Systematic Review of Some Cenozoic Naticidae of Southwest Japan

Katura Oyama*, Hiroyuki Nishimoto** and Yoshitsugu Okumura***

新生代西南日本産タマガイ科5属の分類学的検討

大山　桂*・西本博行**・奥村好次***

(要　　旨)

西南日本の新生界からはタマガイ類が豊産するが，その同定は至難である．その理由の一つは，これまでインド・太平洋区周縁域の多系統の種群との比較が十分できなかったからである．

大山はかって日本産現生タマガイ科の系統について概説した（大山，1969，1985）．小論はその現時点における訂正補註の一つであり，西南日本産数種の属位タクサを吟味し，その分布について考察したものである（第1・2図）．

属位の変更を提唱・紹介した諸属の，日本列島への初渡来期は次のように推定されよう（第3図）．

“カリナッカ属”，サキグロタマツメタガイ属（新称）…中新世前期（明世ファウナ）．

キザミタマツメタガイ属(新称)，ワダツミフクロガイ属，（クシメタマガイ属）？…鮮新－更新世(掛川ファウナ)．

(Abstract)

Eight species belonging to five genera, “*Carinacca*”, *Uberella*, *Laguncula*, *Sigaretotrema* and *Stigmaulax*, of Naticidae are briefly described and figured from the Cenozoic and Recent of southwest Japan. Biogeography, paleobiogeography and migration to Japan of them are discussed.

Introduction

There are considerable numbers of species belonging to the family Naticidae from the Cenozoic formations and modern seas of southwest Japan. To identify them is often difficult because the phylogenetic classification of them had not studied enough compared with species discovered in the Circum-Indo-Pacific Provinces.

Oyama, the senior author, tried to make systematic revision of the Recent Japanese Naticidae (Oyama, 1969, 1985). Although Majima (1989a) redescribed all the known

* Toba Aquarium, Toba 3-3-6, Toba City, Mie Prefecture, 517

** Hoshigadai 1-5-50, Tajimi City, Gifu Prefecture, 507

*** Mizunami Fossil Museum, Yamanouchi, Akeyo-cho, Mizunami City, Gifu Pref., 509-61

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species of the Japanese Cenozoic Naticidae and compared them with species from Java, Alaska, Oregon, *etc*. But many problems on the systematics are remaining.

We treat some selected genera; "*Carinacca*", *Uberella*, *Laguncula*, *Sigaretotrema* and *Stigmaulax* of the fossil and modern naticid in southwest Japan, briefly described and figured. The genera "*Carinacca*" and *Laguncula* are recognized for the first record from Japan. The other three genera are also rarely dealt in Japan or Northwest Pacific.

In southwest Japan, many molluscan genera of fossils which are the species of same genera dwelling in the modern southwest Japanease seas, appear from the Early-Middle Miocene, as "Akeyo" and "Kurosedani" Faunas (Oyama, 1950; Tsuda, 1960; Itoigawa, 1960, 1988, 1989; Itoigawa *et* Shibata, 1986; Tsuda, Itoigawa *et* Yamanoi, 1986, *etc*.). But the species of the same genera, in both "Akeyo" and "Kurosedani" and the modern ones, are generally not the same species. Further, three or two other specific changes recognized in the Middle and Late Miocene. They had migrated one by one to Japanese Islands from the south or southwest on each climatic optimum (Ogasawara, 1993, *etc*.), and had constructed the rich modern molluscan faunas in southwest Japan.

The migration of the naticid in the Japanese Islands mainly from the north briefly studied by Marincovich, 1977, Honda, 1983 and Majima, 1989a, *etc*. Moreover, we deal the problem on the basis of the fossil and modern ones from southwest to southwest Japan (fig. 3).

Systematics

Family Naticidae Forbes, 1838

Subfamily Poliniceinae Gray, 1847

Genus *Carinacca* Marwick, 1924

Type species: *Ampullina waihaoensis* Suter, 1917 (by original designation), Late Eocene, Tahu Member, Waihao Green-sand, McCulloch's Bridge, Kaitan, New Zealand.

Diagnosis: "Shell of moderate to small size. Protoconch multispiral, flattened, with a small nucleus. Umbilicus widely open, bounded by a very strong, broad basal ridge, growth-lines strongly retracted to suture. Operculum unknown." (Finlay *et* Marwick, 1937).

Remarks: *Carinacca* has been treated usually the genus belonging to the subfamily Naticinae (*ex*. Finlay *et* Marwick, 1937; Wenz, 1941; Marincovich, 1977).

"*Carinacca*" *mitsuganoensis* (Shibata, 1970), comb. n.
(Pl. 26, Figs. 7a-d, 8a-d, 9a-d)

1970, *Euspira mitsuganoensis* Shibata, p.74, pl.3, figs. 10a, b.

1976, *Euspira mitsuganoensis*: Masuda *et* Noda, p.210.

1977, *Euspira mitsuganoensis*: Shibata, tab.1.

1983, *Euspira mitsuganoensis*: Shibata, *in* Shibata *et* Ina, p.60, pl.8, figs.12-14.

1989, *Euspira mitsuganoensis*: Majima, p.36, 37, pl.3, figs.5, 6, text-fig.10·4.

Type locality: late Early Miocene, Mitsugano tuff. ss. sh. Member, Oi Formation, Ichishi Group. Ashizaka, Misato-mura, Ichishi-gun, Mie Prefecture.

Description: "Shell small, moderately thick, subspherical in outline; spire low, approximately 3/10 of the total height; whorls about 4 1/2, strongly convex, somewhat depressed below the suture; body whorl large; base rounded, coloured brown; surface ornamented with fine close-set oblique growth lines; suture abutting, slightly channeled on the early whorls; aperture semilunular; outer lip regularly arched, inclined about 35 degrees from vertical; inner lip sharp, nearly straight, fairly thickened near anterior end, forming an obtuse angle with the base; thick callus on parietal wall; umbilicus widely open, deep, circular in outline, without funicle; wall of the umbilicus sharply angled with the base.

Dimensions: Height of holotype (ESN 30019*) 16.8 mm, diameter 17.3 mm. Height of paratype 1 (ESN no. unknown) *ca.* 24 mm, diameter 21.4 mm. Height of paratype 2 (ESN no. unknown) 11.6 mm, diameter 11.8 mm." (Shibata, 1970).

Remarks: This species differs from *Carinacca waihaoensis* in having a larger and taller spire, a lower body whorl and a postrior lobe of the parietal callus which is not thickened. It also differs from *Tahunacca haasti* (Marwick, 1924)**, in having a wider umbilicus and a slender basal ridge.

Distribution: 1, late Early Miocene, Mitsugano tuff. ss. sh. Member, Oi Formation, Ichishi Group. Ashizaka, Misato-mura, *etc*., Age-gun, Mie Prefecture (Shibata, 1970).

2, late Early Miocene, Yamami and Toyohama Formations, Morozaki Group. Various localities, Minamichita-cho, Chita-gun, Aichi Prefecture (Shibata, 1977).

3, late Early Miocene, Tsubosawa Formation, Shidara Group. Nakabayashi, Tsugumura, Kitashitara-gun, Aichi Prefecture (Shibata, *in* Shibata *et* Ina, 1983).

Associated molluscan forms: 1, late Early Miocene, Ashizaka, Misato-mura, Age-gun (rare)…"*Boreonatica*" *ichishiensis* Shibata, 1970, "*Propeamussium*" *tateiwai* Kanehara, 1936, *Carinineilo takeharai* (Shibata, 1970), (Shibata, 1970).

2, late Early Miocene, Minamichita-cho, Chita-gun (rare)…*Acilana tokunagai* (Yokoyama, 1925), *Acila* (*Acila*) *eximia* (Yokoyama, 1925), *Lucinoma autilineatum* (Conrad, 1849), *Ennucula akitana* (Otuka, 1943), *Nipponoscaphander* sp., "*Bortonatica*" *ichishiensis* Shibata (Shibata, 1977).

Genus *Uberella* Finlay, 1928 キザミタマツメタガイ属(新称).

Type species: *Natica vitrea* Hutton, 1873 (by original designation), Recent, Stewart Is., New Zealand.

Diagnosis: Shell small to medium, rounded, thin. Protoconch rather flattened. Spire small, whorls gently abutting, body whorl large, ovate. Sculpture with axial grooves, limited subsuturally. Aperture broad, inner lip with callus, which bears a shallow slight

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* abbreviations. ESN: Department of Earth Sciences, Faculty of Science, Nagoya University. Furo-cho, Chikusa-ku, Nagoya City, 464-01.
TA: Toba Aquarium. Toba 3-3-6, Toba City, Mie Pref., 517.
KPM: Kanagawa Prefectural Museum. Minaminakadori 5-60, Nakaku, Yokohama City, 231.
MFM: Mizunami Fossil Museum, Yamanouchi, Akeyo-cho, Mizunami City, Gifu Pref., 509-61.

** Genus *Tahunacca* Maxwell, 1992. Type species, *Natica* (*Carinacca*) *haasti* Marwick, 1924 (by original designation), Middle-Late Eocene, New Zealand.

depression at adapical part of columella. Operculum corneous, semilunular.

Remarks: The Japanese form is identical with New Zealand type, especially with the Mio-Pliocene fossils.

Uberella plicispira (Kuroda, 1961)
(Pl. 25, Figs. 5a-c, 6a, b, 7, 10)

1960, *Lunatia plicispira* Kuroda (MS): Azuma, p.23, pl.3, fig.8 [*nomen nudum*].

1961, *Lunatia plicispira* Kuroda, p.130-131 [E], p.134-135 [J].

1961, *Lunatia plicispira*: Azuma, p.199, pl.13, fig.6 [radula].

1961, *Lunatia plicispira*: Kuroda *in* Kuroda *et* Ito, p.267, pl.18, fig.11.

1963, *Lunatia plicispira*: Horikoshi, Nomura, Saito *et* Kosuge, p. 39.

1964, *Lunatia plicispira*: Okutani, p.394, pl.1, fig.2.

1965, *Lunatica* [*sic*] plicispira: Nakayama, p. 30.

1967, *Lunatia plicispira*: Ito, p.53, pl.2, fig.5.

1969, *Lunatia plicispira*: Shikama *et* Masujima, tab.3(1).

1969, *Lunatia plicispira*: Oyama, p.76

1971, *Euspira plicispira*: Kuroda, Habe *et* Oyama, p.185 [J], p.121 [E], pl.18, fig.3.

1973, *Euspira plicispira*: Higo, p.100.

1976, *Lunatia plicispira*: Inaba, p.87, pl.1, fig.1 [radula].

1979, *Uberella plicispira*: Matsumoto, p. 26.

1980, *Natica* aff. *stellatus* Hedley, 1913: Noda, p.15, 16, pl.7, fig.18 [*fide* Majima, 1989a].

1980, *Naticarinus* [*sic*] *okinawaensis* Noda, p.16, pl.7, figs. 19a, b, 20. Type locality, Late Plioceme, Shinzato Formation. Loc.334, Ihara, Sashiki-cho, Shimajiri-gun, Okinawa Prefecture [*fide* Majima, 1989a] .

1981, *Polinices plicispirus*: Abott *et* Dance, p.104, fig.

1984, "*Naticarius*" *okinawaensis*: Aoki *et* Baba, p.73, fig.5.

1985, *Lunatia plicispira*: Kondo, p.136.

1988, *Euspira plicispira*: Okutani, *in* Okutani, Tagawa *et* Horikawa, species 16, p.48, 2 figs.

1989a, *Pliconacca atricapilla* Martin: Majima, p.64-65, pl.1, figs. 13-16, tab.24, text-fig.15·7 [radula], [*non Natica* (*Lunatia*) *atricapilla* Martin, 1884].

1990, *Euspira plicispira*: Baba, p.147, pl.7, fig.11.

1991, *Pliconacca atricapilla* Martin: Noda, p.40, figs.14·3a,b [*non Natica* (*Lunatia*) *atricapilla* Martin, 1884].

1991, *Euspira yokoyamai* Kuroda *et* Habe: Noda, p.40, pl.41, fig.14·5 [*non Geneosinum* (?) *yokoyamai* Kuroda *et* Habe, 1952].

1992, *Polinices plicispirus*: Cailliez, p.21.

1992, *Euspira plicispira*: Nobuhara, p.520.

1993, *Euspira plicispira*: Higo *et* Goto, p.146.

1993, *Euspira plicispira*: Nobuhara, p.183.

Type locality: Recent, Tosa Bay, West Japan.

Description: "Shell white, wearing olivaceous periostracum, globose in shape. Spire

small, low, whorls 4, weekly expanded, with rather strong sutural wrinkles. Body whorl large, globose ovoid, with gently curved margin. Aperture ovate, white in color. Outer margin gently rounded, inner margin with dilated callus. Columella thickened, expanded over the umbilicus at adapical part. Umbilicus narrowly present. Operculum corneous, semioval, yellow in color.

Height 24. 0 mm, diameter 19.0 mm [Height of holotype (TA no ?) 33.3 mm, diameter 26.2 mm. Height of paratype (TA no ?) 35.5 mm, diameter 30.0 mm]," (Kuroda, Habe *et* Oyama, 1971 [J]).

Remarks: This species belongs to the genus *Uberella*, because of its thin shell, a depressed protoconch, a gently abutting suture, rather strong wrinkles, a large ovate body whorl, a callus covered over an umbilicus and presence of depressions on a columella.

Distribution: 1, Recent, west Japan, from Sagami Bay and Toyama Bay to off west Kyushu (50–450 m in depth), (Kuròda, Habe *et* Oyama, 1971).

2, Middle Pleistocene, Muramatsu gravel silt Member, Kunosan Formation. Miyakami and Muramatsu-otani, Shimizu City, Shizuoka Prefecture (Kondo, 1985).

3, Early Pleistocene, Sanuki Member, Kazusa Group. Nagahama, Futtsu City, Chiba Prefecture (Baba, 1990).

4, Early Pleistocene, Imaizumi Member, Nojima Formation, Kazusa Group. Nanakubo, Imaizumi, Kamakura City, Kanagawa Prefecture (Shikama *et* Masujima, 1969).

5, Plio-Pleistocene, Hijikata Formation, Kakegawa Group. Hijikata and Hatagaya, Daito-cho, *etc*., Ogasa-gun, Shizuoka Prefecture (Nobuhara, 1993, *etc*.).

6, Late Pliocene, Nobori Formation. Nobori, Hane-machi, Muroto City, Kochi Prefecture (Aoki *et* Baba, 1984).

7, Late Pliocene, Shinzato Formation, Shimajiri Group. Miyagusuku, Yonagusuku-son, Nakagami-gun, Okinawa Prefecture (Coll. J. Itoigawa, Y. Okumura and A. Naruse).

8, Late Pliocene, Shinzato Formation, Shimajiri Group. Shinzato and Ihara, Sashiki-cho; Kuteken, Chinen-son; Shikenbaru, Tamagusuku-son; all Shimajiri-gun, Okinawa Prefecture (Majima, 1989a, *etc*.).

Associated molluscan forms: 1, Recent, Off Kii-oshima Is., Wakayama Prefecture (200–400 m in depth), (frequent)…*Neptunea* (*Neptunea*) *kuroshio* Oyama, 1958, *Fusitriton galea* Kuroda *et* Habe, 1961, *Xenophora japonica* Kuroda *et* Habe, 1971, *Biplex perca* Perry, 1811, *Cuspidaria macrorhynchus* Smith, 1895, *C. hindsiana* (A. Adams, 1864), *C. nobilis consimilis* Habe, 1961, *Rengea caduca* (Smith, 1894), *Cetoconcha eximia* (Pelseneer, 1911), *Solamen spectabilis* (A. Adams, 1862).

2, Middle Pleistocene, Miyakami, Shimizu City (rare) … *Limopsis tokaiensis* Yokoyama, 1910, *Ginebis argenteonites* (Lischke, 1872), (Kondo, 1985).

3, Early Pleistocene, Nagahama, Futtsu City (very rare) … *Nuculana* (*Thestyleda*) *yokoyamai* (Kuroda, 1934), *Granulifusus niponicus suboblitus* (Pilsbry, 1904), *Striodentalium rhabdotum* (Pilsbry, 1905), (Baba, *oral com*.).

4, Early Pleistocene, Nanakubo, Kamakura City (very rare) … *Crenulilimopsis oblonga* (A. Adams, 1860), *Fissidentalium* (*Fissidentalium*) *yokoyamai* (Makiyama, 1931), *Limopsis tokaiensis* (Yokoyama, 1910), *Fusitriton galea* Kuroda *et* Habe, *"Nipponomelon" kamakur-*

ensis (Otuka, 1949), (Shikama *et* Masujima, 1969).

5, Plio-Pleistocene, Hijikata and Hatagaya, Ogasa-gun (rare) ··· *Limopsis tokaiensis* Yokoyama, *Benthindsia magnifica* (Lischke, 1871), *Makiyamaia coreanica* (Adams *et* Reeve, 1850), *Micantapex* (*Parabathytoma*) *luehdorfi* (Lischke, 1872), *Fissidentalium* (*Fissidentalium*) *yokoyamai* (Makiyama), *Neilonella dubia* Prashad, 1932, *N. japonica* Okutani, 1962 (Nobuhara, 1993).

6, Late Pliocene, Miyagusuku, Nakagami-gun (very rare) ··· *Gemmula* spp., *Ancilus oyamai* (Shuto, 1959), *Bellucina okinawaensis* Noda, 1988, *Benthindsia sinensis takabanarensis* (MacNeil, 1961), *Baryspira hinomotoensis chinenensis* (MacNeil, 1961), *Luteamussium caduncum* (Smith, 1885); with *Sigaretotrema inflatum* and ten other naticid species (Coll. J. Itoigawa, Y, Okumura and A. Naruse).

Genus *Laguncula* Benson, 1842 サキグロタマツメタガイ属(新称)

Type spesies: *Laguncula pulchella* Benson, 1842 (by monotypy), Recent, Chusan Is., Chekian, China [Zhoushan Is., Zhejiang].

Synonym: *Bensonia* (Cantor MS) Gray, 1847. Published in synonymy of *Laguncula*.

Synonym: *Scarlatia* Schileyko, 1977. Type species, *Natica fortunei* Reeve, 1855 (by original designation), Recent, Shanghai, China. Golikov *et* Sirenko (1988) regarded this as a synonym of *Lunatia* Gray, 1847. Kabat (1991) dealt it as a synonym of *Laguncula*.

Diagnosis: "Testā, tubinata subglobosā, aperturā majori, integrā, oblongā; peristomate interrupto; labio profundo tortuoso. subreflexo; umbilico." (Benson, 1842).

Shell small to medium in size, with tall spire like *Viviparus*. Whorls slightly rounded, suture abutting. Body whorl large. Umbilicus narrow with small funicle. Aperture large, inner lip with very thin callus, delicate ridge within. Operculum corneous, semilunular.

Remarks: Wrighley (1949) figured *Natica glaucinoides* Agassiz in J. Sowerby of the type species of *Euspira*. *Laguncula* differs from *Euspira* in lacking a extended callus, a posterior part of umbilicus and in having a turreted spire and a small round aperture.

Laguncula ressembles to *Falsilunatia* in having similar umbilicus, but it differs from the latter in having a thin shell, a taller spire and a swollen body whorl. It also differs from *Friginatica* and *Sulconacca*, not having a deeply channeled suture**.

Laguncula pulchella Benson, 1842

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* Genus *Euspira* Agassiz *in* J. Sowerby, 1837. Type species, *Natica glaucinoides* J. Sowerby, 1812 (by subsequent designation, Bucquoy, Dautzenberg *et* Dollffus, 1833), Eocene, Great Britain. Bouchet *et* Waren (1993) described other four independent type designation of *Euspira*.

** Genus *Falsilunatia* Powell, 1951. Type species, *Natica soluta* Gould, 1848 (by original designation), Patagonia-Falkland Is. (Dell, 1956, 1990).

Genus *Friginatica* Hedley, 1916. Type species, *Natica beddomei* Johnston, 1884 (by original designation), Recent, South Australia.

Genus *Sulconacca* Marwick, 1924. Type species, *Sulconacca vaughani* Marwick, 1924 (by original designation), Miocene, Pakaurani Point, Kaipara, New Zealand.

(Pl.25, Figs. 1, 8a,b, 11a-d)

(*non*) 1826 *Natica pulchella* Risso, p.148. Type locality, Recent, Coralline zone, Mediterranian.

1842, *Laguncula pulchella* Benson, p.488 [*non fig.*]. Type locality, Recent, Chusan Is., Chekian, China [Zhoushan Is., Zhejiang].

1847, *Laguncula pulchella*: Gray, p.189 (Naticidae, *Polinicina* ? Operculum horneceous ?).

(*non*) 1851, *Natica tenuis* Recluz, p.388. Type locality, Recent, Valparaiso.

1852 (1851), *Natica tenuis* Philippi, ed. 2, pl.14, fig.3.

1852 (1851), *Natica gilva* Philippi, ed. 2, pl.19, fig.11.

1851, *Natica gilva*: Philippi, p.47, 48. Type locality, Recent, South China.

1852 (1852), *Natica tenuis*: Philippi, p.97. Type locality, Recent, mouth of Yang-the-kwing, China [Yangtze-Jiang]

1852 (1853), *Natica gilva*: Philippi, p.138, 139. Locality, Recent, South China.

1853, *Laguncula pulchella*: Philippi, p.182 (Naticidae), [*fide* Kabat, 1991].

1855, *Natica fortunei* Reeve, species 123. Type locality, Recent, Shanghi, China [Shanghai].

1863, *Natica fortunei*: Crosse *et* Debeaux, p.262, 263, pl.9, fig.5. Locality, Recent small anchorage, Yantai, China [Shandong Pen.].

1869, *Assiminea* (*Laguncula*) *pulchella*: Pease, p.164 (Assimineidae), [*fide* Yen, 1942] .

1883, *Natica fortunei*: G.B. Sowerby [II], p.84, fig.153.

1886, *Natica* (*Lunatia*) *fortunei*: Tryon, p.37, pl.9, fig.72; pl.14, figs.22, 23: pl.21, fig.9, (syn. *Natica tenuis, N. gilva*).

1929, *Laguncula pulchella*: Thiele. p.115 (provisionally assigned Viviparidae).

1933, *Natica fortunei*: Yen, p.38.

1936, *Natica gliva*: Yen, p.200, pl.16, figs.25, 25a.

1940, *Natica gilva*: Zhang, Zhao *et* Zhao, p.11, pl.3, fig.8.

1941, *Laguncula pulchella*: Wenz, p.495 (provisionally assigned Viviparidae).

1942, *Natica gilva*: Yen, p.210, pl.16, fig.93 (syn. *Natica fortunei*).

1942, *Laguncula pulchella*: Yen, p.211, pl.16, fig.95.

1952, *Euspira*(?) *fortunei*: Kuroda *et* Habe, p.57.

1955, *Natica fortunei*: Zhang, Zhai *et* Li, p.11, pl.1, fig.8.

1961, *Lunatia fortunei*: Habe, p.38, pl.17, fig.7.

1962, *Natica fortunei*: Zhang, Zhai *et al.*, p.35, fig.24.

1963, *Lunatia fortunei*: Habe, p.58, pl.17, fig.7.

1965, *Natica fortunei*: Zhao, Zhao *et al.*, p.49, fig.64.

1969, *Lunatia fortunei*: Oyama, p.57.

1969, *Lunatia fortunei*: Takahashi *et* Okamoto, p.40, pl.5, figs.18,19 (globose form: Imazu Bay, Hakata Bay; elongate form: Ariake Sea).

1973, *Euspira fortunei*: Higo, p.100.

1976, *Lunatia fortunei*: Yoo, p.65, pl.10, figs.8, 9.

1977, *Scarlatia fortunei*: Schileyko, p.79-97, fig.6e [reproductive organs].

1979, *Euspira fortunei*: Matsumoto, app. p.5.

1981, *Lunatia fortunei*: Sugano, p.41, p.185.

1982, *Polinices fortunei*: Zhao, Cheng *et* Zhao p.47, pl.5, fig.6 (syn. *Natica gilva*, *N. gilva*: Yen, 1936, *N. gilva*: Zhang, Zhao *et* Zhao, 1940).

1982, *Natica gilva*: Ma, p.58.

1983, *Lunatia gilva*: Zhai, Ma *et al.*, p.26, fig.(syn. *Natica fortunei*).

1983, *Lunatia fortunei*: Inaba, p.97.

1984, *Polinices* (? *Euspira*) *fortunei*: Dixon, p.8, fig.153 [Sowerby's fig.].

1988, *Polinices fortunei*: Wang *et. al.*, p.50, fig.148.

1988, *Lunatia gilva*: Golikov *et* Sirenko, p.14, figs.9, 27 [radula], (syn. *Natica tenuis*, *N. fortunei*, *Lunatia fortunei*: Oyama, *Scalatia fortunei*).

1988, *Lunatia fortunei*: Maeda, p.125, figs.1·1A,B,2·1 [osphradium].

1989, *Lunatia fortunei*: Torigoe, p.46-49, figs.1-5 [radula].

1989b, *Lunatia gilva*: Majima, p.4 (syn. *Natica tenuis*, *N. fortunei*).

1989, *Lunatia gilva*: Zhai, Ma *et al.*, p.49,50, pl.4, fig.14 (syn. *Natica gilva*, *N. tenuis*, *N. fortunei*, *Lunatia fortunei*: Habe, 1964, *Polinices fortunei*: Zhao, Cheng *et* Zhao, 1982).

1991, *Euspira gilva*: Kabat, p.431 (syn. *Natica fortunei*;*Laguncula pulchella*).

1992, *Euspira gilva* : Cailliez, p.14,21 (syn. *Natica fortunei*, *Laguncula pulchella*).

1992, *Euspira tenuis* Philippi: Cailliez, p.24.

1992, *Lunatia fortunei*: Fukuda *in* Fukuda, Masuno *et* Sugimura, p.63, pl.13, fig.196.

1993, *Euspira fortunei*: Higo *et* Goto, p.146.

Type locality: Recent, Chusan Is., Chekian, China [Zhoushan Is., Zhejiang].

Description: "Testā albido-glaucā, ovato-globosā; anfractibus convexis, lineis longitudinalibus elevatiusculis aliisque obliquis decussatis instructis; suturis impressis; aperturā intus fascia latā pallide castaneā ornatā columellāque intus concolore.

Habitat. Said to inhabit canals." (Benson, 1842).

Shell large in this genus, reaches to 50 mm in height. Surface smooth, but appears to have microscopic growth line. Color light blue, purplish black to the apex. Body whorl rounded, swollen. Umbilicus narrow, with low funicle and thin callus. Ovate aperture, rounded columella and operculum castanea brown in color.

Remarks: Before Yen (1942) figured *Laguncula pulchella*, this species had not been illustrated, so that the systematic situation was doubtly decided.

This species widely spreads on the tidal lagoon on the extreme high tide level of Northwest Pacific coast, though there are few names had been called, still these names are synonyms of *Laguncula pulchella*.

Distribution: Recent, Japan (Ise Bay, Seto Inland Sea, Ariake Sea, Hakata Bay); Korea (West coast); China (Chinese coast from south to north).

Ise Bay ··· Isshiki-cho, Hazu-gun, Aichi Prefecture (Majima, 1989b); Matsuzaka City, (15m in depth), Mie Prefecture (Higo, 1973; Matsumoto, 1979).

Seto Inland Sea ··· Ushimado-cho, Oku-gun and Otoshima-cho, Kurashiki City, Okayama Prefecture (Inaba, 1983); Nagahama, Yamaguchi City, Yamaguchi Prefecture (Fukuda, 1992): Ube City, Yamaguchi Prefecture (Torigoe, 1989).

Associated molluscan forms: 1, Recent, Ariake Sea (not uncommon) ··· tidal lagoon, III and IV zone (Fujimori, 1929), (see fig.2).

2, Recent, Huangai and Bohai (Seas), (common) ··· with *Paratectonatica tigrina* [Röding] *etc.* (Zhai, Ma, *et al.*, 1989), (see fig.1).

Laguncula sp. A
(Pl.25, Figs.4a-c)

Remarks: This species has ressemblance to *L. pulchella*, but it differs from the latter, in having a thick shell and a thick funicle, especially in adult. It also differs from *L. pulchella*, in having a straight columella, a swollen spire and body whorl.

Distribution: Holocene, Botujaya, east of Djakarta, Java, Indonesia (Coll. J. Itoigawa).

Associated molluscan forms: Holocene, Botujaya, Java (frequent) ··· *Telescopium telescopium* (Linnaeus, 1758), *Tegillarca paucigranosa* (Dunker, 1866), *Geloina erosa* (Lightfoot, 1786), *Placamen berryi* (Gray *in* Wood, 1828), (after J. Itoigawa, *oral com.*).

Laguncula sp. B
(Pl.25, Figs.2a,b,9a,b)

1979, *Euspira meisensis* (Makiyama): Taguchi, Ono *et* Okamoto, pl.4, fig.7 [*non Polinices* (*Euspira*) *meisensis* Makiyama, 1926].

1986, *Euspira meisensis*: Ohe, Taguchi, Okumura *et* Nishimoto, p.35 [*non P.* (*E.*) *meisensis* Makiyama].

1990, *Euspira meisensis*: Taguchi, p.613 [*non P.* (*E.*) *meisensis* Makiyama].

1990, "*Euspira*" sp.: Okamoto, Katsuhara, Ueno *et* Sumiyoshi, p.43.

Remarks: This species differs from the other species of the genus *Languncula*, in having a small shell, a regularly subovate shape, strong growth lines and a vertical columella.

Distribution: 1, early Middle Miocene, Yoshino Formation, Katsuta Group. Niida, Tsuyama City, Okayama Prefecture (Ohe *et al.*, 1986; Taguchi, 1990).

2, early Middle Miocene, Lower ss. Formation, Bihoku Group. Kubara, Niimi City, Okayama Prefecture (Taguchi *et al.*, 1979).

3, early Middle Miocene, Lower ss. Formation, Bihoku Group. Kaisekidani, Miyauchi-cho, Shobara City, Hiroshima Prefecture (Okamoto *et al.*, 1990).

Associated molluscan forms: early Middle Miocene, Niida, Tsuyama City (rare, 1.2%) ··· The dominant element of about four thousand specimens composed sixteen pelecypods species and twenty-five gastropods as ··· *Tellinella osafunei* Taguchi, 1983b (38.5%), *Perna oyamai* Taguchi, 1983a (27.5%), *Vepricardium* (*Vepricardium*) *okamotoi* Taguchi, 1990 (14.1%), *Vicaryella ishiiana* (Yokoyama, 1926), (9.6%), *Ostrea* sp. n. (2.4%).

Tellinella-Perna-Vepricardium-Vicaryella assemblage (Ohe *et al.*, 1986).

Laguncula sp. C
(Pl.25, Figs.3a-c)

Remarks: This species ressembles *L. pulchella*, in having a viviparoid shape, a thin thread like funicle and an inside ridge of the columella, but it differs from the latter, in having an abutting suture and a somewhat expanded posterior callus.

Distribution: 1, late Early Miocene, Togari Member, Akeyo Formation, Mizunami Group. Ichihara, Toki-cho, Mizunami City, Gifu Prefecture.

2, late Early Miocene, Tsukiyoshi Member, Akeyo Formation, Mizunami Group. Kaminokibora, Shomasamabora, Tsukiyoshi, Akeyo-cho, Mizunami City, Gifu Prefecture.

Associated molluscan forms: 1, late Early Miocene, Ichihara, Mizunami City (rare) ··· *Protorotella depressa* Makiyama, 1925, *Minolops tukiyosiensis* (Oyama *et* Saka, 1944), *Batillaria minoensis* Itoigawa, 1960, *Phacosoma kawagense* (Araki, 1960).

2, late Early Miocene, Kaminokibora, Mizunami City (frequent) ··· *Phos* (*Coraeophos*) *iwakianum tsukiyoshianum* Itoigawa, 1960, *Tateiwaia* sp., *Vicaryella ishiiana* (Yokoyama, 1926), *Minolops tukiyosiensis* (Oyama *et* Saka), *Siphonalia minuta* Itoigawa, 1955, *Rhizophorimurx tiganouranus* (Nomura, 1935), *Moerella* aff. *rutila* (Dunker, 1860), *Phacosoma kawagense* (Araki), *Hiatula minoensis* (Yokoyama, 1926).

Subfamily Sininae Woodring, 1928

Genus *Sigaretotrema* Sacco, 1890

Type species: *Sigaretus michaudi* Michelotki, 1847 (by subsequent designation, Cossmann *et* Peyrot, 1919), Miocene, Elveziano, C. Torinesi, Italy.

Diagnosis: Shell rather small, rather thin, subovate, white in color. Protoconch 2 1/2, whorls smooth. Sculpture consists of fine spiral grooves. Umbilicus narrow, without funicle. Aperture broadened outward, parietal callus thin. Operculum corneous, small for the aperture, slender, like *Sinum*, larger and thicker.

Remarks: Kabat (1991) regarded *Sigaretotrema* as a junior subjective synonym of *Eunaticina* Fisher, 1885*, with *Propesinum* Iredale, 1924**, but *Sigaretotrema* is close to some species of *Sinum* by its shell feature and operculum.

Finlay *et* Marwick (1937) stated *Propesinum* is as a synonym of *Sigaretotrema*. *Propesinum* has an operculum as in *Polinices* (Macpherson *et* Gabriel, 1962), so that this genus belongs to the subfamily Polinicinae.

Sigaretotrema inflatum (Tesch, 1920)

(Pl.26, Figs. 1a,b,2a-c,5a,b,6a,b)

1920, *Sigaretus laevigatus* Récluz: Tesch, p.67, pl.82, figs.202a,b. Pleistocene, Timor Is. [*non Sigaretus laevigatus* Lamarck, 1822], (syn. n.)

1920, *Sigaretus inflatus* Tesch, p.67, pl.82, figs.203a,b. Type locality, Pleistocene Timor Is.

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* Genus *Eunaticina* Fisher, 1885. Type species, *Nerita papila* Gmelin, 1791 (by monotypy, a replacement name of *Naticina* Gray, 1847), Recent, Indo-Pacific.

** Genus *Propesinum* Iredale, 1924. Type species, *Natica umbilicata* Quoy *et* Gaimard, 1832 (by original designation), Recent, Tasmania.

1960, *Sigaretotrema sacculum* Kuroda (MS): Azuma, p.23 [*nomen nudum*].

1965, *Sigaretotrema sacculum* Kuroda (MS): Nakayama, p.30 [*nomen nudum*].

1969, *Sigaretotreme inflata*: Oyama, p.80, pl.4, figs.6,7a,b.

1973, *Sigaretotrema inflata*: Higo, p.101.

1973, *Sigaretotrema sacculum*: Higo, p.101.

1979, *Sigaretotrema inflata*: Matsumoto, p.28, pl.6, fig.3.

1982, *Eunaticina* sp.: Ladd, p.103, pl.36, figs.12-14. Pliocene, Tertiary h. Viti Levu, Fiji Is.

1991, *Eunaticina* (*s.s.*) *majimai* Noda, p.41, figs.14･4a-c. Type locality, Pliocene, Yonabaru Formation, Shimajiri Group. Loc. 265, Onaga, Tomigusuku-son, Shimajiri-gun, Okinawa Prefecture (syn. n.).

1993, *Sigaretotrema inflata*: Higo *et* Goto, p.152.

1993, *Sigaretotrema sacculum*: Higo *et* Goto, p.152.

Type locality: Pleistocene, Timor Is.

Description: "Ein fast kugelförmiges Gehäuse mit stark gewölbter Schlusswindung, das in der allgemeinen Gestalt an *Natica* erinnert; nach allen übrigen Merkmalen muss es jedoch unbedingt zu *Sigaretus* gezogen werden. Die Embryonalschale besteht aus zwei glatten Windungen; die zwei weiteren Windungen tragen eine Längsskulptur, welche aus vielen dicht gestellten Spiralleisten besteht. Diese Spiralen sind gleich stark und stehen fast überall in gleicher gegenseitiger Entfernung. Auf der Schlusswindung beobachtet man mehrere, deutlich ausgeprägte Zuwachslinien, an welchen die Spiralen jedesmal um einen ganz kleinen Betrag verschoben erscheinen. Die Mundöffnung ist rundlich-oval und die Schale zeigt einen deutlichen Nabel. Andere *Sigaretus*-Arten mit einer derartig kugelförmigen Gestalt sind mir gar nicht bekannt.

Länge: 20 mm." (Tesch, 1920).

Remarks: Japanese specimens, both the Recent and Pliocene fossil, agree with Tesch's descriptions and figures. *Sigaretus laevigatus*: Tesch, 1920, *Eunaticina* sp.: Ladd, 1982 and *Eunaticina* (*s.s.*) *majimai* Noda, 1991 are synonyms of this species.

Distribution: 1, Recent, Kowaura Bay, Watarai-gun; off Ichigi, Mihama-cho, Minami-muro-gun, Mie Prefecture, central Japan (250-300 m in depth), (Matsumoto, 1979).

2, Recent, Off Kii-oshima Is., Wakayama Prefecture, central Japan (100-500 m in depth).

3, Tosa Bay, West Japan (100-200 m in depth), (Higo, 1973).

4, Late Pliocene, Shinzato Formation, Shimajiri Group. Miyagusuku, Yonagusuku-son, Nakagami-gun, Okinawa Prefecture (Coll. J. Itoigawa, Y. Okumura and A. Naruse).

5, Late Pliocene, Yonabaru Formation, Shimajiri Group. Loc.265, Onaga, Tomigusuku-son, Shimajiri-gun, Okinawa Prefecture (Noda, 1991).

Associated molluscan forms: 1, Recent, Off Kii-oshima Is. (250-400 m in depth), (very rare) ··· *Neptunea* (*Neptunea*) *kurodai* Oyama, 1958, *Fusitoriton galea* Kuroda *et* Habe, *Guildfordia yoka* Josseaume, 1888, *Trochotugurium giganteum* (Schepman, 1909), *Ginebis argenteonites* (Lischke, 1872), *Luteamusium sibogai* (Dautzenbeg *et* Bavay), *Flavamussium caducum* (Smith, 1885).

2, Late Pliocene, Miyagusuku, Nakagami-gun (very rare) ··· associated with *Uberella*

plicispira (Coll. J. Itoigawa, Y. Okumura and A. Naruse).

Subfamily Naticinae Forbes, 1838

Genus *Stigmaulax* Mörch, 1852

Type species: *Nerita sulcata* Born, 1778 (by subsequent designation, Harris, 1897), Recent, West Indies.

Synonym: *Aloconatica* Shikama, 1971. Type species, *Aloconatica kushime* Shikama, 1971 (by original designation), Recent, Enshu-nada, Central Japan [Off Kii Peninsula ?] .

Diagnosis: "Shell small to medium in size, globose to slightly elongate, body whorl distinctly inflated. Sculpture of sharply incised axial grooves that extend from suture to base, sometimes also with weaker spiral grooves to form a reticulate pattern. Umbilicus broad, with deep sulcus separating umbilical and parietal calluses. Parietal callus thick. Umbilical callus semicircular, with concave anterior surface; posterior portion of callus distinctly extended as a low swelling; funicle massive. Inner lip sinuous. Operculum with several small ribs on outer portion and more massive, elevated inner ridge formed of coalesced ribs." (Marincovich, 1977).

Remarks: Kabat (1991) showed that *Aloconatica* was a junior subjective synonym of *Stigmaulax*, though Majima (1989a) separated the two genera. We followed the Kabat's opinion, because the operculum of the type species have not yet known.

Stigmaulax kushime (Shikama, 1971)

(Pl.26, Figs.3,4)

1971, *Aloconatica kushime* Shikama, p.27, pl.3, figs. 1,2.

1973, *Aloconatica kushime*: Higo, p.97.

1989a, *Aloconatica kushime*: Majima, pl.73, figs.1a-d.

1991, *Stigmaulax kushime*: Kabat, p.426.

1992, *Stigmaulax kushine* [*sic*]: Cailliez, p.16.

1993, *Aloconatica kushime*: Higo *et* Goto, p.152.

Type locality: Recent, Enshu-nada, off central Japan [off Kii Peninsula, west Japan ?].

Description: "Shell small sized, thick and white coloured with no lustre like that of chalk. There are many axial grooves which are narrow, deep, sharply marked and slightly undulated. Last whorl carries about 42 grooves. The space of shell surface between grooves is wider than groove. Suture relatively deep. Teleoconch has 3 volutions. Umbilicus deep and carries a median keel. Aperture large and semicircular with thick inner lip.

Dimensions. Height of holotype [KPM-S-2474] 15.4 mm, diameter 15.8 mm." (Shikama, 1971).

Remarks: This species differs from *S. broderipiana* (Récluz, 1844) and *S. elenae* (Récluz, 1843), by having a thick shell, a semicircular umbilicus, a thin funicle and lacking a solid smooth band bordered the umbilicus (Olsson, 1964). It ressembles *Naticarius* (*Naticarius*) *niasensis* Wissema, 1947, but differs from the latter by lacking a smooth band

bordered the umbilicus and in having coarser grooves, as pointed out by Majima (1989a).

Distribution: Recent, Off Kii Peninsula, West Japan (100-300 m).

Associated molluscan forms: Recent, Off Kii-oshima Is. (100-300 m in depth), (very rare) ··· *Guildfordia triumphans* (Philippi, 1841), *Xenophora japonica* (Kuroda *et* Habe, 1971), *Siratus pliciferoides* (Kuroda, 1992), *Murex* (*Murex*) *troscheli* Lischke, 1868, *Pycnodonte musashiana* (Yokoyama, 1920), *Spondylus* (*Spondylus*) *occidens* Sowerby, 1903.

Biogeography

Species of the family Naticidae, drilling predators, are a dominant molluscan element of tidal lagoons, sand bars and deep waters worldwidely. Valid Recent numerous species of the family are accepted almost 200 species by Kabat (1991), almost 330 species by Dixon (1984), almost 360 species by Cailliez (1992), perhaps containing synonymous species. Marincovich (1977) stated its greatest diversity is in the tropics, and in West Pacific, naticid of dwellers in the tropics changes clearly a small number of other species of naticid, to the north as Latitude 28°N.

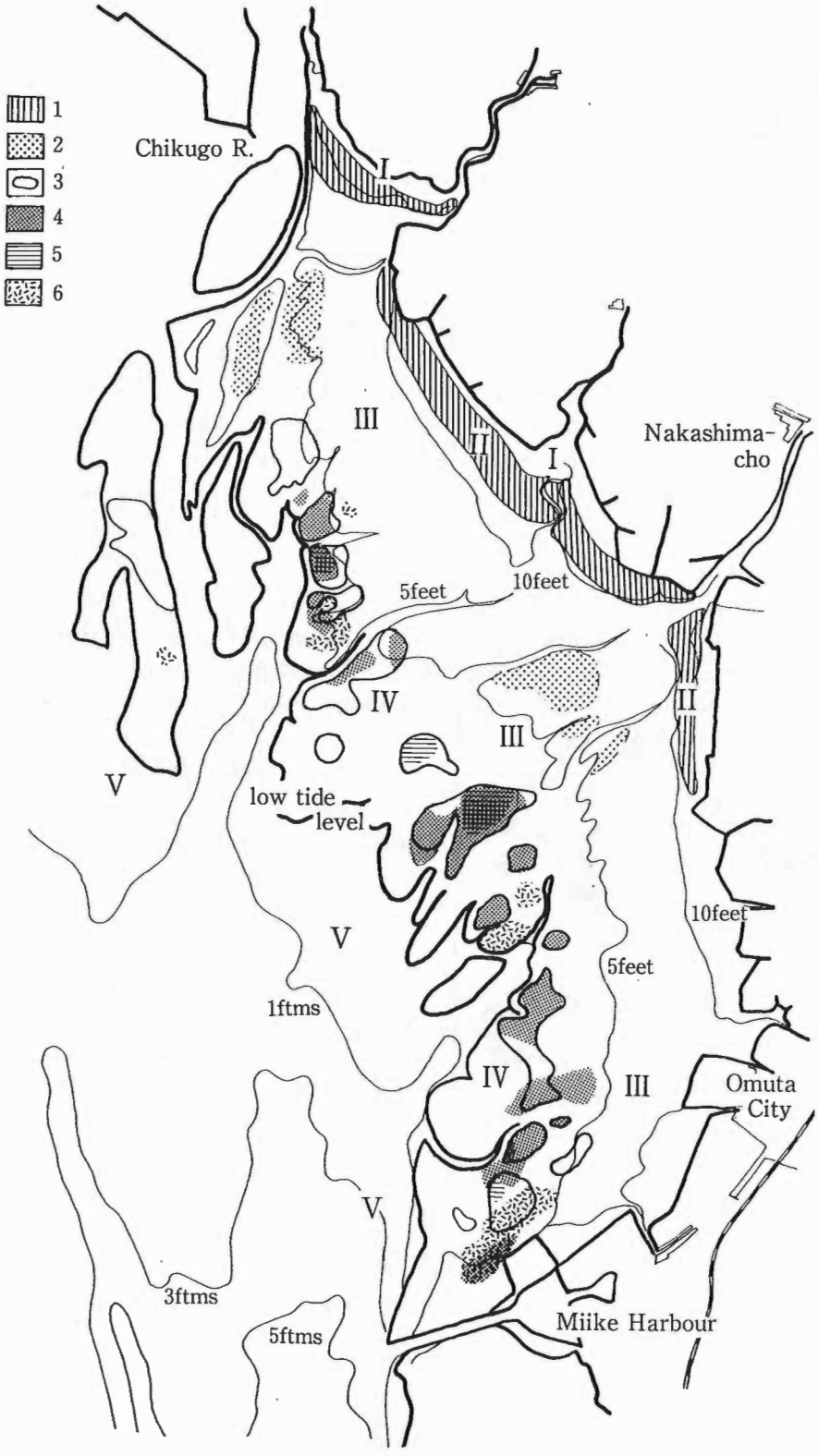
In some species now treated, *Laguncula pulchella* is a dweller of tidal lagoons in the warm temperate bays in northwest Pacific. *L.* sp. A is a same in the tropics of Java, and *Uberella plicispira, Sigaretotrema inflatum* and *Stigmaulax kushime* are dwellers on the upper continental slopes in the subtropical off southwest Japan. Concerning the ecological problems of each species of them, we have not so many data. Then, we attempt to give our view of their geological transitions or changes, with their associated molluscan faunas, throughout the Neogene to the Recent in the Japanese seas.



Fig.1. Distribution of *L. pulchella* in Huangai and Bohai (Seas).
(after Zhai, Ma *et al.*, 1989)
× *Laguncula pulchella*
○ *Paratectonatica tigrina*

Zhai, Ma *et al.* (1983) stated that *L. pulchella* distributes uniformly in the Chinese coast from south to north, and especially occurs in the Zhejiang coast commonly. (They showed, in the coast, it is not only active predators of breeding clams, but of the utilized daily foods). Zhai, Ma *et al.* (1989) described in detail the distribution of it in Huanghai and Bohai (Seas), (fig.1).

In Japan, *L. pulchella* is mainly distributed to the Ariake Sea, west Kyushu, with molluscs of "China Continental Coast Element". When Fujimori (1929) published "Breeding research on the tidal lagoons of the Ariake Sea", he figured a zonal distribution map of the molluscs, before clams breeding years (Fig.2). It


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2
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4
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6
Chikugo R.
I
III
II
I
Nakashima-
cho
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10feet
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low tide
level
V
10feet
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1ftms
IV
III
Omuta
City
V
3ftms
5ftms
Miike Harbour

have occurred his III and IV zones, with *Paratectonatica tigrina* [Röding], 1798.

In the Seto Inland Sea, it is collected rarelly, especially in the west region, with *P. tigrina* which had once been great appearance, but *L. pulchella* became allmost extinct today, becouse of development of reclamation works of the tidal lagoons. In the Ise Bay, it seems to have not dwelt today.

Laguncula sp. A. from the Holocene of Java occurs also in the tidal lagoons, accompanied with the *Telescopium-Geloina* assemblage, which inhabits the mangrove zone in the tropics (Itoigawa, *oral com.*).

In the other three bathyal species, *Uberella plicispira* distributes rather widely from the Sagami Bay and the Toyama Bay to the off west Kyushu (50-450 m in depth), as the subdominant element of molluscan assemblages.

Sigaretotrema inflatum and *Stigmaulax kushime* live with *U. plicispira* or with deeper bathyal dwellers in the subtropical waters off Japanese Islands. Their distribution data have not so enough, because they have collected very seldom today.

U. plicispira and *S. inflatum* seem to distribute to more south to southwest for the Japanese Islands, compared with their fossil records of distribution.

Stigmaulax kushime shows a noteworthy distribution in the Northwest Pacific, whereas

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Fig.2. Zonal distribution of useful benthos of northeastern tidal lagoon in the Ariake Sea, west Japan, before breeding years 1914-1921 (compiled from S. Fujimori, 1929).

I. *Boreophthalmus-Uca* zone (Fujimori's "*Phragmites* zone")*

II. *Sinonovacula* zone, *S. constricta* (Lamarck, 1818) [1]

III. *Lingula* zone (Fujimori's "*Sinonovacula* breeding zone") *L. unguis* (Linnaeus, 1758) [2]

IV. *Modiolus* zone**, *Mactra veneriformis* Reeve, 1854 [6], *Modiolus* (*Modiolus*) *metcalfi* (Hanley, 1843) [3], *Ruditapes philippinarum* (A.Adams *et* Reeve, 1859) [4], *Atrina* (*Servatrina*) *pectinata* (Reeve, 1858) [5]

V. *Theora-Raetellops* zone (Fujimori's "Under low tidal zone")***

Laguncula pulchella occurs III and IV zones, with *Paratectonatica tigrina* [Röding], 1798

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* I zone: *Boreophthalmus pectinirostris* (Linnaeus, 1758), *Uca arcuata* (de Haan, 1838), [*Solinator takii* Kuroda, 1928].
Stream of I and II zones, *Crassostrea gigas* (Thunberg, 1793) [=*C. ariakensis* (Fujita *in* Wakiya, 1929)].

** IV zone: *Scapharca globosa ursus* Tanaka, 1959 (with *Modiolus* nests).
Underside of *Modiolus* nests: *Barnea* (*Umitakea*) *dilatata* (Souleyet, 1843).

*** V zone: *Rapana venosa pechilialis* Grabau *et* King, 1928, [*Fusinus perplexus* (A.Adams, 1854) subsp.], *Babylonia japonica* (Reeve, 1843), *Ostrea denselamellosa* Lishcke, 1869, *Scapharca broughtoni* (Schrenck, 1867), *Meretrix lusoria* [Röding], 1798. [*Theora fragilis* (A. Adams, 1885), *Raetellops pulchella* (A. Adams *et* Reeve, 1850), *Scapharca subcrenata* (Lischke, 1869), *Solen* (*Ensisolen*) *dunkerianus* (Clessin, 1883), *Stenolepis yhleni* (Malmgren, 1867), *Sternaspis scutata* Reiner, 1807), *Astenognathus inaequipes* Stimpson, 1858, *Xenophthalmus pinnotheroides* White, 1846, *fide* Kikuchi, 1985].

the genus *Stigmaulax* is originally a characteristic element of the Caribbean and the Panamic Provinces.

Paleobiogeography

In now dealt three species of the Early-Middle Miocene and two species of the Plio-Pleistocene in southwest Japan, *Laguncula* spp. B and C occur from the tidal lagoon deposits and "*Carinacca*" *mitsuganoensis*, *Uberella plicispira* and *Sigaretotrema inflatum* do from the bathyal. The paleoenvironment of these naticid, and their coexistent benthos (mainely molluscs), seems to have not change generally, during the Pliocene and Recent.

Laguncula sp. C occurs from the late Early Miocene (*ca.* 17 Ma) of central Japan with "the Akeyo Fauna" (Itoigawa, 1988), occupying the outer zone of the *Cyclina-Vicarya* assemblage (Itoigawa, 1960; Itoigawa *et* Shibata, 1986, *etc.*). *L.* sp. B occurs from the early Middle Miocene (16.5 to 16 Ma) of west Japan, with "the Kurosedani Fauna" (Oyama, 1950; Tsuda, 1960; Tsuda, Itoigawa *et* Yamanoi, 1986; Itoigawa, 1988, *etc.*), accompanied with the *Tellinella-Perna-Vepricardium-Vicaryella* assemblage *etc.* (Ohe *et al.*, 1986; Taguchi, 1990).

These two fossil *Laguncula* and a modern *L.* sp. A keep their similar ecological niches on the lagoons in the tropical to subtropical environment from the Early Miocene in

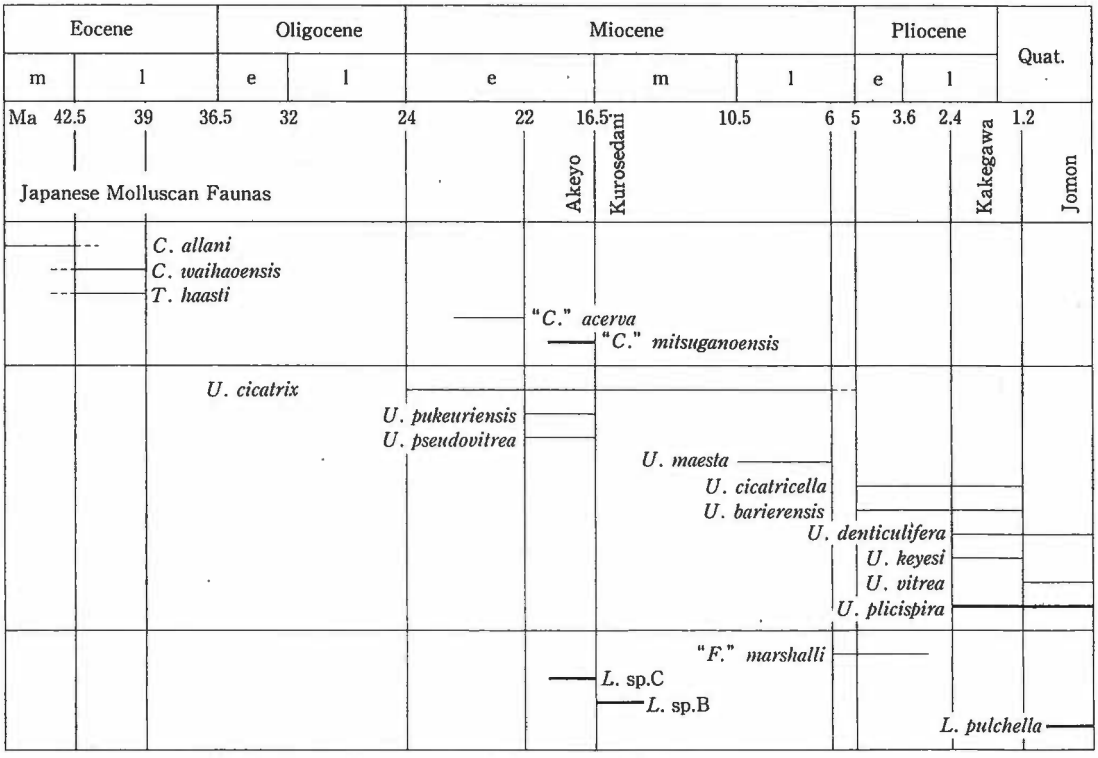


Fig.3. Geological range of the species in three genera.
——Japanese species ——New Zealand species

Japanese Islands to the south.

L. pulchella, however, have extended widely its modern distribution to the warm-temperate zone of Northwest Pacific, accompanied with "China Continental Coast Element", perhaps from the Holocene, "the Jomon Transgression" period.

On the other hand, *Uberella plicispira* appears to keep its bathymetric range from the Late Pliocene to the Recent, in the subtropical zone off Japanese Islands, which have been a dominant element of its molluscan assemblages. It seems to have speciated with allied species of New Zealand, Timor and Java before the Late Pliocene.

Sigaretotrema inflatum distributed to the Okinawa, Timor and Fiji Islands, in the Plio-Pleistocene. This species seems to extend its distribution from the bathyal circum-tropics to subtropics before or since that age.

On *Stigmaulax kushime*, we have not yet studied the akined fossil species.

Migration

Geological ranges of five naticid genera are shown, compared with the same or the ressembled genera distributed in New Zealand (Beu *et* Maxwell, 1990 etc.) (Fig.3).

The genera "*Carinacca*" and *Laguncula* seem to have migrated from the southwest to Japanese Islands, in the Early Miocene with "the Akeyo Fauna". The genera *Carinacca* and *Tafunacca* appeared in the Late Eocene in New Zealand, and they had become exinct after the Early Miocene. Later, "*Carinacca*" which is perhaps akin to *Carinacca* had migrated to Japan, and may be extinct after the Early Miocene.

The genus *Laguncula* remains to the early Middle Miocene in west Japan, and the Recent in central to west Japan, Korea and China, however, it seems to have not remained in the Japanese coast to the southwest, but migrated once and again from the southwest, compared with the shell features of three species of *Laguncula* of Japan.

Laguncula pulchella had not yet known as the fossil record in Japan, even then "the Jomon Transgressive Deposits" in the Holocene (Matsushima, 1984; Matsushima, *oral com.*). The some characteristic molluscan species as "the China Continental Coast Element" are not yet recognized together in "the Jomon Transgressive Deposits" in Japan, but *L. pulchella* had migrated perhaps accompanying them, by reason of their modern distribution.

The genera *Uberella* and *Sigaretotrema* had migrated in the Late Pliocene, with "the Kakegawa Fauna", and remained to the Recent age.

On the genus *Stigmaulax,* we have not yet studied the allied fossil species.

We have deep interests on the facts of next lines, concerning of these naticid migrations to Japanese Islands.

1. The same or the similar genera appeared from New Zealand, occur in the Japanese Islands since the Mio-Pliocene, for example the genera "*Carinacca*" and *Uberella.*

2. Their migration to Japan perhaps seems to show a few chronological retardation, compared with migration in New Zealand.

3. The genus "*Carinacca*"was probably tropical to subtropical dwellers of the bathyal

zone of the Early Miocene of central Japan, of which accompanied with *Acilana tokunagai* and *Acila* (*Acila*) *eximia*, so called "the Cool-temperate Molluscan Element".

4. *Uberella plicispira* appears to keep the bathymetric range from the Late Pliocene to the Recent in subtropics off Japanese Islands, except the glacial stages, with almost same associated molluscan assemblages.

Especially, "the Cool-temperate Molluscan Element" in "the Akeyo Fauna" of Early Miocene seems to have not migrated, at least from the north to the central Japan. The characteristic element of "the Akeyo Fauna", especially the families Nuculidae, Cancellariidae, Naticidae *etc.* may be composed of the Indo-Pasific Province Element (*s.l.*).

The migrations of the naticid from the center of Indo-Pacific Province to Japanese Islands after the Early Miocene, seem to have continued continuously, like as nuculid and cancellarid.

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Plate

Plate 25

Fig. 1. *Laguncula pulchella* Benson; MFM collection; Recent; Otoshima, Kurashiki City, Okayama Prefecture; Height 21.5 mm.

Figs. 2a,b. *Laguncula* sp. B; S. Kishimoto collection; early Middle Miocene, Yoshino Formation, Katsuta Group; Niida, Tsuyama City, Okayama Prefecture; Height 12.5 mm.

Figs. 3a–c. *Laguncula* sp. C; MFM11035; late Early Miocene, Togari Member, Akeyo Formation, Mizunami Group; Ichihara, Toki-cho, Mizunami City, Gifu Prefecture; Height 25.2 mm.

Figs. 4a–c. *Laguncula* sp. A; MFM collection; Holocene; Botujaya, east of Djakarta, Java; Height 21.8 mm.

Figs. 5a–c. *Uberella plicispira* (Kuroda); MFM112115; Late Pliocene, Shinzato Formation, Shimajiri Group; Miyagusuku, Yonagusuku-son, Nakagami-gun, Okinawa Prefecture; Height 13.5 mm.

Figs. 6a,b. *Uberella plicispira* (Kuroda); MFM collection; Recent, Off Isshiki-cho, Hazu-gun, Aichi Prefecture; Height 24.5 mm.

Fig. 7. *Uberella plicispira* (Kuroda); MFM112114; Late Pliocene, Hijikata Formation, Kakegawa Group; Hosoya, Kakegawa City, Shizuoka Prefecture; Height 31.6 mm.

Figs. 8a,b. *Laguncula pulchella* Benson; MFM collection; Recent; Otoshima, Kurashiki City, Okayama Prefecture; Height 27.3 mm.

Figs. 9a,b. *Laguncula* sp. B; S. Kishimoto collection; early Middle Miocene, Yoshino Formation, Katsuta Group; Niida, Tsuyama City, Okayama Prefecture; Height 20.2 mm.

Fig. 10. *Uberella plicispira* (Kuroda); MFM collection; Recent; Off Daiozaki, Mie Prefecture; Height 30.9 mm.

Fig. 11a–d. *Laguncula pulchella* Benson; M. Kosaka collection; Recent; Takeshima, Shimabara City, Nagasaki Prefecture; Height 36.4 mm.

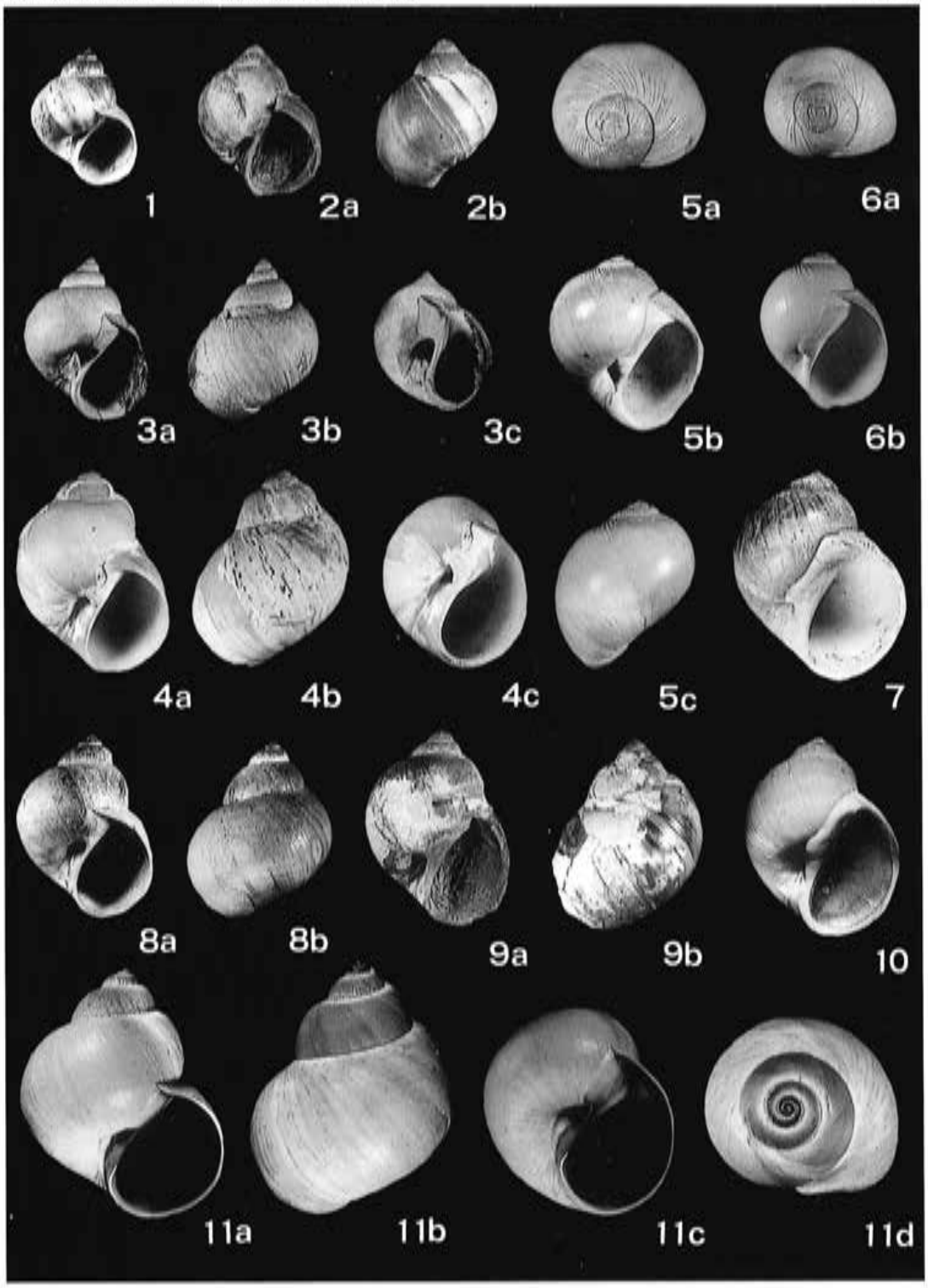

1
2a
2b
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8a
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Plate 26

Figs. 1a,b. *Sigaretotrema inflatum* (Tesch); M. Kosaka collection; Recent; Off Kii-oshima, Wakayama Prefecture; Height 28.0 mm.

Figs. 2a-c. *Sigaretotrema inflatum* (Tesch); K. Oyama collection; Recent; Off Kii-oshima, Wakayama Prefecture; Height of shell (2b,c) 15.0 mm, Height of aperture 14.3 mm, Height of operculum (2a) 5.5 mm.

Fig. 3. *Stigmaulax kushime* (Shikama); S. Ukai collection; Recent; Off Kii-oshima, Wakayama Prefecture; Height 17.0 mm (Photo S. Ukai).

Fig. 4. *Stigmaulax kushime* (Shikama); S. Ukai collection; Recent; Off Kii-oshima, Wakayama Prefecture; Height 16.0 mm (Photo S. Ukai).

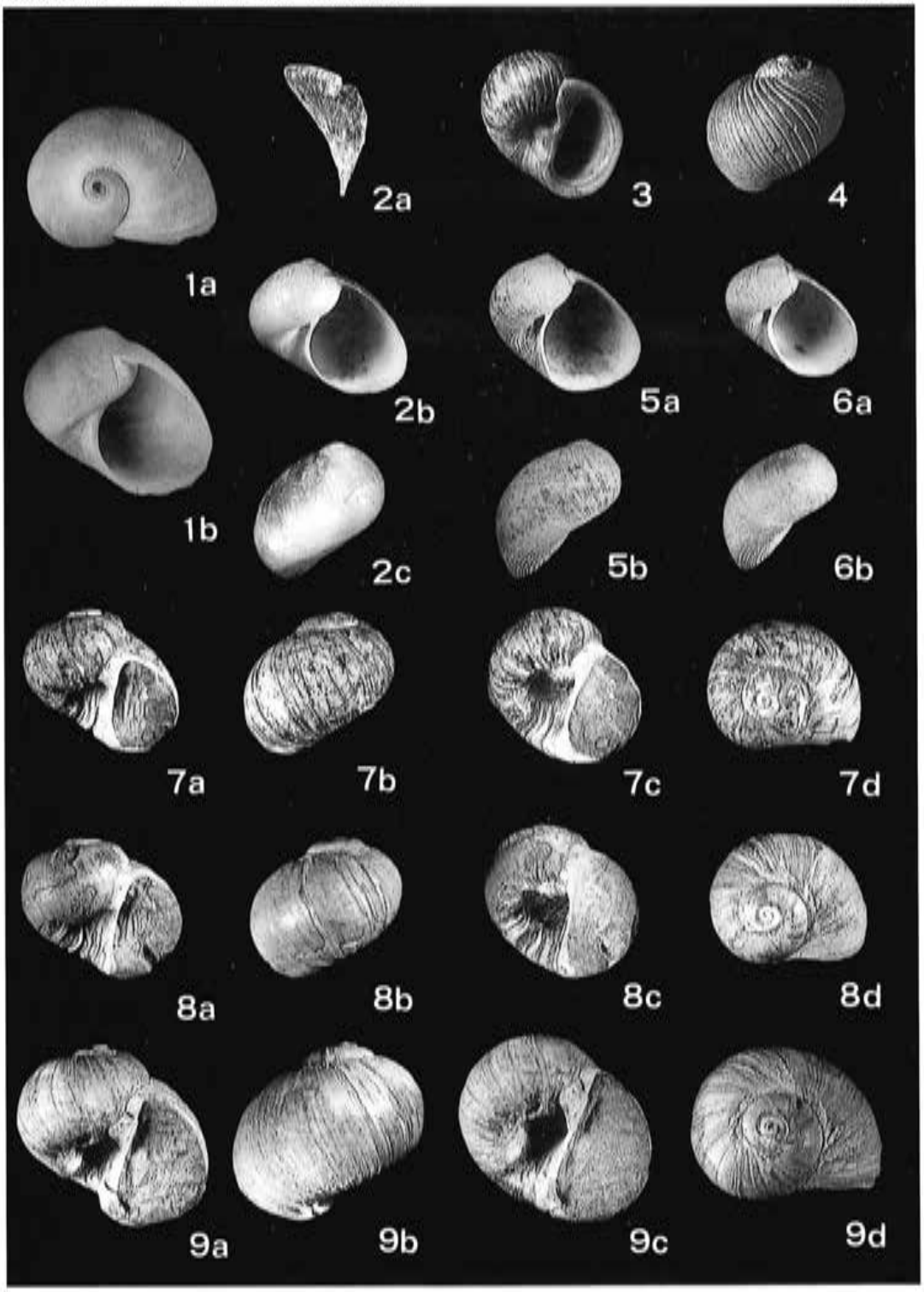
Figs. 5a,b. *Sigaretotrema inflatum* (Tesch); MFM112117; Late Pliocene, Shinzato Formation, Shimajiri Group; Miyagusuku, Yonagusuku-son, Nakagami-gun, Okinawa Prefecture; Height 11.9 mm.

Figs. 6a,b. *Sigaretotrema inflatum* (Tesch); MFM112116; Late Pliocene, Shinzato Formation, Shimajiri Group; Miyagusuku, Yonagusuku-son, Nakagami-gun, Okinawa Prefecture; Height 14.0 mm.

Figs. 7a-d. "*Carinacca*" *mitsuganoensis* (Shibata); M. Kusuhara collection; late Early Miocene, Mitsugano tuff. ss. sh. Member, Oi Formation, Ichishi Group; Ashizaka, Misato-mura, Age-gun, Mie Prefecture; Height 15.0 mm.

Figs. 8a-d. "*Carinacca*" *mitsuganoensis* (Shibata); MFM 21001; late Early Miocene, Mitsugano tuff. ss. sh. Member, Oi Formation, Ichishi Group; Ashizaka, Misato-mura, Age-gun, Mie Prefecture; Height 15.5 mm.

Figs. 9a-d. "*Carinacca*" *mitsuganoensis* (Shibata); M. Kusuhara collection; late Early Miocene, Mitsugano tuff. ss. sh. Member, Oi Formation, Ichishi Group; Ashizaka, Misato-mura, Age-gun, Mie Prefecture; Height 19.2 mm.


1a
2a
3
4
2b
5a
6a
1b
2c
5b
6b
7a
7b
7c
7d
8a
8b
8c
8d
9a
9b
9c
9d