Description of an Endangered New Species of *Lunella* (Gastropoda: Turbinidae) from the Ogasawara Islands, Japan

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**Abstract:** A new turbinid species, *Lunella ogasawarana* n. sp., is described. This species from the Ogasawara Islands was previously identified as *Lunella cinerea*. However, both morphological and preliminary molecular studies have revealed that the new species is distinct from *L. cinerea*. *Lunella ogasawarana* n. sp. occurs only in the Ogasawara Islands and much of its habitat has been destroyed over the last few decades, so that it is in danger of extinction.

**Keywords:** *Lunella ogasawarana*, new species, conservation, endangered species, Ogasawara Islands

**Introduction**

The diversity of turbinids is highest in the Indo-West Pacific province and many species are found in Japan. Of the turbinid genus *Lunella*, three species (or subspecies) occur in Japan (Sasaki, 2000): *Lunella coronata coronata* (Gmelin, 1791), *L. coronata coreensis* (Récluz, 1853) and *L. cinerea* (Born, 1778). A possible fourth species was identified by Fukuda (1993), who suggested that the species from the Ogasawara Islands, southeast of Japan, was morphologically distinct from *L. cinerea*. Reports from the 1960s and 1970s suggested that this species was common on Chichijima and Anijima islands (e.g. Kurata *et al.*, 1969; Matsumoto *et al.*, 1970). However, development on Chichijima (e.g. shore protection) has resulted in serious loss of habitat, with the result that numbers of this species appear to be declining and it has been recognized as endangered (Fukuda, 1996). Most recently, as far as we know, there have been no further records of it in any collections, apart from two live specimens collected from Sakaiura, Ogasawara Islands, in July 2005 (Sasaki, personal communication). On a recent trip to the Ogasawara Islands expressly to look for the species, we found just seven specimens at Sakaiura and one specimen at Ohgiura, in June 2006 (Takahashi & Nakano, 2007).

The purpose of this paper is to describe this endangered species of *Lunella*.

**Materials and Methods**

Materials used for the description were collected from Chichijima, Ogasawara Islands, southeastern Japan (Fig. 1), in the high intertidal zone, on sandy beaches covered with boulders. Most specimens were buried in sand around rocks. We used two additional specimens (CIBML2005018) for molecular phylogeny and examined 35 empty shells (NSMT-Mo 963) deposited in the Institute of Boninology and National Museum of Nature and Sciences, Tokyo, respectively. For comparison, specimens of *Lunella coronata coronata* (from Yakena, Yonashiro, Okinawa Prefecture) (NUGB-T232, 233, 234), *L. coronata coreensis* (from Kiinagashima, Mie Prefecture; Shodoshima, Kagawa Prefecture and Morozaki, Aichi Prefecture) (NUGB-TK18, 66,
Fig. 1. Sampling localities of Lunella ogasawarana n. sp. in Chichijima, Japan, with the localities of the present species collected in previous studies (data from Fukuda, 1993, 1995a).

69) and L. cinerea (Iriomote Island, Okinawa Prefecture) (NUGB-T167, 168, 169) were collected. Specimens were preserved in 95% ethanol.

The radula was dissected out from at three individuals of each species, placed in a 20% concentration of potassium hydroxide (KOH) at room temperature for 24 hours to remove connective tissues, and rinsed in distilled water. It was then examined with a scanning electron microscope.

The methods of DNA extraction, PCR amplification, sequencing, alignment and phylogeny reconstruction were the same as those already described by Nakano & Ozawa (2007). All sequences determined in this study have been deposited in DDBJ and GenBank under accession numbers AB297722-AB297737.

**Abbreviations**: BMNH – Natural History Museum, London, UK; CIBML – Institute of Boninology, Japan; NUGB – Geobiology, Nagoya University, Japan; NSMT – National Museum of Nature and Sciences, Tokyo, Japan.

**Systematics**

Family Turbinidae Rafinesque, 1815

Genus Lunella Röding, 1798

Type species, by subsequent designation (Fischer, 1873): *Turbo versicolor* Gmelin, 1791 [= *Turbo cinereus* Born, 1778].
Lunella ogasawarana n. sp.
(Figs. 2A–T, 3A)

*Turbo lugubris* Kiener, 1847, pl. 28, fig. 3; Fischer, 1873, pp. 72–73 (non *Turbo lugubris* Link, 1807).
*Turbo porphyrites*: Iwakawa, 1909, p. 98; Iwakawa, 1919, p. 32 (non *Turbo porphyrites* Gmelin, 1791).
*Turbo cinerea*: Hirase & Taki, 1954, pl. 74, fig. 3 (non *Turbo cinereus* Born, 1778).
*Lunella cinerea*: Imajima, 1970, pl. 6–7, fig. 7; Takenouchi, 1986, p. 57, unnumbered fig. (non *Turbo cinereus* Born, 1778).
*Lunella* sp.: Fukuda, 1993, pp. 20–21, 69 (pl. 5), fig. 43; Fukuda, 1995b, pp. 274–275, fig. 8; Fukuda, 1996, pp. 14–15, pl. 1, fig. 1; Takahashi & Nakano, 2007, pp. 171–173, fig. 2.

**Diagnosis**: Shell thick, globose; whorls sculptured by granules and weak spiral ribs without nodules; nacreous part of parietal wall widely extended beyond umbilicus; uniformly dark greenish brown in colour; umbilical area orange; operculum white with green margin except at adaxial side; central radular teeth subrectangular with straight cutting edge; snout brown with black transverse pigmentation.

**Descriptions**: *Shell* (Figs. 2A–D, G). Shell thick, globose, with depressed, domed spire and large body whorl. Protoconch eroded. Teleconch consisting of about four convex whorls with rounded periphery and distinct suture. Initial part of teleconch sculptured with fine granules, regularly arranged to form seven spiral lines. Sculpture gradually disappearing and becoming smooth towards body whorl excepting irregular growth lines, but remaining faintly at base. Sutural ramp moderately rugose. Umbilicus circular, narrow and deep. Nacreous part of parietal wall widely extended beyond umbilicus by secondary resorption. Aperture nearly circular. Outer lip simple, sharp and thin. Lower part of columellar lip extended basally, especially in young specimens. Coloration dark greenish brown, aperture pearly white, umbilical area orange.

**Operculum** (Figs. 2E–F). Operculum calcareous, nearly circular, dome-shaped, minutely granulose, paucispiral; white in colour with green margin except at adaxial side. Inner side of operculum simple, dark brown with spiral line.

**External anatomy**. Head with snout, cephalic lappets, cephalic tentacles and eyestalks. Outer lip of mouth forming thick oral disk. Eyes open, plugged with vitreous body at tips of eyestalks. Inhalant and exhalant neck lobes present in neck region. Head part and eyestalks brown; black pigmentation present transversely at tip of snout. Foot with three pairs of epipodial tentacles. Operculum attached to opercular lobe of epipodium.

**Radula** (Fig. 3). Radula rhipidoglossate, with formula n-5-1-5-n. Radular teeth rows bilaterally symmetrical. Central tooth subrectangular, plate-like, with straight cutting edge. Inner four lateral teeth slender, with reduced cusps. Outermost laterals spatulate, almost straight, with reduced cusps. Marginal teeth same both in size and shape, with reduced cusps. Shaft of marginal teeth long, almost straight and flat.

**Variations**. Intraspecific variation extremely low. Shell uniformly thick, globose with dark brown colour.

**Type locality**: Sakaiura, Chichijima, Ogasawara Islands, Japan (27°5′N, 142°12′E).

**Type material** (Table. 1): Holotype, NSMT-Mo 73816; paratype #1, NSMT-Mo 73817; paratype #2, NSMT-Mo 73818; paratype #3, BMNH 20060694; paratype #4, BMNH 20060694; paratype #5, CIBML2005018; paratype #6, NUGB-TK48; paratype #7, NUGB-TK49; paratype #8, NUGB-TK50, paratype #9, NSMT-Mo 73961 (selected from NSMT-Mo 963).

**Distribution**: Chichijima and Anijima (Matsumoto et al., 1970), Ogasawara Islands, Japan.

**Habitat**: The species occurs in the upper intertidal, on sandy beaches covered with boulders. Most specimens examined in this study were found buried in sand around rocks or boulders. Collections were undertaken at low tide in the daytime. The species may be active when the tide

**Table 1.** Measurements and SL/SW ratio of the type specimens of _Lunella ogasawarana_ n. sp. (in mm).

<table>
<thead>
<tr>
<th></th>
<th>Depository</th>
<th>SL</th>
<th>SW</th>
<th>SL/SW</th>
<th>HO</th>
<th>DO</th>
<th>LA</th>
</tr>
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<td>Holotype</td>
<td>NSMT-Mo 73816</td>
<td>34.8</td>
<td>36.8</td>
<td>0.95</td>
<td>6.1</td>
<td>15.6</td>
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<td>13.8</td>
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<td>5.6</td>
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<td>NSMT-Mo 73818</td>
<td>24.8</td>
<td>26.7</td>
<td>0.93</td>
<td>4.6</td>
<td>11.2</td>
<td>19.4</td>
</tr>
<tr>
<td>Paratype #3</td>
<td>BMNH 20060694</td>
<td>27.4</td>
<td>29.4</td>
<td>0.93</td>
<td>4.9</td>
<td>12.6</td>
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<tr>
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<td>BMNH 20060694</td>
<td>22.0</td>
<td>24.2</td>
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<td>4.2</td>
<td>9.8</td>
<td>18.0</td>
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<td>CIBML2005018</td>
<td>24.9</td>
<td>26.4</td>
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<td>11</td>
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<td>Paratype #6</td>
<td>NUGB-TK48</td>
<td>17.6</td>
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<td>34.2</td>
<td>0.86</td>
<td>–</td>
<td>–</td>
<td>22.2</td>
</tr>
</tbody>
</table>

Abbreviations: DO – diameter of operculum; HO – height of operculum; LA – length of aperture; SL – shell length; SW – shell width.
is high, or may be nocturnal. Further work is needed on the ecology of this species.

**Etymology:** The species name ‘*ogasawarana*’ is given to highlight its endemism in Ogasawara Islands, Japan.

**Remarks:** Fukuda (1993) suggested that *Turbo lugubris* Kiener, 1847 could be conspecific with the present new species, although the name was preoccupied by *Turbo lugubris* Link, 1807. Kiener (1847: pl. 2, fig. 3) illustrated his new species without any description. The explanation of the figure was subsequently published by Fischer (1873), who regarded *Turbo lugubris* of Kiener as a junior synonym of *Turbo versicolor* Gmelin, 1791. The original figure of Kiener (1847) seems to be the present species as pointed out by Fukuda (1993) because of its uniformly dark green colour and the presence of a nacreous part on the parietal wall that extends beyond the umbilicus. According to virginie Héros (personal communication) of Muséum National d’Histoire Naturelle, France, type material of Kiener’s species has not been located in that his collection. In any case, the name is preoccupied by *Turbo lugubris* Link, 1807, and no other available name has subsequently been published for this new species until the present study.

**Discussion**

Preliminary work towards a complete molecular phylogeny of the genus *Lunella* has shown that four clades are well supported by high posterior probabilities and bootstrap, and correspond to *L. ogasawarana* n. sp., *L. coronata coronata*, *L. coronata coreensis* and *L. cinerea* (Fig. 4). *L. coronata coronata* and *L. coronata coreensis* should each be elevated to species rank. Although Fukuda (1994, 1995a, 1996) speculated that *L. ogasawarana* n. sp. is closely related to *L. coreensis*, it is most closely related to *L. coronata* and genetically most different from *L. cinerea*.

Although *L. ogasawarana* n. sp. has often been identified as *L. cinerea* (e.g. Kurata et al., 1969; Matsumoto et al., 1970), Fukuda (1993) suggested that the specimens from the Ogasawara Islands were morphologically distinct from *L. cinerea*. *Lunella ogasawarana* n. sp. usually has a dark greenish brown shell and the umbilical area is tinged with orange, while *L. cinerea* has a more brightly coloured maculated shell and the umbilical area is also white. Although the surface sculpture of *L. cinerea* shells is variable, ranging from spiral ribs and minute granules to almost smooth, the shell of *L. ogasawarana* n. sp. usually has fine granules and weak spiral ribs on the surface. Juveniles (Figs. 2H–J) also tend to have very fine granules on the shell surface, so that they look like *L. coronata*. The parietal wall is more extensively resorbed in the present species, but that of *L. cinerea* is smooth without indentation. The shape of the umbilicus is circular in the present species, but more like a keyhole in *L. cinerea*. Based on the examination of radular morphology, the cusp of the central radular teeth is straight in the present species, but that of *L. cinerea* is rounded. Therefore, the present species is not only genetically but also morphologically different from *L. cinerea*.

Our molecular phylogeny suggested that *L. ogasawarana* n. sp. is most closely related to *L. coronata*. The present species, however, can be easily distinguishable from *L. coronata*, which has more prominent ribs with strong knobs and a yellowish inner lip. *Lunella ogasawarana* n. sp. is also different from *L. coreensis* in shell morphology. *Lunella coreensis* has smaller shells roughened by fine granules and prominent spiral ribs with tubercles, and its umbilicus is closed in adult shells. Three species, *L. ogasawarana* n. sp., *L. coreensis* and *L. cinerea*, have a white coloured operculum with a green margin except at the adaxial side, while *L. coronata* has a green coloured operculum with white edge. The radular morphology is very similar among the three species *L. ogasawarana* n. sp., *L. coronata* and *L. coreensis* (Figs. 3A, C, D).

Ecologically, the present species inhabits sandy flats with many boulders inside bays. *L. cinerea* and *L. coronata* occur on rocky shores facing the open sea, while *L. coreensis* can be usually found on sheltered rocky shores or in tidelands. Usually only specimens of *L.*
coreensis are covered with the green algae Cladophora conchophheria (Sasaki, 2000). Regarding geographical distribution, *L. cinerea* has a wide distribution in the Indo-West Pacific region, *L. coronata* is distributed from the Kii Peninsula in central Japan southward, and *L. coreensis* appears in the warm temperate zones of Japan and the Korean Peninsula. *Lunella ogasawarana* n. sp. is the only species of *Lunella* distributed in the Ogasawara Islands, since there are no records of true *L. cinerea* or any other species of *Lunella* from there.

According to Kurata et al. (1969) and Matsumoto et al. (1970), *L. ogasawarana* n. sp. was formerly common in the Ogasawara Islands. Indeed, in the first record of the present species Iwakawa (1919) mentioned 35 shells. However, there are few recent records of this species in the Ogasawara Islands (e.g. Fukuda, 1993; Yamashita, 1994; Sasaki, personal communication). As discussed in Fukuda (1996), the serious loss of habitat has resulted in the drastic reduction of
the populations of the present species. It is important to consider implementation of measures to conserve the habitat of *Lunella ogasawarana* n. sp.

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**References**


Nakano, T. & Ozawa, T. 2007. Worldwide phylogeography of limpets of the order Patellogastropoda:

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小笠原諸島で採取されたスガイ属の1新種

中野智之・高橋恭子・小澤智生

要約


また、福田 (1996)で述べられたように、オオベソスガイという和名（初出は岩川, 1919）の基準となった標本（NSMT-Mo 963）は小笠原産であり、八重山諸島以南のインディアナ州太平洋に広く分布するL. cinereaは和名を失っている。しかし、L. cinereaに対する和名としてオオベソスガイが未だに使われる事も多くあり、また本種は小笠原固有種である事を踏まえ、本論文をもって小笠原固有種をオガサワラスガイ（初出は加藤, 1996）, L. cinereaをオオベソスガイと呼ぶ事にする。

オガサワラスガイLunella ogasawaranana n. sp.（新種）の多くの形態学的特徴はオオベソスガイと類似しているが次の点から明瞭に区別される。

1. 軟体は常に暗褐色であり、脐孔部はオレンジ色に染まる。
2. 腹肋に多数の顆粒がある。
3. 真珠層の伸張部が脐孔を越えて広がる。
4. 真珠層伸張部の縁が刻み目状。
5. 脐孔は丸い。
6. 歯舌の中歯の先端は直線的である。

本種は、砂底転石帯の潮間帯上部に生息しており、昼間は岩縁の砂に埋在している。小笠原固有種であるが、近年採取例がほとんどなく絶滅に瀕していると考えられ、早急な対策が必要である。

タイプ標本: ホロタイプ，34.8 x 36.8 mm，NSMT-Mo 73816。パラタイプ1，13.8 x 15.4 mm，NSMT-Mo 73817, パラタイプ2, 24.8 x 26.7 mm, NSMT-Mo 73818, ほか。

タイプ産地: 小笠原諸島, 父島, 境浦。