

## Taxonomy and Distribution of *Mizuhopecten planicostulatus* (Nomura and Niino)

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**Abstract** The taxonomy of *Mizuhopecten planicostulatus* (Nomura and Niino) has been reexamined. Its newly found traits are a raised byssal fasciole of the right valve and inequilateral auricles truncated behind at an obtuse angle of the left valve. Judging from this point of view as well as the ornamentation of disc, *Mizuhopecten pseudoyessoensis* (Akiyama and Miyajima) and *M. ibaragiensis* (Masuda) are conspecific with *M. planicostulatus*. This species flourished in the “Transitional zone” (Noda & Amano, 1977) during the Pliocene, and its geographic range shrank to the southern Kanto area in the early Pleistocene.

**Key words:** taxonomy, distribution, *Mizuhopecten planicostulatus*, Pliocene, early Pleistocene.

### Introduction

The genus *Mizuhopecten* has much more diverse fauna in the Neogene than the Recent (Masuda, 1962). However, sometimes, the “species” of this genus are discriminated by the slight differences of shell sculpture. Before going to discussion on diversity trend, it is necessary to reexamine the taxonomy of the genus at the first step.

Up to this time, from the Plio-Pleistocene formations along the Pacific-side of Honshu, the following species of *Mizuhopecten yessoensis* group have been illustrated: *M. planicostulatus* (Nomura and Niino), *M. ibaragiensis* (Masuda), *M. pseudoyessoensis* (Akiyama and Miyajima), *M. yessoensis* (Jay), and *M. sp.* (Nomura & Niino, 1932; Masuda, 1953, 1962; Akiyama & Miyajima, 1960; O’Hara & Nemoto, 1975, 1988; Ogasawara *et al.*, 1988; Baba, 1990, 1992; Yamada & Koizumi, 1994; Amano & Nobuhara, 1995; Masuda & Miyasaka, 1996).

Some taxonomic confusions occur in this group. For example, O’Hara and Nemoto (1975) identified the Pliocene Tomioka specimens in Fukushima Prefecture as *Patinopecten (Mizuhopecten) pseudoyessoensis*. Afterwards they changed the species name to *P. (M.) planicostulatus* (Nomura and Niino) without any reasons (O’Hara & Nemoto, 1988). Recently, Masuda and Miyasaka (1996) reexamined the specimens and concluded that this species should be synonymized with *Mizuhopecten yessoensis* (Jay).

The previous studies mainly treated numbers and shape of radial ribs as well as interstitial riblets as taxonomical characters. However, there is no work stressing an importance of auricular character in the taxonomy of *M. yessoensis* group. In this study, we especially examined the auricles of many specimens from the Plio-Pleistocene strata in the Pacific-side of Honshu.

### Localities

Three hundred and sixty specimens were obtained by hand from the following Loc. A–D (Fig. 1). The specimens from Loc. E were collected by Dr. Tomoki Kase of National Science Museum.

Loc. A. Road-side cliff about 100 m south of Hirono power station, Hirono Town, Fukushima Prefecture; pebble-bearing coarse-grained sandstone; Pliocene Tomioka Formation.

Loc. B. Cliff about 650 m north of Hitachi railroad station, Hitachi City, Ibaraki Prefecture [Type locality of *Mizuhopecten ibaragiensis* (Masuda)]; shell-bearing medium- to coarse-grained sandstone; Pliocene Hitachi Formation.

Loc. C. Outcrop at Imaizumi Park, Kamakura City, Kanagawa Prefecture; alternation of conglomerate and coarse-grained sandstone; Lower Pleistocene Nojima Formation.

Loc. D. Outcrop about 1 km east of Ichiyama, Amagi-Yugashima Town, Shizuoka Prefecture [near the type locality of *Mizuhopecten planicostulatus* (Nomura and Niino)]; calcareous medium-grained sandstone; Pliocene Shirahama Group.

Loc. E. River bank near Hirayama Bridge, Hino City, Tokyo Metropolis; Lower Pleistocene Hirayama Formation.

Besides these specimens, *Mizuhopecten yessoensis* (Jay) from the Pliocene Dainenji Formation stored at the museum of Tohoku University and *M. sp.* from the Pliocene Hijikata Siltstone stored at Joetsu University of Education were taxonomically reexamined.

### Systematic Description

Class Bivalvia Linnaeus, 1758

Family Pectinidae Rafinesque, 1815

Subfamily Fortipectininae Masuda, 1962

Genus *Mizuhopecten* Masuda, 1963

***Mizuhopecten planicostulatus* (Nomura and Niino, 1932)**

(Fig. 2 a–g, Fig. 3 a, b, d–f)

*Pecten (Patinopecten) planicostulatus* Nomura and Niino, 1932, p. 177–178, pl. 11, figs. 2–5.

*Patinopecten ibaragiensis* Masuda, 1953, p. 44–46, pl. 5, figs. 1–5, pl. 6, figs. 1–5; Kamada and Hayasaka, 1959, p. 22, pl. 2, figs. 8, 9.

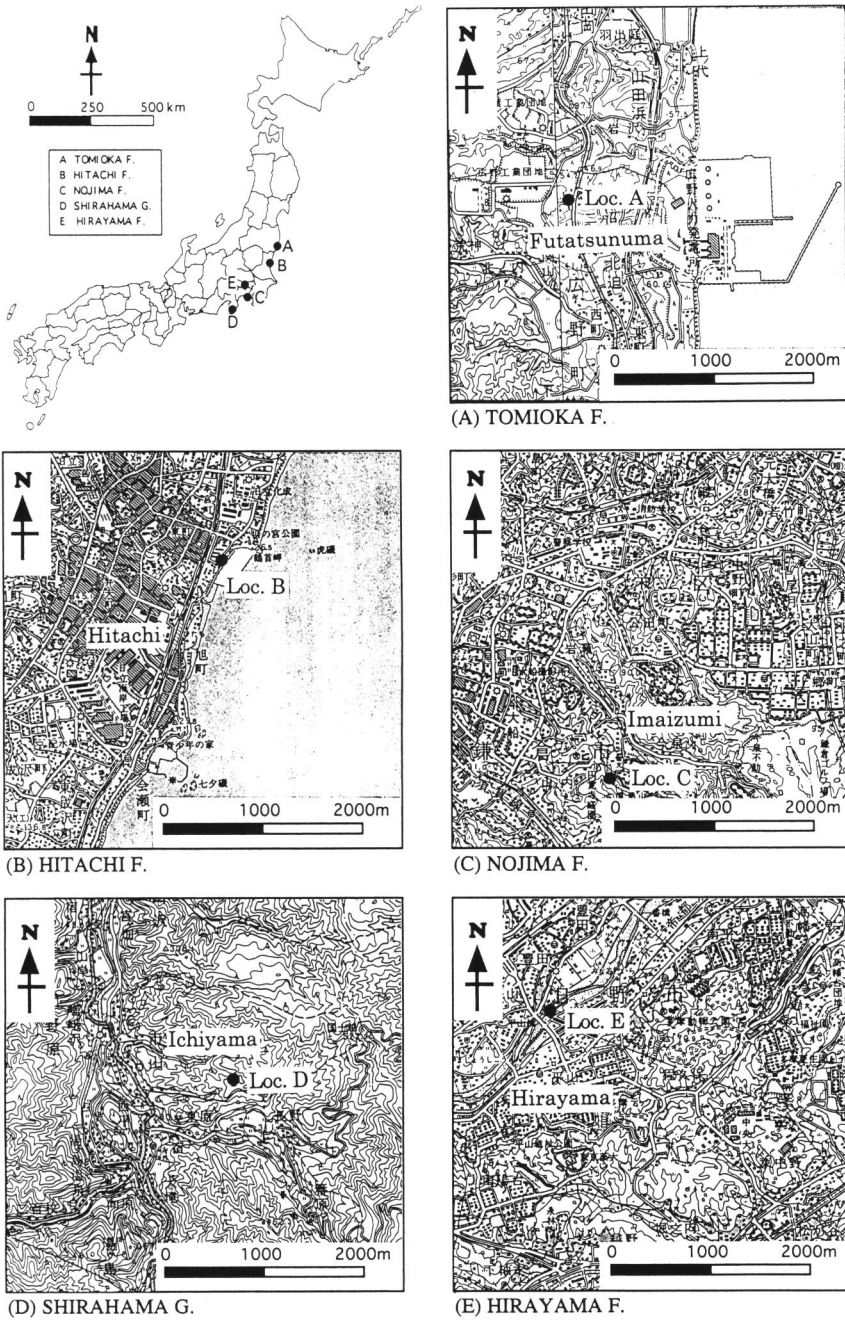
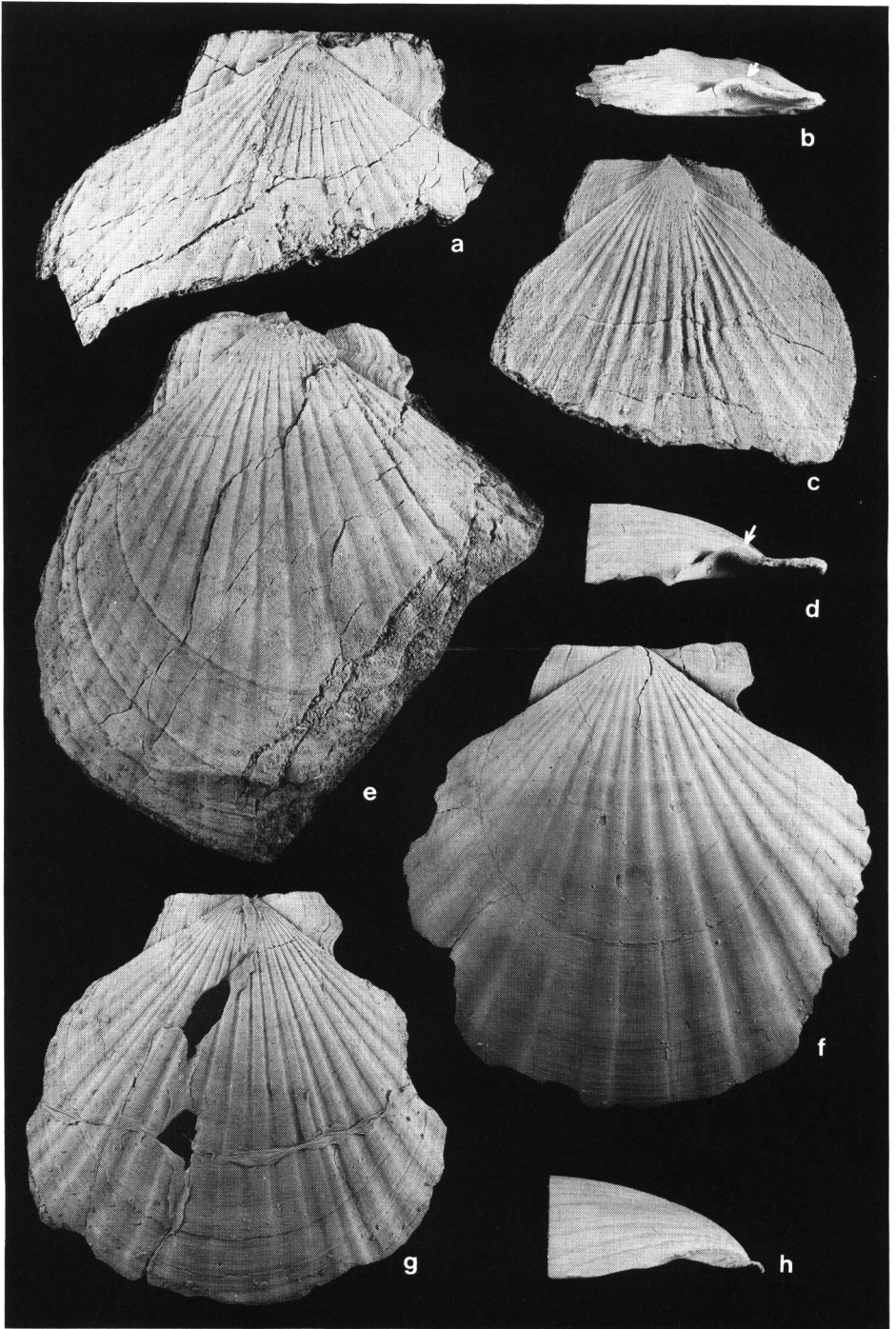


Fig. 1. Collecting localities of *Mizuhopecten planicostulatus* (Nomura and Niino) (using the topographical maps of “Kawamae”, “Ide”, “Hitachi”, “Yokohama”, “Shuzenji”, and “Hachi-oji”, scale 1 : 50,000 published by Geographical Survey Institute of Japan).



- Patinopecten pseudoyessoensis* Akiyama and Miyajima, 1960, p. 99–103, pl. 5, figs. 1–5; O'Hara and Nemoto, 1975, p. 153–154, pls. 1–6; Nemoto and O'Hara, 1979, pl. 3, figs. 1, 2.
- Patinopecten planicostulatus* Nomura and Niino, Masuda, 1962, p. 209, pl. 23, fig. 11, pl. 27, fig. 9.
- Mizuhopecten planicostulatus* (Nomura and Niino), Masuda, 1986 a, pl. 3, fig. 3; Masuda, 1986 b, pl. 10, fig. 7; Okumura and Koyanagi, 1989, pl. 9, figs. 2–5; Yamada and Koizumi, 1994, fig. 2–8, 9; Masuda and Miyasaka, 1996, p. 2–4, pl. 1, figs. 1–3, pl. 2, figs. 1–4.
- Mizuhopecten ibaragiensis* (Masuda), Takahashi, 1986, pl. 13, figs. 2, 4; Noda *et al.*, 1993, p. 143, figs. 16-1–7, 17-1–5.
- Patinopecten (Mizuhopecten) ibaragiensis* Masuda, O'Hara and Nemoto, 1988, p. 491, pl. 1, fig. 3.
- Patinopecten (Mizuhopecten) planicostulatus* (Nomura and Niino), O'Hara and Nemoto, 1988, p. 491–492, pl. 4, figs. 1, 2.
- Mizuhopecten yessoensis* (Jay), Ogasawara *et al.*, 1988, p. 10–11, pl. 1, figs. 18, 19; Baba, 1990, p. 255, pl. 26, fig. 6, pl. 27, fig. 1.
- Mizuhopecten pseudoyessoensis* (Akiyama and Miyajima), Baba, 1990, p. 256, pl. 27, figs. 2, 3; Baba, 1992, pl. 70, fig. 5.
- Mizuhopecten* sp., Amano and Nobuhara, 1995, p. 105–106, fig. 4.

*Types*: Syntype, IGPS no. 48584. Holotype of *Mizuhopecten pseudoyessoensis* (Akiyama and Miyajima), TKD no. 5371. Holotype of *Mizuhopecten ibaragiensis* (Masuda), DGS no. 1031.

*Type locality*: Ichiyama, Amagi-yugashima Town, Shizuoka Prefecture (near Loc. D in Fig. 1).

*Description*: Shell moderate in size (max. shell length=111.3 mm), less inflated, subcircular, subequilateral except for auricles; apical angle about 110°.

Right valve with 11–23 (commonly 17–20; Fig. 4) flat-topped radial ribs, becoming obsolete toward ventral margin; radial ribs low and broader than their interspaces, bifurcate near both anterior and posterior sides; auricles small in size; anterior auricle sculptured by some faint radial threads, with wide and raised byssal fasciole (Fig. 2 b, d); posterior auricle with very weak radial threads, truncated behind at obtuse angle.

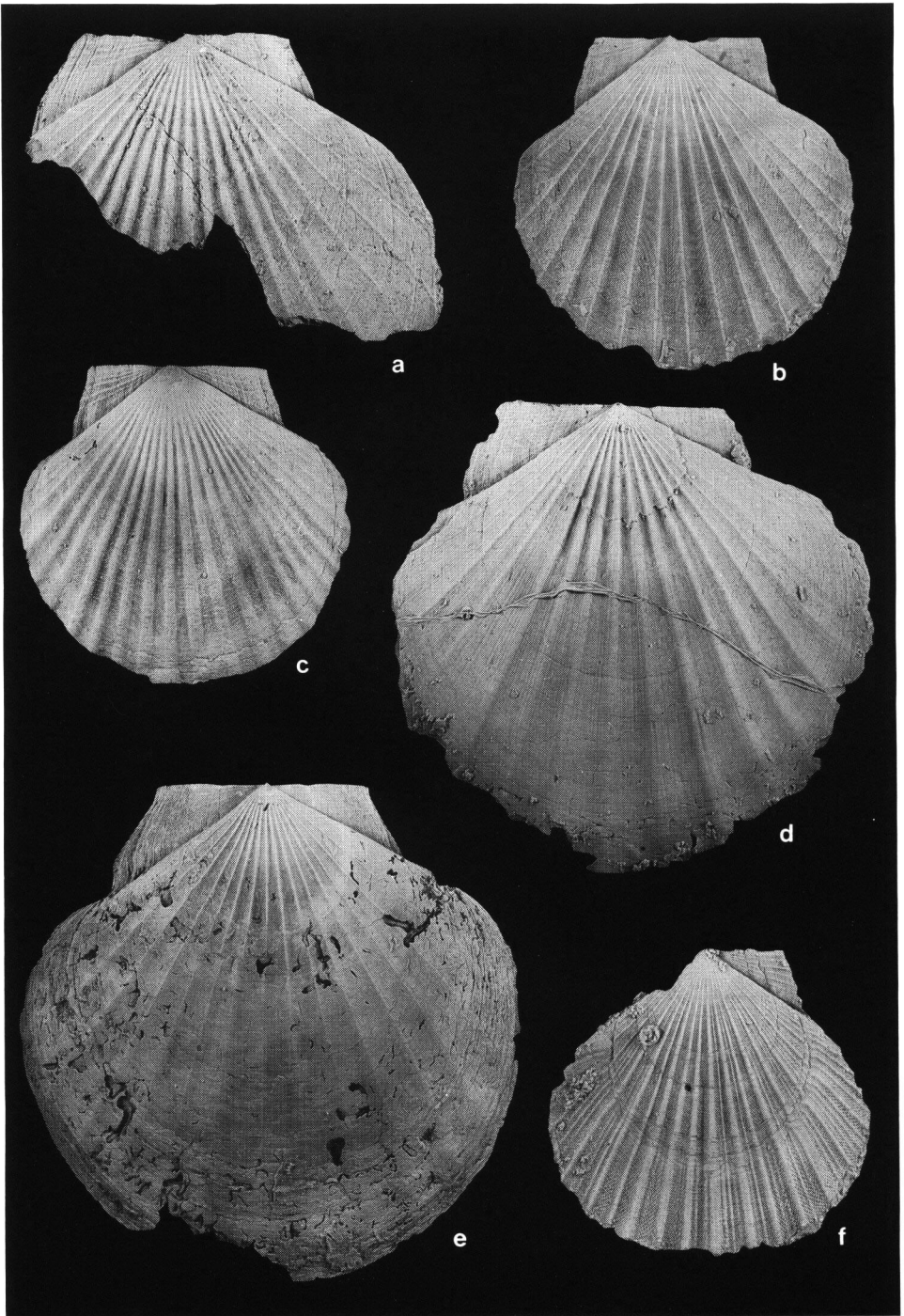
Left valve with 13–22 (commonly 15–19; Fig. 4) narrow and low radial ribs, becoming obsolete toward ventral margin; radial ribs narrower than interspaces; interspaces sculptured frequently by weak interstitial threads and sometimes by network sculpture; auricles inequilateral, anterior auricle larger than posterior one; both anterior and posterior auricles sculptured by weak radial threads, truncated behind at obtuse angle.

Hinge with rather large resilial pit. Interior surface folded by corresponding to external sculpture.

*Remarks*: The present species was established by Nomura and Niino (1932),

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←Fig. 2. *Mizuhopecten planicostulatus* and *M. yessoensis* (1). a–g. *Mizuhopecten planicostulatus* (Nomura and Niino). a, c, e:  $\times 1$ , JUE no. 15630-1–3, Loc. D, Shirahama Group. b, g: b,  $\times 1.4$ , JUE no. 15631-1, (white arrow pointing an raised byssal fasciole); g,  $\times 0.6$ , JUE no. 15631-2; Loc. C, Nojima Formation. d, f: d,  $\times 1.5$  (white arrow pointing an raised byssal fasciole); f,  $\times 0.8$ ; JUE no. 15632-1, Loc. B, Hitachi Formation. h. *Mizuhopecten yessoensis* (Jay),  $\times 1.4$ , Loc. Anden in Akita Pref., JUE no. 15633-1, Shibikawa Formation.





based on the specimens from the Pliocene Shirahama Group. However, as the left valve of this species was undescribed, its morphology had been unknown.

Recently, Masuda and Miyasaka (1996) examined many fossil scallops from the lower Pleistocene Hirayama Formation in Tokyo Metropolis. They came to the conclusion that the Hirayama species should be identified with *Mizuhopecten planicostulatus* (Nomura and Niino). They also considered that *M. pseudoyessoensis* described by Akiyama and Miyajima (1960) from the lower Pleistocene Nojima Formation in Kanagawa Prefecture as a synonym of *M. planicostulatus*.

According to the previous studies, *M. planicostulatus* characteristically has 17–22 flat-topped radial ribs becoming obsolete toward a ventral margin. As the result of our examination of this species from the Shirahama Group, some important characters of this species have been found; namely, the raised byssal fasciole of the right valve and the inequilateral auricles of the left valve. From this point of view, the specimens from the Nojima Formation share all traits above mentioned. Therefore, we agree with Masuda and Miyasaka's (1996) opinion.

*Mizuhopecten ibaragiensis* was described by Masuda (1953) from the Pliocene Hitachi Formation in Ibaraki Prefecture. According to Masuda and Miyasaka (1996) as well as the original description, this "species" can be distinguished from *M. planicostulatus* by its undivided radial ribs and rather conspicuous byssal notch of the right valve, and by having several interstitial riblets between radial ribs of the left valve. However, some right valves of *M. ibaragiensis* from the type locality have weakly subdivided radial ribs (Fig. 2 f). Moreover, some left valve from the Shirahama Group (Fig. 2 c) and the Hirayama Formation (Fig. 3 e) have several weak interstitial threads between ribs. Moreover, the raised byssal fasciole of the right valve (Fig. 2 d) and the inequilateral auricles of the left valve can be observed in the topotype specimens of *M. ibaragiensis*. Therefore, *M. ibaragiensis* should be also a synonym of *M. planicostulatus*.

The left valve specimens from the Tomioka Formation show a variable intensity of interstitial riblets. Some specimens have no riblet like as *M. yessoensis* (Fig. 3 b) while another specimens have several distinct ones (Fig. 3 f). However, all these specimens provide with 13–22 radial ribs and inequilateral auricles. The byssal fasciole of every right valves from the Tomioka are not flat, but conspicuously raised, unlike *M. yessoensis*. Therefore, we partly agree with O'Hara and Nemoto's (1988) opinion on the classification of pectinids.

Ogasawara *et al.* (1988) described and illustrated *Mizuhopecten yessoensis* (Jay)

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←Fig. 3. *Mizuhopecten planicostulatus* and *M. yessoensis* (2). a, b, d–f. *Mizuhopecten planicostulatus* (Nomura and Hatai). a:  $\times 0.9$ , JUE no. 15631-3; Loc. C, Nojima Formation. b, f:  $\times 1$ , JUE no. 15634-1; f,  $\times 1.3$ , JUE no. 15634-2; Loc. A, Tomioka Formation. d:  $\times 1$ , JUE no. 15632-2, Loc. B, Hitachi Formation. e:  $\times 0.8$ , NSM PM 16087; Loc. E, Hirayama Formation. c. *Mizuhopecten yessoensis* (Jay),  $\times 0.6$ , Loc. Anden in Akita Pref., JUE no. 15633-2, Shibikawa Formation.

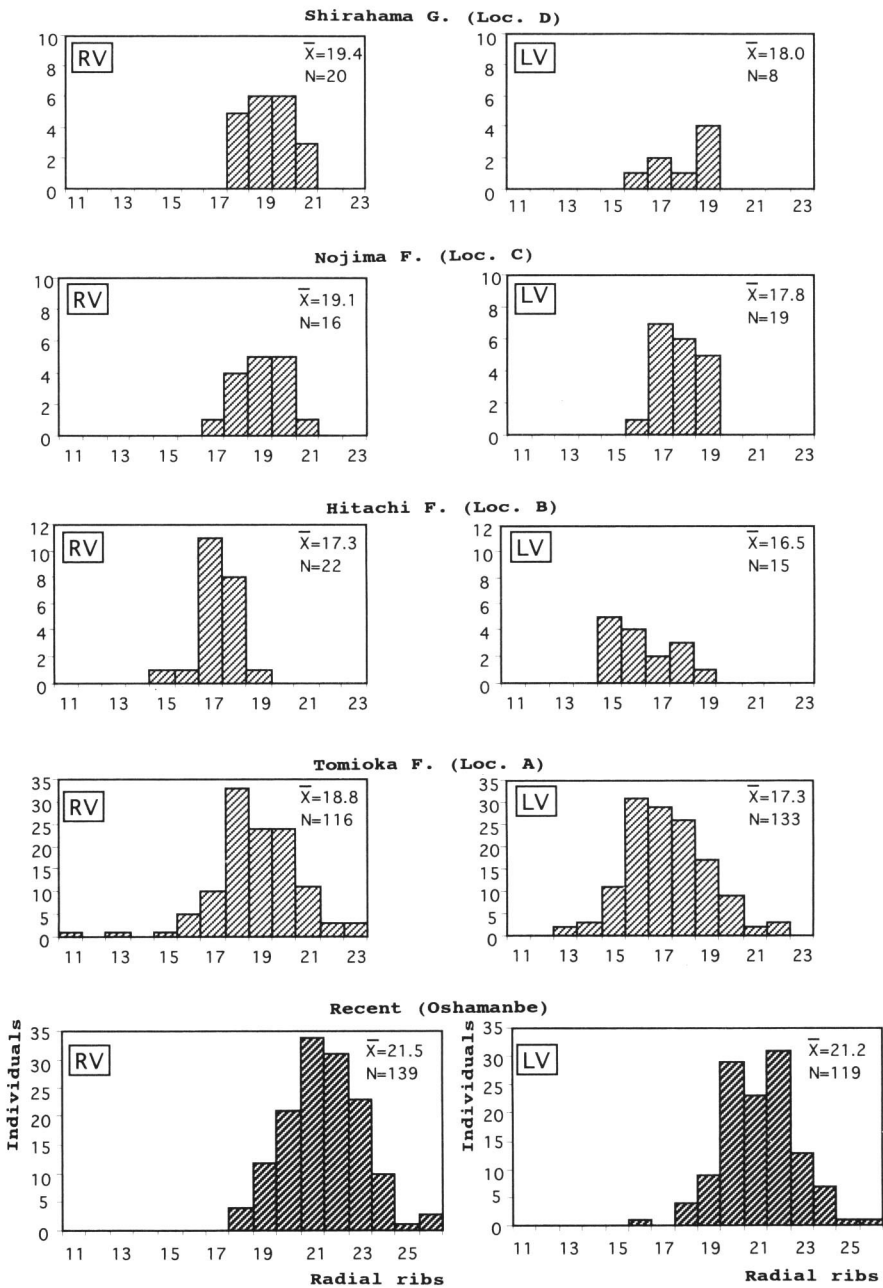


Fig. 4. Intrapopulational variation of number of radial ribs in four fossil samples (Loc. A–D) of *Mizuhopecten planicostulatus* (Nomura and Niino) and in one recent sample (Oshamanbe) of *M. yessoensis* (Jay).



from the uppermost Pliocene Dainenji Formation in Miyagi Prefecture. However, by our observation, the right valve specimens have 16–17 low flat ribs and the raised byssal fasciole. On the other hand, the left valve of Dainenji species have 15–16 narrow ribs becoming obsolete near the ventral margin and the larger anterior auricle than the posterior one. These characters are common with *M. planicostulatus*.

Amano and Nobuhara (1995) found one right valve of *Mizuhopecten* from the Pliocene Hijikata Siltstone. Despite this specimen has 24 radial ribs, its byssal fasciole is slightly raised. Moreover, two radial ribs are distinctly dichotomous. Therefore, the Hijikata specimen should be classified with *M. planicostulatus*.

*Comparison*: The present species is most allied to the recent *Mizuhopecten yessoensis* (Jay). It is easy for the right valve to distinguish the latter from the former by having more numerous (commonly 21–22), distinct and undivided radial ribs near the ventral margin, a flat byssal fasciole, and a more shallow byssal notch. The left valve of the recent species differs from *M. planicostulatus* by its stronger radial ribs without any interstitial threads between ribs, subequilateral auricles, and an anterior auricle truncated behind at a right angle.

The Miocene scallop, *Mizuhopecten paraplebejus* (Nomura and Hatai, 1936), is another allied species to *M. planicostulatus* in having the similar number of radial ribs (16–23 in the right valve) becoming obsolete near the ventral margin. However, the former differs from the latter by having more inflated right valve, shallowly sculptured radial ribs in the right valve, large auricles without a raised byssal fasciole, and also by having an anterior auricle of left valve truncated behind at a right angle.

### Distribution

Consequently, *Mizuhopecten planicostulatus* is occurred from the following deposits only in the Pacific-side of Honshu: Pliocene: Dainenji Formation in Miyagi Prefecture, Tomioka Formation in Fukushima Prefecture, Hitachi and Kume Formations in Ibaraki Prefecture, Kurotaki Formation in Chiba Prefecture, Nakatsu and Ashigara Groups in Kanagawa Prefecture, and Shirahama Group and Hijikata Siltstone in Shizuoka Prefecture; early Pleistocene: Hirayama Formation in Tokyo Metropolitan, Nojima Formation in Kanagawa Prefecture (Fig. 5).

Masuda and Miyasaka (1996) considered that the present species expanded its geographic range northwards through time. However, as a result of this study, *M. planicostulatus* flourished in the “Transitional Zone” by Noda and Amano (1977) from where the mixed Pliocene fauna of the warm-water Kakegawa and the cold-water Tatsunokuchi are recognized. In the early Pleistocene, the geographic range shrank to the southern Kanto area. It is interesting to note that the species suffered extinction in middle or early Pleistocene. At the end of early Pleistocene, most characteristic species of Omma-Manganji fauna in the Japan Sea borderland also suffered extinction (Amano, 1997). According to Amano (1997), the cause of this extinction

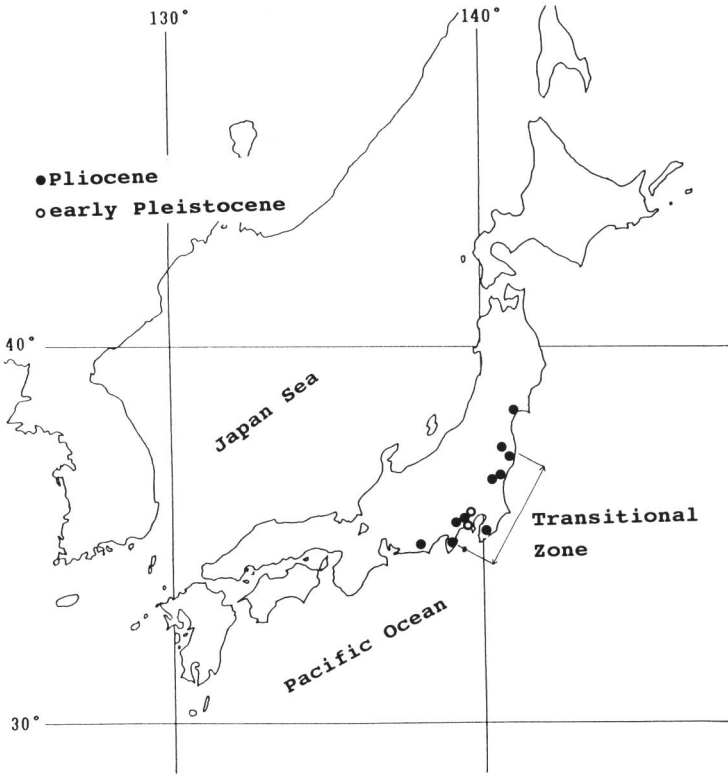


Fig. 5. Distribution of *Mizuhopecten planicostulatus* (Nomura and Niino).

may have been attributed to the effect of glaciation which became outstanding after the middle Pleistocene. It is necessary to examine the paleoecology of this species in detail for elucidating the effect of glaciation upon the extinction event in the Pacific-side of Honshu at the end of early Pleistocene.

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