

A New Species of Land Snail of the Genus *Mandarina* (Gastropoda: Pulmonata) from Hahajima of the Bonin Islands, Western Pacific:
a Species that became extinct after 2000 yr B.P.

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Abstract A new fossil species of the pulmonate genus *Mandarina* Pilsbry, 1894, *Mandarina ogasawarana*, is described on the basis of specimens collected from Holocene dune deposits (2000 yr B.P.) on Hahajima in the Bonin Islands of the western Pacific. The distribution of the new species is restricted to the Hyogidaira and Nakanodaira areas of Hahajima. The new species is similar to *Mandarina aureola* Chiba, 1989 and *M. polita* Chiba, 1989, but can easily be distinguished from the latter two species by apertural morphology and color polymorphisms. *M. ogasawarana* sp. nov. and *M. aureola* are found in the same locality and bed, suggesting that both species were reproductively isolated from each other at that time. The fossil record and ¹⁴C dating indicate that *M. ogasawarana* became extinct after 2000 yr B.P. on Hahajima. Although the cause of the extinction of *M. ogasawarana* is still speculative, this species would have been vulnerable to extinction more than other species because of its small and restricted distribution range.

Key words : Bonin Islands, extinction, Hahajima, land snails, *Mandarina*

Introduction

The land snail genus *Mandarina* Pilsbry 1894 has undergone extensive radiation on the Bonin (Ogasawara) Islands in the western Pacific (Minato, 1978; Chiba, 1989). *Mandarina* is restricted to the Bonin Islands and has been studied taxonomically by many authors who described 12 extant and 5 (or 6) extinct species (e.g., Pilsbry, 1894, 1901, 1902; Emura, 1943; Minato, 1978; Kurozumi, 1988; Chiba, 1989). A recent phylogenetic analysis in terms of mitochondrial DNA sequences has shown that *Mandarina* is closely related to *Euhadra* (one of the most common land snail genus in the Japan Islands) and is a member of the family Bradybaenidae (Chiba, 1999). However, the relationships and taxonomic status of *Mandarina* species are still poorly known because of their high intraspecific variability.

Three ground-dwelling species (*Mandarina aureola* Chiba, 1989, *M. polita* Chiba, 1989 and *M. ponderosa* Pilsbry, 1901) have been hitherto described from Hahajima. However, fossil specimens recently collected from this island include a species that differs morphologically from both of these ground-dwelling species. Here, I described this species as a new species, and discuss its temporal and spatial

distributions and a possible cause of its extinction.

Materials and Methods

The fossil specimens of *Mandarina* here discussed were recovered from dune and cave deposits in the northern part of South Hahajima (Fig. 1). The radiocarbon (^{14}C) ages of the fossil specimens for localities 1, 2, 3, 4 and 8 were determined by Chiba (1989) and are also shown in Figure 1. Although the absolute ages of the samples from localities 3, 5 and 7 were not dated, the ages of these samples are estimated as the late Holocene. Kadota (1975) and Okamoto *et al.* (1995) have shown by ^{14}C dating method that the dune deposits including the land snail shells discussed here were widely present in the Bonin Islands during a period of ca. 1500–2000 yr B.P.

Each species of *Mandarina* was identified on the basis of qualitative characters of the shells (Chiba, 1989). A shell was cut through the coiling axis or X-rayed without cutting in order to determine whether an umbilicus, which is found only in the shells of juvenile snails, was present.

Systematic Description

Order Stylommatophora Schmidt, 1856

Family Bradybaenidae Pilsbry, 1939

Genus *Mandarina* Pilsbry, 1894

Type species: Mandarina mandarina Sowerby, 1839 by designation of Pilsbry, 1894.

Diagnosis: Shell solid, medium to large (20–80 mm), variable in shape, with a large protoconch of 1/4 to 1/3 of teleoconch diameter. Spire high to low. Some species with an open umbilicus and/or a sharp angle in periphery of the body whorl. Coloration, commonly with 2 to 4 reddish brown bands or without color bands.

Distribution: Bonin Islands: Mukojima, Nakodjima, Chichijima, Anijima, Ototojima, Minamijima, Hahajima, Anejima, Meijima, Imotojima, Mukoujima, and Hirashima.

Mandarina ogasawarana sp. nov.

Fig. 2

Diagnosis: Medium-sized species of *Mandarina* characterized by a flat spire, a relatively large body whorl with a weak peripheral anuglation, and a large aperture with a long inner lip. A clearly open umbilicus in juvenile (first whorl of teleoconch) to middle stage (second whorl of teleoconch). Shell surface either with a narrow color band on periphery or without band.

Materials: Holotype, NSM PM14808; paratypes, NSM PM14809, 14810.

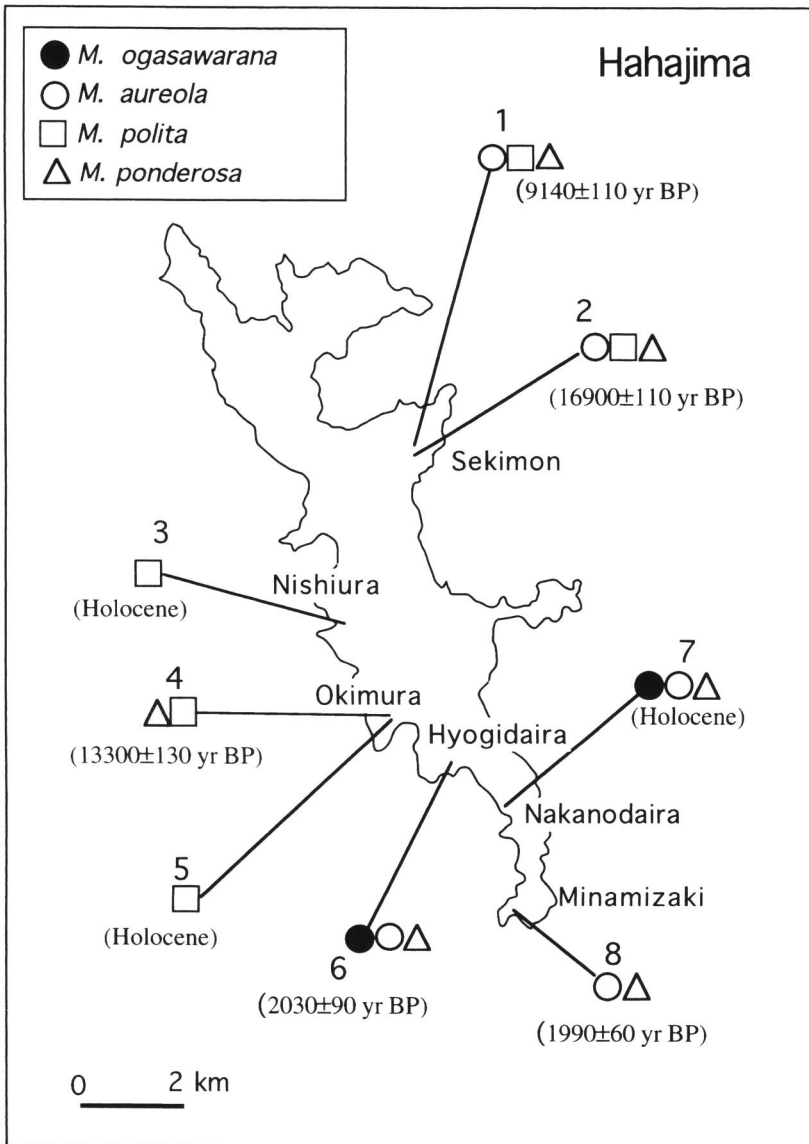


Fig. 1. Localities of the fossil samples in Hahajima and distributions of four species of *Mandarina* (*M. ogasawarana* sp. nov., *M. aureola*, *M. polita* and *M. ponderosa*) in the fossil samples. Estimated ages of some of the samples are also indicated.

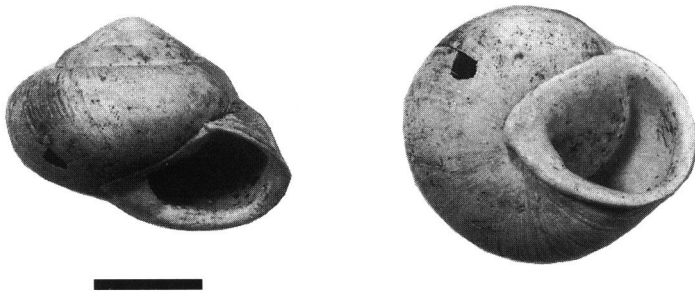


Fig. 2. *Mandarina ogasawarana* sp. nov., (holotype, NSM PM14808) from Nankinhama in Hahajima. Scale bar=1 cm.

Table 1. Measurements of *Mandarina ogasawarana* sp. nov.

Specimen	Height (mm)	Diameter (mm)
NSM PM14808 Holotype	21.3	28.2
NSM PM14809 Paratype	18.8	24.5
NSM PM14810 Paratype	18.8	25.2

Description: Shell solid, medium in size, approximately 20 mm in height and 25 mm in diameter. Spire low in height as this genus, scarcely exceeding 0.9 in relative shell height (height/diameter). Teleoconch with 3.0–3.5 moderately rounded whorls. Surface of teleoconch with fine spiral lines which are clear in early whorls. Protoconch large, approximately 1/4 of teleoconch diameter. Umbilicus closed in adult forms, clearly open in early (first whorl of teleoconch) to middle (second whorl of teleoconch) stage of growth. Body whorl inflated with a peripheral angulation. Aperture large, oval in shape, with a relatively long inner lip (1.84–1.99 in teleoconch (shell) diameter/inner lip length). Aperture slightly angled anteriorly, apertural plane tilted relative to shell axis. Periostome moderately thick and slightly reflected. Base rounded and convex. Shell commonly, with bands completely missing or present as narrow bands on the periphery.

Comparison: Shell form of *Mandarina ogasawarana* sp. nov. is similar to shell forms of *M. aureola* and *M. polita*. *M. ogasawarana* is easily discriminated from *M. polita* by possessing a peripheral angulation in the last whorl and a clearly open umbilicus in the first and second teleoconch whorls, whereas the umbilicus is closed throughout in *M. polita*. *M. ogasawarana* can be discriminated from *M. aureola* in that its inner lip is longer than that of *M. aureola* (Fig. 3). In addition to these differences, the periphery of the last whorl is generally angulated in *M. ogasawarana*, while it is rounded in *M. aureola*.

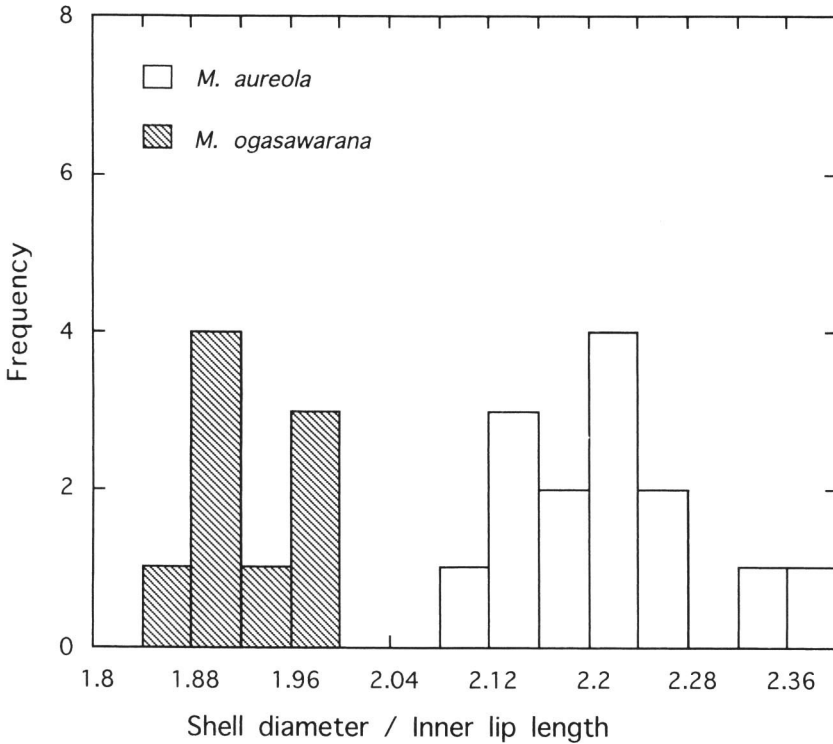


Fig. 3. Distributions in shell diameter/inner lip length among specimens in a sample from Loc. 6. Inner lip of *M. ogasawarana* sp. nov. is relatively longer than that of *M. aureola*.

The color pattern is also a useful character to distinguish *Mandarina ogasawarana* sp. nov. from *M. aureola* and *M. polita*. *M. ogasawarana* commonly includes individuals without color band. However, a color band is always present (or very rarely lost) in the populations of *M. aureola* and *M. polita*. The above three species co-occur at localities 6 and 7, but *M. ogasawarana* is absent from the other localities on Hahajima where *M. aureola* and *M. polita* occur. In addition, *M. aureola* and *M. polita* are still alive on Hahajima, while *M. ogasawarana* is extinct. This is another reason why *M. ogasawarana* should be considered a separate species from *M. aureola* and *M. polita*.

Type locality: Nankinhama (Loc. 6 in Fig. 1), Hahajima.

Distribution: Southern part of Hahajima (Hyogidaira, Nakanodaira); Holocene.

Discussion

The distribution of *Mandarina ogasawarana* sp. nov. is limited to a small area of the southern parts of Hahajima (the Hyogidaira and Nakanodaira areas). Although

there are no Pleistocene fossil records from the southern parts of Hahajima, the absence of *M. ogasawarana* in the Pleistocene sediments from the northern part of Hahajima (Okimura and Sekimon) strongly suggests that this species was restricted to the southern parts of Hahajima during the Pleistocene.

The fossil evidence shows that *Mandarina ogasawarana* sp. nov. coexisted with *M. aureola* before 2000 yr B.P. on south Hahajima without producing intermediates (Fig. 3). This suggests that the two species have been reproductively isolated from each other at that time. *M. ogasawarana* possesses a solid, large shell and a long inner lip, characters typical of ground-dwelling species. This implies that the three ground-dwelling species, *M. ogasawarana*, *M. aureola* and *M. ponderosa* coexisted in the Hyogidaira and Nakanodaira areas prior to 2000 yr B.P. In contrast, there are no areas today on Hahajima or other islands in the Bonin Islands where more than three ground-dwelling species inhabit sympatrically. Competitive interactions seem to have been more serious among the fossil species than among the modern species.

Mandarina ogasawarana sp. nov. and *M. ponderosa* have disappeared from Hyogidaira and Nakanodaira sometimes after 2000 yr B.P. Although the cause of the disappearance of these species is unclear, environmental change due to climatic change after 2000 yr B.P. is the most plausible candidate for this disappearance. Kadota (1975) suggested that Bonin Islands became warm and dry after 2000 yr B.P. A decreasing favorable (wet) habitats and serious competitions among the species may have resulted in the disappearance of *M. ogasawarana* and *M. ponderosa* from these areas. *M. ponderosa* did not become extinct, because *M. ponderosa* had a wide distribution over the island at that time. However, *M. ogasawarana* became extinct when it disappeared from the southern parts of Hahajima. This extinction is most probably resulted from the restricted distribution range of this species. Species with such restricted distribution are much more vulnerable to extinction than those with a large distribution range.

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