaller size and in having massive lobes.

Occurrence.—Upper part of the Hosoo Formation in Kamiyasse (locality KF212).

Distribution.—Roadian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Family RIGBYELLIDAE Williams, Harper and Grant, 2000
Genus *PARALYTTONIA* Wanner in Wanner and Sieverts, 1935

Type species.—*Paralyttonia permica* Wanner in Wanner and Sieverts, 1935.

Paralyttonia kesennumensis Tazawa and Araki, 1984a
(Fig. 51A)

Paralyttonia kesennumensis Tazawa and Araki, 1984a, p. 122, fig. 2.1, 2.2; Tazawa and Araki, 2017, p. 279, fig. 8.4.

Material.—Two specimens from locality AR4, internal moulds of two ventral valves, IGPS98393, 98394.

Remarks.—These specimens were previously described by Tazawa and Araki (1984a, p. 122, fig. 2.1, 2.2) and Tazawa and Araki (2017, p. 279, fig. 8.4) as *Paralyttonia kesennumensis* Tazawa and Araki, 1984a, on the basis of small, transverselly elliptical shell (length about 7 mm, width about 11 mm in the holotype) with 5 septa in ventral valve and 6 lobes in dorsal valve. The Kitakami species resembles *Paralyttonia tenax* Grant (1976, p. 168, pl. 44, figs. 4–36; pl. 45, figs. 32–42, text-fig. 15), from the Rat Buri Formation of Ko Muk, southern Thailand, but differs from the Thailand species in its smaller size and in having longer and more regular septa.

Occurrence.—KY1 Unit in Matsukawa (locality AR4).

Distribution.—Wordian: northeastern Japan (Matsukawa in the South Kitakami Belt).

Superfamily PERMIANELLOIDEA He and Zhu, 1979
Family PERMIANELLIDAE He and Zhu, 1979
Genus *PERMIANELLA* He and Zhu, 1979

Type species.—*Permianella typica* He and Zhu, 1979.

Permianella typica He and Zhu, 1979
(Fig. 51B–G)

Permianella typica He and Zhu, 1979, p. 132, 137, pl. 1, fig. 1; pl. 2, figs. 1–3; pl. 3, figs. 1–3; Wang and Jin, 1991, p. 496, pl. 2, figs. 1–3; Zeng et al., 1995, pl. 21, fig. 16; Shen and Tazawa, 1997, p. 288, figs. 2–4, 5.1–5.14; Campi et al., 2000, p. 41, figs. 4A –C, 5A, B; Campi et al., 2002, fig. 6P; Tazawa, 2002, fig. 10.13; Campi et al., 2005, p.

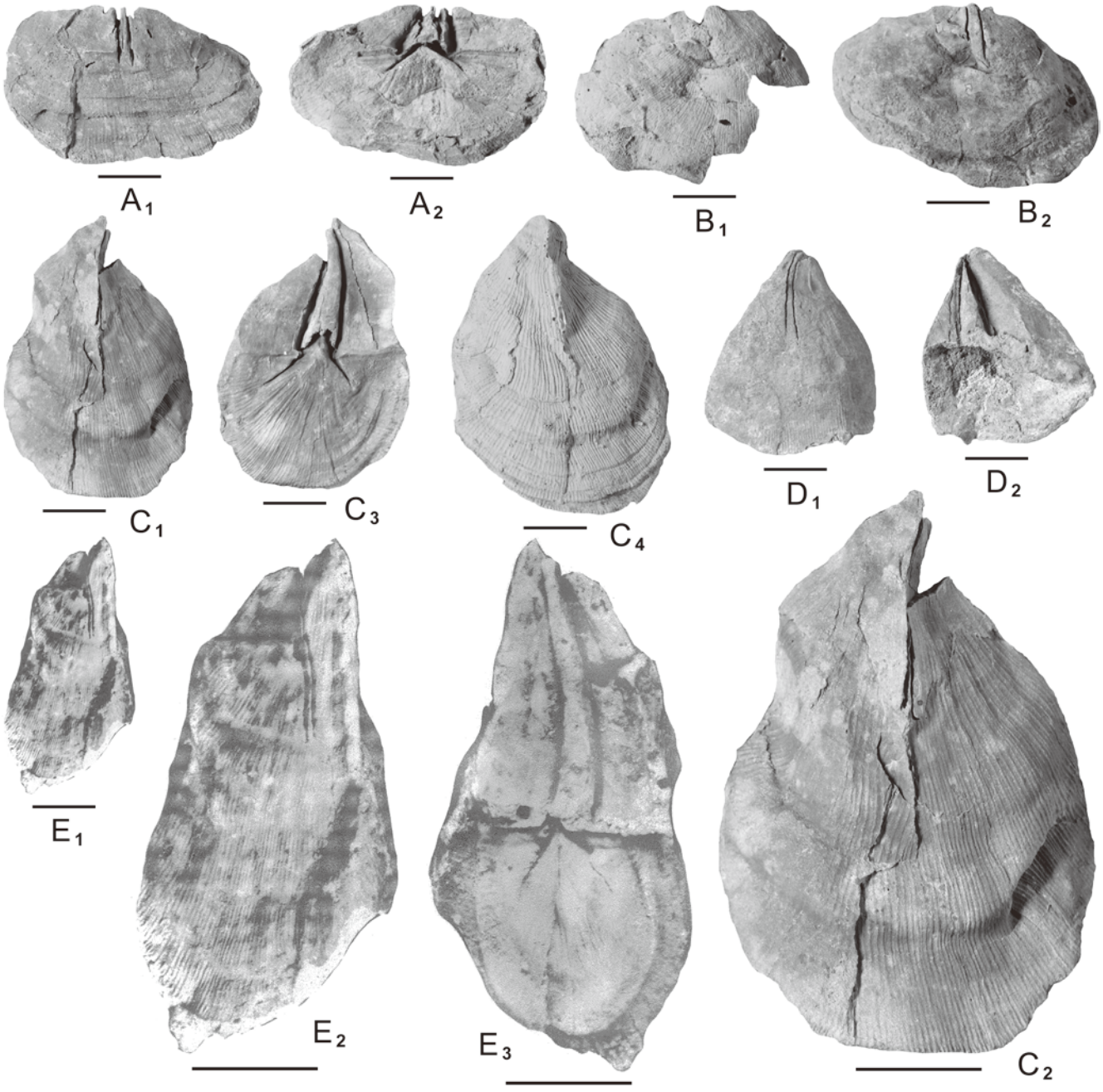

FIGURE 57. **A**, **B**, *Orthothetina transversa* Nakamura; A, ventral (A_1) and dorsal (A_2) views of internal mould of conjoined shell, UHR19532; B, external latex cast (B_1) and internal mould (B_2) of ventral valve, NU-B2498; **C**, **D**, *Orthothetina hayasakai* Nakamura; C, ventral internal mould (C_1, C_2), dorsal internal Mould (C_3) and ventral external latex cast (C_4) of conjoined shell, UHR13572 (holotype); D, ventral (D_1) and dorsal (D_2) views of internal mould of conjoined shell, NU-B2505; **E**, *Orthothetina kitakamiensis* (Hayasaka), ventral (E_1, E_2) and dorsal (E_3) views of internal mould of conjoined shell, sole specimen (not registered) figured by Hayasaka (1953, pl. 9, figs. 1, 2). Scale bars are 1 cm.

127, pl. 4, figs. I, J; Tazawa, 2008b, p. 50, fig. 8.1; Tazawa et al., 2014, p. 383, fig. 2.7; Tazawa, 2015, p. 72, fig. 6.7; Shen et al., 2017, pl. 20, figs. 3–5.

Material.—Thirty-five specimens from localities KF46, KF88, KF91, KF94, KF217 and KF218: (1) two conjoined shells, NU-B51, 59: (2) a ventral valve, NU-B52; (3) external and internal moulds of three ventral valves, NU-B58, 62, 63; (4) internal moulds of twenty-six ventral valves, NU-B54–56, 61, 64–66, 68, 69, 1669–1678, 2027, 2028, 2487–2490; and (5) external moulds of four dorsal valves, NU-B50, 57, 60, 67.

Remarks.—Most of the specimens were described by Shen and Tazawa (1997, p. 288, figs. 2–4, 5.1–5.14) as *Permianella typica* He and Zhu, 1979. The specimens from Setamai and Kamiyasse–Imo can be referred to *Permianella typica* He and Zhu (1979), originally described from the Lungtan Formation of Jiangxi, eastern China and Sichuan, southwestern China, by large size (length 49 mm, width 17 mm in the largest specimen, NU-B64), elongate ovate outline, deep incision, irregular marginal brim and nearly parallel anterolateral sides. *Permianella* sp. He and Zhu (1979, p. 133, 139, pl. 1, figs. 2, 3), from the Lungtan Formation of Jiangxi, eastern China, differs from *Permianella typica* in its nearly plano-convex shell and in having a very low dorsal fold.

Occurrence.—KY1 Unit in Kamiyasse (localities KF46, KF88, KF91 and KF94) and Imo (localities KF217 and KF218).

Distribution.—Wordian–Wuchiapingian: northeastern Japan (Setamai, Kamiyasse–Imo and Hitachi in the South Kitakami Belt), southwestern Japan (Mizukoshi in Kyushu Island), eastern China (Zhejiang and Jiangxi), southwestern China (Sichuan) and Malaysia.

Genus *DICYSTOCONCHA* Termier and Termier in Termier et al., 1974

Type species.—*Dicystoconcha lapparenti* Termier and Termier in Termier et al., 1974.

Dicystoconcha lapparenti Termier and Termier in Termier et al., 1974
(Fig. 52A–E)

Dicystoconcha lapparenti Termier and Termier in Termier et al., 1974, p. 123, pl. 22, figs. 1, 2, text-fig. 22; Wang and Jin, 1991, p. 495, pl. 1, figs. 1–9; pl. 3, figs. 1–7; Shen and Tazawa, 2014, p. 248, fig. 3.1–3.5; Tazawa et al., 2014, p. 383, fig. 2.6; Tazawa, 2015, p. 73, fig. 6.6; Tazawa and Araki, 2018, p. 16, fig. 4.2; Tazawa and Shintani, 2021, p. 11, fig. 4I.

Dipunctella contracta Liang in Wang et al., 1982, p. 229, pl. 102, fig. 3.

Guangjiayanella guangjiayanensis Yang, 1984, p. 212, pl. 31, figs. 11–16, text-fig. 5.9.

Guangdongina xiamaoensis Mou and Liu, 1989, p. 458, pl. 1, figs. 1–9; pl. 2, figs. 1–7, text-fig. 5.

Guangdongina leguminiformis Mou and Liu, 1989, p. 458, pl. 3, figs. 4–8.

Guangdongina perforatus Mou and Liu, 1989, p. 459, pl. 2, fig. 8; pl. 3, figs. 1–3.

Guangdongina sp. Mou and Liu, 1989, p. 459, pl. 2, fig. 9.

Paritisteges latesulcata Liang, 1990, p. 380, pl. 42, figs. 1, 2.

Febulasteges planata Liang, 1990, p. 381, pl. 42, figs. 3, 4.

Material. — Thirteen specimens from localities AR4, KF217 and KF218, internal moulds of ventral valves, KCG58. NU-B1679, 1680, 2491–2494, RCMF10001–10006.

Remarks.—These specimens were previously described by Shen and Tazawa (2014, p. 248, fig. 3.1–3.5) and Tazawa and Araki (2018, p. 16, fig. 4.2) as *Dicystoconcha lapparenti* Termier and Termier in Termier et al., 1974. The specimens from Kamiyasse–Imo and Matsukawa are referred to *Dicystoconcha lapparenti* Termier and Termier in Termier et al., 1974 in small size (length 25 mm, width 27 m in the largest specimen, RCM-F10001; length 19 mm, width 22 mm in an average-sized specimen, RCM-F10003), slightly triangular ovate outline, and strongly convex and bilobate ventral valve. Shen and Tazawa (2014, p. 248) treated the following six species from the Permian of South China as junior synonyms of *Dicystoconcha lapparenti*: *Guangjiayanella guangjiayanensis* Yang, 1984, *Guangdongina xiamaoensis* Mou and Liu, 1989, *Guangdongina leguminiformis* Mou and Liu, 1989, *Guangdongina perforatus* Mou and Liu, 1989, *Guangdongina* sp. Mou and Liu, 1989 and *Fabulasteges planata* Liang, 1990. Moreover, *Paritisteges latesulcata* Liang, 1990, from the lower Lengwu Formation of Lengwu, Zhejiang, eastern China, is also considered to be a junior synonym of the present species.

Occurrence.—KY1 Unit in Imo (localities KF217 and KF218) and Matsukawa (locality AR4).

Distribution.—Kungurian–Wuchiapingian: northeastern Japan (Nagaiwa–Sakamotozawa, Kamiyasse–Imo, Matsukawa and Hitachi in the South Kitakami Belt), northern China (Inner Mongolia), eastern China (Zhejiang), central-southern China (Hubei, Hunan and Guangdong) and Afghanistan.

Genus *LATERISPINA* Wang and Jin, 1991

Type species.—*Laterispina liaoi* Wang and Jin, 1991.

Laterispina parallela Shen, Fan, Zhang and Zhang, 1994
(Fig. 52F)

Laterispina parallela Shen, Fan, Zhang and Zhang, 1994, p. 478, pl. 1, figs. 1–12; pl. 2, figs. 1–11, 14, text-figs. 1–5; Shen and Tazawa, 1997, p. 289, fig. 5.15.

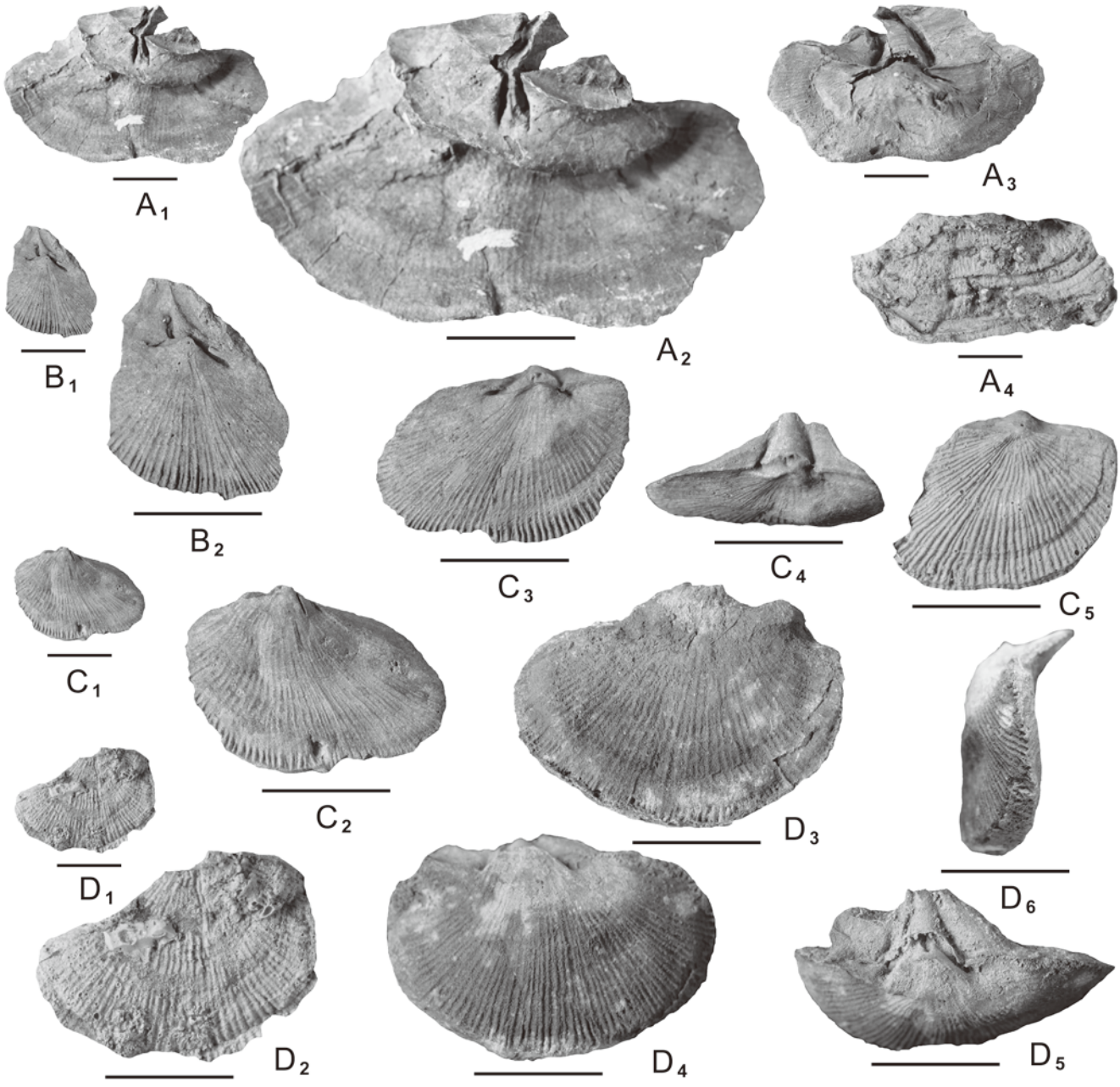

FIGURE 58. **A**, *Orthothetina transversa* Nakamura, ventral internal mould (A_1, A_2), dorsal internal mould (A_3) and ventral external latex cast (A_4) of conjoined shell, UHR13573 (holotype); **B**, **C**, *Streptorhynchus pelargonatus* (Schlotheim); B, dorsal internal mould (B_1, B_2) of conjoined shell, UHR12367; C, ventral (C_1, C_2), dorsal (C_3) and posterior (C_4) views of internal mould and dorsal external latex cast (C_5) of conjoined shell, UHR13584; **D**, *Streptorhynchus cataclinus* Zhang, ventral external latex cast (D_1, D_2) and ventral (D_3), dorsal (D_4) and posterior (D_5) views of internal mould of conjoined shell, NU-B2508. Scale bars are 1 cm.

Material.—One specimen from locality KS9, internal moulds of a ventral valve, NU-B70.

Remarks.—This specimen was previously described by Shen and Tazawa (1997, p. 289, fig. 5.15) as *Laterispina parallela* Shen, Fan, Zhang and Zhang, 1994. The Setamai specimen can be referred to *Laterisma parallela* Shen, Fan, Zhang and Zhang (1994, p. 478, pl. 1, figs. 1–12; pl. 2, figs. 1–11, 14, text-figs. 1–5), from the Changhsing Formation of Sichuan, southwestern China, by large, very long shell (length 55 mm, width 14 mm), with nearly parallel sides and in having marginal brim along lateral commissure. The type species, *Laterispina liaoi* Wang and Jin (1991, p. 497. pl. 2, figs. 4–12), from the Changhsing Formation of Guangxi, central-southern China, differs from *L. parallela* in its less elongate, subtriangular outline.

Occurrence.—KN2 Unit in Setamai (locality KS9).

Distribution.—Wordian–Changhsingian: northeastern Japan (Setamai in the South Kitakami Belt) and southwestern China (Sichuan).

Order ORTHOTETIDA Waagen, 1884
Suborder ORTHOTETIDINA Waagen, 1884
Superfamily ORTHOTETOIDEA Waagen, 1884
Family DERBYIIDAE Stehli, 1954
Genus *DERBYIA* Waagen, 1884

Type species.—*Derbyia regularis* Wagen, 1884.

Derbyia grandis Waagen, 1884
(Fig. 53A, B)

Derbyia grandis Waagen, 1884, p. 597, pl. 51, fig. 1–1c; pl. 52, figs. 1, 3; pl. 53, figs. 3, 5; Tschernyschew, 1902, p. 207, 580, pl. 24, figs. 1, 2; pl. 24, figs. 1, 2; pl. 26, fig. 5, text-figs. 59, 60; Broili, 1916, p. 7, pl. 115, fig. 9; Frebold, 1950, p. 41, pl. 1, fig. 5: Grunt, 1973, p. 84, pl. 3, figs. 1–4; Manankov, 1973, pl. 8, figs. 4, 5; Kulikov, 1974, p. 82, pl. 1, fig. 6; Lee and Gu, 1976, p. 236, pl. 161, fig. 12; Licharew and Kotlyar, 1978, pl. 12, fig. 1; Lee et al., 1980, p. 336, pl. 159, fig. 13; Kalashnikov, 1986, pl. 114, fig. 1; Nakamura et al., 1992, pl. 1, fig. 1; Gu, 1992, p. 215, pl. 67, fig. 17; Kalashnikov, 1993, p. 23, pl. 6, figs. 1, 2; pl. 7, fig. 7; Fang and Fan, 1994, p. 73, pl. 27, figs. 5–8; pl. 28, figs. 1, 2; Angiolini, 1996, p. 9, pl. 1, figs. 7–9; Tazawa and Ibaraki, 2001, p. 13, pl. 2, fig. 9; pl. 3, fig. 3a –c; Wang and Zhang, 2003, p. 120, pl. 24, figs. 1–3; pl. 25, fig. 4; pl. 27, figs. 13–15; Shen et al., 2003b, p. 60, pl. 1, figs. 1–3, text-fig. 4.

Derbyia cf. *grandis* Waagen. Frech, 1911, p. 125, pl. 18, fig. 4a–d; Stepanov, 1937a, p. 110, 174, pl. 1, fig. 5; Harker, 1960, p. 52, pl. 16, figs. 9, 10; Bamber and Waterhouse, 1971, pl. 18, fig. 1; Manankov, 1979, p. 57, pl. 4, fig. 1, text-fig. 25.

Derbyia aff. *grandis* Waagen. Gobbett, 1963, p. 54, pl. 2, figs. 1, 2.

Wardakia grandis (Waagen). Termier et al., 1974, p. 95, pl. 9, figs. 2–5; pl. 10, figs. 1–3, text-fig. 14.

Material.—Two specimens from localities KS1 and KS9, external and internal moulds of two ventral valves, NU-B363, 364.

Remarks.—These specimens were previously described by Tazawa and Ibaraki (2001, p. 13, pl. 2, fig. 9; pl. 3, fig. 3) as *Derbyia grandis* Waagen, 1884. The specimens from Setamai can be referred to *Derbyia grandis* Waagen (1884, p. 597, pl. 51, fig. 1; pl. 52, figs. 1, 3; pl. 53, figs. 3, 5), from the Wargal and Chhidru Formations of the Salt Range, Pakistan, on account of large, transverse shell (length about 63 mm, width 115 mm in better preserved specimen, NU-B363) and external ornament of ventral valve, consisting of strong, irregular rugae and numerous costellae with broad interspaces. The Setamai specimens closely resemble to the shells, described by Harker (1960, p. 52, pl. 16, figs. 9, 10) as *Derbyia* cf. *grandis* Waagen, from the Assistance Formation of Devon Island, northern Canada, in having slightly concave to nearly flat ventral valve.

Occurrence.—KN1 Unit (locality KS1) and KN2 Unit in Setamai (locality KS9).

Distribution.—Asselian–Wuchiapingian: northeastern Japan (Setamai in the South Kitakami Belt), northern Canada (Devon Island and northern Yukon Territory), northeastern Greenland, Spitsbergen, northern Russia (Timan, northern Urals and Kolyma Massif), northern China (Inner Mongolia), northeastern China (Jilin), eastern Russia (South Primorye), eastern China (Jiangsu), Afghanistan (Wardak), Tajikistan (Pamir), southwestern China (Yunnan), Indonesia (Timor), northwestern China (Tibet) and Pakistan (Karakoram and Salt Range).

Derbyia nipponica Nakamura, 1972
(Fig. 54A–F)

Derbyia magnifica Licharew. Hayasaka and Minato, 1956, p. 141, pl. 23, fig. 1; Hayasaka, 1960, p. 45, pl. 2, figs. 5, 6.

Derbyia nipponica Nakamura, 1972, p. 399, pl. 7, figs. 1, 4, 9; Minato et al., 1979, pl. 60, figs. 1–4; Tazawa and Ibaraki, 2001, p. 14, pl. 3, figs. 1, 2, 4; Tazawa, 2008b, p. 50, fig. 8.12–8.16.

Derbyia cf. *buchi* d'Orbigny. Tazawa and Matsumoto, 1998, p. 5, pl. 1, figs. 1, 2.

Material.—Nine specimens from localities KF22, KF121, KS1 and KS9: (1) internal mould of a conjoined shell, with external mould of the ventral valve, UHR17035; (2) external and internal moulds of four ventral valves, NU-B365–367, UHR12470; (3) internal mould of two ventral valves, NU-B38, 2485; and (4) internal mould of two dorsal valves, NU-B369, 2486.

Remarks.—These specimens were previously described

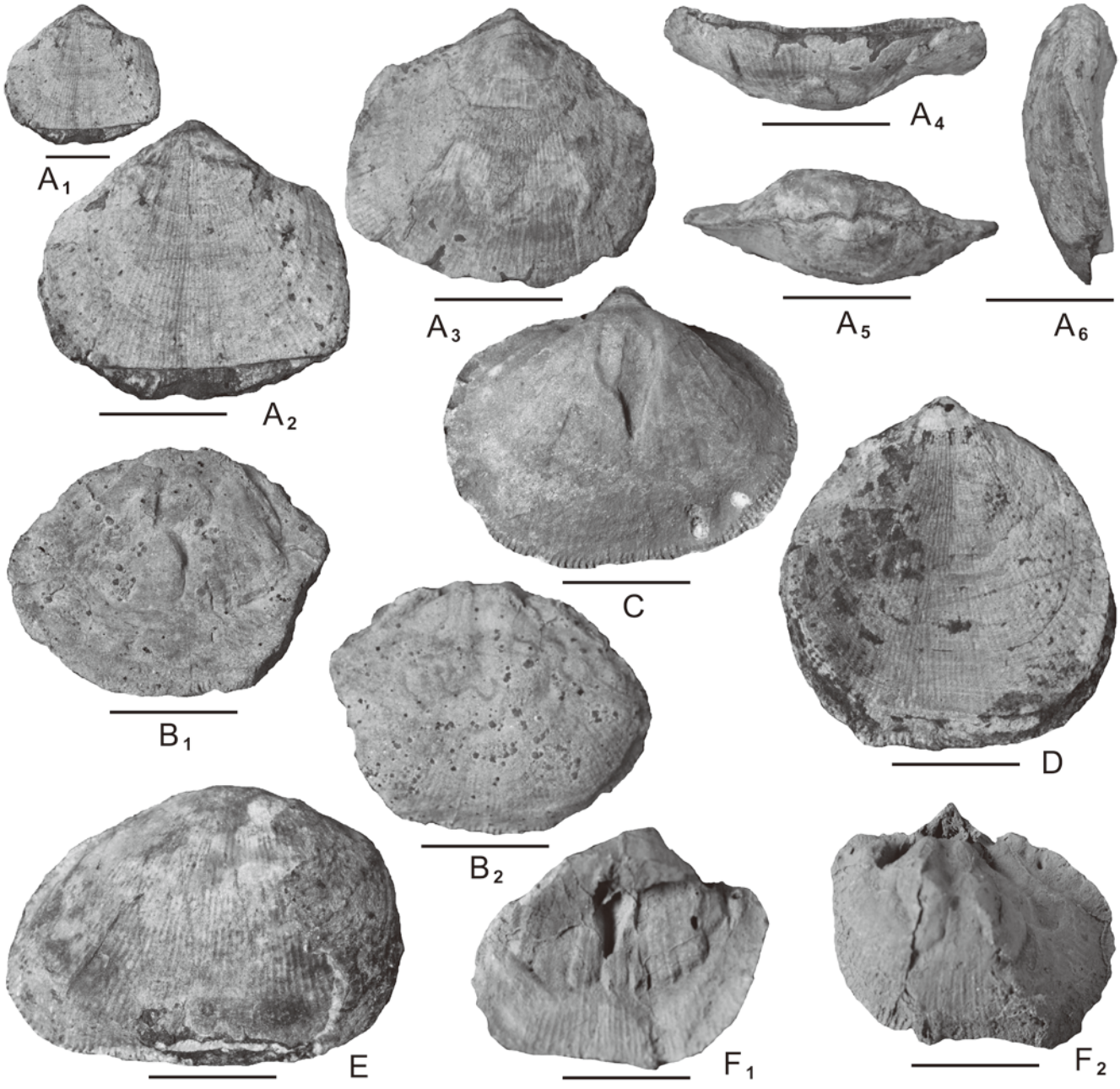

FIGURE 59. **A–F**, *Rhipidomella magna* Tazawa; A, ventral (A_1, A_2), dorsal (A_3), anterior (A_4), posterior (A_5) and lateral A_6) views of conjoined shell, NU-B1757; B, ventral (B_1) and dorsal (B_2) views of conjoined shell, NU-B1759; C, internal mould of ventral valve, NU-B1974; D, ventral valve, NU-B1760; E, dorsal valve, NU-B1762; F, ventral (F_1) and dorsal (F_2) views of conjoined shell, NU-B1762. Scale bars are 1 cm.

by Tazawa and Ibaraki (2001, p. 14, pl. 3, figs. 1, 2, 4) as *Derbyia nipponica* Nakamura, 1972. The specimens from Setamai are referred to *Derbyia nipponica* Nakamura, 1972, originally described from the lower Kanokura Formation of Imo in the South Kitakami Belt, by medium-sized (length 41 mm, width 49 mm in the best-preserved ventral valve specimen, NU-B365; length 51 mm, width about 73 mm in the largest dorsal valve specimen, NU-B369), weakly biconvex and transverse shell with short hinge and regularly developed fine costellae with narrow interspaces. *Derbyia magnifica* Licharew (1932a, p. 18, 40, pl. 1, figs. 1, 2, 6, 7, 13; pl. 2, fig. 1; pl. 3, fig. 1), from the lower Permian of the northern Caucasus, differs from *D. nipponica* in having long hinge marking the greatest width, ventral fold and dorsal sulcus. *Derbyia regularis* Waagen (1884, p. 504, pl. 53, figs. 1, 2, 4), from the Amb and Wargal Formations of the Salt Range, is also medium to large, transverse *Derbyia* species, but differs from the present species in having less dense costellae.

Occurrence.—KN1 Unit (locality KS1) and KN2 Unit in Setamai (locality KS9); KY1 Unit in Kamiyasse (locality KF22) and Imo (locality KF121).

Distribution.—Roadian–Wuchiapingian: northeastern Japan (Setamai and Kamiyasse–Imo in the South Kitakami Belt), central Japan (Oguradani in the Hida Gaien Belt) and southwestern Japan (Mizukoshi in Kyushu Island).

Family MEEKELLIDAE Stehli, 1954
Subfamily MEEKELLINAE Stehli, 1954
Genus *MEEKELLA* White and St. John, 1867

Type species.—*Plicatula striatocostata* Cox, 1857.

Meekella eximia (de Verneuil, 1845)
(Fig. 55A, B)

Orthis eximia de Verneuil, 1845, p. 192, pl. 11, fig. 2.
Meekella striatocostata (Cox). Tschernyschew, 1902, p. 211, 582, pl. 24, figs. 7, 8; pl. 26, fig. 4; pl. 51, fig. 3; Dunbar and Condra, 1932, p. 125, pl. 16, figs. 1 –10; pl. 17, fig. 3.
Meekella eximia (Eichwald). Tschernyschew, 1902, p. 213, 582, pl. 24, fig. 5; pl. 51, fig. 13; Stepanov, 1937a, p. 111, 174, pl. 1, fig. 7; Licharew and Einor, 1939, p. 21, 203, pl. 2, fig. 1; Lapina, 1957, p. 23, pl. 1, fig. 6; Sokolskaya in Sarytcheva and Sokolskaya, 1952, p. 58, pl. 9, fig. 46; Sokolskaya, 1954, p. 157, pl. 17, figs. 4–8; Zavodowsky and Stepanov, 1970, p. 72, pl. 42, figs. 3–5; Kalashnikov, 1980. p. 26, pl. 1, fig. 9; Zhang et al., 1983, p. 277, pl. 125, figs. 14, 15; Wang, 1995, pl. 1, fig. 10; Wang and Yang, 1998, p. 63, pl. 2, fig. 7.
Meekella striatocostata (Cox). Hayasaka, 1937, p. 268, text-figs. 1, 2; Hayasaka, 1963d, fig. 5.
Meekella cf. *eximia* (de Verneuil). Czarniecki, 1969, p. 262, pl. 2, fig. 1.
Meekella cf. *striatocostata* (Cox). Nakamura, 1972, p. 385, pl. 5, fig. 1; Minato et al., 1979, pl. 59, figs. 3, 4.
Meekella cf. *eximia* (Eichwald). Nakamura, 1972, p. 386, pl. 6, figs. 5, 6; Minato et al., 1979, pl. 59, fig. 5.
Mekella eximia (de Verneuil). Manankov, 1979, p. 39, pl. 1, figs. 2–4, text-figs. 2, 15.

Material.—Two specimens from localities KF64 and KF121: (1) internal mould of a ventral valve, UHR13574; and (2) external mould of a dorsal valve, UHR12576.

Remarks.—Among two specimens from Kamiyasse–Imo, the larger one (UHR12576) was previously described by Nakamura (1972, p. 386, pl. 6, figs. 5, 6) as *Meekella* cf. *eximia* (von Eichwald, 1840); and the smaller one (UHR13574) was described by Nakamura (1972, p. 385, pl. 5, fig. 1) as *Meekella* cf. *striatocostata* (Cox, 1857). Subsequently, Manankov (1979, p. 39) treated the Kitakami specimens as synonyms of *Mekella eximia* (de Verneuil, 1845). Czarniecki (1969, p. 262) commented about the author of *Meekella eximia* as follows: According to the Code of Zoological Nomenclature, the author of this species is de Verneuil, who first published its description and figures it. The Kitakami specimens can be referred to *Meekella eximia* (de Verneuil, 1845), redescribed by Sokolskaya (1954, p. 157, pl. 17, figs. 4–8), from the Moscovian–Gzhelian of the Russian Platform, in medium, transverse shell (length about 28 mm, width about 45 mm in the larger specimen, UHR12576) and in having thick and relatively few costae on both ventral and dorsal valves. *Meekella uralica* Tschernyschew (1902, p. 215, 583, pl. 51, figs. 1, 2), from the lower Permian (*Schwagerina* Limestone) of the Urals, differs from *M. eximia* in having thick but shorter costae which occur on posterior half of both ventral and dorsal valves.

Occurrence.—KY1 Unit in Kamiyasse (locality KF64) and Imo (locality KF121).

Distribution.—Moscovian–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), USA (Iowa, Missouri, Nebraska and Kansas), Spitsbergen, northern Russia (Pechora Basin, Novaya Zemlya and Omolon Massif), western Russia (Moscow Basin), central Russia (southern Urals) and northwestern China (Xinjiang).

Meekella nodosa Nakamura, 1972
(Fig. 55C–F)

Meekella sp. Huang, 1933, p. 31, pl. 4, figs. 8, 9.
Meekella garnieri Bayan. Nakamura, 1972, p. 387, pl. 5, figs. 5–7; Minato et al., 1979, pl. 59, figs. 1, 2.
Meekella nodosa Nakamura, 1972, p. 388, pl. 6, figs. 3, 4; Minato et al., 1979, pl. 59, fig. 8; Tazawa and Araki, 2018, p. 17, fig. 4.3.

Material.—Four specimens from localities KF64, KF121 and KZ9: (1) internal mould of a conjoined shell, UHR19533; (2) external moulds of two ventral valves,

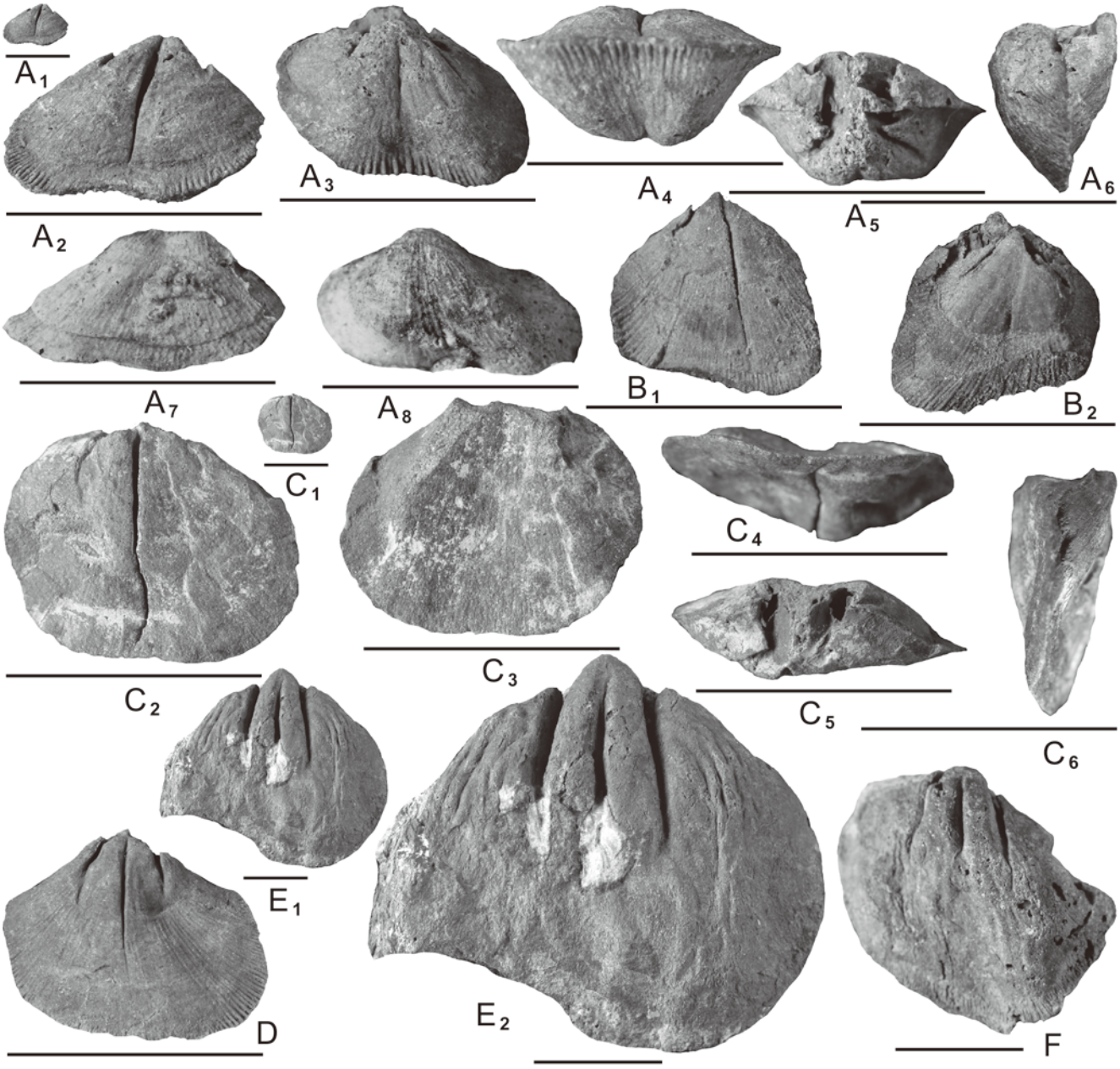

FIGURE 60. **A**, **B**, *Acosarina rectimarginata* Cooper and Grant; A, ventral (A_1, A_2), dorsal (A_3), anterior (A_4), posterior (A_5) and lateral (A_6) views of internal mould and ventral (A_7) and dorsal (A_8) views of external cast of conjoined shell, NU-B2467; B, ventral (B_1) and dorsal (B_2) views of internal mould of conjoined shell, NU-B2468; **C**, **D**, *Acosarina dorsisulcata* Cooper and Grant; C, ventral (C_1, C_2), dorsal (C_3), anterior (C_4), posterior (C_5) and lateral (C_6) views of internal mould of conjoined shell, NU-B2465; D, internal mould of ventral valve, NU-B2466; **E**, **F**, *Orthotichia* sp.; E, internal mould (E_1, E_2) of ventral valve, NU-B2497; F, internal mould of ventral valve, UHR12624. Scale bars are 1 cm.

KCG60, UHR12577; and (3) internal mould of a ventral valve, UHR12578 (holotype).

Remarks. —One of the specimens (UHR12578) from Imo was previously described by Nakamura (1972) as the holotype of *Meekella nodosa* Nakamura, 1972. The specimens from Kamiyasse, Imo and Matsukawa can be referred to *Meekella nodosa* Nakamura, 1972, by medium to large size (length about 44 mm, width about 60 mm in the holotype, UHR12578) and external ornament consisting of numerous nodose costae and irregularly developed strong rugae. As noted by Nakamura (1972, p. 389), *Meekella* sp. Huang, 1933, from the Wuchiapingian of Guizhou, southwestern China, is a synonym of *Meekella nodosa*. Furthermore, two specimens described by Nakamura (1972, p. 388, pl. 6, figs. 3, 4) as *Meekella garnieri* Bayan are referred to the present species. *Meekella irregularis* Schellwien, 1900b (p. 20, pl. 2, figs. 8, 9), from the Trogkofel Limestone of the Karavanke Mountains, Slovenia, also has nodose ornament on ventral valve, but the Karavanke species differs from *M. nodosa* in its much elongate outline. *Mekella magnifica* Cooper and Grant (1974, p. 365, pl. 100, figs. 1–33; pl. 116, figs. 9–18), from the Wolfcampian of Texas, differs from *M. nodosa* in having much longer interarea of the ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (locality KF64), Imo (locality KF121) and Matsukawa (locality KZ9).

Distribution.—Roadian–Wuchiapingian: northeastern Japan (Kamiyasse–Imo and Matsukawa in the South Kitakami Belt) and southwestern China (Guizhou).

Genus *ORTHOTHETINA* Schellwien, 1900a

Type species.—*Orthothetes persicus* Schuchert in Schuchert and LeVene, 1929.

Orthothetina polita (Fliegel, 1901)
(Fig. 56A–C)

Orthothetes politus Fliegel, 1901, p. 97, pl. 6, fig. 8.
Orthotetina polita Fliegel. Nakamura, 1972, p. 380, pl. 3, figs. 4; pl. 4, figs. 1, 2 .
Orthothetina polita Fliegel. Minato et al., 1979, pl. 58, fig. 5.

Material.—Four specimens from localities KF121and KF217: (1) internal mould of two conjoined shells, UHR13663, 13664; (2) external and internal moulds of a ventral valve, UHR13668; and (3) internal mould of a ventral valve, NU-B2501.

Remarks.—These specimens were previously described by Nakamura (1972, p. 380, pl. 3, fig. 4; pl. 4, figs. 1, 2) as *Orthotetina polita* Fliegel, and refigured by Minato et al. (1979, pl. 58, fig. 5) as *Orthothetina polita* Fliegel. The specimens from Imo can be referred to *Orthothetina polita* (Fliegel, 1901) on the basis of medium size (length about 31 mm, width about 40 mm in the largest specimen, UHR13663), subtriangular outline and in having a broad and deep sulcus on dorsal valve and somewhat twisted ventral beak. *Orthothetina planoconvexa* Hayasaka (1933, p. 32, pl. 9, fig. 2; text-fig. 5), from the Nabeyama Limestone of the Ashio Mountains, central Japan, resembles *O. polita* in outline and shape of shell, but larger in size. *Orthothetina azarjani* Kotlyar (1989, p. 118, pl. 21, fig. 7; pl. 22, figs. 2–5), from the Midian of the Caucasus, western Russia, appears to be conspecific with the present species, although comparison of the two species is difficult owing to ill preservation of the Kitakami specimens.

Occurrence.—KY1 Unit in Imo (localities KF121 and KF217).

Distribution.—Upper Carboniferous–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and Indonesia (Sumatra).

Orthothetina kayseri (Fliegel, 1901)
(Fig. 56D–G)

Orthothetes kayseri Jäkel. Fliegel, 1901, p. 127, pl. 6, fig. 9.
Orthotetina kayseri (Jäkel) Fliegel. Minato and Nakamura, 1956, p. 152, pl. 24, fig. 4.
Orthotetina kayseri (Jaekel). Hayasaka, 1963d, p. 753, figs. 1, 2 only.
Orthotetina kayseri (Jäkel). Nakamura, 1972, p. 380, pl. 2, figs. 2–5.
Orhtothetina kayseri (Jäkel). Minato et al., 1979, pl. 58, figs. 3, 4.

Material.—Seven specimens from localities KF91, KF121, KF217 and KZ9: (1) external and internal moulds of a conjoined shell, NU-B2499; (2) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B2502; (3) internal mould of a conjoined shell, with external mould of the dorsal valve, UHR17071; (4) internal moulds of two conjoined shells, UHR13686, 13693; and (5) internal mould of two ventral valves, NU-B2500, 2503.

Remarks.—Most of the specimens (UHR13686, 13693, 17071) were previously described by Minato and Nakamura (1956, p. 152, pl. 24, fig. 4) and Nakamura (1972, p. 380, pl. 2, figs. 2–5) as *Orthothetina kayseri* (Flieger, 1901). This species is medium in size for the genus, slightly longer subrectangular in outline; ventral valve flat to slightly convex in lateral profile, interarea moderately high; dorsal vale slightly convex; length about 36 mm, width about 33 mm, height of ventral interarea about 9 mm in the best-preserved specimen (NU-B2499). The preceding species, *Orthothetina polita* (Fliegel, 1901), is distinguished from the present species in having somewhat twisted ventral beak. *Orthothetina ruber* (Frech, 1911, p. 124, 174, pl. 26, fig. 4), from the Lopingian of Jiangxi, eastern China is also subrectangular in outline, but differs from *O. kayseri* in its much larger size.

Occurrence.—KY1 Unit in Kamiyasse (locality KF91),

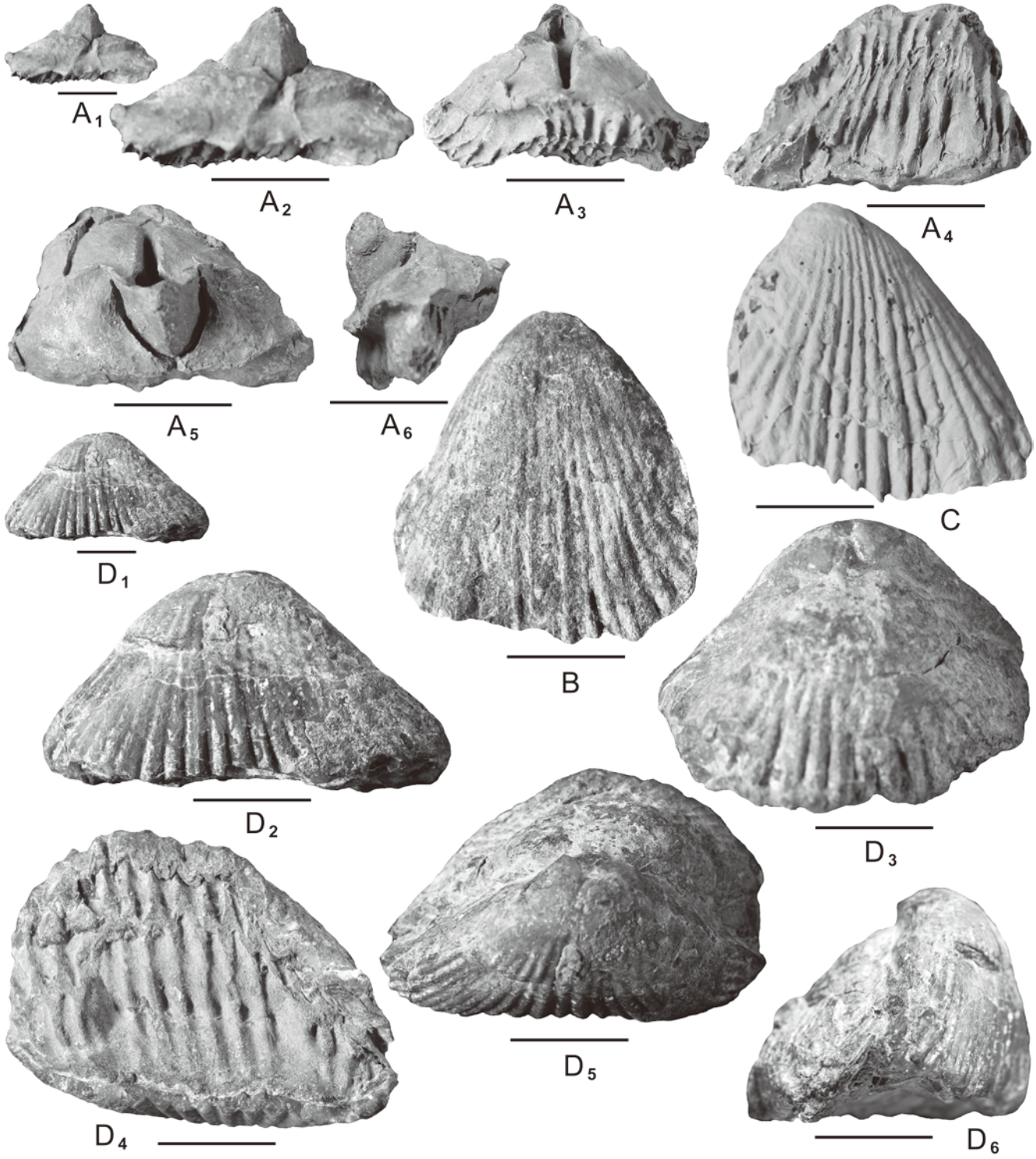

FIGURE 61. **A**–**D**, *Stenoscisma margaritovi* (Tschernyschew); A, ventral (A_1, A_2), dorsal (A_3), anterior (A_4), posterior (A_5) and lateral (A_6) views of internal mould of conjoined shell, NU-B2556; B, ventral valve, NU-B2547; C, ventral valve, NU-B2550; D, ventral (D_1, D_2), dorsal (D_3), anterior (D_4), posterior (D_5) and lateral (D_6) views of conjoined shell, NU-B2555. Scale bars are 1 cm.

Imo (localities KF121 and KF217) and Matsukawa (locality KZ9).

Distribution.—Roadian–Changhsingian: northeastern Japan (Kamiyasse–Imo and Matsukawa in the South Kitakami Belt) and eastern China (Jiangxi).

Orthothetina kitakamiensis (Hayasaka, 1953)
(Fig. 57E)

Hamletella kitakamiensis Hayasaka, 1953, p. 93, pl. 9, figs. 1, 2.
Orthotetina kitakamiensis (Hayasaka). Nakamura, 1972, p. 375, text-fig. 6.

Material.—One specimen from locality KS10, internal mould of a conjoined shell (figured by Hayasaka, 1953, pl. 9, figs. 1, 2).

Remarks.—The single specimen from Setamai were first described by Hayasaka (1953, p. 93, pl. 9, figs. 1, 2) as *Hamletella kitakamiensis* Hayasaka, 1953. Subsequently, the genus *Hamletella* was treated as a synonym of the genus *Orthothetina* by Muir-Wood and Williams (1965, p. 406). *Orthothetina kitakamiensis* (Hayasaka, 1953) has a pair of long, thin and subparallel dental pates in the ventral valve, and is characterized by its elongate outline (length 44 mm, width about 21 mm in the sole specimen), with high ventral interarea (height 23 mm, width of hinge line 17 mm). This species is the most elongate *Orthothetina* species from the South Kitakami region, as noted and illustrated by Nakamura (1972, text-fig. 6).

Occurrence.—KN2 Unit in Setamai (locality KS10).

Distribution.—Wordian: northeastern Japan (Setamai in the South Kitakami Belt).

Orthothetina hayasakai Nakamura, 1972
(Fig. 57C, D)

Orthotetes rugosa Fredericks. Hayasaka, 1925a, p. 92, pl. 9, fig. 1.
Orthotetina kayseri (Jaekel). Hayasaka, 1963b, p. 753, fig. 3 only.
Orthotetina hayasakai Nakamura, 1972, p. 376, pl. 1, figs. 1, 2.
Orthotetina elongata Nakamura, 1972, p. 379, pl. 1, figs. 3–6; pl. 2, fig. 1.
Orthothetina hayasakai Nakamura. Minato et al., 1979, pl. 58, fig. 1.
Orthothetina elongata Nakamura. Minato et al., 1979, pl. 58, fig. 2; Shen et al., 1992, p. 176, pl. 2, figs. 7–10; Shen and Shi, 2007, p. 23, pl. 7, figs. 21–24.
Orthothetina rara Shen, He and Zhu, 1992, p. 176, pl. 2, figs. 7–10.

Material.—Seven specimens from localities KF121 and KF217: (1) external and internal moulds of a conjoined shell, UHR13572 (holotype); (2) internal mould of a conjoined shell, with external mould of the dorsal valve, UHR13567; (3) external and internal moulds of a ventral valve, UHR13689; and (4) internal moulds of four ventral valves, NU-B2504, 2505, UHR13690, 13692.

Remarks.—Five specimens from Imo consists of the holotype of *Orthothetina hayasakai* Nakamura, 1972 (UHR13572) and the holotype (UHR13567) and the paratypes (UHR13689, 13690, 13692) of *Orthothetina elongata* Nakamura, 1972. In the present study, *Orthothetina elongata* is treated as a synonym of *Orthothetina hayasakai* because of both species are characterized by medium size and elongate oval outline. As noted by Shen and Shi (2007, p. 23), *Orthothetina rara* Shen, He and Zhu, 1992 (p. 176, pl. 2, figs. 7–10), from the Changhsingian Formation of Beifengjing, Sichan, southwestern China, is a synonym of the present species. *Orthothetina zhejiangensis* Liang (1990, p. 135, pl. 14, figs. 5–14), from the Lengwu Formation of Zhejiang, eastern China, is also elongate in outline, but differs from *O. hayasakai* in its much larger size.

Occurrence.—KY1 Unit in Imo (localities KF121 and KF217).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and southwestern China (Sichuan).

Orthothetina transversa Nakamura, 1972
(Figs. 57A, B, 58A)

Orthotetina transversa Nakamura, 1972, p. 382, pl. 3, figs. 1–3
Orthothetina transversa Nakamura. Minato et al., 1979, pl. 58, fig. 6.

Material.—Three specimens from locality KF217: (1) external and internal moulds of a conjoined shell, UHR13573 (holotype); (2) internal mould of a conjoined shell, with external mould of the ventral valve, UHR19532; and (3) external and internal moulds of a ventral valve, NU-B2498.

Remarks.—The specimens from Imo, except for one specimen (NU-B2498), were previously described by Nakamura (1972, p. 382, pl. 3, figs. 1–3) as *Orthotetina transversa* Nakamura, 1972. Subsequently Minato et al. (1979, pl. 58, fig. 6) figured the type specimen (UHR13573) as *Orthothetina transversa* Nakamura. This species is characterized by its transverse outline (length about 25 mm, width about 43 mm in the holotype) and in having a broad and large delthyrium on ventral valve. The preceding species, *Orthothetina hayasakai* Nakamura, 1972, is readily distinguished from *O. transversa* by its much elongate outline. *Orthothetina ruber* (Frech, 1911, p. 124, 174, pl. 26, fig. 4), from the Lopingian of Jiangxi, eastern China, differs from the present species in having less transverse ventral valve.

Occurrence.—KY1 Unit in Imo (locality KF217).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo

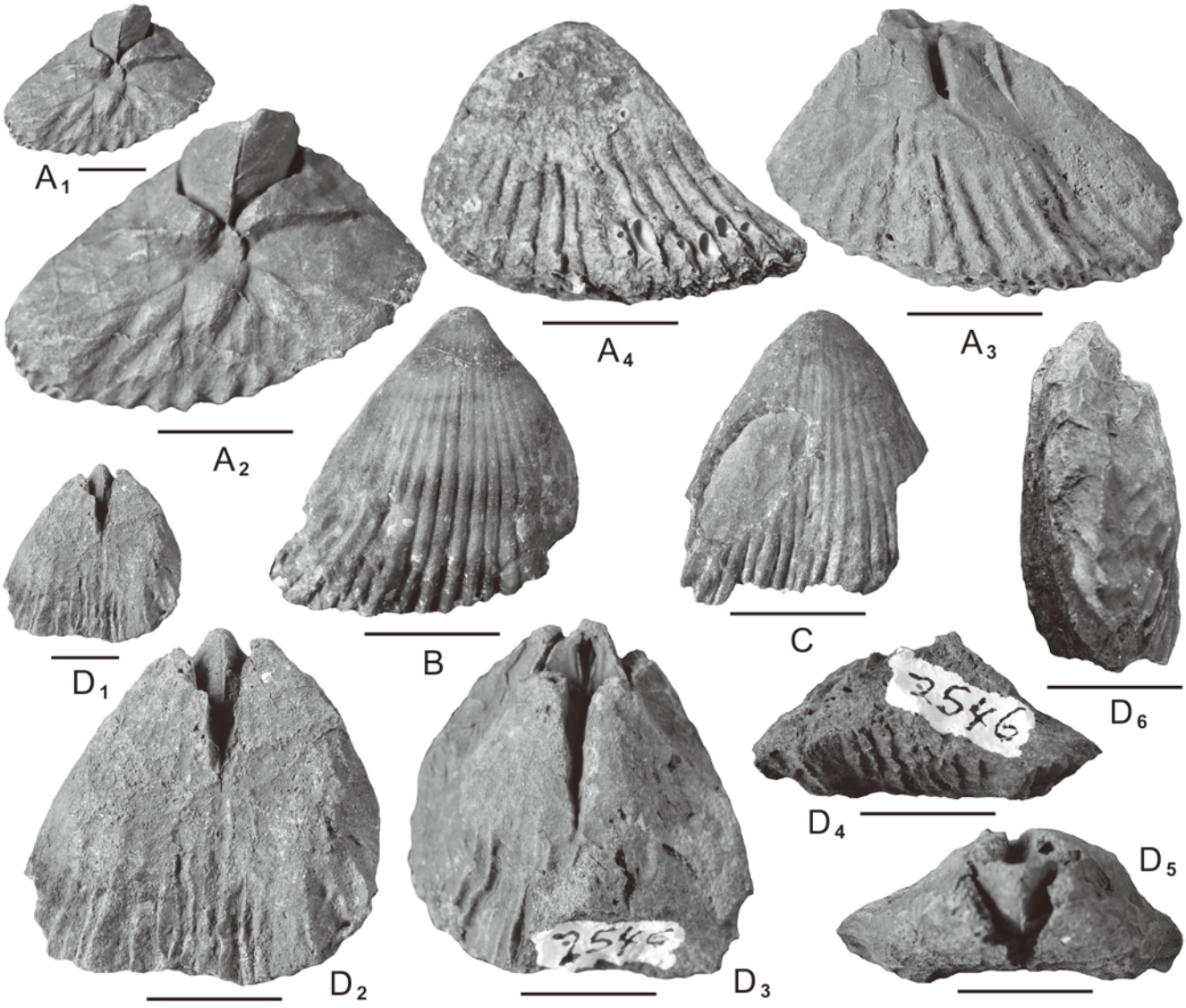

FIGURE 62. **A**–**D**, *Stenoscisma margaritovi* (Tschernuschew), A, ventral (A_1, A_2) and dorsal (A_3) views of internal mould and ventral external latex cast of conjoined shell, NU-B2554; B, ventral valve, NU-B2548; C, ventral valve, NU-B2549; D, ventral (D_1, D_2), dorsal (D_3), anterior (D_4), posterior (D_5) and lateral (D_6) views of internal mould of conjoined shell, NU-B2546. Scale bars are 1 cm.

in the South Kitakami Belt).

Family SCHUCHERTELLIDAE Williams, 1953
Subfamily STREPTORHYNCHINAE Stehli, 1954
Genus *STREPTORHYNCHUS* King, 1850

Type species.—*Terebratulites pelargonatus* von Schlotheim, 1816.

Streptorhynchus pelargonatus (von Schlotheim, 1816)
(Fig. 58B, C)

Terebratulites pelargonatus von Schlotheim, 1816, p. 28, pl. 8, figs. 21–24.

Streptorhynchus pelargonatus (von Schlotheim). Davidson, 1858, p. 32, pl. 2, figs. 32–42; Waagen, 1884, p. 579, pl. 50, figs. 3–5, 7; Licharew, 1932a, p. 11, 36, pl. 4, figs. 2, 4; Huang, 1933, p. 17, pl. 2, fig. 13; Minato and

Nakamura, 1956, p. 149, pl. 24, fig. 1; Nakamura, 1972, p. 397, pl. 9, fig. 3; Minato et al., 1979, pl. 60, figs. 6, 7; Lee et al., 1980, p. 332, pl. 158, figs. 8, 20; Yang, 1984, p. 207, pl. 30, fig. 12; Campi et al., 2005, p. 132, pl. 5, figs. Q–S.

Streptorhynchus pseudopelargonatus Broili, 1916, p. 5, pl. 115, figs. 4, 5.

Streptorhynchus broili Grabau, 1931, p. 245, pl. 24, figs. 3, 4.

Streptorhynchus amygdalis Lee and Gu, 1976, p. 234, pl. 159, fig. 1.

Material.—Four specimens from localities KF27 and KF121: (1) internal mould of a conjoined shell, with external mould of the dorsal valve, UHR13584; (2) internal mould of a conjoined shell, UHR 12367; (3) external and internal moulds of a ventral valve, NU-B2506; and (4) external and internal moulds of a dorsal valve, NU-B2507.

Remarks.—One of the specimens (UHR12367) was previously described by Nakamura (1972, p. 397, pl. 9, fig. 3) and figured by Minato et al. (1979, pl. 60, fig. 7) as *Streptorhynchus pelargonatus* (von Schlotheim, 1816). This species is characterized by its elongate, oval and small shell (length 15 mm, width 15 mm, height of ventral interarea 6 mm, width of hinge line 11 mm in a conjoined shell specimen, UHR12367), high interarea with narrow and convex pseudodeltidium in ventral valve, and a pair of strong socket plates in dorsal valve. Shells described by Frech (1911, p. 122, pl. 18, fig. 7) as *Streptorhynchus pelargonatus* (von Schlotheim, 1816), from Loping, Jiangxi Province, eastern China, differs from the lectotype figured by Williams and Brunton (2000, fig. 481.4) in much larger size. Chinese specimens, described by Grabau (1931, p. 243, pl. 24, fig. 2) and Shen and Shi (2007, p. 33, pl. 12, figs. 15–24) as *Streptorhynchus pelargonatus* (von Schlotheim, 1816), from the Jisu Honguer Formation of Inner Mongolia, and from the Lopingian of Guizhou and Sichuan, respectively, differ from the type specimen in transverse wider outline and in having lower ventral interarea. *Streptorhynchus sulculatum* Grant (1976, p. 50, pl. 8, figs. 1–56), from the Ratburi Formation of Ko Muk, southern Thailand, differs from *S. pelargonatus* in having shallow sulcus in ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (locality KF27) and Imo (locality KF121).

Distribution.—Artinskian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), UK (England), Germany, western Russia (Caucasus), northern China (Inner Mongolia), northeastern China (Jilin), central-southern China (Hubei), southwestern China (Guizhou), Malaysia, Indonesia (Timor) and Pakistan (Salt Range).

Streptorhynchus cataclinus Zhang in Yang et al., 1962
(Fig. 58D)

Streptorhynchus cataclinus Zhang in Yang et al., 1962, p. 36, pl. 10, figs. 7–9, text-fig. 17; Lee and Gu, 1976, p. 234, pl. 161, fig. 5.

Streptorhynchus pelargonatus (von Schlotheim). Tazawa, 1976, pl. 2, fig. 2.

Material.—Three specimens from locality KF20: (1) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B2508; (2) external and internal moulds of ventral valve, NU-B2509; and (3) internal mould of a ventral valve, NU-B2510.

Remarks.—One of the specimens from Kamiyasse was previously figured by Tazawa (1976, pl. 2, fig. 2) as *Streptorhynchus pelargonatus* (von Schlotheim, 1816). But the Kamiyasse specimens can be referred to *Streptorhynchus cataclinus* Zhang (in Yang et al., 1962, p. 36, pl. 10, figs. 7–9, text-fig. 17), from the Maokouan of Qinghai, northwestern China, in being medium size (length about 20 mm, width about 26 mm in the best-preserved specimen, NU-B2508) and transverse outline and in having a comparatively low ventral interarea (height of ventral interarea about 5 mm in the same specimen). The preceding species, *Streptorhynchus pelargonatus* (von Schlotheim, 1816), differs from *S. cataclinus* in its smaller and longer shell, with higher ventral interarea.

Occurrence.—KY1 Unit in Kamiyasse (locality KF20).

Distribution.—Wordian–Capitanian: northeastern Japan (Kamiyasse–Imo in the South KItakami Belt), northwestern China (Qinghai) and northern China (Inner Mongolia).

Order ORTHIDA Schuchert and Cooper, 1932
Suborder DALMANELLIDINA Moore, 1952
Superfamily DALMANELLOIDEA Schuchert, 1913
Family RHIPIDOMELLIDAE Schuchert, 1913
Subfamily RHIPIDOMELLINAE Schuchert, 1913
Genus *RHIPIDOMELLA* Oehlert, 1890

Type species.—*Terebratula michelini* Léveilé, 1835.

Rhipidomella magna Tazawa, 2016a
(Fig. 59A–F)

Rhipidomella sp. Tazawa, 2002, fig. 10.7.

Rhipidomella magna Tazawa, 2016a, p. 85, fig. 6.

Material.—Eight specimens from localities KF8, KF94 and KF217: (1) two conjoined shells, NU-B1757 (holotype), 1758; (2) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B2570; (3) internal mould of a conjoined shell, NU-B1759; (4) external cast and mould of a ventral valve, NU-B1760; (5) external and internal moulds of a ventral valve, NU-B1974; (6) external mould of a ventral valve, NU-B1761; and (7) external cast of a dorsal valve, NU-B1762.

Remarks.—These specimens were previously described by Tazawa (2016a, p. 85, fig. 6) as *Rhipidomella magna* Tazawa, 2016a. This species is characterized by its large size

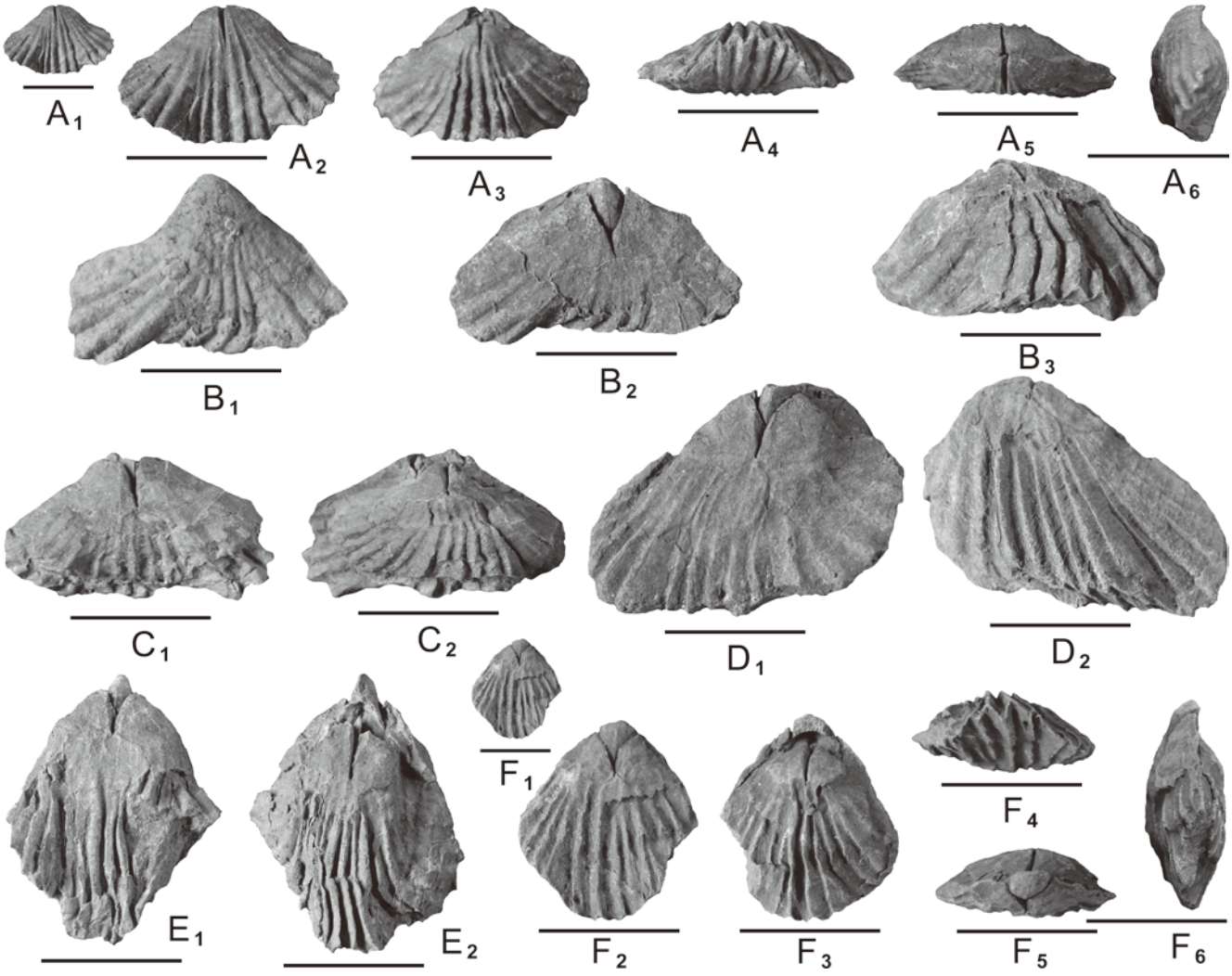

FIGURE 63. **A**–**D**, *Stenoscisma mutabilis* (Tschernyschew); A, ventral (A_1, A_2), dorsal (A_3), anterior (A_4), posterior (A_5) and lateral (A_6) views of internal mould of conjoined shell, NU-B2574; B, ventral external latex cast (B_1) and ventral (B_2) and dorsal (B_3) views of internal mould of conjoined shell, NU-B2557; C, ventral (C_1) and dorsal (C_2) views of internal mould of conjoined shell, NU-B2573; D, ventral (D_1) and dorsal (D_2) views of internal mould of conjoined shell, NU-B2560; **E**, **F**, *Stenoscisma sokolskajae* Koczyrkevicz; E, ventral (E_1) and dorsal (E_2) views of internal mould of conjoined shell, NU-B2563; F, ventral (F_1, F_2), dorsal (F_3), anterior (F_4), posterior (F_5) and lateral (F_6) views of internal mould of conjoined shell, NU-B2564. Scale bars are 1 cm.

(length 22 mm, width 25 mm in the holotype, NU-B1757; length 24 mm, width 30 mm in the largest dorsal valve specimen, NU-B1762) and slightly transverse outline. *Rhipidomella corallina* (Waagen, 1884, p. 572, pl. 56, fig. 1), from the Wargal Formation of the Salt Range, Pakistan, resembles the Kitakami species in size and outline of shell, but differs in having more strongly concave ventral valve. The type species, *Rhipidomella michelini* (Léveilé, 1835), from the Lower Carboniferous of Europe and Asia, is readily distinguished from *R. magna* by its smaller size and more rounded posterior portion of the shell.

Occurrence.—KY1 Unit in Kamiyasse (localities KF8 and KF94) and Imo (locality KF217).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt).

Superfamily ENTELETOIDEA Waagen, 1884
Family SCHIZOPHORIIDAE Schuchert and LeVene, 1929
Genus *ACOSARINA* Cooper and Grant, 1969

Type species.—*Acosarina dorsisulcata* Cooper and Grant, 1969.

Acosarina dorsisulcata Cooper and Grant, 1969
(Fig. 60C, D)

Acosarina dorsisulcata Cooper and Grant, 1969, p. 2, pl. 5, figs. 19–23; Cooper and Grant, 1976b, p. 2621, pl. 667, figs. 1–26; pl. 673, figs. 1–6.

Material.—Two specimens from locality KF217: (1) internal mould of a conjoined shell, NU-B2465; and (2) internal mould of a ventral valve, NU-B2466.

Description.—Shell small in size for genus, roundly subquadrate in outline, wider than long, widest at about midlength, slightly biconvex and having weakly sulcate anterior commissure; length 10 mm, width 12 mm in the larger specimen (NU-B2465). Internally, ventral valve having a pair of short dental plates divergent anteriorly and a long median septum attaining to midlength of valve. Dorsal valve interior not well preserved.

Remarks.—The specimens from Imo can be referred to *Acosarina dorsisulcata* Cooper and Grant (1969, p. 2, pl. 5, figs. 19–23), from the Bone Spring Formation of Texas, in being small size and transversely subeliptical outline, and in having slightly sulcate anterior commissure and relatively short median septum in ventral valve. *Acosarina indica* (Waagen, 1884, p. 568, pl. 56, figs. 7, 8, 14–16), from the Amb and Wargal Formations of the Salt Range, Pakistan, differs from *A*, *dorsisulcata* in its longer outline. *Acosarina strophiria* Xu and Grant (1994, p. 18, figs. 4, 5.1–17, 5.19, 5.20), from the Changhsing Formation of Zhejiang, eastern China, is also having slightly emarginate anterior commissure, but distinguished from *A. dorsisulcata* in its longer median septum extending near anterior margin of ventral valve.

Occurrence.—KY1 Unit in Imo (locality KF217).

Distribution.—Sakmarian–Wordian: northeastern Japan (Kamiyasse–Imo in the South KItakami Belt) and USA (Texas).

Acosarina rectimarginata Cooper and Grant, 1976b
(Fig. 60A, B)

Acosarina rectimarginata Cooper and Grant, 1976b, p. 2624, pl. 674, figs. 1–46; Shen et al., 2011, p. 564, fig. 6.1–6.18; Tazawa in Tazawa et al., 2012, p. 63, fig. 4.9; Tazawa and Oyagi, 2019, p. 34, fig. 3E, F.

Material.—Four specimens from localities KF7 and KF217: (1) external and internal moulds of a conjoined shell, NU-B2467; (2) internal mould of a conjoined shell, NU-B2468; and (3) internal moulds of two ventral valves, NU-B2469, 2571.

Description.—Shell small in size for genus, transversely subquadrate in outline, with greatest width at about midlength, dorsibiconvex and reticulate anterior commissure; length 9 mm, width 11 mm in the largest specimen (NU-B2571); length 7 mm, width 10 mm in the best-preserved specimen (NU-B2467). Ventral valve gently convex, flattened anteriorly. Dorsal valve moderately and unevenly convex in lateral profile, most convex at posterior one-third of valve; no sulcus. External surface of both valves ornamented with numerous fine costellae, numbering 4 in 1 mm at anterior margin of dorsal valve and one or two irregular rugae near anterior margin. Ventral valve interior with a pair of short dental plates slightly diverging anteriorly and a long median septum extending at about three-quarters valve length. Interior of dorsal valve with two strongly divergent brachiophore plates and a large muscle scar.

Remarks.—These specimens are referred to *Acosarina rectimarginata* Cooper and Grant (1976b, p. 2624, pl. 674, figs. 1–46), from the Neal Ranch Formation of the Glass Mountains, Texas, in size and outline of shell, particularly in having reticulate anterior commissure. *Acosarina kanmerai* Yanagida and Nakornsri (1999, p. 111, pl. 26, figs. 1–7), from the Middle–lower Upper Permian of Khao Hin Kling, north-central Thailand, resembles *A rectimarginata* in its small size and transversely subquadrate outline, but differs from the latter in having slightly sulcate anterior commissure. *Acosarina dunbari* Cooper and Grant (1976b, p. 2622, pl. 67, figs. 1–8), from the lower Wolfcampian of Nebraska in the USA, is also having reticulate to faintly sulcate anterior commissure, but differs from *A. rectimarginata* in its rounder outline and in having coarser costellae and numerous concentric rugae on both valves.

Occurrence.—KY1 Unit in Kamiyasse (locality KF7) and Imo (locality KF217).

Distribution.—Asselian–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Japan (Hatahoko, Kuzu and Ryozensan in the Mino Belt) and USA (Texas).

Genus *ORTHOTICHIA* Hall and Clarke, 1892

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

Orthotichia sp.
(Fig. 60E, F)

Material.—Two specimens from localities KF6 and KF121, internal moulds of two ventral valves, NU-B2497, UHR12624.

Remarks.—These specimens can be assigned to the genus *Orthotichia* by medium-sized, slightly convex and transversely subelliptical shell (length 29 mm, width 35 mm

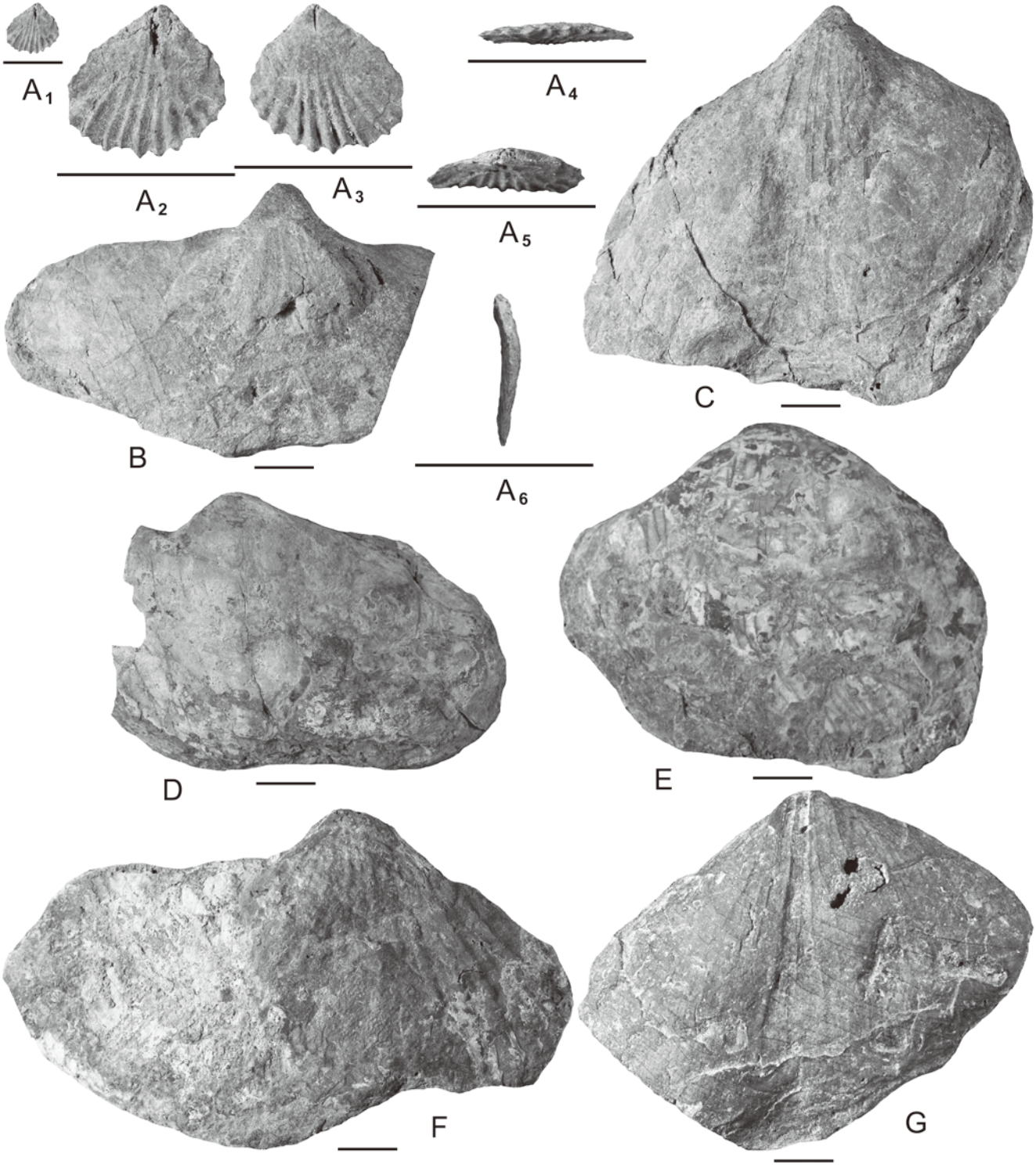

FIGURE 64. **A**, *Rhynchopora tchernyshae* Koczyrkevicz, ventral (A_1, A_2), dorsal (A_3), anterior (A_4), posterior (A_5) and lateral (A_6) views of internal mould of conjoined shell, NU-B2588: **B**–**G**, *Permocryptospirifer omeishanensis* (Huang); B, internal mould of ventral valve, NU-B2514; C, internal mould of ventral valve, NU-B2513; D, ventral valve, NU-B2014; E, ventral valve, NU-B2013; F, abraded ventral valve, NU-B2015; G, internal mould of dorsal valve, NU-B2515. Scale bars are 1 cm.

in the larger specimen, NU-B2497), and in having a pair of strong subparallel dental plates and a long median septum in ventral valve. But the specific identification is difficult for the ill-preserved specimens.

Occurrence.—KY1 Unit in Kamiyasse (locality KF6) and Imo (locality KF121).

Order RHYNCHONELLIDA Kuhn, 1949
Superfamily STENOSCISMATOIDEA Oehlert, 1887
Family STENOSCISMATIDAE Oehlert, 1887
Subfamily STENOSCISMATINAE Oehlert, 1887
Genus *STENOSCISMA* Conrad, 1839

Type species.—*Terebratula schlottheimii* von Buch, 1834.

Stenoscisma margaritovi (Tschernyschew, 1888)
(Figs. 61A–D, 62A–D)

Camarophoria margaritovi Tschernyschew, 1888, p. 355, pl. 1, figs. 1–3; Fredericks, 1924b, p. 48, pl. 1, figs. 32–42, text-fig. 4.
Camarophoria humbletonensis Howse. Hayasaka, 1922a, p. 62, pl. 9, figs. 10–12; pl. 10, fig. 9; Hayasaka, 1966, p. 1226, text-figs. 6−8.
Stenoscisma humbletonensis (Howse). Tazawa, 1976, pl. 2, figs. 9, 10; Minato et al., 1979, pl. 66, figs. 6–8.
Stenoscisma gigantea (Diener). Lee and Gu, 1976, p. 272, pl. 176, fig. 3; pl. 177, fig. 18; Lee et al., 1980, p. 395, pl. 173, figs. 6, 8.
Stenoscisma margaritovi (Tschernyschew). Licharew and Kotlyar, 1978, pl. 17, fig. 7; Koczyrkevicz, 1979b, p. 50, pl. 11, figs. 5, 6; Duan and Li, 1985, p. 120, pl. 43, figs. 5–8; Tazawa and Matsumoto, 1998, p. 9, pl. 2, figs. 1–5; Tazawa et al., 2000, p. 10, pl. 1, figs. 7−11; Tazawa, 2001, p. 298, fig. 8.1–8.4; Tazawa, 2002, fig. 10.5; Wang and Zhang, 2003, p. 130, pl. 33, figs. 6, 7, 12–16; pl. 50, fig. 19; Tazawa and Chen, 2006, p. 333, fig. 5.7, 5.8; Tazawa and Araki, 2018, p. 19, fig. 6.3.
Stenoscisma purdoni (non Davidson). Lee et al., 1980, p. 395, pl. 173, figs. 4, 5, 7.

Material.—Thirteen specimens from localities AR4, KF46, KF86, KF89, KF94, KF217 and KF218: (1) external and internal moulds of two conjoined shells, NU-B2554, 2555; (2) internal moulds of four conjoined shells, KCG56, NU-B2445, 2446, 2556; (3) external and internal moulds of a ventral valve, NU-B2547; (4) external casts of two ventral valves, NU-B2548, 2549; (5) external mould of a ventral valve, NU-B2550; (6) internal mould of a ventral valve, NU-B2551; and (7) internal moulds of two dorsal valves, NU-B2552, 2553.

Remarks.—Part of the specimens from Kamiyasse, Imo and Matsukawa were previously described by Hayasaka (1922a, p. 62, pl. 9, figs. 10−12; pl. 10, fig. 9) as *Camarophoria humbletonensis* (Howse, 1848) and figured by Tazawa (1976, pl. 2, figs. 9, 10) and Minato et al. (1979, pl. 66, figs. 6−8) as *Stenoscisma humbletonensis* (Howse, 1848). However, the Kitakami specimens are referred to *Stenoscisma margaritovi* (Tschernyschew, 1888), originally described by Tschernyschew (1888, p. 355, pl. 1, figs. 1–3) as *Camarophoria margaritovi* Tschernyschew, 1888, from the Middle Permian of Vladivostok, eastern Russia, in having large elongate shell (length about 34 mm, width about 28 mm in the largest specimen, NU-B2551) with shallow ventral sulcus and ornamented with numerous costae over the valve. *Stenoscisma humbletonensis* (Howse, 1848) differs from *S. margaritovi* in its transverse outline and in having a deeper sulcus on ventral valve. *Stenoscisma gigantea* (Diener, 1897a, p. 72, pl. 12, figs. 5, 7, 10), from the Capitanian–Wuchiapingian of the Chitichun No. 1, Himalaya, is also large in size, but differs from *S. margaritovii* in its transverse outline.

Occurrence.—KY1 Unit in Kamiyasse (localities KF46, KF86, KF89 and KF94), Imo (localities KF217 and KF218) and Matsukawa (locality AR4).

Distribution.—Wordian–Wuchiapingian: northeastern Japan (Kamiyasse–Imo, Matsukawa, Ogatsu and Takakurayama in the South Kitakami Belt), central Japan (Moribu and Oguradani in the Hida Gaien Belt); northern China (Inner Mongolia), northeastern China (Heilongjiang and Jilin) and eastern Russia (South Primorye).

Stenoscisma mutabilis (Tschernyschew, 1902)
(Fig. 63A–D)

Camarophoria mutabilis Tschernyschew, 1902, p. 81, 491, pl. 22, fig. 18; pl. 23, fig. 10; pl. 45, figs. 1–15; pl. 46, fig. 14, text-fig. 18; Grabau, 1931, p. 211, pl. 4, fig.7; pl. 5, figs. 1, 2; Grabau, 1934, p. 16, pl. 2, figs. 1, 2; Stepanov, 1937 b, p. 5, pl. 6, figs. 9, 10, text-fig. 1.
Stenoscisma mutabilis (Tschernyschew). Zhao, 1965, p. 429, pl. 2, fig. 9; Mironova, 1967, p. 38, pl. 3, fig. 6; Kalashnikov, 1980, p. 71, pl. 20, figs. 9 –11; Lee and Gu, 1980, p. 486, pl. 1, fig. 5 only: Kalashnikov, 1986, pl. 112, fig. 9; Gu, 1992, p. 243, pl. 74, figs. 11, 12; He et al., 1995, pl. 70, figs. 8–11; Shi and Waterhouse, 1996, p. 114, pl. 21, figs. 4–14; Shen and Shi, 2007, p. 59, pl. 23, figs. 25–35; pl. 24, figs. 1–31, text-fig. 20.

Material.—Eight specimens from localities KF8, KF33, KF121, KF217 and KF218: (1) external and internal moulds of a conjoined shell, NU-B2573; (2) internal moulds of three conjoined shells, with external moulds of the ventral valves, NU-B2557, 2558, 2574; (3) internal moulds of two conjoined shells, NU-B2559, 2560; and (4) external and internal moulds of two ventral valves, NU-B2561, 2562.

Remarks.—The present specimens from Kamiyasse–Imo are small-sized and transverse-shaped *Stenoscisma* (length about 16 mm, width about 22 mm in the largest specimen, NU-B2560), with relatively small spondylium in ventral

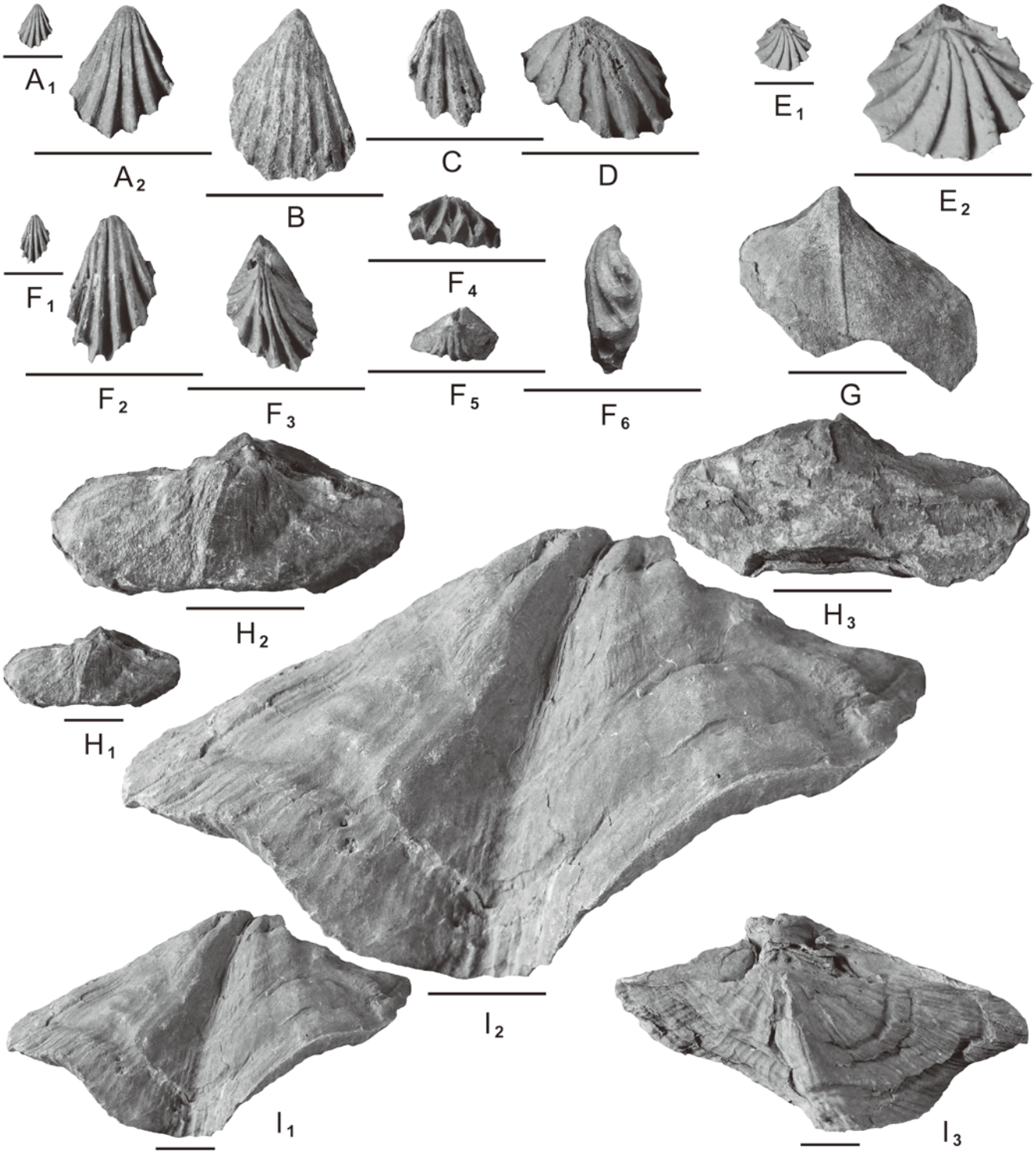

FIGURE 65. **A**–**D**, *Hustedia remota* (von Eichwald); A, internal mould (A_1, A_2) of ventral valve, NU-B2016; B, internal mould of ventral valve, NU-B2017; C, internal mould of ventral valve, NU-B2018; D, internal mould of dorsal valve, NU-B2019; **E**, **F**, *Hustedia ratburiensis* Waterhouse and Piyasin; E, external latex cast (E_1, E_2) of ventral valve, NU-B2512; F, ventral (F_1, F_2), dorsal (F_3), anterior (F_4), posterior (F_5) and lateral (F_6) views of internal mould of conjoined shell, NU-B2511; **G**, **H**, *Martinia semiplana* Waagen; G, internal mould of ventral valve, NU-B2585; H, ventral (H_1, H_2) and dorsal (H_3) views of internal mould of conjoined shell, NU-B2583; **I**, *Neospirifer moosakhailensis* (Davidson), ventral (I_1, I_2) and dorsal (I_3) views of internal mould of conjoined shell, KCG3. Scale bars are 1 cm.

valve and small camarophorium in dorsal valve, and external ornament consisting of simple costae on both valves (4–5 in sulcus and 5 in each flank of the ventral valve). These specimens can be referred to *Stenoscisma mutabilis* (Tschernyschew, 1902), from the *Schwagerina* Horizon of the Urals and Timan, in being medium size and transverse outline, and in having moderately developed ventral sulcus and dorsal fold. *Stenoscisma purdoni* (Davidson, 1861), redescribed by Waagen (1883, p., p. 90, pl. 2, fig. 4) from the Wargal Formation of the Salt Range, Pakistan, differs from *S. mutabilis* in its less transverse and nearly triangular outline. The preceding species, *Stenoscisma margaritovi* (Tschernyschew, 1888), is readily distinguished from *S. mutabilis* by its much larger size and longer outline.

Occurrence.—KY1 Unit in Kamiyasse (localities KF8 and KF33) and Imo (localities KF121, KF217 and KF218).

Distribution.—Kasimovian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), northern Canada (northern Yukon Territory), northern Russia (Timan, Vaygach Island and northern Urals), central Russia (southern Urals), northern China (Inner Mongolia and Shanxi), northeastern China (Jilin), central-southern China (Hunan) and southwestern China (Guizhou and Sichan).

Stenoscisma sokolskajae Koczyrkevicz, 1979b
(Fig. 63E, F)

Stenoscisma tenuistriata (Hamlet). Licharew and Kotlyar, 1978, pl. 21, figs. 11, 12.
Stenoscisma sokolskajae Koczyrkevicz, 1979b, p. 53, pl. 12, figs. 7–9.

Material.—Three specimens from locality KF217: (1) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B2563; and (2) internal moulds of two conjoined shells, NU-B2564, 2565.

Remarks.—These specimens can be referred to *Stenoscisma sokolskajae* Koczyrkevicz (1979b, p. 53, pl. 12, figs. 7–9), from the middle part of the Chandalaz Formation (*Parafusulina stricta* Zone) of South Primorye, eastern Russia, in being small size and longer outline (length about 20 mm, width about 15 mm in the largest specimen, NU-B2563), and in having external ornament consisting of simple costae numbering 4–5 in sulcus and 4 in each flank of the ventral valve. *Stenoscisma tenuistriata* Hamlet (1928, p. 61, pl. 10, figs. 1, 2), from the Wordian–Wuchiapingian of Timor, differs from *S. sokolskajae* in its smaller size and less elongate outline and in having more numerous fine costae on both valves. The preceding species *Stenoscisma mutabilis* (Tschernyschew, 1902) is readily distinguished from the present species in its larger size and transverse outline.

Occurrence.—KY1 Unit in Imo (locality KF217).

Distribution.—Wordian–Capitanian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and eastern Russia (South Primorye).

Superfamily RHYNCHOPOROIDEA Muir-Wood, 1955
Family RHYNCHOPORIDAE Muir-Wood, 1955
Subfamily RHYNCHOPORINAE Muir-Wood, 1955
Genus *RHYNCHOPORA* King, 1865

Type species.—*Terebratula geinitziana* de Verneuil, 1845.

Rhynchopora tchernyshae Koczyrkevicz, 1979a
(Fig. 64A)

Rhynchopora tchernyshae Koczyrkevicz, 1979a, p. 47, pl. 11, figs. 1–4, text-fig. 4; Tazawa et al., 2000, p. 10, pl. 1, fig. 6.

Material.—One specimen from locality KF217, internal mould of a conjoined shell, NU-B2588.

Description.—Shell small in size for genus, bluntly subpentagonal in outline, with greatest width at about midlength; length 9 mm, width 9 mm in the sole specimen. Ventral valve slightly concave, nearly flat in lateral profile; umbo small; sulcus shallow and broad. Dorsal valve gently convex in lateral profile, with low and broad fold. External surface of both valves ornamented with numerous simple costae; 4 in ventral sulcus, 4–5 on each lateral flank of ventral valve; 5 on dorsal fold, 5 on each flank of dorsal valve. Internally, ventral valve with rather long dental plates although they are not well preserved; dorsal valve with a short but high and sharp median septum extending to about one sixth of valve length.

Remarks.—This specimen can be referred to *Rhynchopora tchernyshae* Koczyrkevicz (1979a, p. 47, pl. 11, figs. 1–4, text-fig. 4), from the lower Barabash Formation (*Monodiexodina sutschanica* Zone) of Barabash, South Primorye, eastern Russia, by its size, outline and number of costae on both valves, particularly in its nearly flattened shell. *Rhynchopora tenuicostata* Koczyrkevicz (1979a, p. 42, pl. 10, figs. 1–9, text-fig. 1) from the Chandalaz and Balabash Formations of South Primorye, is also a flattened (weakly biconvex) shell species, but differs from *R. tchernyshae* in having more numerous finer costae on both valves.

Occurrence.—KY1 Unit in Imo (locality KF217).

Distribution.—Wordian–Capitanian: northeastern Japan (Kamiyasse–Imo and Ogatsu in the South Kitakami Belt) and eastern Russia (South Primorye).

Order ATHYRIDIDA Boucot, Johnson and Staton, 1964
Suborder ATHYRIDIDINA Boucot, Johnson and Staton, 1964
Superfamily ATHYRYDOIDEA Davidson, 1881
Family ATHYRIDIDAE Davidson, 1881
Subfamily LOCHENGINAE Ching (Jin) and Yang in Yang et al., 1977
Genus *PERMOCRYPTOSPIRIFER* Shen and Grunt in Shen et al., 2017

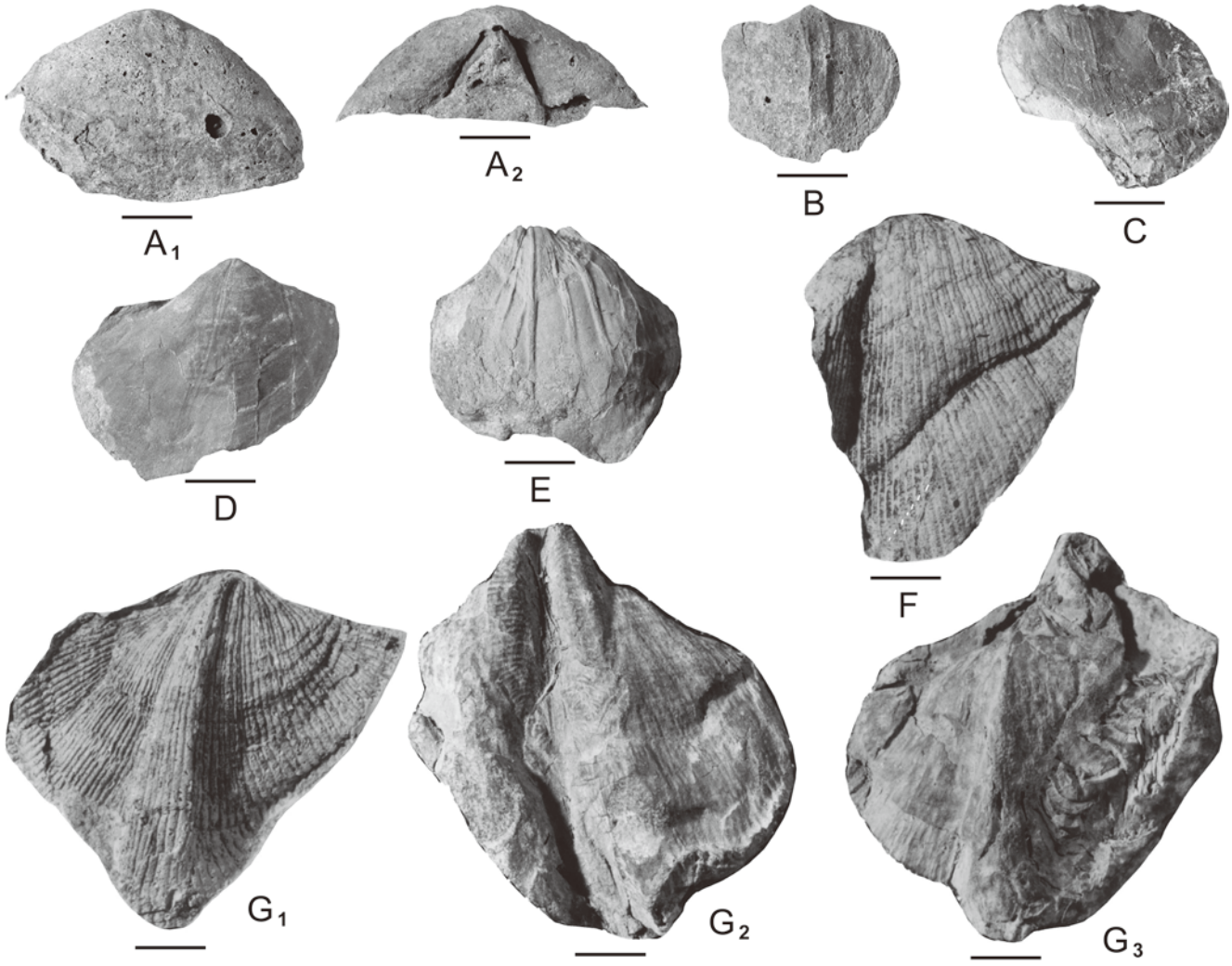

FIGURE 66. **A**–**E**, *Martinia triquetra* Gemmellaro; A, ventral (A_1) and posterior (A_2) views of internal mould of ventral valve, NU-B2577; B, internal mould of dorsal valve, NU-B2578; C, internal mould of dorsal valve, NU-B2579: D, internal mould of ventral valve, NU-B2575; E, internal mould of ventral valve, NU-B2012; **F**, **G**, *Gypospirifer kobiyamai* Tazawa and Araki; F, external latex cast of ventral valve, KCG2; G, dorsal external latex cast (G_1) and ventral (G_2) and dorsal (G_3) views of internal mould of conjoined shell, KCG1 (holotype). Scale bars are 1 cm.

Type species.—*Cryptospirifer omeishanensis* Huang, 1933.

Permocryptospirifer omeishanensis (Huang, 1933)
(Fig. 64B–G)

Cryptospirifer omeishanensis Huang, 1933, p. 44, pl. 6, fig. 4; pl. 8, fig. 1; Wang et al., 1964, p. 512, pl. 95, figs. 4, 7; Jin et al., 1974, p. 310, pl. 163, fig. 17; Yang et al., 1977, p. 413, pl. 163, fig. 5; Tong, 1978, p. 253, pl. 89, fig. 1; Wang, 1984, p. 220, pl. 88, fig. 12; Zeng, 1992, pl. 2, figs. 1–4; Shi and Shen, 2001, p. 250, pl. 3, figs. 1–7, text-figs. 4–6; Jin and Zhan, 2008, p. 9, figs. 8, 9E; Tazawa, 2016b, p. 32, fig. 11.2–11.4.

Cryptospirifer sp. Minato et al., 1979, pl. 67, fig. 9.

Cryptospirifer sp. Hu, 1983, pl. 1, figs. 1–3.

Cryptospirifer minor Yang, 1984, p. 233, pl. 38, fig. 1.

"*Cryptospirifer*" *omeishanensis* Huang. Shen et al., 2016, p. 531, fig. 7A, B.

Permocryptospirifer omeishanensis (Huang). Shen and Grunt in Shen et al., 2017, p. 766, pl. 27, figs. 2–5, text-figs. 29, 30.

Material.—Seven specimens from localities KF217 and KF218: (1) an abraded conjoined shell, NU-B2518; (2) three abraded ventral valves, NU-B2013–2015; (3) internal moulds of two ventral valves, NU-B2513, 2514; and (4) internal mould of a dorsal valve, NU-B2515.

Remarks.—Some of the specimens from Imo in the Kamiyasse–Imo area (NU-B2013–2015) were previously described by Tazawa (2016b, p. 32, fig. 11.2–11.4) as *Cryptospirifer omeishanensis* Huang, 1933. These specimens are represented by imperfect abraded ventral valves, but they can be referred to *Cryptospirifer omeishanensis* Huang, 1933, from the Maokou Formation of Omeishan, Sichuan Province, southwestern China, on account of large size (length about 66 mm, width more than 100 mm in the largest specimen, NU-B2015), transversely elliptical outline, and gently convex, smooth ventral valves. Newly added specimens from Imo (NU-B2013–2015), represented by internal moulds of ventral or dorsal valves, are also referred to *Cryptospirifer omeishanensis* in large, transversely elliptical shell (length about 63 mm, width about 73 mm in the largest specimen, NU-B2513) and in having long and parallel crural bases in dorsal valve. The generic name *Cryptospirifer* was recently replaced by Shen et al. (2017, p. 766) with *Permocryptospirifer* Shen and Grunt in Shen et al., 2017.

Occurrence.—KY1 Unit in Imo (localities KF217 and KF218).

Distribution.—Roadian–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), eastern China (Jiangxi), central-southern China (Hubei), southwestern China (Sichuan and Yunnan) and northwestern China (Tibet).

Suborder RETZIIDINA Boucot, Johnson and Staton, 1964
Superfamily RETZIOIDEA Waagen, 1883
Family NEORETZIIDAE Dagys, 1972
Subfamily HUSTEDIINAE Grunt, 1986
Genus *HUSTEDIA* Hall and Clarke, 1893

Type species.—*Terebratula mormoni* Marcou, 1858.

Hustedia remota (von Eichwald, 1860)
(Fig. 65A–D)

Rhynchonella remota von Eichwald, 1860, p. 768, pl. 35, fig. 10.
Hustedia remota (Eichwald). Tschernyschew, 1902, p. 107, pl. 47, figs. 8–11; Huang, 1933, p. 79, pl. 11, figs. 4, 5; Licharew, 1939, p. 111, pl. 28, fig.6; Campi et al., 2002, fig. 7A–C; Shen et al., 2003a, p. 250, pl. 5, figs. 22, 23; Shen and Zhang, 2008, fig. 6.16–6.21; He et al., 2008, p. 819, fig. 5.15–5.18.
Retzia (*Hustedia*) *radialis* var. *grandicosta* Davidson. Broili, 1916, p. 11, pl. 124, figs. 14–22; pl. 125, figs. 1–3.

Material.—Four specimens from localities KF22 and KF218: (1) internal moulds of three ventral valves, NU-B2016–2018; and (2) internal mould of a dorsal valve, NU-B2019.

Remarks.—These specimens can be referred to *Hustedia remota* (von Eichwald, 1860), redescribed by Tschernyschew (1902, p. 107, pl. 47, figs. 8–11) from the *Schwagerina* Limestone of Ufa, southern Urals, central Russia, in having relatively few strong costae (eight in ventral valve, nine in dorsal valve), with wide and flat-bottomed intercostal troughs. Huang (1933, p. 79) treated *Retzia radialis* var, *grandicosta* Davidson, 1862 [=*Hustedia grandicosta* (Davidson, 1862)], from the Salt Range, Pakistan, as a synonym of *Hustedia remota* (von Eichwald). The Pakistani species is, however, distinguished from *H. remota* in having more numerous costae on both ventral and dorsal valves, and the intercostal troughs are narrower and having round bottom. The type species, *Hustedia mormoni* (Marcou, 1858), refigured by Alvarez and Rong (2002, fig. 1087.1), from the Pennsylvanian of Nebraska in the USA, differs from *H. remota* in having more numerous costae on both valves.

Occurrence.—KY1 Unit in Kamiyasse (locality KF22) and Imo (locality KF218).

Distribution.—Asselian–Changhsingan: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Russia (southern Urals), northwestern China (Qinghai), central-southern China (Hunan), southwestern China (Guizhou), Malaysia, Indonesia (Timor) and northwestern China (Tibet),

Hustedia ratburiensis Waterhouse and Piyasin, 1970
(Fig. 65E, F)

Hustedia ratburiensis Waterhouse and Piyasin, 1970, p. 138, pl. 23, figs. 15–30; Grant, 1976, p. 241, pl. 66, figs. 1–69; pl. 67, figs. 51–58; Sun, 1991, p. 254, pl. 6, figs. 5–8; Yanagida and Nakornsri, 1999, p. 118, pl. 32, figs. 11–16; Archbold, 1999, fig. 5E–H; Tazawa, 2001, p. 299, fig. 8.6; Tazawa, 2008b, p. 53, fig. 8.2–8.6; Tazawa in Tazawa et al., 2015, p. 44, fig. 6.7; Tazawa and Nakamura, 2015, p. 169, fig. 7.1–7.7; Tazawa and Shintani, 2021, p. 13, fig. 5C, D.
Hustedia nakornsrii Yanagida, 1970, p. 79, pl. 14, fig. 9.
Hustedia indica (non Waagen). Koizumi, 1979, pl. 1, fig. 5.

Material.—Two specimens from locality KF218: (1) internal mould of a conjoined shell, NU-B2511; and (2) external mould of a dorsal valve, NU-B2512.

Remarks.—These specimens can be referred to *Hustedia ratburiensis* Waterhouse and Piyasin (1970), originally described from the Middle Permian (Kazanian) limestones of Khao Phrik, southern Thailand, in being small to medium size (length about 8 mm, width about 5 mm in the smaller specimen, NU-B2511; length 9 mm, width 10 mm in the larger specimen, NU-B2512) and in having rotund dorsal valve, and surface ornament of both ventral and dorsal valves consisting of subangular costae (8 in ventral valve, and 9 in

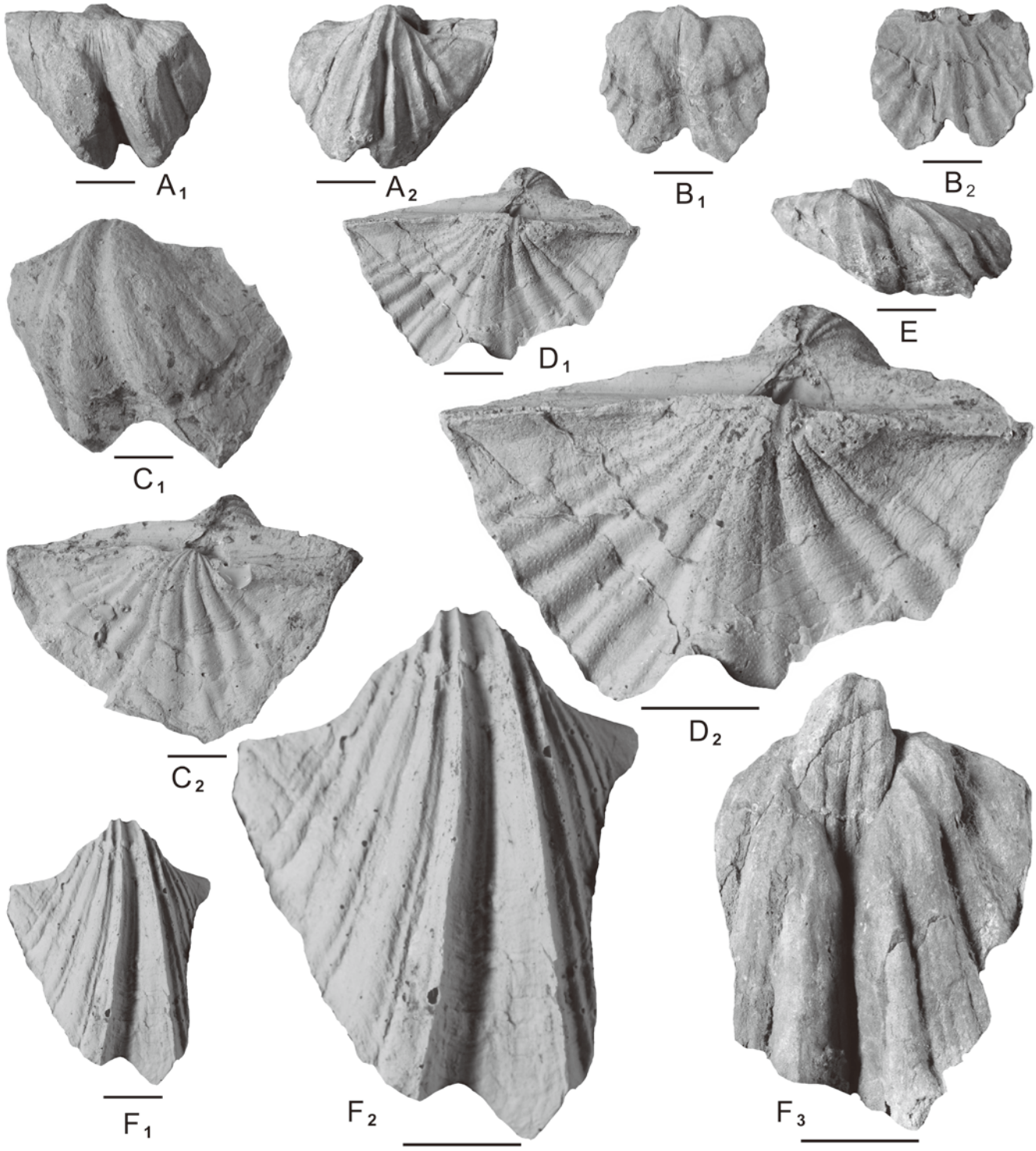

FIGURE 67. **A–F**, *Alispiriferella lita* (Fredericks); A, ventral (A_1) and dorsal (A_2) views of internal mould of conjoined shell, KCG20; B, ventral (B_1) and dorsal (B_2) views of internal mould of conjoined shell, KCG21; C, ventral (C_1) and dorsal (C_2) views of external latex cast of conjoined shell, IGPS96219; D, external latex cast (D_1, D_2) of dorsal valve, IGPS96220; E, internal mould of ventral valve, NU-B326; F, external latex cast (F_1, F_2) and internal mould (F_3) of ventral valve, NU-B315. Scale bars are 1 cm.

dorsal valve), of which the middle one of the dorsal valve is slightly depressed. *Hustedia ratburiensis* is clearly distinguished from the preceding species, *Hustedia remota* (von Eichwald, 1860), by its rotund outline and subangular costae with narrow intercostal troughs.

Occurrence.—KY1 Unit in Imo (locality KF218).

Distribution.—Artinskian–Wuchiapingian: northeastern Japan (Nagaiwa–Sakamotozawa, Kamiyasse–Imo and Takakurayama in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), southwestern Japan (Mizukoshi in Kyushu Island), north-central Thailand (Khao Nong Ta On and Khao Hin King), southern Thailand (Khao Phrik, Khao Tok Nam and Ko Muk) and northwestern China (Tibet).

Order SPIRIFERIDA Waagen, 1883
Suborder SPIRIFERIDINA Waagen, 1883
Superfamily MARTINIOIDEA Waagen, 1883
Family MARTINIIDAE Waagen, 1883
Subfamily MARTINIINAE Waagen, 1883
Genus *MARTINIA* M'Coy, 1844

Type species.—*Spirifer glaber* Sowerby, 1820.

Martinia semiplana Waagen, 1883
(Fig. 65G, H)

Martinia semiplana Waagen, 1883, p. 536, pl. 43, fig. 4; Hayasaka, 1922c, p. 130, pl. 6, fig. 18; Grabau, 1936, p. 237, pl. 24, figs. 1–4; Hayasaka and Minato, 1956, p. 146, pl. 23, fig. 2; Zhang and Ching (Jin), 1961, p. 406, pl. 2, figs. 16–19; He and Fan, 1990, pl. figs. 19–23; Zeng, 1990, p. 228, pl. 7, figs. 6, 7; pl. 8, fig. 11; Shen and Zhang, 2008, fig. 6.6, 6.7; Tazawa, 2008a, p. 37, fig. 5.3, 5.4;
Martinia semiplana var. *lata* Grabau, 1936, p. 239, pl. 21, figs. 1–3; Hayasaka and Minato, 1956, p. 146, pl. 23, fig. 3.
Martinia lata Grabau. Tazawa, 2008a, p. 38, fig. 5.7–5.14; Tazawa and Shintani, 2021, p. 14, fig. 5E–G.

Material.—Four specimens from locality KF212: (1) internal mould of a conjoined shell, with external mould of the ventral valve, NU-B2583; and (2) internal moulds of three ventral valves, NU-B2584–2586.

Remarks.—These specimens can be referred to *Martinia semiplana* Waagen, 1883, originally described by Waagen (1883, p. 536, pl. 43, fig. 4) from the Middle Productus Limestone (Wargal Formation) of the Salt Range, Pakistan, by medium-sized (length about 20 mm, width about 25 mm in the largest specimen, NU-B2585), transversely subeliptical and gently biconvex shell with radial vascular scars on ventral valve. The shells, described by Tschernyschew (1902, p. 182, 565, pl. 60, figs. 15–17) as *Martinia semiplana* Waagen, 1883 from the *Schwagerina* Limestone of the Urals, are deemed to be a different species in its less-transverse outline and much stronger convex ventral valve. *Martinia nealranchensis* Cooper and Grant (1976a, p. 2270, pl. 649, figs. 1–14), from the Neal Ranch Formation of Texas, resembles *M. semiplana*, but differs in its subpentagonal outline and in having shorter hinge.

Occurrence.—Upper part of the Hosoo Formation in Kamiyasse (locality KF212).

Distribution.—Kasimovian–Wuchiapingian: northeastern Japan (Nagaiwa–Sakamotozawa, Kamiyasse–Imo and Takakurayama in the South Kitakami Belt), northern China (Inner Mongolia and Shanxi), northeastern China (Liaoning), eastern China (Anhui), central-southern China (Hunan and Guangxi), southwestern China (Guizhou) and Pakistan (Salt Range).

Martinia triquetra Gemmellaro, 1899
(Fig. 66A–E)

Martinia triquetra Gemmellaro, 1899, p. 17, pl. 32, figs. 23–28; Tschernyschew, 1902, p. 178, 562, pl. 16, figs. 1–6; Heritsche, 1935, p. 363, pl. 1, figs. 1, 10; Grunt, 1973, p. 147, pl. 12, figs. 3, 4; pl. 16, fig. 2, text-fig. 48; Zhang et al., 1983, p. 371, pl. 143, fig. 1; Zhan and Wu, 1987, p. 228, pl. 62, figs. 1–7; Wang, 1995, pl. 4, fig. 9; Wang and Yang, 1998, p. 130, pl. 22, figs. 16–19, 23.
Martinia spp. (*Martinia* sp. A, *Martinia* sp. B and *Martinia* sp. C) Hayasaka, 1960, p. 52, pl. 3, figs. 2–4.
Martinia cf. *triquetra* Gemmellaro. Yang et al., 1962, p. 114, pl. 43, fig. 4.
Martinia sp. Minato et al., 1979, pl. 67, fig. 8.
Martinia sp. Tazawa and Araki, 2017, p. 279, fig. 8.7.

Material.—Nine specimens from localities AR4, KF121 and KF218: (1) internal moulds of four ventral valves, NU-B2012, 2575–2577; and (2) internal moulds of five dorsal valves, NU-B2578–2582.

Remarks.—One of the specimens (NU-B2012) from the lower Kamiyasse Formation of Kamiyasse–Imo and Matsukawa was previously described by Tazawa and Araki (2017, p. 279, fig. 8.7) as *Martinia* sp. However, these specimens can be referred to *Martinia triquetra* Gemmellaro, 1899, redescribed by Tschernyschew (1902, p. 178, 562, pl. 16, figs. 1–6) from the *Schwagerina* Limestone of the Urals, in being large size (length about 30 mm, width about 46 mm in the largest specimen, NU-B2577), rounded subrectangular outline and in having shallow ventral sulcus. *Martinia uralica* Tschernyschew (1902, p. 183, 566, pl. 18, figs. 1–4) from the *Schwagerina* Limestone of the Urals and Timan, is also large-sized *Martinia* species, but differs from *M. triquetra* in its longer outline. *Martinia karawanica* Volgin (1959, p. 121, pl. 6, figs. 8–10), from the Upper Carboniferous of Fergana, differs from *M. triquetra* in having a conspicuous but very narrow ventral sulcus. *Martinia miranda* Cooper and Grant (1976a, p. 2268, pl. 643, figs. 1–39), from the Cathedral Mountains Formation of Texas, is distinguished from the present species in its longer

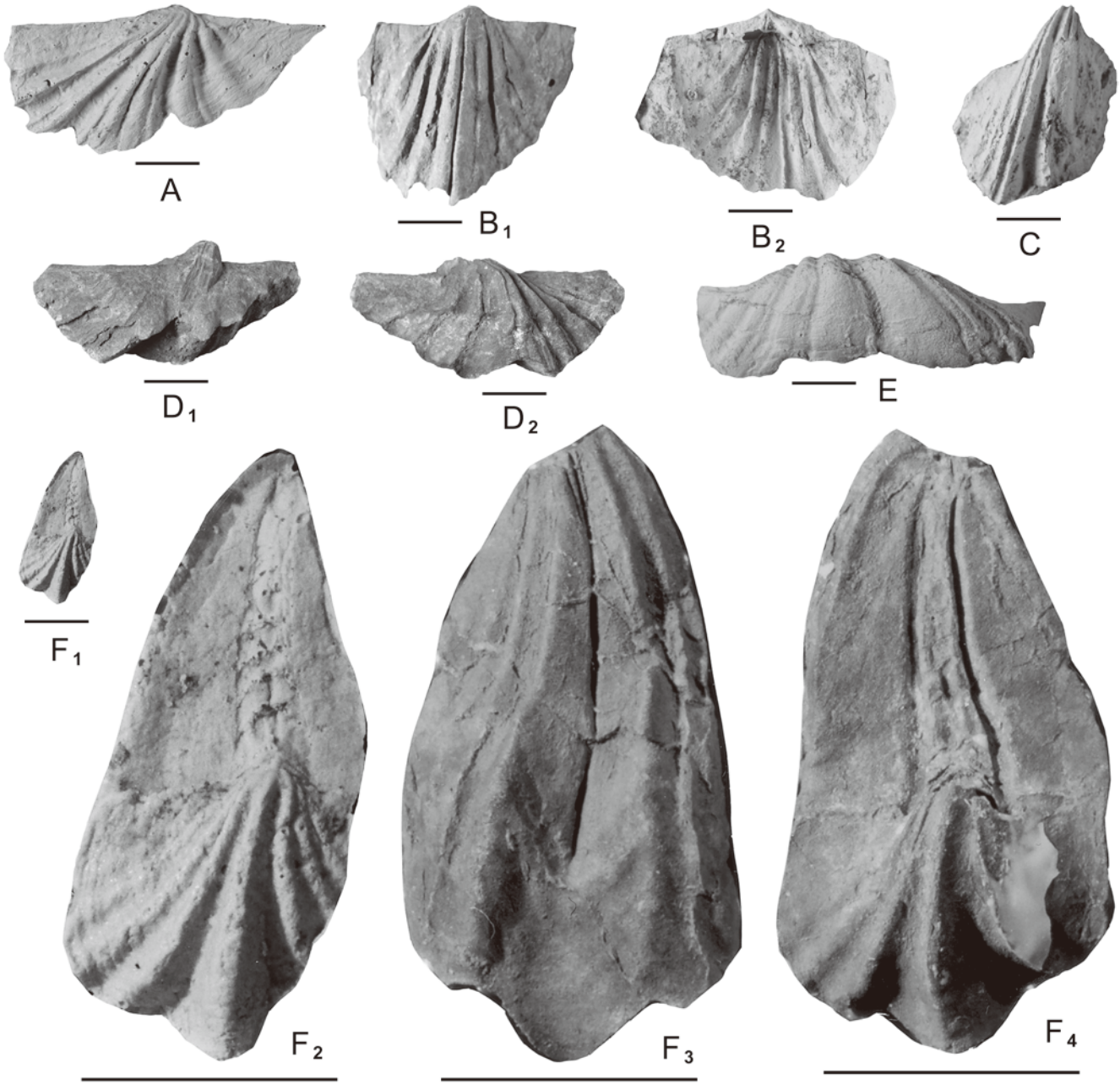

FIGURE 68. **A–E**, *Alispiriferella lita* (Fredericks); A, external latex cast of dorsal valve, NU-B321; B, internal mould (B_1) and internal latex cast (B_2) of dorsal valve, NU-B332; C, external latex cast of ventral valve, NU-B318; D, ventral (D_1) and dorsal (D_2) views of internal mould of conjoined shell, NU-B319; E, external latex cast of ventral valve, NU-B317; **F**, *Licharewina arakii* (Hayasaka), dorsal external latex cast (F_1, F_2) and ventral (F_3) and dorsal (F_4) views of internal mould of conjoined shell, KCG4. Scale bars are 1 cm.

pentagonal outline. The preceding species, *Martinia semiplana* Waagen, 1883, is readily distinguished from the present species by its much smaller size and transversely subelliptical outline.

Occurrence.—KY1 Unit in Imo (localities KF121 and KF218) and Matsukawa (locality AR4).

Distribution.—Kasimovian–Wordian: northeastern Japan (Kamiyasse–Imo and Matsukawa in the South Kitakami Belt), Austria (Carnian Alps), central Russia (southern Urals), northwestern China (Xinjiang and Qinghai), Italy (Sicily) and Tajikistan (Pamir).

Superfamily SPIRIFEROIDEA King, 1846
Family TRIGONOTRETIDAE Schuchert, 1893
Subfamily NEOSPIRIFERINAE Waterhouse, 1968a
Genus *NEOSPIRIFER* Fredericks 1924a

Type species.—*Spirifer fasciger* Keyserling, 1846.

Neospirifer moosakhailensis (Davidson, 1862)
(Fig. 65I)

Spirifer moosakhailensis Davidson, 1862, p. 28, pl. 2, fig. 2; Beyrich, 1865, p. 77, pl. 1, fig. 7; Grabau, 1931, p. 168, pl. 23, figs. 5–7 only; Noda, 1951, p. 46, pl. 1, figs. 1–4.
Spirifer musakheylensis Davidson. Waagen, 1883, p. 512, pl. 45, figs. 1–6; Diener, 1897b, p. 35, pl. 3, figs. 3, 4; pl. 4, figs. 1, 2; pl. 5, fig. 1; Diener, 1899, p. 63, pl. 5, figs. 3–7.
Spirifer fasciger Keyserling. Broili, 1916, p. 37, pl. 120, figs. 10–15; pl. 121, figs. 1–3.
Neospirifer fasciger ambiensis Waagen. Fredericks, 1925, p. 28, pl. 4, fig. 113.
Spirifer fasciger var. *musakheylensis* Davidson. Reed, 1925, p. 42, pl. 6, fig. 2.
Neospirifer moosakhailensis (Davidson). Muir-Wood and Oakley, 1941, p. 30, p. 2, figs. 12, 13; Lee and Gu, 1976, p. 286, pl. 177, fig. 13 only; Lee et al., 1980, p. 412, pl. 177, figs. 7, 10; Tazawa, 2014, p. 19, fig. 3.8.
Spirifer cf. *moosakhailensis* Davidson. Noda, 1956, p. 17, pl. 6, fig. 10 only.
Neospirifer fasciger (Keyserling). Hayasaka, 1960, p. 42, pl. 1, figs. 1–7 only; Koizumi, 1979, pl. 1, fig. 17 only.

Material.—One specimen from locality AR1, internal mould of a conjoined shell, KCG3.

Remarks.—This specimen was previously described by Tazawa (2014, p. 19, fig. 3.8) as *Neospirifer moosakhailensis* (Davidson, 1862). The Kamiyasse specimen is poorly preserved, but can be referred to *Neospirifer moosakhailensis* (Davidson, 1862, p. 28, pl. 2, fig. 2), from the middle and upper Permian of the Salt Range, Pakistan, in its large, transverse shell (length about 40 mm, width about 70 mm), with a deep ventral sulcus and a high dorsal fold and numerous fasciculate costae on both ventral and dorsal valves. Shells, described by Hayasaka (1960, p. 42) as *Neospirifer fasciger* (Keyserling, 1846) from the lower Kamiyasse Formation of Tagara and Takayashiki in the Kesennuma area, South Kitakami Belt, include two different species: *Neospirifer moosakhailensis* (Davidson, 1862), a transverse spiriferid having distinct fasciculate costae (Hayasaka, 1960, pl. 1, figs. 1–7) and *Gypospirifer kobiyamai* Tazawa and Araki, 2013, a broader and larger spiriferid with less fasciculate costae (Hayasaka, 1960, pl. 2, figs. 1, 2). *Neospirifer fasciger* (Keyserling, 1846, p. 231, pl. 8, fig. 3), from the lower Permian of Timan, northern Russia, is readily distinguished from *N. moosakhailensis* by its much smaller size.

Occurrence.—KY1 Unit in Kamiyasse (locality AR1).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), northern China (Inner Mongolia), northeastern China (Heilongjiang and Jilin), eastern Russia (South Primorye), Indonesia (Timor), Pakistan (Salt Range) and northern India (Sikkim, Garhwal, Spiti and Kashmir).

Genus *GYPOSPIRIFER* Cooper and Grant, 1976a

Type species.—*Gypospirifer nelsoni* Cooper and Grant, 1976a.

Gypospirifer kobiyamai Tazawa and Araki, 2013
(Fig. 66F, G)

Spirifer fasciger var. *simplex* Grabau. Kobiyama, 1956, fig. 4.
Neospirifer fasciger (Keyserling). Hayasaka, 1960, p. 42, pl. 2, figs. 1, 2 only; Yanagida, 1963, p. 71, pl. 8, figs. 3, 6; pl. 9, fig. 3 only; Koizumi, 1979, pl. 1, fig 16 only.
Neospirifer aff. *cameratus* Morton. Yanagisawa, 1967, p. 91, pl. 2, fig. 11.
Neospirifer striato-paradoxus (Toura). Licharew and Kotlyar, 1978, pl. 18, fig. 1; Lee et al., 1980, p. 412, pl. 177, figs. 3, 6, 9.
Gypospirifer kobiyamai Tazawa and Araki, 2013, p. 7, fig. 2.3, 2.4.

Material.—Two specimens from locality AR1: (1) internal mould of a conjoined shell, with external mould of the dorsal valve, KCG1; and (2) external mould of a ventral valve, KCG2.

Remarks.—These specimens were previously described by Tazawa and Araki (2013, p. 7, fig. 2.3, 2.4) as *Gypospirifer kobiyamai* Tazawa and Araki, 2013. This species is characterized by its large size (length 49 mm, width about 65 mm in the better-preserved specimen, KCG1) and in having a narrow deep ventral sulcus and a narrow high dorsal fold and numerous fine costae on the both valves (10–11 in 10 mm at midlength of ventral valve). *Gypospirifer kobiyamai* most resembles *Gypospirifer gryphus* Cooper and Grant 1976a, p. 2211, pl. 591, figs. 1–5), from the Graham Formation of Texas, in size and shape of shell, but the Texan

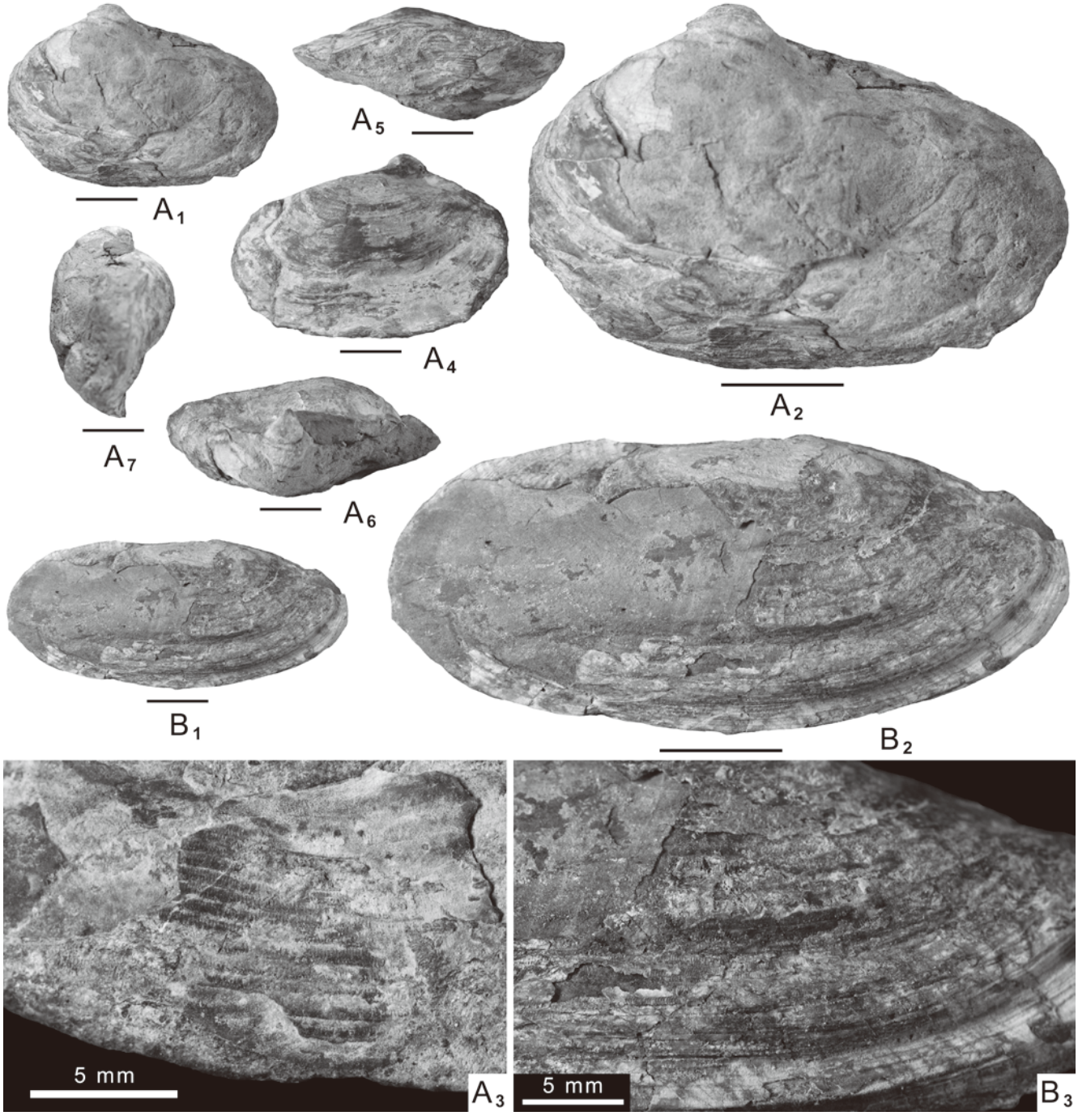

FIGURE 69. **A**, **B**, *Phricodothyris catatona* (Cooper and Grant); A, ventral (A_1), dorsal (A_4), anterior (A_5), posterior (A_6) and lateral (A_7) views of conjoined shell, and enlarged concentric lamellae and rows of very fine spinules on the ventral valve, NU-B2516; B, dorsal valve (B_1, B_2) and enlarged concentric lamellae and rows of very fine spinules on the dorsal valve, NU-B2517. Scale bars are 1 cm, except for A_3 and B_3.

species differs from the present species in having a shallower sulcus and coarser costae on ventral valve. *Gypospirifer volatilis* Duan and Li (1985, p. 127, 207, pl. 48, figs. 1, 2; pl. 49, figs. 1, 2) from the Zhesi (Jisu) Formation of Zhesi, Inner Mongolia, north China, differs from *G. kobiyamai* in having much broader and higher fold on dorsal valve.

Occurrence.—KY1 Unit in Kamiyasse (locality AR1).

Distribution.—Wordian–Wuchiapingian: northeastern Japan (Kamiyasse–Imo, Kesennuma and Takakurayama in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), southwestern Japan (Mizukoshi in Kyushu Island), northeastern China (Heilongjiang) and eastern Russia (South Primorye).

Family SPIRIFERELLIDAE Waterhouse, 1968a
Genus *ALISPIRIFERELLA* Waterhouse and Waddington, 1982

Type species.—*Spirifer* (*Spiriferella*) *keilhavii* var. *ordinaria* Einor in Licharew and Einor, 1939.

Alispiriferella lita (Fredericks, 1924b)
(Figs. 67A–F, 68A–E)

Spiriferella saranae mut. *lita* Fredericks, 1924b, p. 36, pl. 1, figs. 16–27; text-fig. 2.
Spirifer cf. *saranae* mut. *lita* Fredericks. Hayasaka, 1925a, p. 98, pl. 5, fig. 14.
Spiriferella cf. *saranae* mut. *lita* Fredericks. Nonaka, 1944, p. 86, pl. 7, figs. 12–14.
Spiriferella keilhavii (von Buch). Yanagida, 1963, p. 72, pl. 9, figs. 4–9; pl. 10, figs. 1–7; Minato et al., 1979, pl. 67, figs. 1–3: Tazawa and Gunji, 1982, p. 70, pl. 4, figs. 4–7; Tazawa, 1999a, p. 5, pl. 1, figs. 2–6; Tazawa and Ibaraki, 2001, p. 16, pl. 4, figs. 1–10; Tazawa, 2002, fig. 10.4; Tazawa and Chen, 2006, p. 335, fig. 6.1, 6.2, 6.8.
Alispirifer aff. *laminosus transversa* Maxwell. Yanagisawa, 1967, p. 90, pl. 2, fig. 3.
Cancellospirifer? *maxwelli* Campbell. Yanagisawa, 1967, p. 92, pl. 3, fig. 16.
Timaniella harkeri Waterhouse. Licharew and Kotlyar, 1978, pl. 18, figs. 2, 3.
Spiriferella grandis Kotlyar in Licharew and Kotlyar, 1978, p. 73, pl. 18, figs. 7, 8.
Spiriferella lita (Fredericks). Tazawa, 1979, p. 28, pl. 4, figs. 12, 13; pl. 5, figs. 1–4, 6; Tazawa, 2001, p. 302, fig. 8.19–8.22; Tazawa and Chen, 2006, p. 336, fig. 6.4.
Alispiriferella sp. Yanagida, 1996, fig. 2.2, 2.4.
Spiriferella cf. *lita* (Fredericks). Tazawa et al., 2000, p. 12, pl. 1, figs. 16, 17.
Alispiriferella ordinaria (Einor). Tazawa, 2001, p. 302, fig. 8.14.
Alispiriferella japonica Tazawa, 2001, p. 303, fig. 8.15−8.18.
Alispiriferella neimongolensis Wang and Zhang, 2003, p. 154, pl. 46, figs. 9–18; pl. 50, figs. 5, 9; Tazawa and Chen, 2006, p. 336, fig. 6.3.
Alispiriferella lita (Fredericks). Tazawa and Hasegawa, 2007, p. 9, fig. 5.3–5.11; Tazawa, 2008b, p. 55, fig. 9.8–9.14; Tazawa, 2009, p. 74, fig. 5.4–5.9; Tazawa, 2016b, p. 34, fig. 11.1; Tazawa and Araki, 2017, p. 279, fig. 8.8–8.11.
Spiriferella sp. Tazawa, Kikuchi, Nikaido, Adachi and Okumura, 2014, p. 385, fig. 4.3.
Spiriferella sp. Tazawa, 2015, p. 79, fig. 8.3.

Material.—Forty specimens from localities AR4, AR5, KF217 and KS9: (1) external and internal moulds of a conjoined shell, IGPS96219: (2) internal mould of a conjoined shell, with external mould of the ventral valve, IGPS96221; (3) internal mould of two conjoined shells, with external mould of the dorsal valves, IGPS96220, NU-B319; (4) internal moulds of three conjoined shells, KCG20, 21, NU-B2016, NU-B325; (5) external and internal moulds of five ventral valves, IGPS96222–96224, NU-B315, 316; (6) external moulds of two ventral valves, NU-B317, 318; (7) internal moulds of nine ventral valves, IGPS96225–96227, NU-B326–331; (8) external and internal moulds of four dorsal valves, IGPS96228–96230, NU-B320; (9) external mould of a dorsal valve, IGPS96231; and (9) internal moulds of seven dorsal valves, IGPS96232–96235, NU-B332–334.

Remarks.—Most of the specimens from Setamai and Matsukawa were previously described by Tazawa (1979, p. 28, pl. 4, figs. 12, 13; pl. 5, figs. 1–4, 6) as *Spiriferella lita* (Fredericks, 1924b) and by Tazawa and Ibaraki (2001, p. 16, pl. 4, figs. 1–10) as *Spiriferella keilhavii* (von Buch, 1846). Subsequently, Tazawa and Araki (2017, p. 279, fig. 8.8–8.11) redescribed the specimens as *Alispiriferella lita* (Fredericks, 1924b). These specimens can be referred to *Alispiriferella lita* (Fredericks, 1924b), from the middle Permian (Wordian) of South Primorye, eastern Russia, by large transverse shells and deep ventral sulcus with smooth V-shaped bottom and strong simple costae on ventral valve. The type species, *Alispiriferella ordinaria* (Einor in Licharew and Einor, 1939, p. 140, 217, pl. 23, figs. 6, 7; pl. 24, fig. 1), from the lower Permian of Novaya Zemlya, northern Russia, differs from *A. lita* by its smaller and less transverse shell with ventral sulcus bearing two prominent sulcal costae. *Alispiriferella keilhavii* (von Buch, 1846), redescribed by Dunbar (1955, p. 139, pl. 25, figs. 1–9; pl. 26, figs. 1–11; pl. 27, figs. 1–44), from the middle Permian of eastern Greenland, differs from the present species in having weakly fasciculate costae on both valves.

Occurrence.—KN2 Unit in Setamai (locality KS9); and KY1 Unit in Imo (locality KF217) and Matsukawa (localities AR4 and AR5).

Distribution.—Roadian–Changhsingian: northeastern Japan (Setamai, Kamiyasse–Imo, Matsukawa, Ogatsu, Ichinoseki, Takakurayama, Soma and Hitachi in the South Kitakami Belt), central Japan (Moribu in the Hida Gaien Belt), southwestern Japan (Mizukoshi in Kyushu Island, and Tsunemori in the Akiyoshi Belt), northern China (Inner

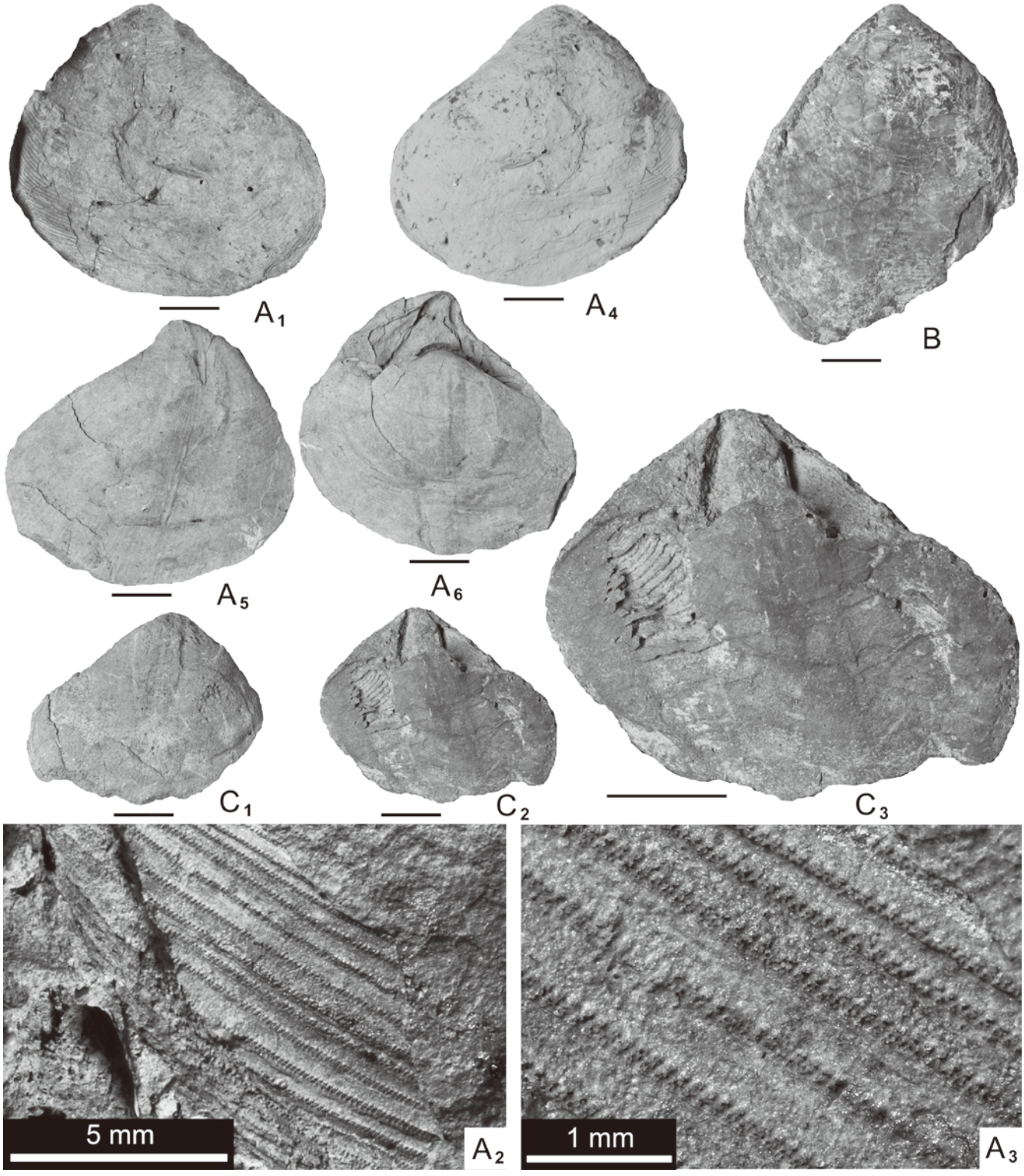

FIGURE 70. **A–C**, *Permophricodothyris grandis* (Chao); A, ventral external mould (A_1) enlarged rows of spine bases on the external mould of ventral valve (A_2, A_3), external latex cast (A_4) and ventral (A_5) and dorsal (A_6) views of internal mould of conjoined shell, NU-B1961; B, ventral valve, NU-B1965; C, ventral (C_1) and dorsal (C_2, C_3) views of internal mould of conjoined shell, NU-B1962. Scale bars are 1 cm, except for A_2 and A_3.

Mongolia), northeastern China (Heilongjiang) and eastern Russia (South Primorye).

Suborder DELTHYRIDINA Ivanova, 1972
Superfamily RETICULARIOIDEA Waagen, 1883
Family ELYTHIDAE Fredericks, 1924a
Subfamily PHRICODOTHYRIDINAE Caster, 1939
Genus *PHRICODOTHYRIS* George, 1932

Type species.—*Phricodothyris lucerna* George, 1932.

Phricodothyris catatona (Cooper and Grant, 1976a)
(Fig. 69A, B)

Neophricodothyris catatona Cooper and Grant, 1976a, p. 2250, pl. 636, figs. 1–28.
Phricodothyris sp. Minato et al., 1979, pl. 67, fig. 6.
Phricodothyris catatona (Cooper and Grant). Tazawa et al., 2016, p. 381, fig. 9.4.

Material.—Two specimens from locality KF84: (1) an abraded conjoined shell, NU-B2516; and (2) an abraded dorsal valve, NU-B2517.

Description.—Shell large in size for genus, transversely suboval in outline, moderately biconvex, anterior commissure slightly uniplicate, with greatest width at about midlength; length 28 mm, width 59 mm in the larger specimen (NU-B2517; length 32 mm, width 46 mm in the smatter specimen (NU-B2516). Ventral valve moderately and evenly convex in lateral profile; sulcus weak near anterior margin. Brachial valve slightly less strongly convex than opposite valve; fold absent or very low near anterior margin. External surface of both valves ornamented with numerous regular concentric lamellae bearing dense very fine spinules; concentric lamellae numbering 9–15 in 5 mm at near anterior margin of ventral valve. Interior of both valves not well preserved.

Remarks.—These specimens can be referred to *Phricodothyris catatona* (Cooper and Grant, 1976a), originally described by Cooper and Grant (1976a, p. 2250, pl. 636, figs. 1–28) as *Neophricodothyris catatona* Cooper and Grant, 1976a, in large, transverse shell with slightly sulcate anterior commissure and in having numerous regular concentric lamellae. *Phricodothyris transversa* (Cooper and Grant, 1976a, p. 2255, pl. 639, figs. 1–28), from the lower Wolfcampian of Texas, is also a large, transverse *Phricodothyris* species, but differs from *P. catatona* in having strong uniplicate anterior commissure.

Occurrence.—KY1 Unit in Kamiyasse (locality KF84).

Distribution.—Artinskian–Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central Japan (Kuzu in the Mino Belt) and USA (Texas).

Genus *PERMOPHRICODOTHYRIS* Pavlova, 1965

Type species.—*Permophricodothyris ovata* Pavlova, 1965.

Permophricodothyris grandis (Chao, 1929)
(Fig. 70A–C)

Squamularia grandis Chao, 1929, p. 97, pl. 11, figs. 1–3; Jin et al., 1974, p. 312, pl. 164, figs. 17–19; Yang et al., 1977, p. 452, pl. 179, fig. 11; Feng and Jiang, 1978, p. 296, pl. 105, figs. 2, 3; Tong, 1978, p. 261, pl. 91, fig. 2; Liao, 1980, pl. 8, figs. 50, 51; Liu et al., 1982, p. 214, pl. 158, fig. 1; Wang et al., 1982, p. 248, pl. 94, fig. 10; Ding and Qi, 1983, p. 412, pl. 139, fig. 10; Yang, 1984, p. 238, pl. 38, fig. 23; Xu, 1987, p. 235, pl. 16, figs. 4–9; Kotlyar, 1989, pl. 24, figs. 6–8; Zeng et al., 1995, pl. 13, figs. 1, 2.
Permophricodothyris grandis (Chao). Licharew and Kotlyar, 1978, pl. 22, fig. 3; Zhan, 1979, p. 97, pl. 8, figs. 1, 2, 4–6, text-fig. 19; Shi et al., 2002, p. 378, figs. 3B, C, 4B, 5.1–5.13, 6.1–6.9; Tazawa and Kaneko, 2016, p. 26, fig. 3.

Material.—Six specimens from localities KF62, KF79, KF217 and KF218: (1) internal moulds of two conjoined shells, with external moulds of the ventral valves, NU-B1961, 1962; (2) external and internal moulds of two ventral valves, NU-B1963, 1964; and (3) external casts of two ventral valves, NU-B1965, 1966.

Remarks.—These specimens were previously described by Tazawa and Kaneko (2016, p. 26, fig. 3) as *Permophricodothyris grandis* (Chao, 1929). The Kamiyasse–Imo specimens can be referred to *Permophricodothyris grandis* (Chao, 1929), from the Lungtan Formation of Zhejiang, eastern China, in large size (length about 61 mm, width about 48 mm in the largest specimen, NU-B1965), slightly elongate oval outline, and in having broad and shallow sulcus on ventral valve. Besides, the Kitakami species is ornamented with numerous regular concentric lamellae with a row of very fine biramous spine bases on anterior margin, and has posterior directed spiralia. *Permophricodothyris indica* (Waagen, 1883, p. 542, pl. 43, fig. 6; pl. 44, fig. 2), from the Wargal Formation of the Salt Range, Pakistan, is distinguished from *P. grandis* by its nearly equidimentional shell and shallower ventral sulcus. The type species, *Permophricodothyris ovata* Pavlova (1965, p. 135, figs. 1e, 2–4), from the upper Permian (Dzulfian) of Transcaucasia, is clearly distinguished from *P. grandis* by its smaller size, more elongate outline and shallower ventral sulcus.

Occurrence.—KY1 Unit in Kamiyasse (localities KF62 and KF79) and Imo (localities KF217 and KF218).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), northwestern China (Shaanxi), eastern Russia (South Primorye), eastern China (Zhejiang and Jiangxi), central-southern China (Hubei, Hunan, Guangdong and Guangxi) and southwestern China (Guizhou and Sichuan).

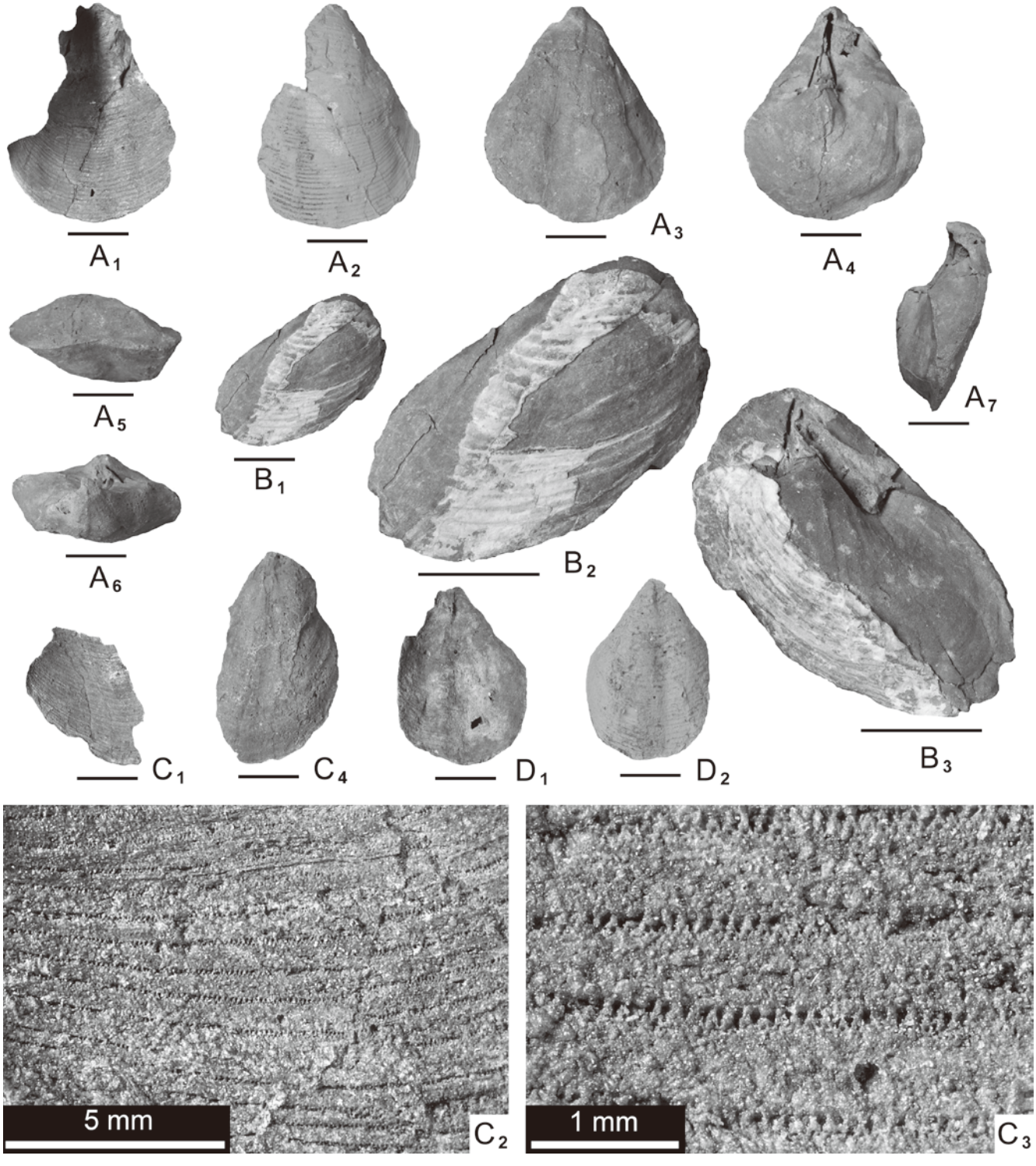

FIGURE 71. **A**–**D**, *Permophricodothyris squamularioides* (Huang); A, ventral external mould (A_1), ventral external latex cast (A_2) and ventral (A_3), dorsal (A_4), anterior (A_5), posterior (A_6) and lateral (A_7) views of internal mould of conjoined shell, UHR12582; B, ventral (B_1, B_2) and dorsal (B_3) views of abraded conjoined shell, NU-B1969; C, ventral external mould (C_1), enlarged rows of spine bases and interspinous pustues on the external mould (C_2, C_3) of ventral valve, NU-B1970; D, external mould (D_1) and external latex cast (D_2) of ventral valve, NU-B1972. Scale bars are 1 cm, except for C_2 and C_3.

Permophricodothyris squamularioides (Huang, 1933)
(Fig. 71A–D)

Martinia squamularioides Huang, 1933, p. 50, pl. 7, fig. 2; pl. 8, fig. 8.
Squamularia squamularioides (Huang). Feng and Jiang, 1978, p. 295, pl. 105, fig. 1; Tong, 1978, p. 261, pl. 90, fig. 11; Liao, 1979, pl. 1, fig. 23; Liao, 1980, p. 266, pl. 7, figs. 36, 37; Yang, 1984, p. 238, pl. 38, fig. 20; Zeng et al., 1995, pl. 14, figs. 6, 8.
Phricodothyris cf. caroli (Gemmellaro). Minato et al., 1979, pl. 67, fig. 7.
Permophricodothyris squamularioides (Huang). Shen and Zhang, 2008, fig. 5.24–5.30; Tazawa and Kaneko, 2016, p. 28, fig. 4.

Material.—Eight specimens from localities KF18, KF28, KF94 and KF217: (1) external and internal moulds of three conjoined shells, NU-B1967–1969; (2) internal moulds of three conjoined shells, with external moulds of the ventral valves, NU-B1970, 1971, UHR12582; (3) external and internal moulds of a ventral valve, NU-B1972; and (4) external cast of a ventral valve, NU-B1973.

Remarks.—These specimens were previously described by Tazawa and Kaneko (2016, p. 28, fig. 4) as *Permophricodothyris squamularioides* (Huang, 1933), on the basis of ventral valve of medium size (length 36 mm, width 30 mm in the largest specimen, UHR12582), elongate oval outline, and in having a distinct ventral sulcus, besides regularly spaced growth lamellae with a row of numerous dense spine bases and very fine interspinous pustules at frontal margin. *Permophricodothyris calori* (Gemmellaro, 1899), redescribed by Pavlova (1969, p. 103, pl. 10, fig. 1) on the specimens from the upper Permian of the Caucasus Mountains, differs from *P. squamularioides* in its larger size and shallower ventral sulcus. The preceding species, *Permophricodothyris grandis* (Chao, 1929), is readily distinguished from the present species by its larger size, less elongate outline, and in having a wider and shallower ventral sulcus.

Occurrence.—KY1 Unit in Kamiyasse (localities KF18, KF28 and KF94) and Imo (locality KF217).

Distribution.—Wordian–Changhsingian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt), central-southern China (Hubei and Hunan) and southwestern China (Guizhou and Sichuan).

Order SPIRIFERINIDA Ivanova, 1972
Suborder CYRTINIDINA Carter and Johnson in Carter et al., 1994
Superfamily CYRTINOIDEA Fredericks, 1911
Family CYRTINIDAE Fredericks, 1911
Genus *LICHAREWINA* Kotlyar, Zakharov and Polubotko, 2004

Type species.—*Licharewina praetriassica* Kotlyar, Zakharov and Polubotko, 2004.

Licharewina arakii (Hayasaka, 1963b)
(Fig. 68F)

Geyerella arakii Hayasaka, 1963b, p. 481, figs. 2, 3.
Licharewina arakii (Hayasaka). Tazawa and Araki, 2013, p. 9, fig. 3.1, 3.2; Tazawa and Araki, 2017, p. 280, fig. 8.5.

Material.—Two specimens from localities AR2 and AR4: (1) internal mould of a conjoined shell, with external mould of the dorsal valve and interarea of the ventral valve, KCG4; and (2) internal mould of a conjoined valve, KCG6.

Remarks.—These specimens were first described by Hayasaka (1963b, p. 481, figs. 2, 3) as *Geyerella arakii* Hayasaka, 1963b. Subsequently, Tazawa and Araki (2013, p. 9, fig. 3.1, 3.2) redescribed the specimens as *Licharewina arakii* (Hayasaka, 1963b). This species is characterized by its large size (length about 27 mm, width 19 mm in the better-preserved specimen, KCG4) and the highly pyramidal ventral valve. *Licharewina josephinae* (Gemmellaro, 1899), redescribed by Shen and Clapham (2009, p. 732, pl. 6, figs. 1–15) from the Episkopi Formation (Wuchiapingian) of Hidra island, Greece, differs from *L. arakii* in its smaller size and less pyramidal outline. The type species, *Licharewina praetriassica* Kotlyar, Zakharov and Polubotko (2004, p. 522, fig. 6.13–6.20), from the upper Permian (Changhsingian) of the Caucasus Mountains, is readily distinguished from the present species by its much smaller size.

Occurrence.—KY1 Unit in Kamiyasse (locality AR2) and Matsukawa (locality AR4).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo and Matsukawa in the South Kitakami Belt).

Suborder SPIRIFERINIDINA Ivanova, 1972
Superfamily PENNOSPIRIRINOIDEA Dagys, 1972
Family PARASPIRIFERINIDAE Cooper and Grant, 1976b
Genus *CALLISPIRINA* Cooper and Muir-wood, 1951

Type species.—*Spiriferina ornata* Waagen, 1883.

Callispirina sheni Tazawa, sp. nov.
(Fig. 72A, B)

Etymology.—Named for Shen Shuzhong, who contributed to the Permian brachiopod taxonomy and biogeography, and studied with the present author (J. Tazawa) on the Perman brachiopod faunas of Japan.

Material.—Three specimens from localities KF65 and KF69: (1) external and internal moulds of a dorsal valve, NU-B2566 (holotype); (2) external mould of a ventral valve, NU-B2567; and (3) external mould of a dorsal valve, NU-B2568.

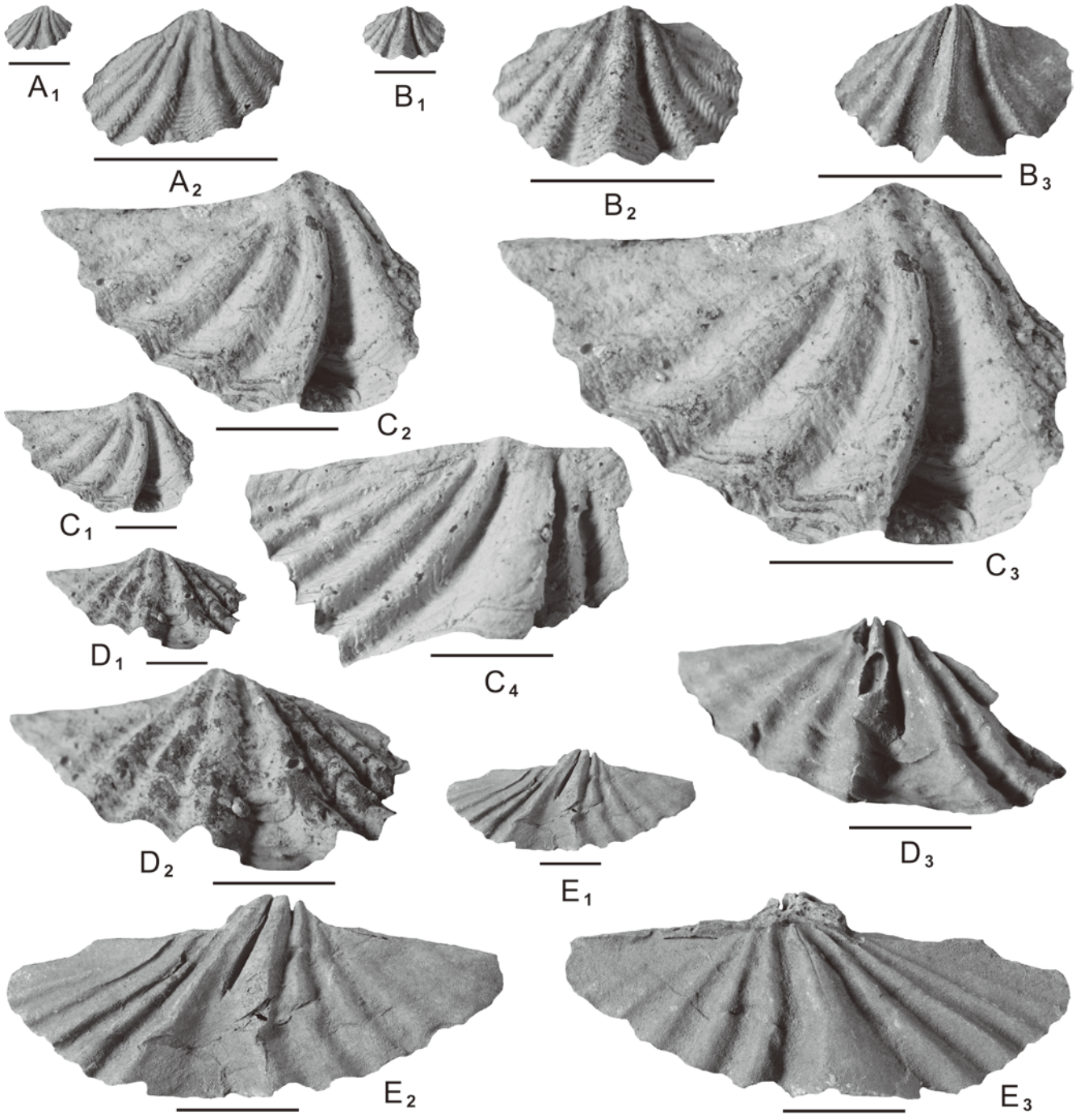

FIGURE 72. **A**, **B**, *Callispirina sheni* sp. nov.; A, external latex cast (A_1, A_2) of ventral valve, NU-B2567; B, external latex cast (B_1, B_2) and internal mould (B_3) of dorsal valve, NU-B2566 (holotype); **C–E**, *Spiriferellina fredericksi* Tazawa, C, ventral external latex cast (C_1, C_2, C_3) and dorsal external latex cast (C_4) of conjoined shell, NU-B1763 (holotype); D, external latex cast (D_1, D_2) and internal mould (D_3) of ventral valve, NU-B1767; E, ventral (E_1, E_2) and dorsal (E_3) views of internal mould of conjoined shell, NU-B1768. Scale bars are 1 cm.

Diagnosis.—Medium-sized *Callispirina* having a ventral sulcus with flat bottom.

Description.—Shell medium in size for genus, transversely subelliptical in outline, widest at midlength; length 9 mm, width 14 mm in the largest specimen (NU-B2566). Ventral valve strongly convex in lateral profile; sulcus originating at beak, widening anteriorly, with flat bottom. Dorsal valve unevenly convex in lateral profile, most convex at umbonal region; fold originating at beak, widening anteriorly. External surface of both valves ornamented with some coarse rounded costae and microornament consisting of numerous regular concentric lamellae; 4–5 costae on each flank of both ventral and dorsal valves; 3–4 lamellae in 1 mm at near anterior margin of both valves. Internal structure of dorsal valve not well preserved.

Remarks.—These specimens are safely assigned to the genus *Callispirina* Cooper and Muir-Wood, 1951 in being small size and in having microornament consisting of numerous dense concentric lamellae over both ventral and dorsal valves. The Kamiyasse specimens are seemed to be a new species in having flat-bottomed ventral sulcus. *Callispirina rotunda* Cooper and Grant (1976b, p. 2743, pl. 705, figs. 66–82), from the Bell Canyon Formation of Texas, differs from *Callispirina sheni* by its larger size and in having ventral sulcus with narrow depression bearing a low costa. *Callispirina austrina* Grant (1976, p. 231, pl. 63, figs. 1–37), from the Ratburi Formation of Ko Muk, southern Thailand, differs from *C. sheni* by its smaller size and in having ventral sulcus with V-shaped bottom. The type species, *Callispirina ornata* (Waagen, 1883), originally described by Waagen (1883, p. 505, pl. 50, figs. 1, 2) from the Chhidru Formation of the Salt Range, Pakistan, differs from the present new species in having V-shaped bottom in ventral valve.

Occurrence.—KY1 Unit in Kamiyasse (localities KF65 and KF69).

Family SPIRIFERELLINIDAE Ivanova, 1972
Genus *SPIRIFERELLINA* Fredericks, 1924a

Type species.—*Terebratulites cristatus* von Schlotheim, 1816.

Spiriferellina fredericksi Tazawa, 2014
(Figs. 72C–E, 73A, B)

Spiriferina cristata (Schellwien). Hayasaka, 1922a, p. 66, pl. 9, figs. 5–9.
Spiriferina cristata (von Schlotheim). Hayasaka, 1960, p. 53, pl. 1, fig. 10.
Spiriferellina cristata biplicata (Davidson). Fredericks, 1924b, p. 35, pl. 1, fig. 15.
Spiriferellina cristata (von Schlotheim). Tazawa, 1976, pl. 2, fig. 2, fig. 3; Minato et al., 1979, pl. 67, figs. 4, 5.
Spiriferellina fredericksi Tazawa, 2014, p. 19, fig. 3.5-3.7.

Material.—Sixteen specimens from localities KF29, KF88, KF217 and KF218: (1) external mould of a conjoined shell, NU-B1763 (holotype); (2) internal moulds of two conjoined shells, with external moulds of the ventral valves, NU-B1764, 1765; (3) internal mould of a conjoined shell, with external mould of the dorsal valve, NU-B2592; (4) internal moulds of three conjoined shells, NU-B1768–1770; (5) external and internal moulds of two ventral valves, NU-B1766, 1767; (6) internal moulds of four ventral valves, NU-B1771–1774; (7) external cast of a dorsal valve, NU-B1775; and (8) internal moulds of two dorsal valves, NU-B1776, 1777.

Remarks.—The specimens from Kamiyasse–Imo were previously described by Tazawa (2014, p. 19, fig. 3.5–3.7) as *Spiriferellina fredericksi* Tazawa, 2014. This species is characterized by its large, transverse shell (length about 21 mm, width about 50 mm in the holotype, NU-B1763; length about 21 mm, width about 54 mm in the largest ventral valve specimen, NU-B1766), with 5–6 costae on each lateral flank of both valves. The type species, *Spiriferellina cristata* (von Schlotheim, 1816), redescribed and refigured by Campbell (1959, p. 358, pl. 59, figs. 1–9; pl. 60, fig. 3) on the specimens from the Zechstein of Thuringia, Germany, differs from *S. fredericksi* by its smaller size, less transverse outline and in having fewer costae on both ventral and dorsal valves. *Spiriferellina cristata biplicata* (non Davidson, 1863), described by Fredericks (1924b, p. 35, pl. 1, fig. 15) from the Chandalaz Formation of South Primorye, eastern Russia, may be a synonym of the present species.

Occurrence.—KY1 Unit in Kamiyasse (localities KF29 and KF88) and Imo (localities KF217 and KF218).

Distribution.—Wordian: northeastern Japan (Kamiyasse–Imo in the South Kitakami Belt) and eastern Russia (South Primorye).

Order TEREBRATULIDA Waagen, 1883
Suborder TEREBRATULIDINA Waagen, 1883
Superfamily DIELASMATOIDEA Schuchert, 1913
Family DIELASMATIDAE Schuchert, 1913
Subfamily DIELASMATINAE Schuchert, 1913
Genus *DIELASMA* King, 1859

Type species.—*Terebratulites elongatus* von Schlotheim, 1816.

Dielasma sp.
(Fig. 74A)

Dielasma sp. Tazawa, 1979, p. 30, pl. 5, fig. 5; Tazawa and Araki, 2017, p. 280, fig. 8.6.

Material.—One specimen from locality AR5, external and internal moulds of a dorsal valve, IGPS96236.

Remarks.—This specimen was previously described by Tazawa (1979, p. 30, pl. 5, fig. 5) and Tazawa and Araki (2017, p. 280, fig. 8.6) as *Dielasma* sp. Tazawa, 1979. The

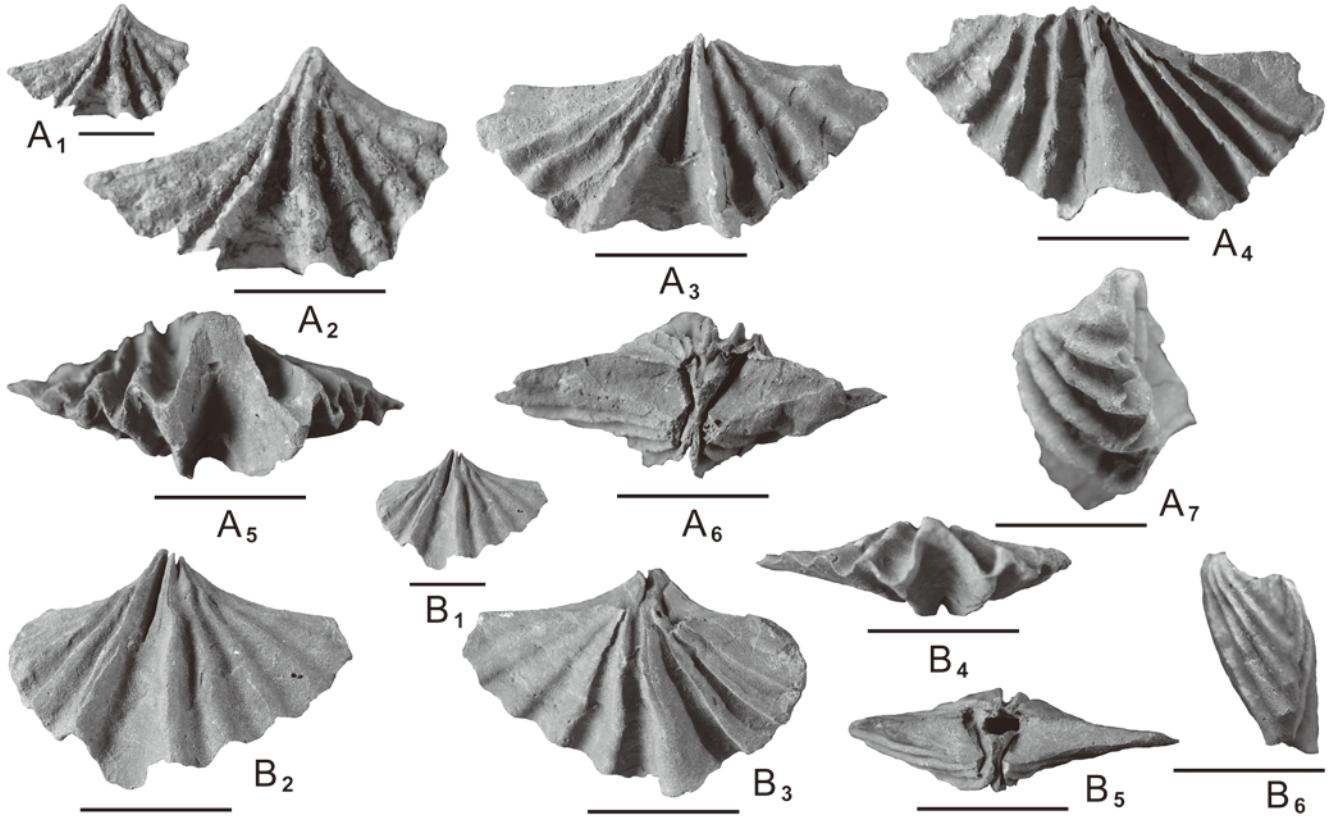

FIGURE 73. **A**, **B**, *Spiriferellina fredericksi* Tazawa; A, ventral external latex cast (A_1, A_2) and ventral (A_3), dorsal (A_4), anterior (A_5), posterior (A_6) and lateral (A_7) views of internal mould of conjoined shell, NU-B1764; B, ventral (B_1, B_2), dorsal (B_3), anterior (B_4), posterior (B_5) and lateral (B_6) views of conjoined shell, NU-B1770. Scale bars are 1 cm.

Matsukawa species is large in size for genus (length 29 mm, width 20 mm in the dorsal valve, IGPS96236), and characterized by presence of a sharp fold on anterior portion of dorsal valve. The Matsukawa species resembles *Dielasma plica* (Kutorga, 1842), redescribed by Diener (1903, p. 44, pl. 2, fig. 2) from the middle Permian (Capitanian) of the Chitichun No. 1, southern Tibet, in having a dorsal fold. But accurate comparison is difficult for the poorly preserved specimen. *Dielasma* sp. Tazawa (2001, p. 303, fig. 8.27, 8.28), from the Moribu Formation of Moribu, Hida Gaien Belt, central Japan, is readily distinguished from the present species in having a distinct median fold on ventral valve.

Occurrence.—KY1 Unit in Matsukawa (locality AR5).

Genus *WHITSPAKIA* Stehli, 1964

Type species.—*Dielasma biplex* Waagen, 1882.

Whitspakia nipponica Tazawa, sp. nov.
(Fig. 74B–D)

Etymology.—Named after the country, Nippon.

Matrial.—Seven specimens from localities KF217 and KF218: (1) internal and external moulds of a conjoined shell, NU-B1864; (2) internal moulds of three conjoined shells, NU-B1865 (holotype), 2471, 2587; (3) internal mould of a ventral valve, NU-B2470; (4) a dorsal valve, NU-B1866; and (5) external and internal moulds of a dorsal valve, NU-B1975.

Diagnosis.—Large, elongate subpentagonal and gently biconvex shell, with biplicate anterior commissure.

Description.—Shell medium in size for genus, elongate subpentagonal in outline, with greatest width slightly anterior to midlength of valve; length about 42 mm, width about 24 mm in the holotype (NU-B1865). Ventral valve gently and unevenly convex in lateral profile, rather strongly convex at

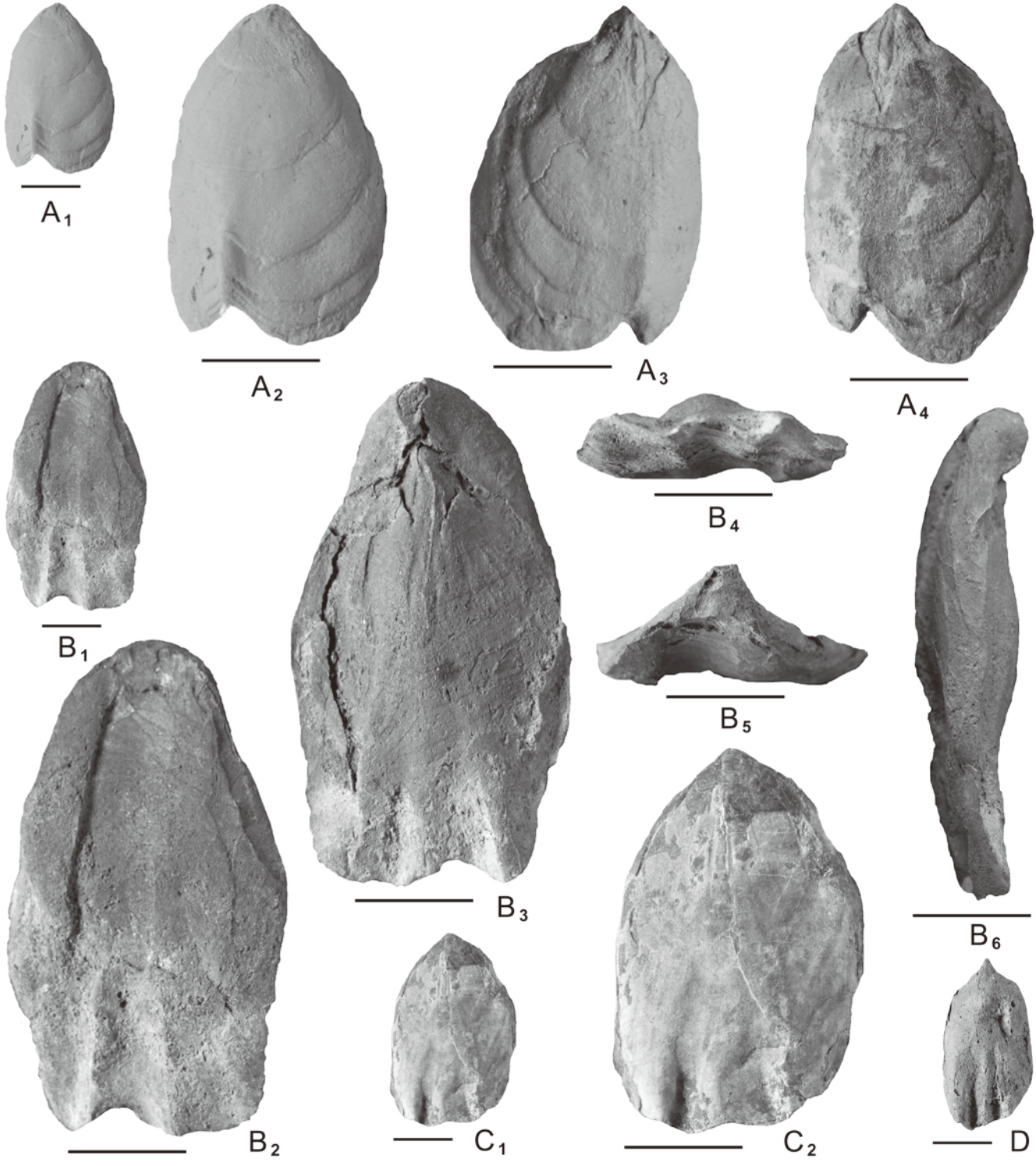

FIGURE 74. **A**, *Dielasma* sp., external latex cast (A_1, A_2), internal latex cast (A_3) and internal mould (A_4) of dorsal valve, IGPS96236; **B**–**D**, *Whitspakia nipponica* sp. nov., B, ventral (B_1, B_2), dorsal (B_3), anterior (B_4), posterior (B_5) and lateral (B_6) views of internal mould of conjoined shell, NU-B1865 (holotype); C, dorsal view (C_1, C_2) of dorsal valve, NU-B1866; D, internal mould of dorsal valve, NU-B1975. Scale bars are 1 cm.

umbonal region but nearly flattened on venter; foramen large, permesothirid; sulcus broad and shallow, with two short diverging costae on anterior one third valve length. Dorsal valve slightly convex in lateral profile; fold wide and low, with a median costa and two diverging costae on anterior half of valve. External surface of both valves ornamented with some irregular concentric rugae. Internal structures of both ventral and dorsal valves not well preserved.

Remarks.—These specimens can be assigned to the genus *Whitspakia* by its large, elongate subpentagonal and slightly biconvex shell, with a large permesothirid foramen. The present species resembles *Whitspakia biplex* (Waagen, 1882), originally described by Waagen (1882, p. 349, pl. 25, figs. 3–5) as *Dielasma biplex* Waagen from the Wargal Formation of the Salt Range, in size and outline of shell, but differs from the Pakistani species in having valves with biplicate anterior commissure. *Whitspakia introplicata* Yang (1984, p. 239, pl. 38, fig. 24) from the Maokouan of Hubei, central-southern China has also biplicate anterior commissure, but differs from *W. nipponica* sp. nov. by its much smaller size and less elongate outline.

Occurrence.—KY1 Unit in Imo (localities KF217 and KF218).

ACKNOWLEDGEMENTS

We sincerely thank Kenshiro Ogasawara (Professor Emeritus of the University of Tsukuba, Tsukuba) and Soichiro Kawabe (Fukui Prefectural Dinosaur Museum, Katsuyama) for editing the manuscript; Shuzhong Shen (Nanjing University, Nanjing) and an anonymous reviewer for their constructive comments and suggestions on the manuscript; Yoshitsugu Kobayashi and Hiroki Echizenya (Hokkaido University Museum, Sapporo), Yasufumi Iryu and Jun Nemoto (Tohoku University Museum, Sendai), and Masaru Kumagai (Rikuzentakata City Museum, Rikuzentakata, Iwate Prefecture) for loan of the type specimens; Tomoharu Ikeda (Fuji City, Shizuoka Prefecture) for help in the field (Imo); and Hideo Araki (Kesennuma City, Miyagi Prefecture) for providing part of the brachiopod specimens.

REFERENCES

Abramov, B. S. 1970. Biostratigraphy of the Carboniferous of Sette -Davana (Southern Verkhoyansk). Nauka, Moskva, 176 pp.***

Afanasjeva, G. A. 1975. Middle and Late Carboniferous Chonetacea (Brachiopoda) of the Russian Platform. Paleontologicheskiy Zhurnal 1975 (2): 96–113.***

Afanasjeva, 1977, G. A. 1977. Systematic descriptions; Suborder Chonetidina; pp. 5–41 *in* T. G. Sarytcheva (ed.), Late Palaeozoic Productida of Siberia and Arctic Region. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 161.***

Afanasjeva, G. A. 1988. Brachiopoda of the order Chonetida. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 228: 1–122.***

Afanasjeva, G. A., and J. Tazawa. 2007. New large chonetids (Brachiopoda) from the Middle Permian of the southern Kitakami Mountains, northeast Japan. Paleontologicheskiy Zhurnal 2007 (4): 71–74.***

Afanasjeva, G. A., and J. Tazawa. 2010. *Kanokurachonetes*—new genus (Brachiopoda, Chonetida) from the Middle Permian of the Southern Kitakami Mountains, Northeast Japan. Paleontologicheskiy Zhurnal 2010 (1): 17–20.***

Afanasjeva, G. A., J. Tazawa and T. Shintani. 2015. Brachiopods of the Order Chonetida from the Lower and Middle Permian of the South Kitakami Mountains, Northeast Japan. Paleontologicheskiy Zhurnal 2015 (1): 21–25.***

Albrecht, J. 1924. Paläontologische und stratigraphische Ergebnisse der Forschungsreise nach Westserbien 1918. Denkschriften der Akademie der Wissenschaten, Mathematisch–Naturwissenschaftliche Klasse 99: 289–307.

Alexandrov, V. A., and O. L. Einor. 1979. Descriptions of Fauna and Flora: Brachiopoda; pp. 55–76 *in* O. L. Einor (ed.), Atlas of the Middle–Upper Carboniferous Fauna and Flora of Bashkiria. Nedra, Moskva.***

Alvarez, F., and J.-Y. Rong. 2002. Suborder Retziidina; pp. 1584–1601 in R. L. Kaesler (ed.), Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 4: Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence.

Angiolini, L. 1996. Permian brachiopods from Karakorum (Pakistan), Pt. 2. Rivista Italiana di Paleontologia e Stratigrafia 102: 3–36.

Araki, H. 1961. Permian trilobites from Kesennuma City, Kitakami Mountains. Chigaku Kenkyu 12: 224–226.*

Araki, H. 1980. Discovery of *Helicoprion*, a Chondrichthyes from Kesennuma City, Miyagi Prefecture, Japan. Journal of the Geological Society of Japan 86: 135–137.*

Araki, H., and H. Koizumi. 1968. Permo-Carboniferous trilobites from the Kitakami Mountains (1). Chigaku Kenkyu 19: 151–158.*

Archbold, N. W. 1982. Classification and evolution of the brachiopod family Rugosochonetidae Muir-Wood 1962. Proceedings of the Royal Society of Victoria 94: 1–10.

Archbold, N. W. 1993. Studies on western Australian Permian brachiopods 11. New genera, species and records. Proceedings of the Royal Society of Victoria 105: 1–29.

Archbold, N. W. 1999. Additional records of Permian brachiopods from near Rat Buri, Thailand. Proceedings of the Royal Society of Victoria 111: 71–86.

Bamber, E. W., and J. B. Waterhouse. 1971. Carboniferous and Permian stratigraphy and paleontology, northern Yukon Territory, Canada. Bulletin of Canadian Petroleum Geology 19: 29–250.

Beyrich, H. E. 1865. Über eine Kohlenkalk-Fauna von Timor. Abhandllungen der Königlichen Akademie der Wissenschaften zu Berlin 1864: 61–98.

Booker, F. W. 1932. A new species of *Productus* from the Lower Bowen Series—Queensland. Proceedings of the Royal Society of Queensland 43: 66–72.

Boucot, A. J., J. G. Johnson and R. D. Staton. 1964. On some atrypoid, retzioid, and athyridoid Brachiopoda. Journal of Paleontology 38: 805–822.

Brabb, E. E., and R. E. Grant. 1971. Stratigraphy and paleontology of the revised type section for the Tahkandit Limestone (Permian) in east-central Alaska. United States Geological Survey Professional Paper 703: 1–26.

Briggs, D. J. C. 1998. Permian Productidina and Strophalosiidina from the Sydney–Bowen Basin and New England Orogen: Systematics and Biostratigraphic Significance. Association of Australasian Palaeontologists Memoir 19, Association of Australasian Palaeontologists, Canberra, 258 pp.

Broili, F. 1916. Die permischen Brachiopoden von Timor; pp. 1–104 in J. Wanner (ed.), Palaeontologie von Timor, No. 7, Pt. 12. E. Schweizerbartchen Verlag Buch-handlumg, Stuttgart.

Bronn, H. G. 1862. Die Klassen und Ordnungen der Weichthiere (Malacozoa), Vol. 3. C. F. Winter'sche Verlagshandlung, Leipzig and Heidelberg, 518 pp.

von Buch, L. 1834. Über Terebrateln, mit einem Versuch sie zu classificiren und zu beschreiben. Physikalisch Abhandlungen Königliche Akademie für Wissenschaften aus dem Jahre 1833: 1–124.

von Buch, L. 1846. Ueber *Spirifer keilhavii*. Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin 1846: 65–80.

Campbell, K. S. W. 1959. The type species of three Upper Palaeozoic punctate spiriferids. Palaeontology 1: 351–363.

Campi, M. J., S.-Z. Shen, M. S. Leman and G. R. Shi. 2000. First record of *Permianella* He and Zhu, 1979 (Permianellidae; Brachiopoda) from Peninsular Malaysia. Alcheringa 24: 37–43.

Campi, M. J., G. R. Shi and M. S. Leman. 2002. The *Leptodus* Shales of central Peninsular Malaysia: distribution, age and palaeobiogeographical affinities. Journal of Asian Earth Sciences 20: 703–717.

Campi, M. J., G. R. Shi and M. S. Leman. 2005. Guadalupian (Middle Permian) brachiopods from Sungai Toh, a *Leptodus* Shale locality in the Central Belt of Peninsular Malaysia. Palaeontographica Abhandlung A 273: 97–160.

Carter, J. L., J. G. Johnson, R. Gourvennec and H.-F. Hou. 1994. A revised classification of the spiriferid brachiopods. Annals of Carnegie Museum 63: 327–374.

Caster, K. E. 1939. A Devonian fauna from Colombia. Bulletins of American Paleontology 24: 1–218.

Chang, M.-L. 1987. Fossil Brachiopoda from Chihsia Formation, Anqing, Anhui. Acta Palaeontologica Sinica 26: 753–766.

Chao, Y. T. 1925. On the age of the Taiyuan Series of North China. Bulletin of the Geological Society of China 4: 221–249.

Chao, Y. T. 1927. Productidae of China, Part 1: Producti. Palaeontologia Sinica, Series B 5 (2): 1–244.

Chao, Y. T. 1928. Productidae of China, Part 2. Chonetinae, Productinae and Richthofeninae. Palaeontologia Sinica, Series B 5 (3): 1–103.

Chao, Y. T. 1929. Carboniferous and Permian spiriferids of China. Palaeontologia Sinica, Series B 11: 1–133.

Chen, Z.-Q., M. J. Campi, G. R. Shi and K. Kaiho. 2005. Post-extinction brachiopod faunas from the Late Permian Wuchiapingian Coal Series of South China. Acta Palaeontologica Polonica 50: 343–363.

Chen, Z.-Q., K. Kaiho, D. G. Annette and J.-N. Tong. 2006. Survival brachiopod faunas of the end-Permian mass extinction from the Southern Alps (Italy) and South China. Geological Magazine 143: 301–327.

Chen, Z.-Q., and G. R. Shi. 2002. Late Carboniferous to Early Permian brachiopod faunas from the Bachu and Kalpin areas, Tarim Basin, NW China. Alcheringa 25: 293–326.

Chen, Z.-Q., and G. R. Shi. 2006a. Artinskian–Kungurian (Early Permian) brachiopod faunas from Tarim Basin, Northwest China. Palaeontographica, Abteilung A 274: 113–177.

Chen, Z.-Q., and G. R. Shi. 2006b. *Isogramma* Meek and Worthen, 1870 (Dictyonellida, Brachiopoda) from the upper Palaeozoic of East Asia: Implications for biogeography and evolutionary trends. Journal of Asian Earth Sciences 26: 405–423.

Chi-Thuan, T. T. 1961. Les Brachiopodes permiens du Phnon-Tup (Sisophon-Cambodge). Annales de la Faculté des Science, Université de Saigon, 1961: 267–308.

Chi-Thuan, T. T. 1962. Les brachiopods permiens de Cam-lo (Province de Quang-Tri). Annales de la Faculté des Sciences, Université de Saigon 1962: 485–498.

Choi, D. R. 1970. Permian fusulinids from Imo, Southern Kitakami Mountains, N. E. Japan. Journal of the Faculty of Science, Hokkaido University 14: 327–354.

Choi, D. R. 1973. Permian fusulinids from the Setamai–Yahagi district, Southern Kitakami Mountains, N. E. Japan. Journal of the Faculty of Science, Hokkaido University, Series 4 16: 1–132.

Choi, D. R., H. Suetomi and K. Nakamura. 1979. Chapter 212 The Kanokura Series; pp. 177–182 *in* Minato, M., M. Hunahashi, J. Watanabe and M. Kato (eds.), Variscan Geohistory of Northern Japan: The Abean Orogeny. Tokai University Press, Tokyo.

Chronic, J. 1953. Part 2. Invertebrate paleontology (excepting fusulinids and corals); pp. 43–165 *in* N. D. Newell, J. Chronic and T, G. Roberts, Upper Paleozoic of Peru. Geological Society of America, Memoir 58.

Colani, M. M. 1919. Sur quelques fossiles ouralo-permiens de Hongay. Bulletin du Service Géologique de l'Indochine 6: 1–27.

Conrad, T. A. 1839. Descriptions of new species of organic remains: Second annual report on the Palaeontological Department of the Survey. New York State Geological Survey, Second Annual Report 3: 57–66.

Cooper, G. A. 1952. Unusual specimens of the brachiopod family Isogrammidae. Journal of Paleontology 26: 113–119.

Cooper, G. A. 1956. Chazyan and related brachiopods. Smithsonian Miscellaneous Collections 127: 1–1245.

Cooper, G. A. 1957. Permian brachiopods from central Oregon. Smithsonian Miscellaneous Collections 134: 1–79.

Cooper, G. A., and R. E. Grant. 1969. New Permian brachiopods from West Texas. Smithsonian Contributions to Paleontology 1: 1–20.

Cooper, G. A., and R. E. Grant. 1974. Permian brachiopods of West Texas, 2. Smithsonian Contributions to Paleobiology 15: 233–794.

Cooper, G. A., and R. E. Grant. 1975. Permian brachiopods of West Texas, 3. Smithsonian Contributions to Paleobiology 19: 795–1922.

Cooper, G. A., and R. E. Grant, 1976a. Permian brachiopods of West Texas, 4. Smithsonian Contributions to Paleobiology 21: 1923–2608.

Cooper, G. A., and R. E. Grant, 1976b. Permian brachiopods of West Texas, 5. Smithsonian Contributions to Paleobiology 24: 2609–3160.

Cooper, G. A., and H. M. Muir-Wood. 1951. Brachiopod homonyms. Journal of the Washington Academy of Sciences 41: 195–196.

Cox, T. 1857. A description of some of the most characteristic shells of the principal coal seams in the western basin of Kentucky. Geological Survey of Kentucky Report 3: 557–576.

Czarniecki, S. 1969. Sedimentary environment and stratigraphical position of the Treskelodden Beds (Vestspitsbergen). Prace Museum Ziemi 16: 201–336.

Dagys, A. S. 1972. Morphology and systematics of Mesozoic retzioid brachiopods. Trudy Sibirskoe Otdelenie, Institut Geologii i Geofiziki 112: 94–105.***

Davidson, T. 1848. Mémoire sur les Brachiopodes du Système Silurien supérieur de l'Angleterre. Société Géologique de France, Bulletin, Seres 2 5: 309–338 and 370–374.

Davidson, T. 1858–1863. A Monograph of the British Fossil Brachiopoda, Vol. 2. Permian and Carboniferous Species. Palaeontographical Society, London, 280 pp.

Davidson, T. 1862. On some Carboniferous Brachiopoda collected in India by A. Fleming, M. D. and W. Purdon, Esq., F. G. S. Geological Society of London, Quarterly Journal 18: 25–35.

Davidson, T. 1881. On genera and species of spiral-bearing Brachiopoda, from specimens developed by the Rev. Norman Glass: with notes on the results obtained by Mr. George Maw from extensive washing of the Wenlock and Ludlow shales of Shropshire. Geological Magazine, New Series 8: 1–13.

Derby, O. A. 1874. On the Carboniferous Brachiopoda of Itaituba, Rio Tapajos, Province of Para, Brazil. Cornell University Scientific Bulletin, Series 2 1: 1–63.

Diener, C. 1897a. The Permocarboniferous fauna of Chitichun, No. 1. Palaeontologia Indica, Series 15 1 (3): 1–105.

Diener, C. 1897b. The Permian fossils of the Productus Shales of Kumaon and Gurhwal. Palaeontologia Indica, Series 15 1 (4): 1–54.

Diener, C. 1899. Himalayan fossils, Volume 1, Part 2. Anthracolithic fossils of Kashmir and Spiti. Palaeontologia Indica, Series 15 1 (2): 1–95.

Diener, C. 1903. Himalayan fossils, Volume 1, Part 5. Permian fossils of the Central Himalayas. Palaeontologia Indica, Series 15 1 (5): 1–204.

Diener, C. 1915. The Anthracolithic faunae of Kashmir and Spiti. Palaeontologia Indica, New Series 5: 1–135.

Ding, P., and W. Qi, 1983. Phylum Brachiopoda (Carboniferous–Permian); pp. 244–425 *in* Xian Institute of Geology and Mineral Resources (ed.), Palaeontological Atlas of Northwest China; Shaanxi, Gansu and Ningxia Volume, Part 2. Upper Palaeozoic. Geological Publishing House, Beijing.**

Duan, C.-H., and W.-G. Li. 1985. Descriptions of fossils, 4. Phylum Brachiopoda; pp. 99–145 *in* Ding, Y.-J., G.-Y. Xia, C.-H. Duan, W.-G. Li, X.-L. Liu and Z.-F. Liang, Study on the early Permian stratigraphy and fauna in Zhesi district, Nei Mongol Zizhiqu (Inner Mongolia). Bulletin of the Tianjin Institute of Geology and Mineral Resources, Chinese Acadeny of Geological Sciences 10. **

Dunbar, C. O. 1955. Permian brachiopod faunas of central east Grønland. Meddelelser om Grønland 110: 1–169.

Dunbar, C. O., and G. E. Condra. 1932. Brachiopoda of the Pennsylvanian System in Nebraska. Nebraska Geological Survey Bulletin, Series 2 5: 1–377.

Ehiro, M. 1977. The Hizume–Kesennuma Fault—With special reference to its character and significance on the geologic development—. Contributions from the Institute of Geology and Paleontology, Tohoku University 77: 1–37.*

Ehiro, M. 1997. Ammonoid palaeobiogeography of the South Kitakami Palaeoland and palaeogeography of Eastern Asia during Permian to Triassic time; pp. 18–28 *in* Y.-G. Jin and D. Dineley (eds.), Proceedings of the 30th International Geological Congress. Beijing, China, 4–14 August 1996, Volume 12. Palaeontology and Historical Geology. VSP, Utrecht.

Ehiro, M. 1998. Permian ammonoid fauna of the Kitakami Massif, Northeast Japan—Biostratigraphy and paleobiogeography. Palaeoworld 9: 113–122.

Ehiro, M. 2001. Origins and drift histories of some microcontinents distributed in the eastern margin of Asian Continent. Earth Science (Chikyu Kagaku) 55: 71–81.

Ehiro, M. 2010. Permian ammonoids of Japan: their stratigraphic and paleobiogeographic significance; pp. 233–241 *in* Tanabe, K., Y. Shigeta, T. Sasaki and H. Hirano (eds.), Cephalopods—Present and Past. Tokai University Press, Tokyo.

Ehiro, M. 2015. Extraordinarily large Permian nautiloid *Tainoceras* from the Kamiyasse–Imo area, South Kitakami Belt, Northeast Japan. Earth Science (Chikyu Kagaku) 69: 303–310.

Ehiro, M., and H. Araki. 1997. Permian cephalopods of

Kurosawa, Kesennuma City in the southern Kitakami Massif, northeast Japan. Paleontological Research 1: 55–66.

Ehiro, M., and A. Misaki. 2005. Middle Permian ammonoids from the Kamiyasse –Imo district in the Southern Kitakami Massif, Northeast Japan. Paleontological Research 9: 1–14.

von Eichwald, C. E. 1840. Ueber das silurische Schichtensystem in Esthland. St. Petersburg, 210 pp.

von Eichwald, E. 1860. Lethaea Rossica ou Paléontologie de la Russie décrite et figurée. Permian volume, Ancienne Periode. E. Schweizerbart, Stuttgart, 1635 pp.

Endo, R. 1924. Stratigraphical studies of the Paleozoic formations of the southern part of the Kitakami Mountainland. Journal of the Geological Society of Japan 31: 230–249.*

Fang, R.-S., and J.-C. Fan. 1994. Middle to Upper Carboniferous–Early Permian Gondwana Facies and Paleontology in Western Yunnan. Yunnan Science and Technology Press, Kunming, 121 pp.**

Fantini Sestini, N., and M. Glaus, 1966. Brachiopods from the Upper Perman Nesen Formation (North Iran). Rivista Italiana de Paleontologia e Stratigrafia 72: 887–930.

Feng, R.-L., and Z.-L. Jiang, 1978. Phylum Brachiopoda; pp. 231–305 *in* Geological and Palaeontological Team of Guizhou (ed.), Palaeontological Atlas of Southwest China, Guizhou, Part 2. Carboniferous to Quaternary. Geological Publishing House, Beijing.**

Fliegel, G. 1901. Üeber obercarbonische Faunen aus Ost- und Südasien. Palaeontographica 48: 91–136.

Frebold, H. 1950. Stratigraphie und Brachiopodenfauna des marinen Jungpalaeozoikums von Holms und Amdrups Land (Nordostgrönland). Muséum de Minéralogie et de Géologie de l'Université de Copenhague, Communications Géologiques 37: 1–97.

Frech, F. 1911. Die Dyas; pp. 103–202 *in* F. von Richthofen (ed.), China, Fünfter Band. Dietrich Reimer, Berlin.

Fredericks, G. 1911. Bemerkung über einige oberpalaeozoische Fossilien von Krasnoufimik. Prilozhenie k protokolam zasedanii Obshcestva Estestvoispytatelei pri Imperatorckom Kazanskom Universitete 269: 1–12.***

Fredericks, G. 1916. The palaeontological notes, 2. On some Upper Palaeozoic Brachiopoda of Eurasia. Trudy Geologicheskago Komiteta, Novaya Seriya 156: 1–87***

Fredericks, G. 1924a. Paleontological studies, 2: On Upper Carboniferous spiriferids from the Urals. Izvestyia Geologicheskogo Komiteta 38: 295–324.***

Fredericks, G. 1924b. Upper Paleozoic of the Ussuriland, 1: Brachiopoda. Materialy po Geologii i Poleznym Iskopaemym Dalnego Vostoka 28: 1–53.***

Fredericks, G. 1925. Upper Palaeozoicum of Oussouriland, 2. Permian Brachiopoda of Cape Kalouzin. Materialy po Geologii i Poleznym Iskopaemym Dalnego Vostoka 40: 1–30.***

Fredericks, G. 1926. Study on the fauna from sandy-argillaceous beds in the Kejim–Terovey River. Izvestiya Geologicheskogo Komiteta 45: 81–91.**

Fujimoto, H. 1956. A new species of *Parafusulina* from the Kitakami Massif, Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 21: 157–160.

Gemmellaro, G. G. 1891. Sopra un nuovo genere di Brachiopodi proveniente dei calcari con Fusulina della Provincia di Palermo. Società di Scienze Naturali ed Economiche di Palermo 4: 22–23.

Gemmellaro, G. G. 1899. La fauna dei calcari con Fusulina della valle del fiume Sosio nella Provincia di Palermo, Part 4 Brachiopoda. Giornale di Scienze Naturali ed Economiche di Palermo 22: 95–214.

George, T. N. 1932. The British Carboniferous reticulate Spiriferidae. Quarterly Journal of the Geological Society of London 88: 516–575.

Girty, G. H. 1909. Paleontology of the Manzano Group; pp. 41–137 *in* W. T. Lee and G. H. Girty, The Manzano Group of the Rio Grande Valley, New Mexico. United States Geological Survey, Bulletin 389.

Gobbett, D. J. 1963. Carboniferous and Permian brachiopods of Svalbard. Norsk Polarinstitute Skrifter 127: 1–201.

Grabau, A. W. 1931. The Permian of Mongolia: A Report of the Permian Fauna of the Jisu Honguer Limestone of Mongolia and its Relations to the Permian of Other Parts of the World. Natural History of Central Asia, Vol. 4. American Museum of Natural History, New York, 665 pp.

Grabau, A. W. 1934. Early Permian fossils of China 1. Early Permian brachiopods, pelecypods and gastropods of Kueichow. Palaeontologia Sinica, Series B 8: 1–214.

Grabau, A. W. 1936. Early Permian fossils of China, Pt. 2. Fauna of the Maping Limestone of Kwangsi and Kweichow. Palaeontologia Sinica, Series B 8: 1–441.

Grant, R. E. 1976. Permian brachiopods from southern Thailand. Journal of Paleontology 50: 1–269.

Gray, J. E. 1840. Synopsis of the Contents of the British Museum, 42nd Edition. British Museum, London, 370 pp.

Grigorjewa, A. D. 1962. Productids of the Kazan Stage of the Russian Patform and their environmental conditions. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 92: 1–86.***

Grunt, T. A. 1973. Systematic part, pp. 74–161 *in* T. A. Grunt and V. Yu. Dmitriev, Permian Brachiopoda of the Pamir. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 116.***

Grunt, T. A. 1986. Classification of brachiopods of the order Athyridida. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 215: 1–200.***

Gu, F. 1992. Carboniferous and Permian Brachiopoda; pp. 210–255 *in* Jilin Institute of Geology and Mineral Resources (ed.), Paleontological Atlas of Jilin. Jilin Science and Technology Publishing House, Changchung.**

Gu, F., and R.-F. Zhu. 1985. Lower Permian brachiopods from Lin-Dong, Nei Mongol. Bulletin of the Shenyang Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences 12: 74–97.**

Hall, J., and J. M. Clarke. 1892. An Introduction to the Study of

the Genera of Palaeozoic Brachiopoda, Natural History of New York, Palaeontology, Vol. 8, Part 1. Charles van Benthuysen and Sons, Albany, 367 pp.

Hall, J., and J. M. Clarke. 1893. An Introduction to the Study of the Genera of Palaeozoic Bachiopoda. Palaeontology of New York, Vol. 8, Part 2. Charles van Benthuysen & Sons, Albany, 317 pp.

Hamlet, B. 1928. Permische Brachiopoden, Lamellibranchiaten und Gastropoden von Timor. Jaarboek van het Mijnwezen in Nederlandsch-Indie, 1927 (2): 1–115.

Harker, P. 1960. Part 3. Permian brachiopods and molluscs of Grinnell Peninsula; pp. 39–79 *in* P. Harker and R. Thorsteinsson, Permian rocks and faunas of Grinnel Peninsula, Arctic Canada. Geological Survey of Canada, Memoir 309.

Hatai, K., and T. Omura. 1941. On a species of *Isogramma* (Brachiopoda) from Manchoukuo. Journal of the Geological Society of Japan 48: 43–46.

Hayasaka, I. 1917. On the brachiopod genus *Lyttonia* with several Japanese and Chinese examples. Journal of the Geological Society of Tokyo 24: 43–53.

Hayasaka, I. 1920. A new species of *Conularia* from southern Kitakami, Japan. Journal of the Geological Society of Tokyo 27: 1–4.

Hayasaka, I. 1922a. Some Permian brachiopods from the Kitakami Mountains. Japanese Journal of Geology and Geography 1: 51–70.

Hayasaka, I. 1922b. Paleozoic Brachiopoda from Japan, Korea and China, Part 1. Middle and southern China. Science Reports of Tohoku Imperial University, Second Series 8: 1–116.

Hayasaka, I. 1922c. Paleozoic Brachiopoda from Japan, Korea and China, Part 2. Upper Carboniferous Brachiopoda from the Hon-kei-ko Coal Mines, Manchuria. Science Reports of Tohoku Imperial University, Second Series 8: 117 –137.

Hayasaka, I. 1923. Some Permian fossils from Kitakami Mountains. Japanese Journal of Geology and Geography 2: 107–116.

Hayasaka, I. 1925a. On some brachiopods from the *Lyttonia* Horizon of the Kitakami Mountains. Japanese Journal of Geology and Geography 4: 89–103.

Hayasaka, I. 1925b. On some Paleozoic molluscs of Japan, 1. Lamellibranchiata and Scaphopoda. Science Reports of Tohoku Imperial University, Second Series 8: 1–29.

Hayasaka, I. 1933. On the Carboniferous brachiopod fauna from the Nabeyama region, Totigi Prefecture, Japan. Memoirs of the Faculty of Science and Agriculture, Taihoku Imperial University, Formosa, Japan, 6: 9–44.

Hayasaka, I. 1937. *Meekella striato-costata* (Cox) aus Japan. Transactions, Natural History Society of Formosa 27: 268–270.

Hayasaka, I. 1940. On two Permian ammonoids from the Kitakami Mountains, north Japan. Journal of the Geological Society of Japan 47: 422–427.

Hayasaka, I. 1953. *Hamletella*, a new Permian genus of Brachiopoda, and a new species from the Kitakami Mountains, Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 12: 89–95.

Hayasaka, I. 1960. On the occurrence of *Neospirifer fasciger* (Keyserling) in Japan, and a note on some associate Permian brachiopods from around Kesen-numa City, northeast Japan; pp. 34–57 *in* Shimane University (ed.) Collection of Essays in Commemoration of the Tenth Anniversary (1959) of Shimane University (Natural Science). Shimane University, Matsue.

Hayasaka, I. 1963a. Some Permian fossils from southern Kitakami, 1. Proceedings of the Japan Academy 39: 474–478.

Hayasaka, I. 1963b. Some Permian fossils from southern Kitakami, 2. Two brachiopod species. Proceedings of the Japan Academy 39: 479–483.

Hayasaka, I. 1963c. Some Permian fossils from Southern Kitakami, 3. Ammonoidea. Proceedings of the Japan Academy 39: 594–599.

Hayasaka, I. 1963d. Some Permian fossils of southern Kitakami, 4. Brachiopod superfamily Orthotetacea Williams. Proceedings of the Japan Academy 39: 753–757.

Hayasaka, I. 1966. Some Permian fossils from southern Kitakami, 6. Three brachiopods. Proceedings of the Japan Acdemy 42: 1223–1228.

Hayasaka, I. 1967. Some Permian fossils from southern Kitakami, 10. Two smooth-shelled spiriferids: *Martinia* and *Martiniopsis*. Proceedings of the Japan Acdemy 43: 522–525.

Hayasaka, I., and M. Minato. 1956. Some brachiopods from the lower Kanokura Series of the Kitakami Mountains, Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 21: 141–147.

He, W.-H., G. R. Shi, J.-J. Bu and Z.-J. Niu. 2008. A new brachiopod fauna from the Early to Middle Permian of southern Qinghai Province, Northwest China. Journal of Paleontology 82: 811–822.

He, X.-L., and B.-H. Fan. 1990. Brachiopod assemblages from Penchi and Taiyuan Formations in Eastern Hill of Taiyuan, Shanxi. Journal of China Coal Society 15: 41–47.**

He, X.-L., and M.-L. Zhu. 1979. A new form of brachiopods and its systematical classification. Journal of China Institute of Mining Technology 4: 131–140.**

He, X.-L., M.-L. Zhu, B.-H. Fan, S.-Q. Zhuang, H. Ding and Q.-Y. Xue. 1995. The Late Paleozoic Stratigraphic Classification, Correlation and Biota from Eastern Hill of Taiyuan City, Shanxi Province. Jilin University Press, Changchun, 149 pp.**

Heritsche, F. 1935. Neue Versteinerungen aus den Nassfeldschichten der Karnischen Alpen. Sitzungsberichten der Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Klasse, Abteilung 1 144: 349–375.

Heritsche, F. 1938. Die stratigraphische Stellung des Trogkofelkalkes. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Abteilung 79: 63–186.

Hill, D. 1950. The Productinae of the Artinskian Cracow fauna of Queensland. Papers of the Department of Geology,

University of Queensland 3: 1–36.

Hirokawa, O., and T. Yoshida. 1954. Explanatory Text of the Geological Map of Japan, Scale 1:50,000, Hitokabe. Geological Survey of Japan, Kawasaki, 33 pp.*

Howse, R. 1848. A catalogue of the fossils of the Permian System of the counties of Northumberland and Durham. Tyneside Naturalists' Field Club, Transactions 1: 219–264.

Hu, S.-Z. 1983. Discovery of *Cryptospirifer* in Xiushui Jiangxi Province, and its stratigraphic significance. Bulletin of the Nanjing Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences 4: 115–124.**

Huang, T.-K. 1932. Late Permian Brachiopoda of southwestern China. Palaeontologia Sinica, Series B 9 (1): 1–139.

Huang, T.-K. 1933. Late Permian Brachiopoda of southwestern China , Part 2. Palaeontologia Sinica, Series B 9 (2): 1–172.

Huang, T.-K. 1936. On the occurrence of *Lyttonia* in the Wolfcamp Series of the Glass Mountains of Texas with notes on lyttonids from southwestern China. Bulletin of the Geological Society of China 15: 489–493.

Ifanova, V. V. 1972. Permian brachiopods of the Pechora Basin; 72–161 *in* Ifanova, V. V. and E. G. Semenova, Middle Carboniferous and Permian brachiopods from east and north of the European part of the USSR. Nauka, Moskva.***

Ishida, N., F. Toyohara and M. Murata. 2010. Guadalupian age of the Mizukoshi Formation, western Kyushu, Japan, based on radiolarians. Journal of the Geological Society of Japan 116: 55–59.

Ivanova, E. A. 1972. Main features of spiriferid evolution (Brachiopoda). Paleontologicheskiy Zhurnal, 1922 3: 28–42.***

Jimbo, Y. 1966. Trilobite from the Middle Permian Kanokura Series. Journal of the Geological Society of Japan 72: 593–594.*

Jin, X.-C., and L.-P. Zhan. 2008. Spatial and temporal distribution of the *Cryptospirifer* fauna (Middle Permian brachiopods) in the Tethyan Realm and its paleogeographic implications. Acta Geologica Sinica 82: 1–16.

Jin, Y.-G. 1963. *Urushtenia* from the Lower Permian of China. Acta Palaeontologica Sinica 11: 2–31.**

Jin, Y.-G. 1985. Permian Brachiopoda and palaeogeography of the Qinghai –Xizang (Tibet) Plateau. Palaeontologia Cathayana 2: 19–71.

Jin, Y.-G., and S.-Z. Hu, 1978. Brachiopods of the Kuhfeng Formation in South Anhui and Nanking Hills. Acta Palaeontologica Sinica 17: 101–127.**

Jin, Y.-G., Z.-T. Liao and B.-X. Fang. 1974. Descriptions of Fossils; Permian Brachiopoda; pp. 308–313 *in* Nanjing Institute of Geology and Palaeontology, Chinese Academy of Science (ed.), Handbook of Stratigraphy and Palaeontology in Southwest China. Science Press, Beijing.**

Jin, Y.-G., B. R. Wardlaw, B. F. Glenister and G. V. Kotlyar. 1997. Permian chronostratigraphic subdivisions. Episodes 20: 10–15.

Jin, Y.-G., Y. Wang, D.-L. Sun and Q. Shi. 1985. Late Palaeozoic and Triassic brachiopods from the east of the Qinghai–Xizang Plateau; pp. 182–237 in Regional Geological Surveying Team of Sichuan Province and Nanjing Institute of Geology and Palaeontology, Academia Sinica (eds.), Stratigraphy and Palaeontology in W. Sichuan and E. Xizang, China, Part 3. Sichuan Science and Technology Publishing House, Chengdu.**

Jin, Y.-G., S.-L. Ye, H.-K. Xu and D.-L. Sun. 1979. Phylum Brachiopoda; pp. 60–217 *in* Nanjing Institute of Geology and Palaeontology and Qinghai Institute of Geological Sciences (eds.), Palaeontological Atlas of Northwest China ; Qinghai, Part 1. Geological Publishing House, Beijing.**

Kaesler, R. L. (ed.). 2000a. Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 2: Linguliformea, Craniiformea, and Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence. 423 pp. (1–423).

Kaesler, R. L. (ed.). 2000b. Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 3: Linguliformea, Craniiformea, and Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence. 496 pp. (424–919).

Kaesler, R. L. (ed.). 2002. Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 4: Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence. 768 pp. (921–1688).

Kaesler, R. L. (ed.). 2006. Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 5: Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence. 632 pp. (1689–2320).

Kalashnikov, N. V. 1980. Brachiopods of the Upper Palaeozoic of European Siberia, USSR. Nauka, Leningrad, 132 pp.***

Kalashnikov, N. V. 1986. Systematic descriptions; Brachiopoda; pp. 89–94 *in* V. P. Gorsky and M. A. Kalmykova (eds.), Atlas of characteristic Permian Fauna and Flora of the Urals and Russian Platform. Trudy VSEGEI, Vol. 331, Nedra, Leningrad.***

Kalashnikov, N. V. 1993. Permian Brachiopods of the Northern European Russia. Nauka, Sankt-Peterburg, 114 pp.***

Kambe, N., and M. Shimazu. 1961. Explanatory Text of the Geologic Map of Japan, Scale 1: 50,000, Kesennuma. Geological Survey of Japan, Kawasaki, 73 pp.*

Kanomata, N., and T. Chisaka. 1967. Studies on the Upper Permian fusulinids from Kiritoshi near Obayashi Village, Kesennuma City, south-eastern part of the Kitakami Mountainland. Professor H. Shibata Memorial Volume, 407–414.

Kanomata, N., and A. Miyawaki. 1967. On the fusulinids at Kamiyatsuse district in Kesennuma City, Miyagi Prefecture, Northeast Japan. Journal of the College of Arts and Sciences, Chiba University 5: 159–165.

Kaschirtzev, A. S. 1959. Field Atlas of the Fauna from the Permian of the Northeastern USSR. Akademii Nauk SSSR, Moskva, 85 pp.***

Kato, M., K. Takeuchi, A. Hendarsyah and D. Sundari. 1999. On the occurrence of the Permian brachiopod genus *Leptodus* in Timor. Geological Research and Development Centre, Bandong, Paleontology Series 9: 42–51.

Kawamura, T., T. Uchino, M. Kawamura, K. Yoshida, M. Nakagawa and H. Nagata, 2013. Geology of Hayachine San District. Quadrangle Series, 1:50, 000, Akita (6) No. 24. Geological Survey of Japan, AIST, Tsukuba, 101 pp.*

Kayser, E. 1883. Obercarbonische Fauna von Lo-ping; pp. 160–208 *in* F. von Richthofen (ed.), China, Vierter Band. Palaeontologischen Theil. D. Reimer, Berlin.

Keidel, H. 1906. Geologische Untersuchungen im südlicher Tian-Schan nebst Beschreibung einer obercarbonischen Brachiopoden-fauna aus dem Kukurtuk-Tal. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie 22: 266–284.

Keyserling, A. 1846. Geognostische Beobachtungen; pp. 151–406 *in* P. von Krusenstein and A. von Keyserling (eds.), Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land. Carl Kray, St. Petersburg.

Keyserling, A. 1853. Sur les fossiles du calcaire Carbonifére de Sterlitemak (Russie). Bulletin de la Sociéte Géologique de France, 2e Serie 10: 242–254.

King, R. E. 1931. The geology of the Glass Mountains, Texas, Part 2: Faunal summary and correlation of the Permian formations with description of Brachiopoda. University of Texas Bulletin 3042: 1–245.

King, W. 1846. Remarks on certain genera belonging to the class Palliobranchiata. Annals and Magazine of Natural History, London 18: 26–42 and 83–94.

King, W. 1850. A Monograph of the Permian Fossils of England. Palaeontological Society Monograph 3, London, 258 pp.

King, W. 1859. On *Gwynia*, *Dielasma*, and *Macandrevia*, three new genera of Palliobranchiata Mollusca, one of which has been dredged in Strangford Lough. Dublin University Zoological and Botanical Association, Proceedings 1: 256–262.

King, W. 1865. Remarks on the histology of two specimens of *Rhynchopora geinitziana* de Verneuil, from near the River Oukhla, Province of Archangel, and belonging to the collection of the Corps des Mines of St. Petersburg. Annals and Magazine of Natural History, Series 3 16: 124–128.

Klets, A. G. 2005. Upper Paleozoic of Marginal Seas of Angarida. Academic Publishing House "Geo", Novosibirsk, 239 pp.***

Kobayashi, F., Y. Shiino and Y. Suzuki. 2009. Middle Permian (Midian) foraminifers of the Kamiyasse Formation in the Southern Kitakami Terrane, NE Japan. Paleontological Research 13: 79–99.

Kobayashi, T., and T. Hamada. 1984. Permian trilobites of Japan in comparison with Asian, Pacific and other faunas. Palaeontological Society of Japan Special Papers 26: 1–92.

Kobiyama, M. 1956. On the age of the Takakurayama Formation. Bulletin of the Taira Chigaku Dokokai 3: 7–10.*

Koczyrkevicz, B. V. 1979a. New species of *Rhynchopora* (Brachiopoda) from South Primorye and some problems on the morphology; pp. 41–49 *in* M. N. Gramm (ed.), Invertebrate Fossils from the Far East Russia. DVNTS, Vladivostok.***

Koczyrkevicz, B. V. 1979b. Permian Stenoschismatacea (Brachiopoda) from South Primorye; pp. 50–59 in M. N. Gramm (ed.), Invertebrate Fossils from the Far East Russia. DVNTS, Vladivostok.***

Koizumi, H. 1979. Permian brachiopods from Takakura-yama Formation and its geological age, N. E. Japan. Bulletin of the Taira Chigaku Dokokai, Special Volume: 1–2.*

Koizumi, H., and K. Sasaki. 1978. On the occurrence of Permian trilobites from Omote-Matsukawa and Myougasawa, Kesennuma City, Miyagi Prefecture, Northeast Japan. Chigaku Kenkyu 29: 297–311.*

de Koninck, L. 1847, Recherches sur les Animaux Fossiles, Part 1. Monographie des genres *Productus* et *Chonetes*. H. Dessain, Liège, 246 pp.

Kotlyar, G. V. 1961. Genus *Yakovlevia* Fredericks. Doklady, Akademii Nauk SSSR 140: 459–461.***

Kotlyar, G. V. 1989: Palaeontological description; brachiopods; pp. 117–125 *in* Kotlyar, G. V. and Yu. D. Zakharov (eds.), Evolution of the Latest Permian Biota; Midian Regional Stage in the USSR. Nauka, Leningrad.***

Kotlyar, G. V., Yu. D. Zakharov and I. V. Polubotko. 2004. Late Changhsingian fauna of the northwestern Caucasus Mountains, Russia. Journal of Paleontology 78: 513–527.

Kozlowski, R. 1914. Les brachiopodes du Carbonifère supérieur de Bolivie. Annales de Paléontologie 9: 1–100.

Kuhn, O. 1949. Lehrbuch der Paläozoologie. E. Schweizerbart, Stuttgart, 326 pp.

Kulikov, M. V. 1974. Brachiopods from the Kungurian Stage of the Urals; pp. 77–123 *in* G. N. Papulov and B. I. Chuvashov (eds.), Algae, Brachiopod and Miospore from the Permian Deposits of the Western Urals. UNTS AN SSSR, Sverdlovsk.***

Kutorga, S. S. 1842. Beitrag zu Paläontologie Russlands. Russisch-Kaiserliche Mineralogische Geselschaft zu St. Petersbourg, Verhandlungen 1842: 1–34.

Kutorga, S. S. 1844. Zweiter Beitrag zur Paleontologie Russlands. Russisch-Kaiserliche Mineralogische Gesellschaft zu St. Petersbourg, Verhandlungen 1844: 62 –104.

Lapina, N. N. 1957. Brachiopods of the Carboniferous deposits of the Perm region, Priurals. Trudy VNIGRI 108: 1–132.***

Lee, L., and C.-H. Duan. 1985. Phylum Brachiopoda; 209–260 *in* Tianjin Institute of Geology and Mineral Resources (ed.), Palaeontological Atlas of North China, Part 1. Palaeozoic Volume. Geological Publishing House, Beijing.**

Lee, L., and F. Gu, 1976. Carboniferous and Permian Brachiopoda; pp. 228–306 *in* Geological Bureau of Nei Mongol and Geological Institute of Northeast China (eds.), Palaeontological Atlas of Northeast China; Nei Mongol, Part 1. Palaeozoic Volume. Geological Publishing House, Beijing.**

Lee, L., and F. Gu. 1980. Late Carboniferous brachiopods from

Yanji of Jilin, NE China. Acta Palaeontologica Sinica 19: 483–491.**

Lee, L., F. Gu and Y.-Z. Su. 1980. Carboniferous and Permian Brachiopoda; pp. 327–428 in Shenyang Institute of Geology and Mineral Resources (ed.), Paleontological Atlas of Northeast China (1) Paleozoic Volume. Geological Publishing House, Beijing.**

Leman, M. S. 1994. The significance of Upper Permian brachiopods from Merapoh area, northern Pahang. Geological Society of Malaysia, Bulletin 15: 113 –121.

Léveilé, C. 1835. Aperçu géologique de quelques localités très riches en conquilles sur les frontières de France et de Belgique. Memoires de la Société Géologique de la France 2: 29–40.

Li, W.-Z., and S.-Z. Shen. 2008. Lopingian (late Permian) brachiopods around the Wuchiapingian–Changhsingian boundary at the Meishan Section C and D, Changxing, South China. Geobios 41: 307–320.

Li, Y., and M. Takeuchi. 2022. U-Pb dating of detrital zircon from Permian successions of the South Kitakami Belt, Northeast Japan: Clues to the paleogeography of the belt. The Island Arc 31: e12435.

Liang, W.-P. 1990. Lengwu Formation of Permian and its Brachiopod Fauna in Zhejiang Province. Geological Memoir 10, Ministry of Geology and Mineral Resources, People's Republic of China, Geological Publishing House, Beijing, 522 pp.**

Liao, Z.-T. 1979. Brachiopod assemblage zone of Changhsing Stage and brachiopods from Permo-Triassic boundary beds in China. Acta Stratigraphica Sinica 3: 200–207.**

Liao, Z.-T. 1980. Upper Permian brachiopods from western Guizhou; pp. 241–277 in Nanjing Institute of Geology and Palaeontology, Academia Sinica (ed.), Stratigraphy and Palaeontology of the Upper Permian Coal-bearing Formation in Western Guizhou and Eastern Yunnan. Science Press, Beijing.**

Liao, Z.-T. 1987. Paleoecological characters and stratigraphic significance of silicified brachiopods of the Upper Permian from Heshan, Laibin, Guangxi; pp. 81–125 *in* Nanjing Institute of Geology and Palaeontology, Academia Sinica (ed.), Stratigraphy and Palaeontology of Systematic Boundaries in Chnna: Permian–Triassic Boundary (1). Nanjing University Press, Nanjing.**

Liao, Z.-T., and F.-Y. Meng. 1986. Late Chanxsingian brachiopods from Huatang of Chen Xian County, southern Hunan. Memoirs of Nanjing Institute of Geology and Palaeontology, Academia Sinica 22: 71–94.**

Liao, Z.-T., and J.-T. Xu, 2002. Late Permian brachiopods from the lower part of the Wuli Group, southwestern Qinghai and the geographic distribution of *Waagenites*. Acta Palaeontologica Sinica 41: 130–136.**

Licharew, B. K. 1928. Über einige seltene und neue Brachiopoden aus dem Unterperm des mördlichen Kaukasus. Paläeontologische Zeitchrift 10: 258–289.

Licharew, B. K. 1932a. Fanua of the Permian deposits of northern Caucasus, 1. Brachiopoda subfamily Orthotetinae Waagen. Trudy Vsesoyuznogo Geologo-Razvedochnogo Obedineniya NKTP SSSR 215: 1–54.***

Licharew, B. K. 1932b. Fanua of the Permian deposits of northern Caucasus, 2. Brachiopoda family Lyttoniidae Waagen. Vsesoyuznogo Geologo-Razvedochnogo Obedineniya NKTP SSSR 215: 55–111.***

Licharew, B. K. 1939. Class Brachiopoda; pp. 79–113 *in* I. I. Gorsky (ed.), The Atlas of the Leading Forms of the Fossil Faunas of USSR, Volume 5. The Middle and Upper Carboniferous. GONTI, Leningrad.***

Licharew, B. K., and O. L. Einor. 1939. Contribution to the knowledge of the Upper Palaeozoic Fauna of Novaya Zemlya, Brachiopoda. Trudy Arkticheskogo Nauchno-Issledovatelskogo Instituta 127: 1–245.***

Licharew, B. K., and G. V. Kotlyar. 1978. Permian brachiopods from South Primorye; pp. 63 – 75 *in* L. I. Popeko (ed.), Upper Palaeozoic of northastern Asia. Dalnevostochny Nauchny Tsentra, Akademiya Nauk SSSR, Vladibostok.***

Liu, F., and J. B. Waterhouse. 1985. Permian strata and brachiopods from Xiujimqinqi region on Neimongol (Inner Mongolia) Autonomous Region, China. Papers, Department of Geology, University of Queensland 11: 1–44.

Liu, Z.-H., Z.-X. Tan and Y.-L. Ding. 1982. Phylum Brachiopoda; pp. 172 –216 *in* Geological Bureau of Hunan (ed.), The Palaeontological Atlas of Hunan. Geological Publishing House, Beijing.**

Malkowski, K. 1988. Paleoecology of Productacea (Brachiopoda) from the Permian Kapp Starostin Formation, Spitsbergen. Polish Polar Research 9: 3 –60.

Manankov, I. N. 1973. Revision of the genera *Orthotetes* and *Derbyia* (Brachiopoda). Paleontologicheskiy Zhurnal 1973 (2): 52–60.***

Manankov, I. N. 1979. Strophomenids of the Late Paleozoic of Siberia and the Arctic. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 171: 1–101.***

Manankov, I. N. 1991. Systematical part; Family Buxtoniidae; pp. 108–114 *in* L. P. Tatarinov, B. Luvsandansan, G. A. Afanasjeva, R. Barsbold, I. P. Morozova, L. I. Novitskaja, A. P. Rasnitsyn, V. Yu. Reschetov, A. Yu. Posanov, V. A. Sysoev and B. A. Trofimov. (eds.), Invertebrates of Southern Mongolia: The Joint Soviet–Mongolian Paleontological Expedition (Transactions, Vol. 40). Nauka, Moskva.***

Manankov, I. N. 1998. Late Permian Productida (Brachiopoda) from southern Mongolia. Paleontologicheskiy Zhurnal 1998-5; 49–55.***

Mansuy, H. 1913. Faunes des Calcaires à *Productus* de l'Indochine, Première Série. Memoires du Service Géologique de l' Indochine 2: 1–133.

Mansuy, H. 1914. Faunes des Calcaires a *Productus* de l'Indochine, Deuxième Série. Memoires du Service Géologique de l'Indochine 3: 1–59.

Marcou, J. 1858. Geology of North America, with Two Reports on the Prairies of Arkansas and Texas, the Rocky Mountains of New Mexica and the Sierra Nevada of California. Züricher

and Furrer, Zürich, 144 pp.

Mashiko, K. 1934. Discovery of *Lyttonia* in a limestone exposed at Takauti, Nakayakuno-mura, Amada-gun, Kyoto Prefecture. Japanese Journal of Geology and Geography 11: 181–183.

Masunaga, M., and Y. Shiino. 2021. Death or living assemblage? The middle Permian discinid brachiopods in the Kamiyasse area, southern Kitakami Mountains, northeastern Japan. Paleontological Research 25: 258–278.

M'Coy, F. 1844. A Synopsis of the Characters of the Carboniferous Limestone of Ireland. Williams and Norgate, London, 207 pp.

Meek, F. B. 1877. Palaeontology. United States Geological Exploration of the 40th Parallel by Clarence King 4: 1–197.

Meek, F. B., and A. H. Worthen, 1870. Descriptions of new species and genera of fossils from the Paleozoic rocks of the western states. Academy of Natural Sciences of Philadelphia, Proceedings, Series 2 22: 22–56.

Miloradovich, B. V. 1935. Materials for the study of the Upper Paleozoic Brachiopoda from the Northern Island of Novaya Zemlya. Trudy Arkticheskogo Instituta 19: 1–167.***

Minato, M. 1942. Unconformity of the Pre-Sakamotozawa Stage (Pre-Sakmarian) in the Kitakami Mountainland, Northeast Japan. Journal of the Geological Society of Japan 49: 47–72.*

Minato, M. 1955. *Isogramma paotechowensis* (Grabau et Chao) from the Permian of Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 18: 29–30.

Minato, M., S. Hashimoto, K. Suyama, H. Takeda, Y. Suzuki, S. Kimura, K. Yamada, T. Kakimi, T. Ichikawa and H. Suetomi. 1954. Zur Biostratigraphie der permischen Formation des Setamai-Geländes in Süd-Kitakami Gebirge (Stratigraphische und tektonische Untersuchungen des Japanischen Paläozoikums, Teil 9). Journal of the Geological Society of Japan 60: 378–387.*

Minato, M., M. Hunahashi, J. Watanabe and M. Kato (eds.). 1979. Variscan Geohistory of Northern Japan: Abean Orogeny. Tokai University Press, Tokyo, 427 pp.

Minato, M., M. Kato, K. Nakamura, Y. Hasegawa, D. R. Choi and J. Tazawa. 1978. Biostratigraphy and correlation of the Permian of Japan. Journal of the Faculty of Science, Hokkaido University, Series 4 18: 11–47.

Minato, M., and K. Nakamura. 1956. On four brachiopod species of the subfamily Orthotetinae from the Kanokura Series of the Kitakami Mountains, Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 21: 149–155.

Mironova, M. G. 1967. Late Carboniferous brachiopods from Bashkirii. Leningradskogo Universiteta, Leningrad, 63 pp.***

Misaki, A., and M. Ehiro, 2004. Stratigraphy and geologic age of the Middle Permian in the Kamiyasse–Imo district, Southern Kitakami Massif, Northeast Japan. Journal of the Geological Society of Japan 110: 129–145.*

Moore, R. C. 1952. Brachiopoda; pp. 197–267 *in* R. C. Moore, C. G. Lalicker and A. G. Fischer, Invertebrate Fossils. McGrew-Hill, New York.

Morikawa, R. 1953. Fusulinids from the Kitakami Mountainous Land. Journal of the Geological Society of Japan 59: 149–159.*

Mou, C.-J., and C.-L. Liu 1989. A new type of brachiopods–*Guangdongina* and its ecological environment. Acta Palaeontologica Sinica 28: 455–462. **

Muir-Wood, H. M. 1955. A History of the Classification of the Phylum Brachiopoda. British Museum (Natural History), London, 124 pp.

Muir-Wood, H. M. 1962. On the Morphology and Classification of the Brachiopod Suborder Chonetoidea. British Museum (Natural History), London, 132 pp.

Muir-Wood, H. M., and G. A. Cooper. 1960. Morphology, classification and life habits of the Productoidea (Brachiopoda). Geological Society of America, Memoir 81: 1–447.

Muir-Wood, H. M., and K. P. Oakley. 1941. Upper Palaeozoic faunas of North Sikkim. Palaeontologia Indica, New Series 31: 1–91.

Muir-Wood, H. M., and A. Williams. 1965. Strophomenida; pp. 361–521 *in* R. C. Moore (ed.), Treatise on Invertebrate Paleontology, Part H Brachiopoda, Volume 1. Geological Society of America, New York and University of Kansas Press, Lawrence.

Murata, M. 1964. Some middle Permian Aviculopectinidae from the Kitakami Massif, Northeast Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 54: 215–233.

Murata, M. 1967. Some Permian Conulariidae from the Kitakami Masssif, Northeast Japan. Saito Ho-on Kai Museum Research Bulletin 36: 9–18.

Nakamura, K. 1959a. Some Lower Permian Sakamotozawa brachiopods. Journal of the Faculty of Science, Hokkaido University, Series 4 10: 199–207.

Nakamura, K. 1959b. *Spinomarginifera* found in Japanese Permian. Transactions and Proceedings of the Palaeontological Sosiety of Japan, New Series 35: 143 –146.

Nakamura, K. 1960. *Dictyoclostus* derived from the middle Permian Kanokura Series and the lower Permian Sakamotozawa Series of the Kitakami Mountains, Japan. Journal of the Faculty of Science, Hokkaido University, Series 4 10: 495 –511.

Nakamura, K. 1970. *Isogramma* from the Permian Kanokura Series of the Kitakami Mountains, Japan. Journal of the Faculty of Science, Hokkaido University, Series 4 14: 301–311.

Nakamura, K. 1972. Permian Davidsoniacea from the southern Kitakami Mountains, Japan. Journal of the Faculty of Science, Hokkaido University, Series 4 15: 361–425.

Nakamura, K. 1979. Additional occurrences of *Urushtenoidea* (Brachiopoda) from the Permian of Asia. Journal of the Faculty of Science, Hokkaido University, Series 4 19: 221–233.

Nakamura, K., M. Kato and D. R. Choi. 1970. On *Permundaria*, a new genus of the brachiopod family Linoproductidae. Journal of the Faculty of Science, Hokkaido University,

Series 4 14: 293–299.

Nakamura, K., D. Shimizu and F. Golshani. 1981. On the occurrence of *Tyloplecta* in the Permian of the Abadeh region, Central Iran. Geological Survey of Iran, Report 49: 39–53.

Nakamura, K., and J. Tazawa. 1990. Faunal provinciality of the Permian brachiopods in Japan; pp. 313–320 *in* Ichikawa, K., S. Mizutani, I. Hara, S. Hada and A. Yao (eds.), Pre-Cretaceous Terranes of Japan. Nippon Insatsu Shuppan, Osaka.

Nakamura, K., J. Tazawa and F. Kumon. 1992. Permian brachiopods of the Kapp Starostin Formation, West Spitsbergen; pp. 77 – 95 *in* K. Nakamura (ed.), Investigations on the Upper Carboniferous–Upper Permian Succession of West Sitsbergen, 1989–1991. Hokkaido University Press, Sapporo.

Nakazawa, K., and N. D. Newell. 1968. Permian bivalves of Japan. Memoirs of the Faculty of Science, Kyoto University, Series of Geology and Mineralogy 35: 1–108.

Netschajew, A. W. 1911. Die Fauna der Perm-Ablagerungen vom Osten und vom Aeussersten Norden des Europaeischen Russlands. Trudy Geologicheskago Komiteta, Novaya Seriya 61: 1–161.***

Noda, M. 1951. A Lower Permian fauna from North Manchuria. Journal of the Geological Society of Japan 57: 45–50.

Noda, M. 1956. Stratigraphical and palaeontological studies of the Toman Formation in the Kaishantun and Kamisanbo districts. Reports on Earth Science, Department of General Education, Kyushu University 2: 1–22.

Noetling, F. 1904. Über den Bau und die Organisation der Lyttoniidae Waagen. Verhandlungen der Deutschen Zoologischen Gesellschaft 1904: 103–122.

Noetling, F. 1905. Untersuchungen die Familie Lyttoniidae Waagen emend. Noetling. Palaeontographica 51: 129–154.

Nonaka, J. 1944. Some Permian brachiopods from Inner Mongolia. Japanese Journal of Geology and Geography 19: 83–87.

Oehlert, D. P. 1887. Appendice sur les brachiopodes; pp. 189–1334 *in* P. Fischer, Manuel de Conchyliologie et de Paléontogie conchyliologique ou Histoire naturelle des Mollusques vivants et fossiles, Vol. 4, Part 11. Librairie F. Savy, Paris.

Oehlert, D. P. 1890. Note sur différents groups établic dans le genre *Orthis* et en particulier sur *Rhipidomella* Oehlert (= *Rhipidomys* Oehlert, olim). Journal de Conchyliologie 30: 366–374.

Onuki, Y. 1938. On the Chichibu System of the Kesen-gun district, Iwate Prefecture. Journal of the Geological Society of Japan 45: 48–78.*

Onuki, Y. 1956. Geology of the Kitakami Massif; pp. 1–189 *in* Iwate Prefecture (ed.), Explanation Text of Iwate Prefecture. Sasaki Shuppan, Sendai.*

Onuki, Y. 1969. Geology of the Kitakami Massif, Northeast Japan. Contributions from the Institute of Geology and Paleontology, Tohoku University 69: 1 –239.*

d'Orbigny, A. 1842. Voyage dans l'Amérique Méridionale. Géologie, Paléontologie; Foraminifères 3: 50–56.

d'Orbigny, A. 1847. Considérations zoologiques et géologiques sur les Brachiopodes ou Palliobranches. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences 25: 193–195 and 266–269.

Ozaki, K. 1931. Upper Carboniferous brachiopods from North China. Bulletin of the Shanghai Science Institute 1: 1–205.

Pavlova, E. E. 1965. Revision of the genus *Neophricodothyris* (Order Spiriferida). Palaeontologicheskiy Zhurnal 1965 (2): 133–137.***

Pavlova, E. E. 1969. The development of brachiopods of the family Reticulariidae. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 120: 1–130.***

Pečar, J. 1986. Upper Carboniferous and Permian mesolobid chonetacean brachiopods of Karavanke Mountains (Yugoslavia) and Carnian Alps (Italy). Geologija 28/29: 9–53.

Pitakpaivan, K., R. Ingavat and P. Pariwatvorn. 1969. Fossils of Thailand. Thailand Geological Survey Memoir 3: 1–26.

Prendergast, K. L. 1935. Some western Australian Upper Palaeozoic fossils. Journal of the Royal Society of Western Australia 21: 9–35.

Ramovs, A. 1958. Razvoj zgorniega perma v Loških in Polhograjskih hribih. Razprave, Slovenska Akademija Znanosti in Umetnosti 4: 451–622.

Ramovs, A. 1965. Razvoj Mlajšega Paleozoika v Okolici Ortneka na Dolenjskem. Sloveniska Akademija Znanosti in Umetnosti, Lyubljana, 416 pp.

Reed, F. R. C. 1925. Upper Carboniferous fossils from Chitral and the Pamirs. Palaeontologia Indica, New Series 6: 1–134.

Reed, F. R. C. 1944. Brachiopoda and Mollusca from the Productus Limestone of the Salt Range. Palaeontologia Indica, New Series 23: 1–596.

Ruzhentsev, V. E., and T. G. Sarytcheva. 1965. The Development and Change of Marine Organisms at the Palaeozoic – Mesozoic Boundary. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 108: 1–432.***

Saito, Y. 1966. Geology of the Setamai district, Southern Kitakami Massif, Northeast Japan. Contributions from the Institute of Geology and Paleontology, Tohoku University 62: 55–67.*

Saito, Y. 1968. Geology of the Younger Paleozoic System of the Southern Kitakami Massif, Iwate Prefecture, Japan. Science Reports of the Tohoku University, Sendai, Japan, Second Series (Geology) 40: 79–139.

Sakagami, S. 1961. Japanese Permian Bryozoa. Palaeontological Society of Japan, Special Papers 7: 1–58.

Samtleben, C. 1971. Zur Kenntnis der Produktiden und Spiriferiden des bolivianischen Unterperms. Beihefte zum Geologischen Jahrbuch 111: 1–163.

Sarytcheva, T. G. 1964. Oldhaminoid brachiopods from the Permian of Trans-Caucasia. Paleontologicheskiy Zhurnal 1964 (3): 58–72.***

Sarytcheva, T. G. (ed.). 1977. Late Palaeozoic Productida of

Siberia and arctic regions. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 161: 1–220.***

Sarytcheva, T. G., and A. N. Sokolskaya. 1952. Description of the Palaeozoic Brachiopoda of the Moscow Basin. Trudy Paleontologicheskogo Instituta, Akadamiya Nauk SSSR 38: 1–307.***

Sarytcheva, T. G., and A. N. Sokolskaya. 1959. On the classification of pseudopunctate brachiopods. Doklady, Akademii Nauk SSSR 125: 181–184.***

Sarytcheva, T. G., and A. N. Sokolskaya. 1965. Order Productida; pp. 205–232 *in* V. E. Ruzhentsev and T. G. Sarytcheva (eds.), The Development and Change of Marine Organisms at the Palaeozoic–Mesozoic Boundary. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR 108.***

Schellwien, E. 1892. Die Fauna des karnischen Fusulinenkalks. Palaeontographica 39: 1–56.

Schellwien, E. 1900a. Beitrage zur Systematik der Strophomeniden des Oberen Palaeozoicum. Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie 1: 1–15.

Schellwien, E. 1900b. Die Fauna der Trogkofelschichten in den Karnischen Alpen und den Karawanken, 1 Theil: Die Brachiopoden. Abhandlungen der KaiserlichKöniglichen Geologischen Reichsanstalt 16: 1–122.

von Schlotheim, E. F. 1816. Beitrage zur Naturgeschichte der Versteinerungen in geognostischer Hinsicht. Akademi Wissenschaften München Mathematische-physike Klasse Denkschriften 6: 13–36.

Schréter, Z. 1963. A Bükkhegység felsö-permi brachiopodai. Geologica Hangarica, Series Palaeontologica 28: 1–181.

Schuchert, C. 1893. Classification of the Brachiopoda. American Geologist 11: 141–167.

Schuchert, C. 1913. Class Brachiopoda; pp. 290–449 *in* C. Schuchert, C. K., Swartz, T. P. Maynard and R. B. Rowe, The Lower Devonian Deposits of Maryland. Maryland Geological Survey, Baltimore.

Schuchert, C. 1929. Classification of brachiopod genera, fossil and recent; pp. 10–25 *in* J. F. Pompeckj (ed.), Fossilium Catalogus, Vol. 1. W. Junk, Berlin.

Schuchert, C., and G. A. Cooper. 1932. Brachiopod genera of the suborder Orthoidea and Pentameroidea. Memoirs of the Peabody Museum of Natural History 4: 1–270.

Schuchert, C., and C. M. LeVene. 1929. Brachiopoda (generum et genotyporum index et bibliographia); 140 pp. *in* J. E. Pompeckj (ed.), Fossilium Catalogus, Vol. 1. Animaria, Pars 42, W. Junk, Berlin.

Scotese, C. R. 2004. A continental drift flipbook. Journal of Geology 112 : 729–774.

Selden, P. A. (ed.). 2007. Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 6: Supplement. Geological Society of America, Boulder and University of Kansas, Lawrence, 906 pp. (2321–3226).

Sergunkova, O. I., and O. R. Zhizhilo. 1975. Brachiopods of the Lower and Upper Carboniferous and the Lower Permian of Southern Fergana; pp. 54–77 in R. I. Khodanovich (ed.), Biostratigraphy of the Upper Paleozoic of the Marginal Mountains, Southern Fergana. Izdatelstvo FAN, Tashkent.***

Shen, S.-Z., and N. W. Archbold. 2002. Chonetoidea (Brachiopoda) from the Lopingian (Late Permian) of South China. Alcheringa 25: 327–349.

Shen, S.-Z., N. W. Archbold, G.-R. Shi and Z.-Q. Chen. 2000. Permian brachiopods from the Selong Xishan section, Xizang (Tibet), China. Part 1: Stratigraphy, Strophomenida, Productida and Rhynchonellida. Geobios 33: 725 –752.

Shen, S.-Z., and M. E. Clapham. 2009. Wuchiapingian (Lopingian, Late Permian) brachiopods from the Episkopi Formation of Hydra Island, Greece. Palaeontology 52: 713–743.

Shen, S.-Z., B.-H. Fan, C. Zhang and X.-P. Zhang. 1994. A new species of Permianellids (Brachiopoda): Taxonomic and palaeoecologic significance. Geobios 27: 477–485.

Shen, S.-Z., X.-L. He and M.-L. Zhu. 1992. Changhsingian brachiopods from Zhongliang Hill of Chongqing, Sichuan Province; pp. 171–196 and 214–218 *in* Editorial Committee of Stratigraphy and Palaeontology of Oil and Gas Bearing Areas in China (ed.), The Symposium on Stratigraphy and Palaeontology of Oil and Gas Bearing Areas in China (3). Petroleum Industry Press, Beijing.**

Shen, S.-Z., Y.-G. Jin, Y. Zhang and A. W. Weldon. 2017. Permian brachiopod genera on type species of China; pp. 651–881 in J.-Y. Rong, Y.-G. Jin, S.-Z. Shen and R.-B. Zhan (eds.) Phanerozoic Brachiopod Genera of China. Science Press, Beijing.

Shen, S.-Z., and G. R. Shi. 2007. Lopingian (Late Permian) brachiopods from South China, Part 1: Orthotetida, Orthida and Rhynchonellida. Bulletin of the Tohoku University Museum 6: 1–102.

Shen S.-Z., and G. R. Shi. 2009. Latest Guadalupian brachiopods from the Guadalupian/Lopingian boundary GSSP section at Penglaitan in Laibin, Guangxi, South China and implications for the timing of the pre -Lopingian crisis. Palaeoworld 18: 152–161.

Shen, S.-Z., G. R. Shi and N. W. Archbold. 2003a. A Wuchiapingian (Late Permian) brachiopod fauna from an exotic block in the Indus –Tsangpo Suture Zone, southern Tibet, and its palaeobiogeographical and tectonic implications. Palaeontology 46: 225–256.

Shen, S.-Z., G. R. Shi and N. W. Archbold. 2003b. Lopingian (Late Permian) brachiopods from the Qubuerga Formation at the Qubu section in the Mt. Qomolangma region, southern Tibet (Xizang), China. Palaeontographica, Abteilung A 268: 49–101.

Shen, S.-Z., G. R. Shi and Z.-J. Fang. 2002. Permian brachiopods from the Baoshan and Simao Blocks in western Yunnan, China. Journal of Asian Earth Sciences 20: 665–682.

Shen, S.-Z., D.-L. Sun and G. R. Shi. 2003c. A biogeographically mixed late Guadalupian (late Middle Permian) brachiopod fauna from an exotic limestone block at Xiukang in Lhaze county, Tibet. Journal of Asian Earth Sciences 21: 1125–1137.

Shen, S.-Z., T.-R. Sun, Y.-C. Zhang and D.-X. Yuan. 2016. An upper Kungurian/lower Guadalupian (Permian) brachiopod fauna from south Qiangtang Block in Tibet and its palaeobiogeographical implications. Palaeoworld 25: 519–538.

Shen, S.-Z., and J. Tazawa. 1997. Two permianellids (Brachiopoda) from the Middle Permian of the southern Kitakami Mountains, northeast Japan. Paleontological Research 1: 285–290.

Shen, S.-Z., and J. Tazawa. 2014. *Pararigbyella* and *Dicystoconcha* (Lyttoniidina, Brachiopoda) from the middle Permian (Wordian) of Japan. Paleontological Research 18: 245–249.

Shen, S.-Z., J. Tazawa and Y. Miyake. 2011. A Kungurian (Early Permian) Panthalassan brachiopod fauna from Hatahoko in the Mino Belt, central Japan. Journal of Paleontology 85: 553–566.

Shen, S.-Z., J.-F. Xie, Z. H. Zhang and G. R. Shi. 2009. Roadian–Wordian (Guadalupian, Middle Permian) global palaeobiogeography of brachiopods. Global and Planetary Change 65: 166–181.

Shen, S.-Z., and Y.-C. Zhang. 2008. Earliest Wuchiapingian (Lopingian, Late Permian) brachiopods in southern Hunan, South China: Implications for the pre-Lopingian crisis and onset of Lopingian recovery/radiation. Journal of Paleontology 82: 924–937.

Shi, G. R. 2006. The marine Permian of East and Northeast Asia: an overview of biostratigraphy, palaeobiogeography and palaeogeographical implications. Journal of Asian Earth Sciences 26: 175–206.

Shi, G. R., Z.-Q. Chen and N.-R. Han. 2002. *Permophricodothyris* Pavlova, 1965 (Brachiopoda, Spiriferida) from the Permian of South China: its morphology, biostratigraphy and distribution. Paläontologische Zeitschrift 76: 369–383.

Shi, G. R., Z.-Q. Chen and J.-N. Tong. 2008. New latest Carboniferous brachiopods from the Hexi Corridor Terrane, North China: Faunal migrations and palaeogeographical implications. Proceedings of the Royal Society of Victoria 120: 277–304.

Shi, G. R., and S.-Z. Shen. 2001. A biogeographically mixed, Middle Permian brachiopod fauna from the Baoshan Block, western Yunnan, China. Palaeontology 44: 237–258.

Shi, G. R., and J. Tazawa, 2001. *Rhynchopora* and *Blasispirifer* (Brachiopoda) from the Middle Permian of the Hida Gaien Belt, central Japan, and their paleobiogeographical significance. Journal of the Geological Society of Japan 107: 755–761.

Shi, G. R., and J. B. Waterhouse. 1996. Lower Permian brachiopods and molluscs from the upper Jungle Creek Formation, northern Yukon Territory, Canada. Geological Survey of Canada, Bulletin 424: 1–241.

Shiida, I. 1940. Geology of the Kesennuma-cho, Miyagi Prefecture. Contributions from the Institute of Geology and Paleontology, Tohoku University 82: 1–72.*

Shiino, Y. 2009. Middle Permian echinoconchoide brachiopod *Vediproductus* in the Kamiyasse area, Southern Kitakami Mountains, northeast Japan. Paleontological Research 13: 251–258.

Shiino, Y., and Y. Suzuki, 2007. Articulatory and musculatory systems in a Permian concavo-convex brachiopod *Waagenoconcha imperfecta* Prendergast, 1935 (Productida, Brachiopoda). Paleontological Research 11: 265–275.

Shimizu, D. 1961. Brachiopod fossils from the Upper Permian Gujo Formation of the Maizuru Group, Kyoto Prefecture, Japan. Memoirs of the College of Science, University of Kyoto, Series B 28: 243–255.

Simič, V. 1933. Das oberperm in Westserbien. Rasprave Geološkog Instituta Karlj. Jugoslavije, Sveska, Sveska 1 1: 1–130.

Sokolskaya, A. N. 1954. Strophomenids of the Russian Platform. Trudy Paleontologicheskii Institut, Akademiia Nauk SSSR 51: 1–191.***

Solomina, R. V. 1960. Some Permian brachiopods from Pai Khoi. Svornik Statey po Paleontologii i Biostratigrafii 19: 24–73.***

Solomina, R. V. 1970. Part 2. Descriptions of fauna and flora: Brachiopoda; pp. 70 –113 *in* V. V. Menner, T. G. Sarytcheva and T. G. Tschernjak (eds.), Stratigraphy of Carboniferous and Permian of the Northern Verkhoyansk. Nedra, Leningrad.***

Sone, M., M. S. Leman and G. R. Shi. 2001. Middle Permian brachiopods from central Peninsular Malaysia—faunal affinities between Malaysia and West Cambodia. Journal of Asian Earth Sciences 19: 177–194.

Sowerby, J. 1818–1822. The Mineral Conchology of Great Britain, Vol. 3. W. Ardling, London, 184 pp.

Sremac, J. 1986. Middle Permian brachiopods from the Velebit Mts. (Croatia, Jugoslavia). Palaeontologia Jugoslavica 35: 1–43.

Stehli, F. G. 1954. Lower Leonardian Brachiopoda of the Sierra Diablo. Bulletin of the American Museum of Natural History 105: 257–358.

Stehli, F. G. 1964. New names for two homonyms. Journal of Paleontology 3: 610.

Stepanov, D. L. 1937a. Permian brachiopods from Spitsbergen. Trudy Arkticheskogo Instituta 76: 105–192.***

Stepanov, D. L. 1937b. Brachiopoda of the Bryozoa Limestone from the Kolva-River region (Northern Urals). Trudy NGRI, Seriya A 37: 1–101.***

Stuckenberg. A. A. 1898. Allgemeine geologische Karte von Russland, Blatt 127. Comité Géologique St. Petersburg, Mémoir 16: 1–362.

Sugiyama, T. 1942. Studies on the Japanese Conularida. Journal of the Geological Society of Japan 49: 390–399.

Sun, D.-L. 1991. Permian (Sakmarian – Artinskian) brachiopod fauna from Gegyai County, northwestern Xizang (Tibet) and its biogeographic significance; pp. 215–275 *in* D.-L. Sun et al., Stratigraphy and Palaeontology of Permian, Jurassic and Cretaceous from the Rutog region, Xiznag (Tibet). Nanjing University Press, Nanjing.**

Tatarinov, L. P., B. Luvsandansan, G. A. Afanasjeva, R. Barsbold, I. P. Morozova, L. I. Novitskaja, A. P. Rasnitsyn, V. Yu. Reschetov, A. Yu. Posanov, V. A. Sysoev and B. A. Trofimov. 1991. Permian Invertebrates of Southern Mongolia: The Joint Soviet–Mongolian Paleontological Expedition. Nauka, Moskva, 173 pp.***

Tazawa, J. 1973. Geology of the Kamiyasse area, Southern Kitakami Mountains. Journal of the Geological Society of Japan 79: 677–686.*

Tazawa, J, 1974a. Two species of *Permundaria* from the Kitakami Mountains, northeast Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 94: 313–318.

Tazawa, J. 1974b. *Waagenoconcha* (Brachiopoda) from the Permian of the southern Kitakami Montains, northeast Japan. Journal of the Faculty of Science, Hokkaido University, Series 4 16: 121–143.

Tazawa, J. 1976. The Permian of Kesennuma, Kitakami Mountains: A Preliminary Report. Earth Science (Chikyu Kagaku) 30: 175–185.

Tazawa, J. 1979. Middle Perman brachiopods from Matsukawa. Kesennuma region, southern Kitakami Mountains. Saito Ho-on Kai Museum, Natural History, Research Bulletin 47: 23–35.

Tazawa, J. 1987. Permian brachiopod faunas of Japan and their palaeobiogeography. Chikyu Monthly (Gekkan Chikyu) 9: 752–755.*

Tazawa, J. 1991. Middle Permian brachiopod biogeography of Japan and adjacent regions in East Asia; pp. 213–230 *in* K. Ishii, X. Liu, K. Ichikawa and B. Huang (eds.), Pre-Jurassic Geology of Inner Mongolia, China: Report of China–Japan Cooperative Research Group, 1987–1989. Matsuya Insatsu, Osaka.

Tazawa, J. 1992. Middle Permian brachiopod faunas in East Asia and their zoogeographic significance. Journal of the Geological Society of Japan 98: 483–496.*

Tazawa, J. 1998. Pre-Neogene tectonic divisions and Middle Permian brachiopod faunal provinces of Japan. Proceedings of the Royal Society of Victoria 110: 281–288.

Tazawa, J. 1999a. *Leptodus* and *Spiriferella* (Permian Brachiopoda) from the Usuginu Conglomerate, southern Kitakami Mountains, northeast Japan. Science Reports of Niigata University, Series E 14: 1–13.

Tazawa, J. 1999b. Occurrence of the Boreal-type brachiopod *Yakovlevia* from the middle Permian of the Hida Gaien and South Kitakami belts, Japan and its tectonic implications. Journal of the Geological Society of Japan 105: 227 –230.*

Tazawa, J. 1999c. Boreal-type brachiopod *Yakovlevia* from the middle Permian of Japan. Paleontological Research 3: 88–94.

Tazawa, J. 2000. Permian brachiopod faunas and pre-Neogene tectonics in the Inner Side of Sowthwest Japan. Monograph (Chidanken Senpo) 49: 3–22*.

Tazawa, J. 2001. Middle Permian brachiopods from the Moribu area, Hida Gaien Belt, central Japan. Paleontological Research 5: 283–310.

Tazawa, J. 2002. Late Paleozoic brachiopod faunas of the South Kitakami Belt, northeast Japan, and their paleobiogeographic and tectonic implications. The Island Arc 11: 287–301.

Tazawa, J. 2003. *Kochiproductus* and *Leptodus* (Brachiopoda) from the Middle Permian of the Obama area, South Kitakami Belt, northeast Japan. Science Reports of Niigata University, Series E 18: 25–39.

Tazawa, J. 2007. Middle Permian brachiopod faunas of Japan and their significance for understanding the Paleozoic–Mesozoic tectonics of the Japanese Islands; pp. 565–573 *in* Th. E. Wong (ed.), Proceedings of the 15th International Congress on Carboniferous and Permian Stratigraphy. Utrecht, the Netherlands, 10–16 August 2003. Royal Netherlands Academy of Arts and Sciences, Amsterdam.

Tazawa, J. 2008a. Brachiopods from the Upper Permian Takakurayama Formation, Abukuma Mountains, northeast Japan. Science Reports of Niigata University (Geology) 23: 13–53.

Tazawa, J. 2008b. Permian brachiopods from the Mizukoshi Formation, central Kyushu, SW Japan: Systematics, palaeobiogeography and tectonic implications. Paleontological Research 12: 37–61.

Tazawa, J. 2008c. A bipolar brachiopod genus *Terrakea* Booker, 1930 from the middle Permian of the South Kitakami Belt, northeast Japan. Proceedings of the Royal Society of Victoria 120: 332–340.

Tazawa, J. 2009. Brachiopods from the Upper Permian Tsunemori Formation of the Akiyoshi area, southwest Japan, and their tectonic implications. Paleontological Research 13: 65–78.

Tazawa, J. 2012. Late Permian (Changhsingian) brachiopod fauna from Nabekoshiyama in the Kesennuma area, South Kitakami Belt, northeast Japan. Science Reports of Niigata University (Geology) 27: 15–50.

Tazawa, J. 2014. Antitropical brachiopods from the middle Permian (Wordian) of the southern Kitakami Mountains, northeast Japan. Earth Science (Chikyu Kagaku) 68: 15–22.

Tazawa, J. 2015. Systematics and palaeobiogeography of Permian brachiopods from Pliocene conglomerate of Hitachi, central Japan. Science Reports of Niigata University (Geology) 30: 57–88.

Tazawa, J. 2016a. Three new brachiopod species from the middle Permian (Wordian) of the South Kitakami Belt, northeastern Japan. Paleontological Research 20: 80–89.

Tazawa, J. 2016b. Middle Permian (Wordian) mixed Boreal–Tethyan brachiopod fauna from Kamiyasse–Imo, South Kitakami Belt, Japan. Science Reports of Niigata University (Geology) 31: 7–43.

Tazawa, J. 2017. *Spinomarginifera* and *Waagenoconcha* (Productida, Brachiopoda) from the middle Permian (Wordian–Capitanian) of the South Kitakami Belt, Japan. Science Reports of Niigata University (Geology) 32: 33–56.

Tazawa, J. 2018. Palaeobiogeographical studies on the Palaeozoic brachiopods of Japan, and their tectonic

significance: A review. Journal of the Geological Society of Japan 124: 655–673.*

Tazawa, J., and H. Araki. 1984a. *Paralyttonia* (Oldhamina, Brachiopoda) from the Permian of Northeast Japan. Journal of the Geological Society of Japan 90: 121–123.

Tazawa, J., and H. Araki. 1984b. A new species of *Richthofenia* (Brachiopoda) from the Permian of Northeast Japan. Saito Ho-on Kai Museum Natural History, Research Bulletin 25: 1–6.

Tazawa, J., and H. Araki. 1999. *Scacchinella* (Permian Brachiopoda) from the southern Kitakami Mountains, northeast Japan. Earth Science (Chikyu Kagaku) 53: 452–455.

Tazawa, J., and H. Araki. 2013. Four brachiopod species from the Middle Permian of Kesennuma, South Kitakami Belt, northeast Japan. Science Reports of Niigata University (Geology) 28: 1–14.

Tazawa, J., and H. Araki. 2016. A Boreal-type brachiopod species, *Waagenoconcha irginae* (Stuckenberg), from the middle Permian (Wordian) of the South Kitakami Belt, Japan. Journal of the Geological Society of Japan 122: 155–161.

Tazawa, J., and H. Araki. 2017. Middle Permian (Wordian) mixed Boreal –Tethyan brachiopod fauna from Matsukawa, South Kitakami Belt, Japan. Paleontological Research 21: 265–287.

Tazawa, J., and H. Araki. 2018. Middle Permian (Wordian) brachiopod fauna from Matsukawa, South Kitakami Belt, Japan, Part 2. Science Reports of Niigata University (Geology) 33: 9–24.

Tazawa, J., and Z.-Q. Chen. 2006. Middle Permian brachiopods from the Tumenling Formation in the Wuchang area, southern Heilongjiang, NE China, and their palaeobiogeographical implications. Journal of Asian Earth Sciences 26: 327–338.

Tazawa, J., and Y. Gunji. 1982. Middle Permian brachiopods from the Oashi Formation, Abukuma Mountains, northeast Japan. Saito Ho-on Kai Museum Natural History, Research Bulletin 50: 67–75.

Tazawa, J., and S. Hasegawa. 2007. *Anidanthus*, *Gypospirifer* and *Alispiriferella* (Brachiopoda) from the Upper Permian Mizukoshi Formation, central Kyushu, SW Japan. Science Reports of Niigata University (Geology) 22: 1–14.

Tazawa, J., and Y. Ibaraki. 2001. Middle Permian brachiopods from Setamai, the type locality of the Kanokura Formation, southern Kitakami Mountains, northeast Japan. Science Reports of Niigata University (Geology) 16: 1–33.

Tazawa, J., and N. Kaneko. 2016. Two species of *Permophricodothyris* (Reticularioidea, Brachiopoda) from the middle Permian, South Kitakami Belt, Japan. Paleontological Research 20: 24–30.

Tazawa, J., N. Kaneko, C. Suzuki and S. Hasegewa. 2015. Late Permian (Wuchiapingian) brachiopod fauna from the lower Takakurayama Formation, Abukuma Mountains, northeastern Japan. Paleontological Research 19: 33–51.

Tazawa, J., Y. Kikuchi, A. Nikaido, S. Adachi and Y. Okumura. 2014. Permian brachiopods from boulders in the Pliocene basal conglomerate of Hitachi, central Japan, and their tectonic implications. Journal of the Geological Society of Japan 120: 377–391.*

Tazawa, J., and T. Matsumoto. 1998. Middle Permian brachiopods from the Oguradani Formation, Ise district, Hida Gaien Belt, central Japan. Science Reports of Niigata University, Series E 13: 1–19.

Tazawa, J., and Y. Miyake. 2011. Late Permian (Changhsingian) brachiopod fauna from Maeda in the Ofunato area, South Kitakami Belt, NE Japan. Science Reports of Niigata University (Geology) 26: 1–22.

Tazawa, J., and K. Nakamura. 2015. Early Permian (Kungurian) brachiopods from Nakadaira, South Kitakami Belt, northeastern Japan. Paleontological Research 19: 156–177.

Tazawa, J., Y. Okumura, Y. Miyake and T. Mizutani. 2016. A Kungurian (early Permian) brachiopod fauna from Ogama, Kuzu area, central Japan, and its palaeobiogeographical affinity with the Wolfcampian – Leonardian (early Permian) brachiopod fauna of Texas, USA. Paleontological Research 20: 367–384.

Tazawa, J., Y. Okumura and M. Shimizu. 2012. Permian brachiopods from Yamasuge in the Kuzu area, Ashio Mountains, central Japan, Part 2. Science Reports of Niigata University (Geology) 27: 51–71.

Tazawa, J., and T. Ono. 2013. Permian lyttoniid brachiopod *Petasmaia* from Akasaka, Mino Belt, central Japan. Journal of the Geological Society of Japan 119: 51–55.

Tazawa, J., T. Ono and M. Hori. 1998. Two Permian lyttoniid brachiopods from Akasaka, central Japan. Paleontological Research 2: 239–245.

Tazawa, J., and K. Oyagi. 2019. Early Permian (Artinskian) brachiopods from the Ryozensan area, Mino Belt, southwestern Japan. Science Reports of Niigata University (Geology) 34: 27–38.

Tazawa, J., and T. Shintani. 2010. A Lower Permian mixed Boreal–Tethyan brachiopod fauna from the Nagaiwa–Sakamotozawa area, South Kitakami Belt, NE Japan. Science Reports of Niigata University (Geology) 25: 51–62.

Tazawa, J., and T. Shintani. 2015. Early Permian (Sakmarian) brachiopods from the Nagaiwa–Sakamotozawa area, South Kitakami Belt, northeastern Japan, Part 3: Productidina. Science Reports of Niigata University (Geology) 30: 39 –55.

Tazawa, J., and T. Shintani. 2021. Early Permian (Kungurian) brachiopods from near the base of the Kanokura Formation in the Nagaiwa–Sakamotozawa area, South Kitakami Belt, Japan. Science Reports of Niigata University (Geology) 36: 1–20.

Tazawa, J., and T. Shintani. 2022. Early Permian (Cisuralian) brachiopods from Nagaiwa–Sakamotozawa, South Kitakami Belt, Japan. Memoir of the Fukui Prefectural Dinosaur Museum 21, 1–58.

Tazawa, J., and Y. Takaizumi. 1987. *Poikilosakos* (Oldhaminidina, Brachiopoda) from the Permian of northeast Japan. Transactions and Proceedings of the Palaeontological Society of Japan, New Series 145: 10–15.

Tazawa, J., F. Takizawa and K. Kamada. 2000. A Middle Permian Boreal–Tethyan mixed brachiopod fauna from Yakejima, southern Kitakami Mountains, NE Japan. Science Reports of Niigata University, Series E 15: 1–21.

Tazawa, J., K. Yoshida and H. Machiyama. 1999. Permian brachiopods from a sandstone block in the Usuginu Conglomerate, southern Kitakami Mountains, northeast Japan and their geological significance. Earth Science (Chikyu Kagaku) 53: 159–163.*

Termier, G., H. Termier, A. F. de Lapparent and P. Marin. 1974. Monographie du Permo-Carbonifere de Wardak (Afghanistan Central). Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon, Hors Série 2. 167 pp.

Termier. H,. and G. Termier. 1960. Contribution à la classification des Brachiopodes: le lophophore des Collolophides nov. ord., Appendice. Les Oldhaminid és du Cambodge. Société Géologique de France, Bulletin, Série 7 1: 233–243.

Termier, H., and G. Termier. 1970. Les Productoidés du Djoulfien (Permien supérieur) dans la Téthys orientale: essai sur l'agonie d' un phylum. Société Géologique du Nord, Annales 90: 443–461.

Ting, P.-C. 1965. The Permian and Triassic brachiopods from Yangkang Valley, Tienchung district, Tsinghai Province. Acta Palaeontolica Sinica 13: 259–290.**

Tong, Z.-X. 1978. Phylum Brachiopoda (Carboniferous–Permian Part); pp. 210–267 *in* Geological Institute of Southwest China (ed.), Palaeontological Atlas of Southwestern China, Sichuan Province, Volume 2. Geological Publishing House, Beijing.**

Toula, F. 1875. Permo-Carbon-Fossilien von der Westküste von Spitzbergen. Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Jahrgang 1875: 225–264.

Tschernyschew, Th. N. 1888. Note on the Carboniferous collection from around Vladivostok. Izvestiia Geologicheskogo Komiteta 7: 353–359.***

Tshernyschew, Th. 1889. Allgemeine geologische Karte von Russland, Blatt 139. Beschreibung des Central-Urals und des Westabhanges. Mémoires du Comité Géologique 3: 1–393***

Tschernyschew, Th. 1902. Die obercarbonischen Brachiopoden des Ural und des Timan, Mémoires du Comité Géologique 16: 1–749.***

Ueno, K. 2006. The Permian antitropical fusulinoidean genus *Monodiexodina*: Distribution, taxonomy, paleobiogeography and paleoecology. Journal of Asian Earth Sciences 26: 380–404.

Ustritsky, V. I. 1960. Carboniferous and Permian strata and faunas of the western Kunlun Mountains. Memoirs of the Geological Institute, Ministry of Geology and Mineralogy, People's Republic of China, Series B 5: 1–132.**

Ustritsky, V. I., and G. E. Tschernjak. 1963. Biostratigraphy and brachiopods of the Upper Palaeozoic of Taimyr. Trudy NIIGA 134: 1–139.***

de Verneuil, E. 1845. Paléontologie, Mollusques, Brachiopodes; pp. 17–395 *in* R. I. Murchison, E. de Verneuil and A. Keyserling (eds.), Géologie de la Russie d'Europe et des Montagnes de l' Oural, Vol. 2. John Murray, London.

Volgin, V. I. 1959. New species of Upper Paleozoic brachiopod (Order Rhynchonellida, Spiriferida and Terebratulida). Paleontologicheskiy Zhurnal 1959 (4): 115–124.***

Volgin, V. I. 1960. Brachiopods of the Upper Carboniferous and Lower Permian of Southern Fergana. Izdatelstvo Leningradskogo Universiteta, Leningrad, 203 pp.***

Waagen, W. 1882–1885. Salt Range fossils, 1. Productus-Limestone fossils: Brachiopoda. Palaeontologia Indica, Series 13 1: 329–390 (1882), 391–546 (1883), 547–728 (1884) and 729–770 (1885).

Wang, C.-W. 1995. Brachiopod fauna from Kangkelin Formation in Akesu, Xinjiang Autonomoud Region. Journal of Changchun University of Earth Sciences 25: 15–23.**

Wang, C.-W., and S.-P. Yang. 1998. Late Carboniferous–Early Permian Brachiopods of Central Xinjiang and their Biostratigraphical Studies. Geological Publishing House, Beijing, 156 pp.**

Wang, C.-W., and Zhang. S.-M. 2003. Zhesi Brachiopod Fauna. Geological Publishing House, Beijing, 210 pp.**

Wang, G., Q. Liu, S. Hu, W. Liang and Z. Liao. 1982. Phylum Brachiopoda; pp. 186–256 *in* Nanjing Institute of Geology and Mineral Resources (ed.), Palaeontological Atlas of East China, Part 1. Late Palaeozoic Volume. Geological Publishing House, Beijing.**

Wang, H.-Y., and Y.-G. Jin. 1991. On permianellids (Brachiopoda). Acta Palaeontologica Sinica 30: 481–501.**

Wang, S.-M. 1984. Phylum Brachiopoda; pp. 128–236 *in* Regional Geological Surveying Team of Hubei (ed.), The Palaeontological Atlas of Hubei Province. Hubei Science and Technology Press, Wuhan.**

Wang, Y., Y.-G. Jin and D. Fang (eds.). 1964. Brachiopod Fossils of China, Part 1. Science Press, Beijing, 354 pp.**

Wanner, J., and H. Sieverts. 1935. Zur Kenntnis der Permischen Brachiopoden von Timor, 1. Lyttoniidae und ihre biologische und stammes geschichtliche Bedeutung. Neues Jahrbuch für Mineralogie und Palaeontologie, Abteilung B 74: 201–281.

Wardlaw, B., R. E. Grant and C. H. C. Brunton. 2000. Richthofenioidea; pp. 610–619 *in* Kaesler, R. L. (ed.), Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 3: Linguliformea, Craniiformea, and Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence.

Waterhouse, J. B. 1968a. The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. Palaeontographica, Abteilung A 129: 1–94.

Waterhouse, J. B. 1968b. New species of *Megousia* Muir-Wood and Cooper and allied new genus from the Permian of Australia and North America. Journal of Paleontology 42: 1171–1185.

Waterhouse, J. B. 1975. New Permian and Triassic brachiopod taxa. Papers of the Department of Geology, University of Queensland 7: 1–23.

Waterhouse, J. B. 1986. Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica, Abteilung A 193: 1–76.

Waterhouse, J. B. 2002: Classification within Productidina and Strophalosiidina (Brachiopoda). Earthwise 5: 1–60.

Waterhouse, J. B., and D. J. C. Briggs. 1986. Late Palaeozoic Scyphozoa and Brachiopoda (Inarticulata, Strophomenida, Productida and Rhynchonellida) from the southeast Bowen Basin, Australia. Palaeontographica, Abteilung A 193: 1–76.

Waterhouse, J. B., D. J. C. Briggs and S. M. Parfrey. 1983. Major faunal assemblages in the Early Permian Tiverton Formation near Homevale Homestead, northern Bowen Basin, Queensland; pp. 121–138 *in* C. Foster (ed.), Permian Geology of Queensland. Geological Society of Australia, Queensland Division, Brisbane.

Waterhouse, J. B., and S. Piyasin. 1970. Mid-Permian brachiopods from Khao Phrik, Thailand. Palaeontographica, Abteilung A 135: 83–197.

Waterhouse, J. B., and J. Waddington. 1982. Systematic descriptions, paleoecology and correlations of the Late Paleozoic superfamily Spiriferellinae (Brachiopoda) from the Yukon Territory and the Canadian Arctic Archipelago. Geological Survey of Canada, Bulletin 289: 1–73.

Watson, D. M. S. 1917. *Poikilosakos*, a remarkable new genus of brachiopods from the Upper Coal-Measures of Texas. Geological Magazine 4: 212–219.

White, C. A., and O. St. John. 1867. Descriptions of new Sub-Carboniferous Coalmeasure fossils, collected upon the geological survey of Iowa, together with a notice of new generic characters involved in two species of Brachiopoda. Chicago Academy of Sciences Transactions 1: 115–127.

Williams, A. 1953. The morphology and classification of the oldhaminid brachiopods. Journal of the Washington Academy of Sciences 43: 279–287.

Williams, A., and C. H. C. Brunton. 2000. Orthotetidina; pp. 644–689 *in* R. L. Kaesler (ed.), Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 3: Linguliformea, Craniiformea, and Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence.

Williams, A., D. A. T. Harper and R. E. Grant. 2000. Lyttoniidina; pp. 619–642 *in* R. L Kaesler (ed.), Treatise on Invertebrate Paleontology, Part H Brachiopoda Revised, Volume 3: Linguliformea, Craniiformea, and Rhynchonelliformea (Part). Geological Society of America, Boulder and University of Kansas, Lawrence.

Xu, G.-R. 1987. Descriptions of fossils, 3. Brachiopoda; pp. 215–235 *in* Z.Y. Yang, H.- F. Yin, S.-B. Wu, F.-Q. Yang, M.-H. Ding and G.-R. Xu (eds.) Permian–Triassic Boundary Stratigraphy and Fauna of South China. Geological Publishing House, Beijing.**

Xu, G.-R., and R. E. Grant. 1994. Brachiopods near the Permian–Triassic boundary in South China. Smithsonian Contributions to Paleobiology 76: 1–68.

Yabe, H. 1900. The brachiopod *Lyttonia* from Rikuzen Province. Journal of the Geological Society of Tokyo 7: 1–4.

Yanagida, J. 1963. Brachiopods from the Upper Permian Mizukoshi Formation, central Kyushu. Memoirs of the Faculty of Science, Kyushu University, Series D 14: 69–78.

Yanagida, J. 1964. Permian brachiopods from central Thailand. Memoirs of the Faculty of Science, Kyushu University, Series D 15: 1–22.

Yanagida, J. 1970. Permian brachiopods from Khao Phrik, near Rat Buri, Thailand. Geology and Palaeontology of Southeast Asia 8: 69–96.

Yanagida, J. 1996. Permian brachiopods from the Tsunemori Formation, SW Japan, and their palaeobiogeographic implication; pp. 313–315 *in* P. Copper and J. Jin (eds.), Brachiopods. A. A. Balkema, Rotteldam.

Yanagida, J., S. Imamura and M. Kawai. 1993. Reexamination of the brachiopod fauna from the Permian Karita Formation, southwest Japan. Memoirs of the Faculty of Science, Kyushu University, Series D 28: 1–21.

Yanagida, J., and N. Nakornsri. 1999. Permian brachiopods from the Khao Hin Kling area near Phetchabun, Northcentral Thailand. Bulletin of the Kitakyushu Museum of Natural History 18: 105–136.

Yanagisawa, I, 1967. Geology and paleontology of the Takakurayama –Yaguki area, Yotsukura-cho, Fukushima Prefecture. Science Reports of the Tohoku University, Second series 39: 63–112.

Yang, D.-L. 1984. Systematic description of palaeontology: Brachiopoda; pp. 203–239, 330–333 and 387–396 *in* Yichan Institute of Geology and Mineral Resources (ed.), Biostratigraphy of the Yangtze Gorge Area (3) Late Palaeozoic Era. Geological Publishing House, Beijing.**

Yang, D.-L., S.-Z. Ni, M.-L. Chang and R.-X. Zhao. 1977. Phylum Brachiopoda; pp. 303–470 *in* Geological Institute of Hubei et al. (eds.), Palaeontological Atlas of South-Central China, Part 2. Late Palaeozoic Volume. Geological Publishing House, Beijing.**

Yang, S.-P., and J.-H. Gao. 1996. Chapter 7.4. Systematic description: Brachiopods; pp. 211–218 *in* X.-L. Zeng, W.-Y. Zhu, X.-Y. He, F.-K. Teng and others, Permo–Carboniferous Biostratigraphy and Sedimentary Environment of West Qinling. Geological Publishing House, Beijing.**

Yang, Z.-Y., P.-Z. Ting (Ding), H.-F. Yin, S.-X. Zhang and J.-S. Fang. 1962. Carboniferous, Permian and Triassic brachiopod faunas from the Chilianshan region; pp. 1–129 *in* Institute of Geology and Paleontology, Geological Institute, Academia Sinica and Beijing University of Geology (eds.), Monograph on Geology of the Chilianshan Mountains, Vol. 4, Pt. 4. Science Press, Beijing.**

Zavodowsky, V. M., and D. L. Stepanov. 1970. Phylum Brachiopoda; pp. 70–182 *in* M. V. Kulikov (ed.), Field Atlas of Permian Fauna and Flora of the Northeastern USSR. Magadanskoe Knizhnoe Izdatelstvo, Magadan.***

Zeng, Y. 1990. Chapter 10 Systematic description to the different kinds of fossils, 3. Description of brachiopods; pp.

205–238 *in* He, X.-L., Y.-J. Zhang, M.-L. Zhu, G.-Y. Zhang, S.-Q. Zhuang, Y. Zeng and P. Song, Research on the Late Paleozoic Coal-bearing Stratigraphy and Biota in Jungar, Nei Mongol (Inner Mongolia) Autonomous Region. China University of Mining and Technology Press, Xizhou.**

Zeng, Y. 1992. Succession and replacement of brachiopod communities in the Maokou Stage of Huayinshan area, east Sichuan. Journal of China University of Mining and Technology 21: 54–64.**

Zeng, Y., X. He and M. Zhu. 1995. Permian Brachiopods and Community Succession in the Huayin Mountains, Sichuan. China University of Mining and Technology Press, Xuzhou, 187 pp.**

Zhan, L.-P. 1979. Descriptions of fossils, (2) Brachiopoda; pp. 61–100 *in* H.-F. Hou, L.- P. Zhan, B.-W. Chen et al. (eds.), The Coal-bearing Strata and Fossils of Late Permian from Guangtung. Geological Publishing House, Beijing.**

Zhan, L.-P., and L. Lee. 1962. Early Permian Maokouan brachiopods from the eastern Qinling Mountains. Acta Palaeontologica Sinica 10: 472–493.**

Zhan, L.-P., and S.-Z Wu. 1987. Brachiopoda; pp. 201–232 *in* Institute of Geology, Xinjiang Geological Bureau and Institute of Geology, China Academy of Geological Sciences (eds.), The Carboniferous and Permian Stratigraphy and Biota in Kalpin Region, Xinjiang. Ocean Press, Beijing.**

Zhang, C., S.-Z. Zhang, Z.-X. Zhang and Z. Wang. 1983. Phylum Brachiopoda; pp. 262–386 *in* Regional Geological Surveying Team of Xinjiang, Institute of Geoscience of Xinjiang and Geological Surveying Group of Petroleum Bureau of Xinjiang (eds.), Palaeontological Atlas of Northwest China; Xinjiang Autonomous Region, Part 2. Late Palaeozoic Volume. Geological Publishing House, Beijing.**

Zhang, Y. 1990. Early Permian brachiopod fauna from Ekenalsileng region of Badain Jaran Desert south margin, Nei Mongol. Bulletin of the Xian Institute of Geology and Mineral Resources, Chinese Academy of Geological Sciences 28: 57–64.**

Zhang, Y., and Y.-G. Jin. 1961. An Upper Permian brachiopod fauna from Jiangxian, Anhui Province. Acta Palaeontologica Sinica 9: 401–417.**

Zhao, J.-K., J.-Z. Sheng, Z.-Q. Yao, X.-L. Liang, C.-Z. Chen. L. Rui and Z.-T. Liao. 1981. The Changhsingian and Permian–Triassic boundary of South China. Bulletin of the Nanjing Institute of Geology and Palaeontology, Academia Sinica 2: 58–85.

Zhao, T.-G. 1965. Late Carboniferous brachiopods from central Inner Mongolia. Acta Palaeontologica Sinica 13: 420–454.**

Zhu, T. 1990. The Permian Coal-bearing Strata and Palaeobiocoenosis of Fusian. Geological Publishing House, Beijing. 127 pp.**

* in Japanese
** in Chinese
*** in Russian

＜ 地名・地層名 ＞

Anabuchi …… 穴淵
Budosawa Valley …… 葡萄沢
Chayazawa Valley …… 茶屋沢
Doyasawa Valley …… 洞屋沢
Futatsumori Formarion …… 二ツ森層
Hizume–Kesennuma Fault …· 日詰–気仙沼断層
Hosoo Formation …… 細尾層
Imo …… 飯森
Imosawa Valley …… 飯森沢
Iwaizaki Stage …… 岩井埼階
Kacchizawa (Kattizawa, Kattisawa) Valley … 合地沢
Kamiyasse …… 上八瀬
Kanokura Formation …… 叶倉層
Kesen-gun …… 気仙郡
Kiritoshi …… 切通
Kokitamukaisawa Valley …… 小北向沢
Kurosawa Formation …… 黒沢層
Matashirosawa Valley …… 又四郎沢
Matsukawa …… 松川
Minamizawa Valley …… 南沢
Minokerazawa Valley …… ミノケラ沢
Mt. Kurosawayama …… 黒沢山
Nagaiwa Formation …… 長岩層
Nakadaira Formation …… 中平層
Obama …… 小浜
Omotematsukawa …… 表松川
Onimarusawa Valley …… 鬼丸沢
Rikuzentakata …… 陸前高田
Sakamotozawa Series …… 坂本沢統
Setamai …… 世田米
Shigejisawa Valley …… 茂路沢
Sumita-cho …… 住田町
Tateishizawa Valley …… 立石沢
Toyazawa Valley …… 戸屋沢
Toyoma Formation …… 登米層
Yahigi-cho …… 矢作町
Yakejima …… 八景島
Yukizawa Series …… 雪沢統

APPENDIX

AR1: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 13″ N, 141° 31′ 44″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Neospirifer moosakhailensis* and *Gypospirifer kobiyamai*.

AR2: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 04″ N, 141° 31′ 33″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Licharewina arakii*.

AR3: Kamiyasse in the Kamiyasse – Imo area (38° 58′ 53″ N, 141° 31′ 19″ E), lower Kokitamukaisawa Valley, a tributary of Shigejisawa Valley, greenish grey fine-grained sandstone, middle KY1 Unit of the Kamiyasse Formation, with *Orbiculoidea verum* and *Anidanthus mizukoshiensis*.

AR4: Anabuchi in the Matsukawa area (38° 55′ 12″ N, 141° 32′ 32″ E), cliff along the Matsukawa River, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyasse Formation, with *Neochonetes* (*Huangichonetes*) *matsukawensis*, *Hexiproductus echidniformis*, *Kunlunia* sp., *Urushtenoidea crenulata*, *Permundaria asiatica*, *Permundaria tenuistriata*, *Yakovlevia mammata*, *Neorichthofenia mabutii*, *Leptodus nobilis*, *Paralyttonia kesennumensis*, *Dicystoconcha lapparenti*, *Stenoscisma margaritovi*, *Martinia triquetra*, *Alispiriferella lita* and *Licharewina arakii*.

AR5: Kiritoshi in the Matsukawa area (38° 54′ 55″ N, 141° 32′ 33″ E), road cutting, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Capillomesolobus heritschi*, *Linoproductus hayasakai*, *Costatumulus cancriniformis*, *Yakovlevia kaluzinensis*, *Alispiriferella lita* and *Dielasma* sp.

KF3: Kamiyasse in the Kamiyasse – Imo area (38 ° 59′ 03″ N, 141° 31′ 41″ E), upper Shigejisawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Anidanthus mizukoshiensis*.

KF6: Kamiyasse in the Kamiyasse – Imo area (38 °59′ 23″ N, 141° 31′ 08″ E), upper Minamizawa Valley, float, dark grey argillaceous limestone, upper KY1 Unit of the Kamiyasse Formation, with *Orthotichia* sp.

KF7: Kamiyasse in the Kamiyasse – Imo area (38 ° 59′ 23″ N, 141° 31′ 08″ E), upper Minamizawa Valley, float, dark grey argillaceous limestone, upper KY1 Unit of the Kamiyasse Formation, with *Spinomarginifera lopingensis* and *Acosarina rectimarginata*.

KF8: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 31″ N, 141° 30′ 53″ E), upper Minokerazawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Kitakamichonetes multicallatus*, *Rhipidomella magna* and *Stenoscisma mutabilis*.

KF9: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 02″ N, 141° 31′ 44″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, lower KY2 Unit of the Kamiyasse Formation, with *Waagenoconcha irginae*.

KF11: Kamiyasse in the Kamiyasse – Imo area (38° 58′ 59″ N, 141° 30′ 31″ E), upper Shigejisawa Valley, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyasse Formation, with *Waagenoconcha irginae*.

KF13: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 11″ N, 141° 31′ 22″ E), lower Kokitamukaisawa Valley, a tributary of Shigejisawa Valley, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyasse Formation, with *Leptodus nobilis*.

KF17: Kamiyasse in the Kamiyasse –Imo area (38° 59′ 07″ N, 141°31′ 57″ E), northern ridge of Mt. Kurosawayama, float, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Asperlinus japonicus*.

KF18: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 06″ N, 141° 31′ 49″ E), upper Shigejisawa Valley, float, dark grey argillaceous limestone, lower KY1 Unit of the Kamiyasse Formation, with *Permophricodothyris squamularioides*.

KF20: Kamiyasse in the Kamiyasse – Imo area (38° 58′ 59″ N, 141°31′ 29″ E), upper Shigejisawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Streptorhynchus cataclinus*.

KF21: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 04″ N, 141° 31′ 22″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Globiella tschernyschewi* and *Grandaurispina kozlowskiana*.

KF22: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 06″ N, 141° 31′ 35″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Grandaurispina kozlowskiana*, *Derbyia nipponica* and *Hustedia remota*.

KF27: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 16″ N, 141°31′ 07″ E), upper Minamizawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Streptorhynchus pelargonatus*.

KF28: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 18″ N, 141° 31′ 08″ E), upper Minamizawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Asperlinus japonicus* and *Permophricodothyris squamularioides*.

KF29: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 18″ N, 141° 31′ 08″ E), upper Minamizawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Spiriferelina fredericksi*.

KF33: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 42″ N, 141° 30′ 55″ E), upper Tateishizawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Stenoscisma mutabilis*.

KF37: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 12″ N, 141°31′ 17″ E), upper Shigejisawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the

Kamiyasse Formation, with *Limbella* sp.

KF39: Kamiyasse in the Kamiyasse – Imo area (38° 58′ 35″ N, 141° 31′ 10″ E), upper Chayazawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Kanokurachonetes kanokurensis*, *Chonetinetes elongatus*, *Waagenoconcha irginae*, *Urushtenoidea crenulata* and *Anidanthus mizukoshiensis*.

KF46: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 11″ N, 141° 31′ 39″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Bathymyonia neimongolica*, *Grandaurispina kozlowskiana*, *Permianella typica* and *Stenoscisma margaritovi*.

KF50: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 21″ N, 141°31′ 02″E), upper Minamizawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Grandaurispina kozlowskiana*.

KF55: Kamiyasse in the Kamiyasse – Imo area (38° 58′ 19″ N, 141° 31′ 1″ E), upper Doyasawa Valley, dark grey shale, upper KY1 Unit of the Kamiyasse Formation, with *Kanokurachonetes kanokurensis*.

KF61: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 09″ N, 141°31′ 41″E), upper Shigejisawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Kitakamichonetes multicapillatus*.

KF62: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 21″ N, 141° 31′ 01″ E), upper Minamizawa Valley, float, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Chonosteges* sp. and *Permophricodothyris grandis*.

KF63: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 22″ N, 141°31′ 02″E), upper Minamizawa Valley, greenish grey fine-grained sandstone, middle KY1 Unit of the Kamiyasse Formation, with *Spinomarginifera kueichowensis*.

KF64: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 26″ N, 141°31′ 04″E), upper Minamizawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Vediproductus punctatiformis*, *Meekella eximia* and *M. nodosa*.

KF65: Kamiyasse in the Kamiyasse – Imo area (38° 58′ 51″ N, 141 ° 31′ 22″ E), lower Kokitamukaisawa Valley, a tributary of Shigejisawa Valley, float, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyasse Formation, with *Callispirina sheni* sp. nov.

KF67: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 02″ N, 141° 31′ 39″ E), upper Shigejisawa Valley, float, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyasse Formation, with *Leptodus nobilis*.

KF69: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 01″ N, 141° 31′ 31″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Callispirina sheni* sp. nov.

KF71: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 13″ N, 141°31′ 10″E), upper Shigejisawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Kitakamichonetes multicapillatus* and *Spinomarginifera kueichowensis*.

KF79: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 07″ N, 141°31′ 40″E), upper Shigejisawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Paramesolobus kitakamiensis* sp. nov., *Kitakamichonetes multicapillatus*, *Asperlinus japonicus* and *Permophricodothyris grandis*.

KF80: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 08″ N, 141° 31′ 47″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Permundaria asiatica*.

KF84: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 26″ N, 141° 31′ 04″ E), upper Minamizawa Valley, float, dark grey argillaceous limestone, lower KY1 Unit of the Kamiyasse Formation, with *Spinomarginifera kueichowensis*, *Leptodus nobilis* and *Phricodothyris catatona*.

KF86: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 20″ N, 141° 31′ 26″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Asperlinus japonicus*, *Permianella typica* and *Stenoscisma margaritovi*.

KF88: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 15″ N, 141° 31′ 22″ E), upper Shigejisawa Valley, float, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyasse Formation, with *Kitakamichonetes multicallatus*, *Spinomarginifera kueichowensis*, *Permianella typica*, *Stenoscisma margaritovi* and *Spiriferellina fredericksi*.

KF89: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 16″ N, 141° 31′ 22″ E), upper Shigejisawa Valley float, greenish grey fine-grained sandstone, middle KY1 Unit of the Kamiyasse Formation, with *Spinomarginifera alpha*, *Edriosteges multispinosus* and *Stenoscisma margaritovi*.

KF90: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 14″ N, 141° 31′ 23″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, upper KY1 Unit of the Kamiyasse Formation, with *Spinomarginifera lopingensis*, *S. kueichowensis*, *S. alpha*, *Urushtenoidea crenulata* and *Asperlinus japonicus*.

KF91: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 05″ N, 141° 31′ 45″ E), upper Shigejisawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Permianella typica* and *Orthothetina kayseri*.

KF94: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 30″ N, 141° 31′ 08″ E), upper Minamizawa Valley, float, dark grey argillaceous limestone, middle KY1 Unit of the Kamiyase Formation, with *Kitakamichonetes multicapillatus*, *Permianella typica*, *Rhipidomella magna*, *Stenoscisma margaritovi* and *Permophricodothyris*

squamularioides.

KF96: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 28″ N, 141° 31′ 08″ E), upper Minamizawa Valley, float, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Tyloplecta yangtzeensis*.

KF99: Kamiyasse in the Kamiyasse – Imo area (38° 59′ 07″ N, 141° 31′ 43″ E), upper Shigejisawa Valley, dark grey argillaceous limestone, upper KY1 Unit of the Kamiyasse Formation, with *Lamiproductus kamiyassensis*, *Permundaria asiatica* and *P. tenuistriata*.

KF121: Imo in the Kamiyasse–Imo area (38 ° 59′ 55″ N, 141° 31′ 18″ E), upper Imosawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Paramarginifera* sp., *Tyloplecta yangtzeensis*, *Waagenoconcha humboldti*, *Derbyia nipponica*, *Meekella eximia*, *M. nodosa*, *Orthothetina polita*, *O. kayseri*, *O. hayasakai*, *Streptorhynchus pelargonatus*, *Orthotichia* sp., *Stenoscisma mutabilis* and *Martinia triquetra*.

KF212: Kamiyasse in the Kamiyasse –Imo area (38° 58′ 49″ N, 141° 31′ 11″ E), middle Matashirosawa Vallley, a tributary of Shigejisawa Valley, dark grey shale, upper Hosoo Formation, with *Poikilosakos kamiyassensis* and *Martinia semiplana*.

KF217: Imo in the Kamiyasse–Imo area (38 ° 59′ 55″ N, 141° 31′ 14″ E), upper Imosawa Valley, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Isogramma heritschi*, *I. nakamurai*, *Paramesolobus kitakamiensis* sp. nov., *Transennatia gratiosa*, *Spinomarginifera lopingensis*, *S. kueichowensis*, *S. alpha*, *Paramarginifera* sp., *Costiferina spiralis*, *Tyloplecta yangtzeensis*, *Bathymyonia neimongolica*, *Vediproductus punctatiformis*, *Waagenoconcha humboldti*, *Urushtenoidea crenulata*, *Asperlinus japonicus*, *Leptodus nobilis*, *Permianella typica*, *Dicystoconcha lapparenti*, *Orthothetina polita*, *O. kayseri*, *O. hayasakai*, *O. transversa*, *Rhipidomella magna*, *Acosarina dorsisulcata*, *A. rectimarginata*, *Stenoscisma margaritovi*, *S. mutabilis*, *S. sokolskajae*, *Rhynchopora tchernyshae*, *Permocryptospirifer omeishanensis*, *Alispiriferella lita*, *Permophricodothyris grandis*, *P. squamularioides*, *Spiriferellina fredericksi* and *Whitspakia nipponica* sp. nov.

KF218: Imo in the Kamiyasse–Imo area (38°59′ 55″N, 141°31′ 16″E), upper Imosawa Valley, dark grey argillaceous limestone, lower KY1 Unit of the Kamiyasse Formation, with *Kitakamichonetes multicapillatus*, *Transennatia gratiosa*, *Bathymyonia neimongolica*, *Vediproductus punctatiformis*, *Edriosteges multispinosus*, *Urushtenoidea crenulata*, *Grandaurispina kozlowskiana*, *Asperlinus japonicus*, *Leptodus nobilis*, *Pararigbyella doulingensis*, *Permianella typica*, *Dicystoconcha lapparenti*, *Stenoscisma margaritovi*, *S. mutabilis*, *Permocryptospirifer omeishanensis*, *Hustedia remota*, *H. ratburiensis*, *Martinia triquetra*, *Permophricodothyris grandis*, *Spiriferellina fredericksi* and *Whitspakia nipponica* sp. nov.

KS1: Setamai area (39 ° 07′ 53″ N, 141 ° 31′ 33″ E), middle Kanokurasawa Valley, greenish grey fine-grained sandstone, upper KN1 Unit of the Kanokura Formation, with *Linoproductus hayasakai*, *Leptodus nobilis*, *Derbyia grandis* and *D. nipponica*.

KS2: Setamai area (39° 06′ 44″ N, 141° 31′ 25″ E), upper Onimarusawa Valley, a tributary of Kacchizawa Valley, greenish grey fine-grained sandstone, upper KN1 Unit of the Kanokura Formation, with *Transennatia gratiosa*.

KS3: Setamai area (39° 07′ 52″ N, 141° 30′ 51″ E), upper Kanokurasawa Valley, greenish grey fine-grained sandstone, upper KN1 Unit of the Kanokura Formation, with *Linoproductus hayasakai*.

KS4: Setamai area (39° 07′ 51″ N, 141° 31′ 18″ E), upper Kanokurasawa Valley, greenish grey fine-grained sandstone, upper KN1 Unit of the Kanokura Formation, with *Linoproductus hayasakai*.

KS7: Setamai area (39°07′ 42″N, 141°32′ 10″E), a tributary of Kanokurasawa Valley, greenish grey fine-grained sandstone, upper KN2 Unit of the Kanokura Formation, with *Leptodus nobilis*.

KS8: Setamai area (39°07′ 33″N, 141°32′ 26″E), a tributary of Kacchizawa Valley, greenish grey fine-grained sandstone, upper KN1 Unit of the Kanokura Formation, with *Tyloplecta yangtzeensis*.

KS9: Setamai area (39° 08′ 01″ N, 141° 32′ 09″ E), middle Kanokurasawa Valley, greenish grey fine-grained sandstone, upper KN2 Unit of the Kanokura Formation, with *Transennatia gratiosa*, *Waagenoconcha irginae*, *Urushtenoidea crenulata*, *Grandaurispina kozlowskiana*, *Laterisma parallela*, *Derbyia grandis*, *Derbyia nipponica* and *Alispiriferella lita*.

KS10: Setamai area (39° 07′ 43″ N, 141° 32′ 18″ E), upper Budosawa Valley, a tributary of Kacchizawa Valley, dark grey impure limestone, upper KN2 Unit of the Kanokura Formation, with *Permundaria asiatica* and *Orthothetina kitakamiensis*.

KZ9: Omotematsukawa in the Matsukawa area (38° 55′ 09″ N, 141° 32′ 33″ E), sandstone quarry, greenish grey fine-grained sandstone, lower KY1 Unit of the Kamiyasse Formation, with *Transennatia gratiosa*, *Hexiproductus echidniformis*, *Scacchinella gigantea*, *Keyserlingina* sp., *Petasmaia expansa*, *Meekella nodosa* and *Orthothetina kayseri*.

TY1: Imo in the Kamiyasse-Imo area (38 ° 59′ 22″ N, 141° 31′ 59″ E), upper Toyazawa Valley, greenish grey fine-grained sandstone, middle KY1 Unit of the Kamiyasse Formation, with *Waagenoconcha irginae*.

TABLE 1 (1). Occurrence of brachiopod species from the Kanokura, Hosoo and Kamiyasse Formations in the Setamai, Kamiyasse–Imo and Matsukawa areas, South Kitakami Belt.

Areas, units and localities / Species	Setamai								Kamiyasse–Imo																																																			Matsu-kawa		
	Kanokura Formation								Hosoo F.	Kamiyasse Formation																																																	Kamiyasse Formation		
	KN1 Unit					KN2 U.				KY1 Unit																																																KY2	KY1		
	KS1	KS2	KS3	KS4	KS8	KS9	KS7	KS10	KF212	KF3	KF8	KF20	KF27	KF28	KF29	KF39	KF18	KF33	KF50	KF61	KF79	KF91	KF64	KF71	KF84	KF218	KF29	KF37	KF69	KF96	KF121	KF217	AR3	TY1	KF11	KF13	KF65	KF67	KF88	KF94	KF63	KF89	KF21	KF22	KF28	KF46	AR1	KF62	KF80	KF86	KF90	KF99	AR2	KF17	KF46	KF55	KF6	KF7	KF9	AR5	KZ9	AR4
Orbiculoidea verum																																	R																													
Isogramma heritschi																																A																														
I. nakamurai																																C																														
Neochonetes (Huangichonetes) matsukawensis																																																														R
Paramesolobus kitakamiensis sp. nov.																					R											A																														
Kanokurachonetes kanokurensis																R																																								C						
Capillomesolobus heritschi																																																												R		
Chonetinetes elongatus																R																																														
Kitakamichonetes multicapillatus																				C	C			R		R														A																						
Transennatia gratiosa		R				C																				C						C																													C	
Spinomarginifera lopingensis																																R																			C							C				
S. kueichowensis																								R	R							R							C		C										C											
S. alpha																																R										C									R											
Paramarginifera sp.																															R	R																														
Hexiproductus echidniformis																																																													C	R
Kuniania sp.																																																														R
Costiferina spiralis																																C																														
Tyloplecta yangtzeensis					R																									R	C	A																														
Bathymyonia neimongolica																										R						R														C																
Vediproductus punctatiformis																							R			R						A																														
Waagenoconcha humboldti																															A	R																														
W. irginae						R										R																		A	A																								R			
Edriosteges multispinosus																										A																R																				
Limbella sp.																												R																																		
Chonosteges sp.																																																R														
Urushtenoidea crenulata						R										A										R						A																			R										R	R
Scacchinella gigentea																																																													A	
Linoproductus hayasakai	A		A	C																																																								R		
Globiella tschernyschewi																																											R																			
Asperlinus japonicus																					R					A						A													R					R	R			R								
Lamiproductus kamiyassensis																																																				A										
Anidanthus mizukoshiensis										R						R																																														
Costatumulus cancriniformis																																																												R		
Permundaria asiatica								R																																									R			R										R
P. tenuistriata																																																				R										R
Grandaurispina kozlowskiana						R																				R																	R	A												R							
Yakovlevia mammata																																																														R
Y. kaluzinensis																																																												R		
Neorichthofenia mabutii																																																														A
Leptodus nobilis	A						A																		R	R						R				C		A																								R
Keyserlingina sp.																																																													R	

TABLE 1 (2). Continue

Species \ Areas, units and localities	Setamai: Kanokura Formation, KN1 Unit: KS1	KS2	KS3	KS4	KS8	KN2 U.: KS9	KS7	KS10	Kamiyasse–Imo: Hosoo F.: KF212	Kamiyasse Formation, KY1 Unit: KF3	KF8	KF20	KF27	KF28	KF29	KF39	KF18	KF33	KF50	KF61	KF79	KF91	KF64	KF71	KF84
Petasmaia expansa																									
Pararigbyella doulingensis																									
Poikilosakos kamiyassensis									A																
Paralyttonia kesennumensis																									
Permianella typica																						C			
Dicystoconcha lapparenti																									
Laterispina parallela						R																			
Derbyia grandis	R					R																			
D. nipponica	R					R																			
Meekella eximia																							R		
M. nodosa																							R		
Orthothetina polita																									
O. kayseri																						R			
O. kitakamiensis								R																	
O. hayasakai																									
O. transversa																									
Streptorhynchus pelargonatus													R												
S. catoclinus												C													
Rhipidomella magna											C														
Acosarina dorsisulcata																									
A. rectimarginata																									
Orthotichia sp.																									
Stenoscisma margaritovi																									
S. mutabilis											C							R							
S. sokolskajae																									
Rhynchopora tchernyshae																									
Permocryptospirifer omeishanensis																									
Hustedia remota																									
H. ratburiensis																									
Martinia semiplana									C																
M. triquetra																									
Neospirifer moosakhailensis																									
Gypospirifer kobiyamai																									
Alispiriferella lita						A																			
Phricodothyris catatona																									R
Permophricodothyris grandis																					R				
P. squamularioides														R			C								
Licharewina arakii																									
Callispirina sheni sp. nov.																									
Spiriferellina fredericksi																									
Dielasma sp.																									
Whitspakia nipponica sp. nov.																									

Species	Kamiyasse–Imo, Kamiyasse Formation, KY1 Unit: KF218	KF29	KF37	KF69	KF96	KF121	KF217	AR3	TY1	KF11	KF13	KF65	KF67	KF88	KF94	KF63	KF89	KF21	KF22	KF28	KF46
Petasmaia expansa																					
Pararigbyella doulingensis	R																				
Poikilosakos kamiyassensis																					
Paralyttonia kesennumensis																					
Permianella typica	A						A							R	R						C
Dicystoconcha lapparenti	C						A														
Laterispina parallela																					
Derbyia grandis																					
D. nipponica						C													C		
Meekella eximia						R															
M. nodosa						R															
Orthothetina polita						C	R														
O. kayseri						R	C														
O. kitakamiensis																					
O. hayasakai						C	C														
O. transversa							C														
Streptorhynchus pelargonatus						R															
S. catoclinus																					
Rhipidomella magna							R								C						
Acosarina dorsisulcata							R														
A. rectimarginata							C														
Orthotichia sp.						R															
Stenoscisma margaritovi	C						R								C		R				R
S. mutabilis	R					R	R														
S. sokolskajae							C														
Rhynchopora tchernyshae							R														
Permocryptospirifer omeishanensis	A						R														
Hustedia remota	R																		C		
H. ratburiensis	R																				
Martinia semiplana																					
M. triquetra	C					C															
Neospirifer moosakhailensis																					
Gypospirifer kobiyamai																					
Alispiriferella lita							C														
Phricodothyris catatona																					
Permophricodothyris grandis	R						R														
P. squamularioides							R								R						
Licharewina arakii																					
Callispirina sheni sp. nov.				R								R									
Spiriferellina fredericksi	C	A					C							A							
Dielasma sp.																					
Whitspakia nipponica sp. nov.	C						C														

Species	Kamiyasse–Imo, Kamiyasse Formation, KY1 Unit: AR1	KF62	KF80	KF86	KF90	KF99	AR2	KF17	KF46	KF58	KF6	KF7	KY2: KF9	Matsukawa, Kamiyasse Formation, KY1: AR5	KZ9	AR4
Petasmaia expansa															R	
Pararigbyella doulingensis																
Poikilosakos kamiyassensis																
Paralyttonia kesennumensis																R
Permianella typica																
Dicystoconcha lapparenti																R
Laterispina parallela																
Derbyia grandis																
D. nipponica																
Meekella eximia																
M. nodosa															R	
Orthothetina polita																
O. kayseri															R	
O. kitakamiensis																
O. hayasakai																
O. transversa																
Streptorhynchus pelargonatus																
S. catoclinus																
Rhipidomella magna																
Acosarina dorsisulcata																
A. rectimarginata												R				
Orthotichia sp.											R					
Stenoscisma margaritovi				R												R
S. mutabilis																
S. sokolskajae																
Rhynchopora tchernyshae																
Permocryptospirifer omeishanensis																
Hustedia remota																
H. ratburiensis																
Martinia semiplana																
M. triquetra																R
Neospirifer moosakhailensis	R															
Gypospirifer kobiyamai	R															
Alispiriferella lita														C		C
Phricodothyris catatona																
Permophricodothyris grandis		C														
P. squamularioides																
Licharewina arakii							R									R
Callispirina sheni sp. nov.																
Spiriferellina fredericksi																
Dielasma sp.														R		
Whitspakia nipponica sp. nov.																