Kochiproductus and *Leptodus* (Brachiopoda) from the Middle Permian of the Obama area, South Kitakami Belt, northeast Japan

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Abstract

Two brachiopod species, a Boreal element *Kochiproductus* sp. and a Tethyan element *Leptodus nobilis* (Waagen), are described from the Middle Permian (Wordian) Oyakejima Formation of the Obama area, South Kitakami Belt, northeast Japan. The stratigraphical and geographical distributions of the genus *Kochiproductus* and *Leptodus nobilis* are summarized.

Key words: Boreal-Tethyan mixed fauna, *Kochiproductus*, *Leptodus*, Middle Permian, palaeobiogeography, South Kitakami.

Introduction

Middle Permian brachiopod faunas of the South Kitakami Belt, northeast Japan are characterized by the mixture of the Boreal and Tetyan elements (Tazawa, 1979; 1987, 1991, 1998; Nakamura and Tazawa, 1990; Tazawa et al., 2000; Tazawa and Ibaraki, 2000). These faunas suggest that the South Kitakami region was a part of the continental shelf bordering the northern and eastern margins of Sino-Korea (North China) in the middle palaeolatitude of the Northern Hemisphere in the Middle Permian time (Tazawa, 1991, 1998, 2000a, 2000b, 2002).

In this paper, two brachiopod species, *Kochiproductus* sp. and *Leptodus nobilis* (Waagen, 1883), from the lower part of the Oyakejima Formation (Wordian) in the Obama area, South Kitakami Belt are systematically described. The fossil specimens together with some another brachiopods were collected from dark grey sandy or muddy impure limestone of 1-5 m thick at two localities (KOG3, KOG7) by two students, T. Yokoyama (Tohoku University) and M. Adachihara (Chiba University) and by myself in the course of regional mapping in Ogatsu-Cho, Miyagi Prefecture. The grey impure limestones of the localities KOG3 and KOG7 are exposed on the western- and eastern wing of a NNE-SSW trending anticline, "Ogatsu anticline" (see Takizawa et al., 1990), and they are developed at about 10 m below from the base of grey

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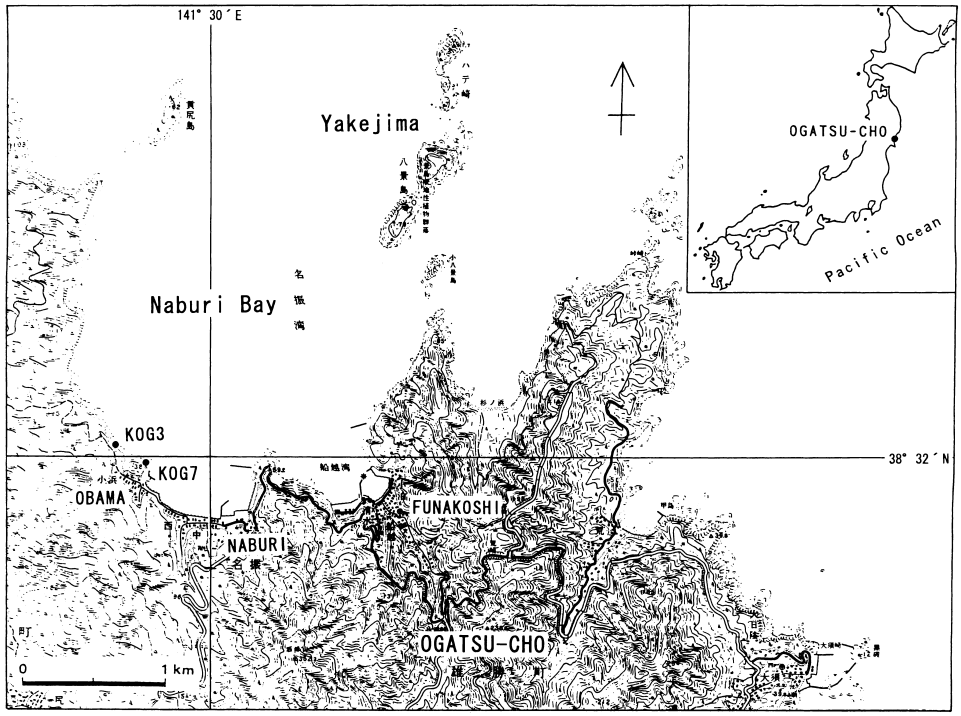

Fig. 1. Map showing the fossil localities, KOG3, KOG7, in the Obama area, southern Kitakami Mountains. Using the topographical maps of "Osu" and "Ogatsu" scale 1:25,000 published by the Geographical Survey of Japan.

limestone containing a fusulinacean *Lepidolina* sp. The geographical and stratigraphical positions of the fossil localities are shown on Fig. 1 and Fig. 2, respectively.

Kochiproductus is a typical Boreal-type genus. On the other hand, *Leptodus* is a typical Tethyan-type genus. Consequently the Obama fauna is one of the Boreal-Tethyan mixed brachiopod faunas of the South Kitakami Belt. This study agrees with and confirms Tazawa et al. (2000), who described a Middle Permian Boreal-Tethyan mixed brachiopod fauna consisting of 9 species from Yakejima, 3 km NE of Obama. The brachiopod specimens described herein are housed in the Department of Geology, Faculty of Science, Niigata University.

Distribution of *Kochiproductus* and *Leptodus*

Stratigraphical and geographical distributions of the genus *Kochiproductus*, all of the reliable *Kochiproductus* species, and *Leptodus nobilis* are summarized as follows, and their Permian geographical distributions are illustrated in Fig. 3. It is noteworthy that the coexistence of *Kochiproductus* and *Leptodus nobilis* is limited within a zone, named by Tazawa (1991) as

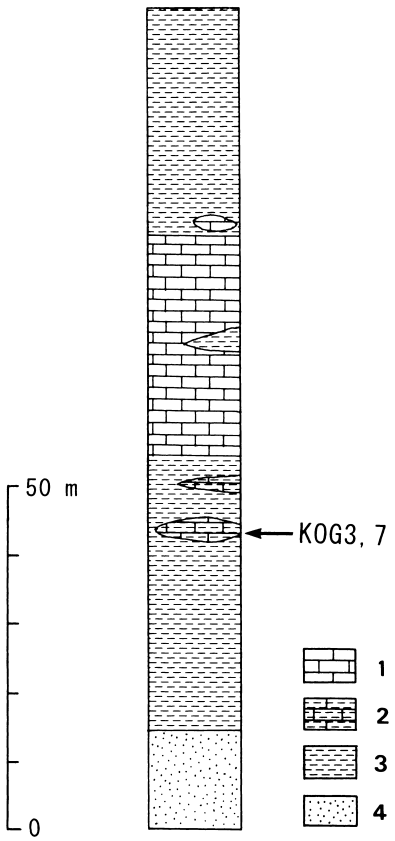

Fig. 2. Columnar section of the Oyakejima Formation in the Obama area, showing the stratigraphical position of the fossil localities, KOG3, KOG7 (redrawn and adapted from Takizawa et al., 1990). 1: Limestone, 2: Sandy or muddy impure limestone, 3: Sandy shale, 4: Sandstone.

the Inner Mongolian-Japanese Transitional Zone, which occupied the shallow sea between Mongolia and Sino-Korea continents in the Middle Permian.

Kochiproductus is distributed in the Middle Carboniferous (Bashkirian) of Taimyr, northern Russia (Ustritsky and Tschernjak, 1963); Upper Carboniferous (Kasimovian to Gzelian) of western Urals (Prokofiev, 1975; Alexandrov and Einor, 1979); Lower and Middle Permian of northern Yukon Territory (Bamber and Waterhouse, 1971; Shi and Waterhouse, 1996), Devon Island, Arctic Canada (Harker, 1960), Spitsbergen (Stepanov, 1937; Gobbett, 1963; Malkowski, 1988; Nakamura et al., 1992), east Greenland (Frebold, 1931, 1933; Frebold and Noe-Nygaard, 1938; Dunbar, 1955), Novaya Zemlya (Licharew and Einor, 1939; Kalashnikov and Ustritsky, 1981), Kanin Peninsula, northern Russia (Stepanov et al., 1975), Timan, northern Russia (Tschernyschew, 1902; Licharew, 1939; Kalashnikov, 1993), southern Urals (Kutorga, 1844), Pechora Basin, northern Russia (Solomina, 1957, 1960; Ifanova, 1972; Kalashnikov, 1983, 1986, 1993), Verkhoyansk (Kashirzew, 1959; Abramov, 1970; Solomina, 1970), Kolyma-Omolon, northern Russia (Zavodowsky, 1960; Zavodowsky and Stepanov, 1970), Xinjiang, northwest China (Wang and Yang, 1998), Gansu, northwest China (Ustritsky, 1963), southern Mongolia (Manankov, in Tatarinov et al., 1991), Zhesi, western

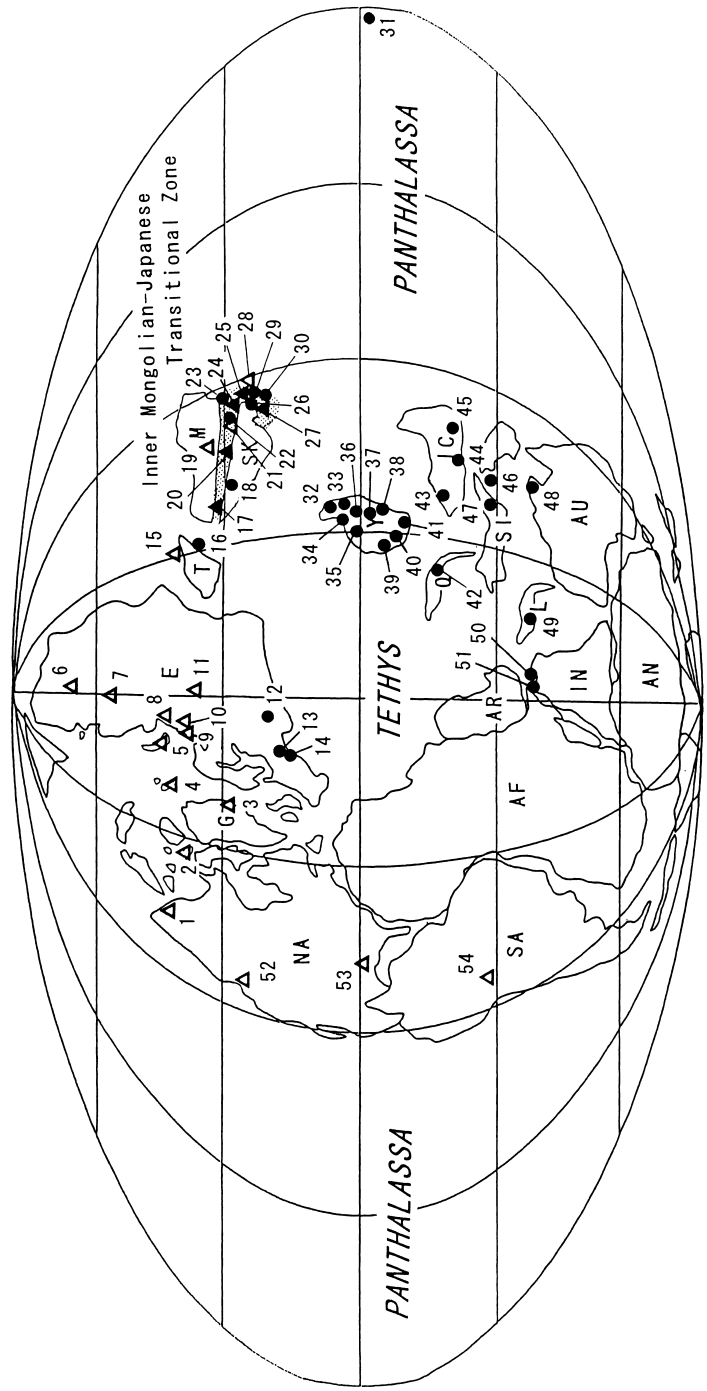

Fig. 3. Geographical distribution of *Kochiproductus* (△) and *Leptodus nobilis* (●) in the Permian (plotted on the modified base map by Ziegler et al., 1996). The solid triangle (▲) shows the coexistence of *Kochiprodustus* and *Leptodus nobilis*. 1: northern Yukon Territory, 2: Devon Island, 3: east Greenland, 4: Spitsbergen, 5: Novaya Zemlya, 6: Kolyma-Omolon, 7: Verkhoyansk, 8: Pechora Basin, 9: Kanin Peninsula, 10: Timan, 11: southern Urals, 12: Caucasus, 13: Bukk Mountains, 14: Slovenia-Croatia-Serbia, 15: Xinjiang, 16: Qinghai, 17: Gansu, 18: Shaanxi, 19: southern Mongolia, 20: Zhesi, 21: Dongujimqinqi-Xiujimqinqi, 22: Lindong-Huangganggliang, 23: Heilongjiang, 24: Jilin, 25: South Primorye, 26: Hida Gaien, 27: South Kitakami, 28: Okutadami, 29: Yakuno, 30: Akiyoshi, 31: Akasaka, 32: Zhejiang, 33: Fujian, 34: Anhui, 35: Hubei, 36: Jiangxi, 37: Hunan, 38: Guangdong, 39: Sichuan, 40: Guizhou, 41: Guangxi, 42: Tibet, 43: western Yunnan, 44: Laos, 45: Cambodia, 46: Timor, 47: Malaysia, 48: Port Keats, 49: Kumaon Himalayas, 50: Kashmir, 51: Salt Range, 52: British Columbia, 53: west Texas, 54: Pervian-Bolivian Basin.

Inner Mongolia (Grabau, 1931, Wang et al., 1964; Lee and Gu, 1976; Duan and Li, 1985), Dongujimqinqi-Xiujimqinqi, eastern Inner Mongolia (Lee and Gu, 1976; Lee et al., 1983; Liu and Waterhouse, 1985; Tazawa et al., 2001), Jilin, northeast China (Lee et al., 1980), South Primorye, eastern Russia (Fredericks, 1924), Okutadami, central Japan (Tazawa, 2001a), South Kitakami, northeast Japan (Tazawa et al., 2000), British Colombia (Yole, 1963), west Texas (King, 1931; Cooper, 1957; Muir-Wood and Cooper, 1960; Cooper and Grant, 1975), Pervian-Bolivian Basin (d'Orbigny, 1842; Kozlowski, 1914; Chronic, 1953; Samtleben, 1971).

Leptodus nobilis (Waagen) is distributed in the Lower Permian (Kungurian) to Upper Permian (Changhsingian) of Slovenia-Croatia-Serbia (Albrecht, 1924; Simic, 1933; Ramovs, 1958; Sremac, 1986), Bukk Mountains, Hungary (Schréter, 1963), Caucasus Mountains (Licharew, 1932a, 1932b; Sarytcheva, 1964; Ruzhentsev and Sarytcheva, 1965), Qinghai, northwest China (Jin et al., 1979), Gansu, northwest China (Zhang et al., 1983), Shaanxi, north China (Zhang et al., 1983), Zhesi, western Inner Mongolia (Grabau, 1931; Lee and Gu, 1976; Duan and Li, 1985), Lindong-Huangganglіang, eastern Inner Mongolia (Lee et al., 1980; Gu and Zhu, 1985), Jilin, northeast China (Lee et al., 1980), Heilongjiang, northeast China (Lee et al., 1980), South Primorye, eastern Russia (Licharew and Kotlyar, 1978; Kotlyar, in Kotlyar and Zakharov, 1989), Hida Gaien, central Japan (Tazawa, 1987, 2001b; Tazawa and Matsumoto, 1998), South Kitakami, northeast Japan (Yabe, 1900; Hayasaka, 1917, 1922a; Tazawa, 1976, 1987, 2002; Minato et al., 1979; Tazawa and Ibaraki, 2001), Yakuno, southwest Japan (Mashiko, 1934; Shimizu, 1961), Akiyoshi, southwest Japan (Yanagida, 1996), Akasaka, central Japan (Tazawa et al., 1998), Zhejiang, east China (Wang et al., 1982; Liang, 1990), Fujian, east China (Wang et al., 1982; Zhu, 1990), Anhui, east China (Wang et al., 1982), Jiangxi, east China (Frech, 1911; Hayasaka, 1922b; Huang, 1936), Hubei, central-south China (Yang et al., 1977; Yang, 1984), Hunan, central-south China (Liao and Meng, 1986; Yang et al., 1977), Guangdong, central-south China (Yang et al., 1977; Zhan, 1979), Guangxi, central-south China (Yang et al., 1977), Guizhou, southwest China (Huang, 1932; Feng and Jiang, 1978), Sichuan, southwest China (Huang, 1932), Tibet, southwest China (Zhan and Wu, 1982), western Yunnan, southwest China (Huang, 1936; Fang and Fan, 1994), Laos (Mansuy, 1912), Cambodia (Mansuy, 1913, 1914; Termier and termier, 1960; Chi-Thuan, 1961), Timor (Hamlet, 1928; Wanner and Sieverts, 1935; Kato et al., 1999), Malaysia (Leman, 1994), Port Keats, northern Australia (Thomas, 1957), Kumaon Himalayas (Diener, 1897), Kashmir, India (Diener, 1915), Salt Range, Pakistan (Waagen, 1883; Noetling, 1904, 1905; Fredericks, 1916; Cooper and Grant, 1974; Grant, 1976).

Description of species

Order Productida Sarytcheva and Sokolskaya, 1959

Suborder Productidina Waagen, 1883

Superfamily Productoidea Gray, 1840
Family Productidae Gray, 1840
Subfamily Buxtoninae Muir-Wood and Cooper, 1960
Tribe Buxtonini Muir-Wood and Cooper, 1960
Genus *Kochiproductus* Dunbar, 1955

Kochiproductus sp.
Figs. 4.3, 4.4.

Kochiproductus sp. Tazawa, Takizawa and Kamada, p. 8, pl. 1, figs. 13a-c.

Material.—Two specimens from KOG3: (1) external cast of a ventral valve, NU-B627; (2) internal mould of a ventral valve, NU-B628.

Description.—Shell small to medium for genus, elongate-oval to subquadrate in outline; length 61 mm, width about 40 mm in the larger specimen (NU-B627), length 46 mm, width about 33 mm in the smaller specimen (NU-B628). Ventral valve gently convex in lateral profile, except for umbonal region, which strongly incurved over hinge; flanks steep; hinge slightly shorter than maximum width at just anterior to midvalve; ears large, triangular in shape; sulcus originating at umbo, narrow and moderately deep. External surface of ventral valve ornamented by numerous discontinuous costae swollen anteriorly to from spine bases, and several concentric rugae. Internal structures of ventral valve are obscure in the present material.

Remarks.—These specimens are safely assigned to the genus *Kochiproductus* by their size, shape and external ornament of ventral valve. The Kitakami species is characterized by its elongate and comparatively small shell.

Kochiproductus sultanaevi Kulikov and Stepanov (in Stepanov et al., 1975, p. 59, pl. 1, figs. 5, 6), from the Middle Permian (Ufimian) of Kanin Peninsula, is also a elongate and small to medium-sized species, but it differs from the present species in having much stronger spine bases on the ventral valve.

Kochiproductus elongatus Cooper and Grant (1975, p. 1049, pl. 358, figs. 4-6; pl. 360, fig. 3; pl. 361, figs. 9-11), from the upper Wolfcampian (Skinner Ranch Formation) and the lower Leonardian (Bone Spring Formation) of west Texas, has a elongate shell, but it differs from the present species in having larger and more strongly convex ventral valve.

Suborder Lyttoniidina Williams, Harper and Grant, 2000
Superfamily Lyttonioidea Waagen, 1883
Family Lyttoniidae Waagen, 1883
Subfamily Lyttoniinae Waagen, 1883
Genus *Leptodus* Kayser, 1883

Leptodus nobilis (Waagen, 1883)
Figs. 4.1, 4.2.

Lyttonia nobilis Waagen, 1883, p. 398, pl. 29, figs. 1-3; pl. 30, figs. 1, 2, 5, 6, 8, 10, 11; Diener, 1897, p. 37, pl. 1, figs. 5-7; 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, figs. 7a-d; pl. 7, figs. la-e; Diener, 1915, p. 99, pl. 10, fig. 15; Albrecht, 1924, p. 289, figs. la, b; Grabau, 1931, pars, p. 285, pl. 28, figs. 4, 5 only; Huang, 1932, p. 89, pl. 7, figs. 9, 10; pl. 8, figs. 8, 9; pl. 9, figs. 1-8; text-figs. 8-11; Simic, 1933, p. 49, pl. 4, fig. 1.

Lyttonia tenuis Waagen, 1883, p. 401, pl. 30, figs. 3, 4, 7, 9.

Lyttonia sp. Yabe, 1900, p. 2, text-figs. 1, 2.

Lyttonia richthofeni (Kayser): Frech, 1911, pars, p. 135, pl. 20, figs. 2a, b only; 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; Licharew, 1932b, p. 56, 86, pl. 1, figs. 1-16; pl. 2, figs. 1, 2, 5, 7, 10, 12; pl. 3, figs. 2-7; pl. 4, figs. 1-17; pl. 5, figs. 1-4, 6; Mashiko, 1934, p. 182, text-fig.

Lyttonia cf. *tenuis* Waagen: Mansuy, 1912, p. 19, pl. 4, fig. 4; pl. 5, figs. 1a-e; Huang, 1936, p. 493, pl. 1, fig. 6.

Oldhamina (*Lyttonia*) *richthofeni* var. *nobilis* Waagen: Fredericks, 1916, p. 76, pl. 4, fig. 2; text-fig. 22.

Lyttonia (*Leptodus*) *richthofeni* Kayser: Hamlet, 1928, p. 31, pl. 6, figs. 1-4.

Lyttonia cf. *richthofeni* (Kayser): Huang, 1932, p. 87, pl. 8, figs. 4a, b.

Lyttonia richthofeni Kayser forma *nobilis* Waagen: Licharew, 1932a, p. 69, 96, pl. 2, figs. 13, 14; pl. 5, figs. 1-4, 6; text-fig. 3.

Leptodus nobilis (Waagen): Wanner and Sieverts, 1935, p. 249, pl. 9, figs. 27, 28; text-figs. 16-18; Ramovs, 1958, p. 497, pl. 2, fig. 3; pl. 10, fig. 3; Termier and Termier, 1960, p. 241, pl. 3, figs. 1-10; Chi-Thuan, 1961, p. 274, pl. 1, figs. 1a, b; Schréter, 1963, pl. 3, figs. 5-8; Sarytcheva, 1964, p. 65, pl. 7, figs. 5-8; text-fig. 1; Ruzhentsev and Sarytcheva, 1965, pl. 39, figs. 6-8; 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; Wang et al., 1982, p. 229, pl. 95, fig. 20; Zhan and Wu, 1982, pl. 4, fig. 4; Zhang et al., 1983, p. 297, pl. 102, figs. 7, 8; Yang, 1984, p. 226, pl. 35, fig. 12; 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; Tazawa, 1987, text-fig. 1.11; Kotlyar, in Kotlyar and Zakharov, 1989, pl. 20, fig. 6; pl. 23, fig. 12; Liang, 1990, p. 225, pl. 40, figs. 1, 5; Fang and Fan, 1994, p. 83, pl. 23, figs. 1-3; pl. 30, fig. 5; Leman, 1994, pl. 1, figs. 3, 4; Tazawa and Matsumoto, 1998, p. 7,

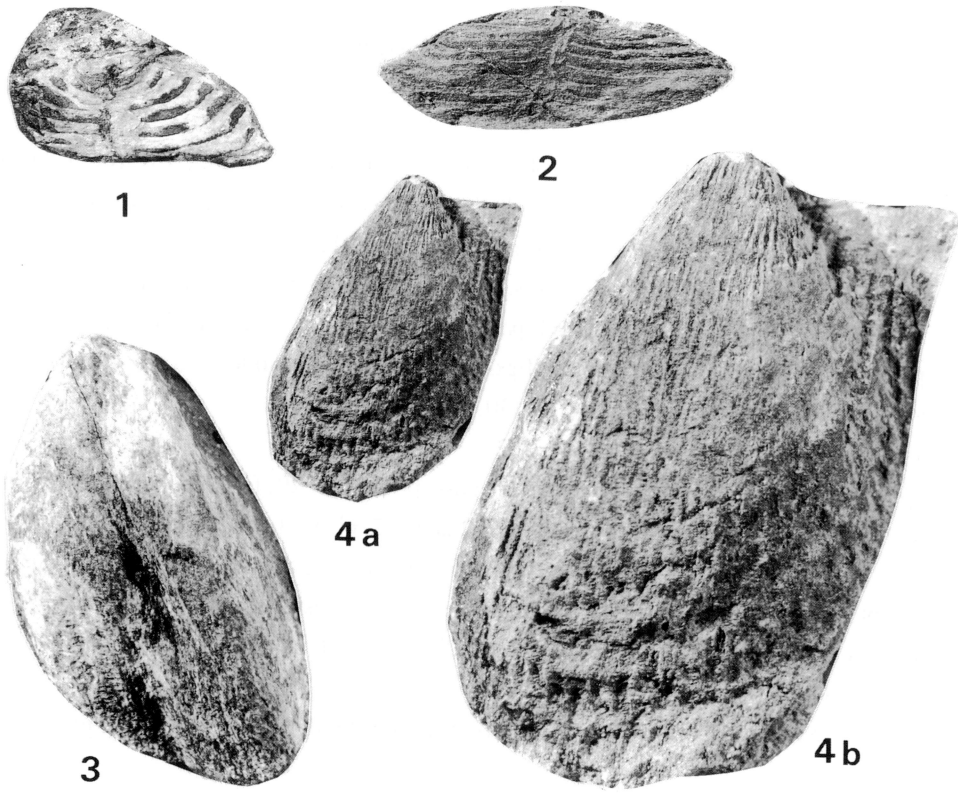

Fig. 4. Brachiopods from the Oyakejima Formation in the Obama area. **1, 2**: *Leptodus nobilis* (Waagen), 1: internal mould of a ventral valve, NU-B490, 2: internal mould of a ventral valve, NU-B489, **3, 4**: *Kochiproductus* sp., 3: external cast of a ventral valve, NU-B627, 4a, 4b: internal mould of a ventral valve, NU-B628, (4b × 2). (All figures are in natural size unless otherwise indicated).

pl. 2, figs. 7-12; Tazawa et al., 1998, p. 241, figs. 2.1, 2.2, 4; Kato et al., 1999, p. 47, figs. 4a, b; Tazawa, 2000b, figs. 3.14, 3.15, 7.1a, 7.1b; Tazawa and Ibaraki, 2001, p. 11, pl. 1, figs. 7-10; Tazawa, 2001b, p. 297, figs. 7.13-7.16; Tazawa, 2002, fig. 10.14.

Lyttonia cf. *nobilis* Waagen: Huang, 1936, p. 493, pl. 1, fig. 5.

Leptodus cf. *nobilis* (Waagen): Thomas, 1957, p. 177, pl. 20, figs. 1-6.

Leptodus richthofeni Kayser: Shimizu, 1961, pl. 18, figs. 14, 15; Schréter, 1963, p. 106, pl. 3, fig. 4; Sarytcheva, 1964, p. 65, pl. 7, figs. 2-4; Yang et al., 1977, p. 372, pl. 147, fig. 10; Yang, 1984, p. 226, pl. 35, fig. 11; Duan and Li, 1985, p. 119, pl. 35, figs. 17-19.

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

Leptodus sp. Minato et al., 1979, pl. 66, fig. 2; Tazawa, 1987, text-fig. 1.10; Yanagida, 1996, fig. 2.14.

Leptodus tenuis (Waagen): Wang et al., 1982, p. 229, pl. 86, fig. 14; pl. 88, fig. 6; pl. 100, fig. 7; Duan and Li, 1985, p. 119, pl. 35, figs. 14-16; Liang, 1990, p. 226, pl. 40, fig. 9; Zhu, 1990, p. 79, pl. 18, figs. 19-21; Fang and Fan, 1994, p. 83, pl. 23, figs. 4, 5; pl. 30, fig. 6.
Gubleria sp. Zhu, 1990, p. 80, pl. 16, fig. 24.

Material.—Two specimens, from locality KOG7, internal moulds of two ventrl valves, NU-B489, 490.

Remarks.—These specimens can be referred to *Leptodus nobilis* (Waagen, 1883), originally described from the Wargal and Chhidru Formations of the Salt Range, by their flat ventral valve with thick lateral ridges and nearly straight lateral lobes. The Obama specimens are more or less deformed. The dimensions of the better preserved specimen (NU-B489) with 9 pairs of lateral lobes are: length 16 mm, width 45 mm. Comparison with the type species, *Leptodus richthofeni* Kayser, 1883, was discussed by Tazawa (in Tazawa and Ibaraki, 2001, p. 13).

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