Online ISSN 2435-0931 Print ISSN 0385-0900
DOI: 10.50897/bmfm.49.0_59

Bulletin of the Mizunami Fossil Museum, no. 49, 59–65, 2 figs., 2 tables.

Manuscript accepted on June 15, 2022; online published on August 5, 2022
http://zoobank.org/urn:lsid:zoobank.org:pub:1052FCD9-00CD-4D8C-9FA5-0533A25BD203

A new species of *Astralium* (Gastropoda: Turbinidae) from the Middle Miocene of the Izu Peninsula, central Japan

Susumu Tomida[1)], Keisuke Inoue[2)], and Tomoki Kase[3)]

1) 2-20-63, Hime-cho, Tajimi, Gifu 507-0061, Japan
< t_susumu@ob.aitai.ne.jp >
2) Graduate School of Environmental Studies, Nagoya University, Nagoya, Aichi 464-8601, Japan
< inoue.keisuke2@gmail.com >
3) Department of Geology and Paleontology, National Museum of Nature and Science, 4-1-1 Amakubo, Tsukuba, Ibaraki 305-0005, Japan
< neritopsis@gmail.com >

Abstract

Fossil molluscs from the Ena, Shikura and Shirakawa limestones within the Middle Miocene Sakurada Formation (Yugashima Group) on the Izu Peninsula, central Japan represent the tropical shallow marine community lived around a volcanic island(s) that located at latitudes much lower than the present. A new gastropod species, *Astralium ena*, is described from the Ena Limestone. This new species is distinct from the most similar species *Astralium verbeeki* Icke from the Lower Miocene of Nias in Indonesia by the higher shell profile, more impressed suture, thicker axial ribs and more number of spiral cords on the base. This is the second species of the genus *Astralium* recognized from the Miocene of Japan.

Key words: *Astralium ena* n. sp., Ena Limestone, Middle Miocene, Sakurada Formation, Japan

1. Introduction

The Ena, Shikura and Shirakawa limestones are small-scale allochthonous sedimentary bodies that are intercalated within the Middle Miocene volcano-clastic Sakurada Formation (Yugashima Group) in Matsuzaki and Nishi-izu towns of Izu Peninsula, Shizuoka Prefecture, central Japan (Misawa et al., 2007). These limestone bodies contain quite rich tropical rocky shore molluscs and provide a window into the paleobiodiversity of a tropical island(s) in the northeastern Philippine Sea Plate (Tomida and Kadota, 2012a, b, 2014; Tomida et al., 2013, 2017, 2019, 2021; Kadota, 2015; Kase et al., 2020). The Sakurada Formation has been correlated to nannofossil zone CN4 (Okada et al., 1986; Okada, 1987) and dated between 14.9–13.5 Ma based on Gradstein et al. (2012).

This paper is the eighth installment of the systematic studies in the fossil molluscs from the Middle Miocene limestone bodies on the Izu Peninsula. We here describe a new species of the genus *Astralium* based on the material from the Ena Limestone in the Matsuzaki area (Fig. 1). The Ena Limestone consists of two limestone blocks: the larger and smaller ones are approximately 10 m and 7 m in length and 0.8 m and 1.2 m in thickness, respectively. These blocks contain reef-building corals, larger foraminifers and rocky shore molluscs. For detailed locality description and

faunal composition of the Ena Limestone, see Kadota (2015), Tomida and Kadota (2014), Tomida et al. (2019) and Kase et al. (2020).

Repository abbreviations: MGVC (Matsuzaki Geopark Visiting Center, Matsuzaki); NMNS (National Museum of Natural and Sciences, Tsukuba); NUM (Nagoya University Museum, Nagoya); SPMN (Museum of Natural and Environmental History, Shizuoka).

2. Systematic Description

Family Turbinidae Rafinesque, 1815
Genus *Astralium* Link, 1807

Astralium ena, new species

(Fig. 2)

[New Japanese name: Ena-urauzugai]

Diagnosis: Small, coniform *Astralium* less than 24 mm high, with angular to subangular basal periphery, flat to concave and spirally ornamented base. Whorls flat to concave in earlier, convex and constricted by rather deeply impressed suture in later. Sculpture of opisthocline transverse axial ribs, variable in number from 18 to over 40 on last whorl. Basal periphery tuberculate or slightly spiny.

Type material: Holotype, NMNS PM65696; 4 paratypes, NMNS PM65692–65695; 1 paratype, NUM-Fa456; 1 paratype, SPMN FL25008; 2 paratypes MGVC F0042, 0043.

Type locality: Ena, Matsuzaki-cho, Kamo-gun, Shizuoka Prefecture (34°45′42″N; 138°47′9″E).

Type horizon: Ena Limestone intercalated within the Sakurada Formation.

Etymology: The species is named after its type-locality, Ena. The name is used as a noun in apposition.

Table 1. Shell measurements for *Astralium ena*, new species.

Specimen number	Type	Shell height (in mm)	Shell width (in mm)
NMNS PM65692	Paratype	15.2	14.8
NMNS PM65693	Paratype	14.6	16.1
NMNS PM65694	Paratype	14.5	16.7
NMNS PM65695	Paratype	14.7	15.1
MGVC-F0042	Paratype	15.3	14.7
SPMN FL25008	Paratype	19.7	17.4
NUM-Fa456	Paratype	16.6	16.5
MGVC-F0043	Paratype	20.2	20.7
NMNS PM65696	Holotype	23.8	21.7

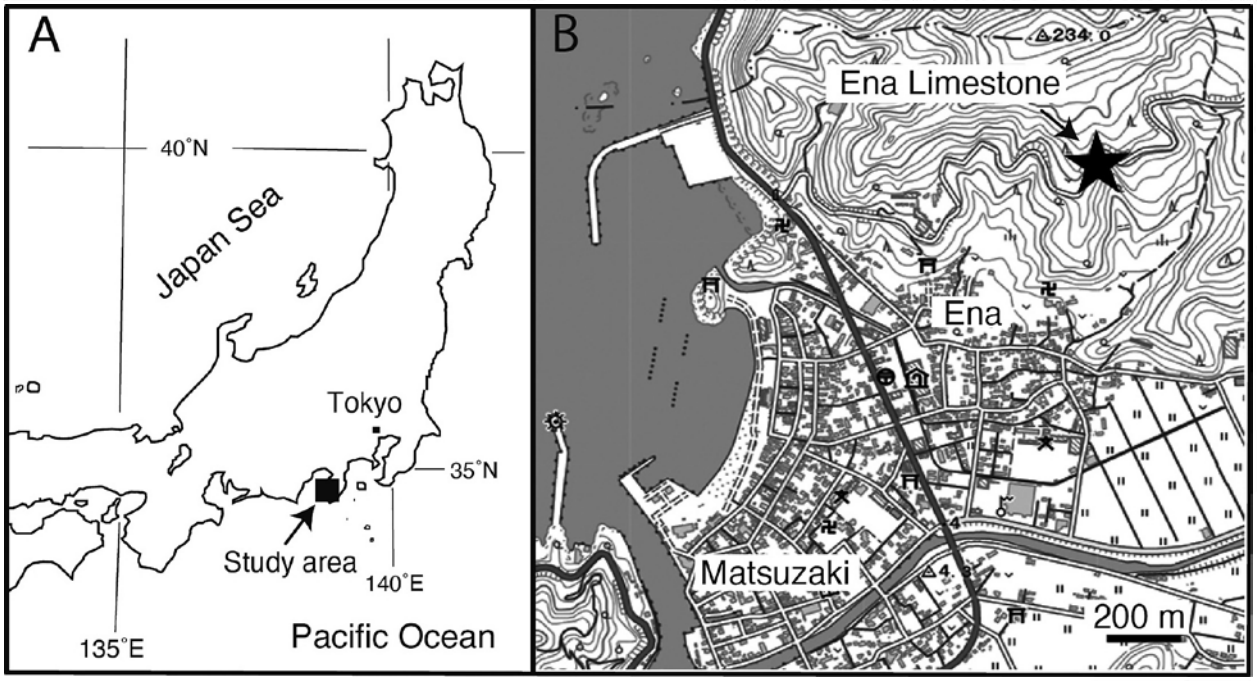

Fig. 1. Index maps showing the fossil locality in central Japan (A), and the fossil collecting site (★), in Matsuzaki-cho (B), Kamo-gun, Shizuoka Prefecture; Topographic map in B was obtained from 1:25,000 scale electric map of the Geospatial Information Authority of Japan.

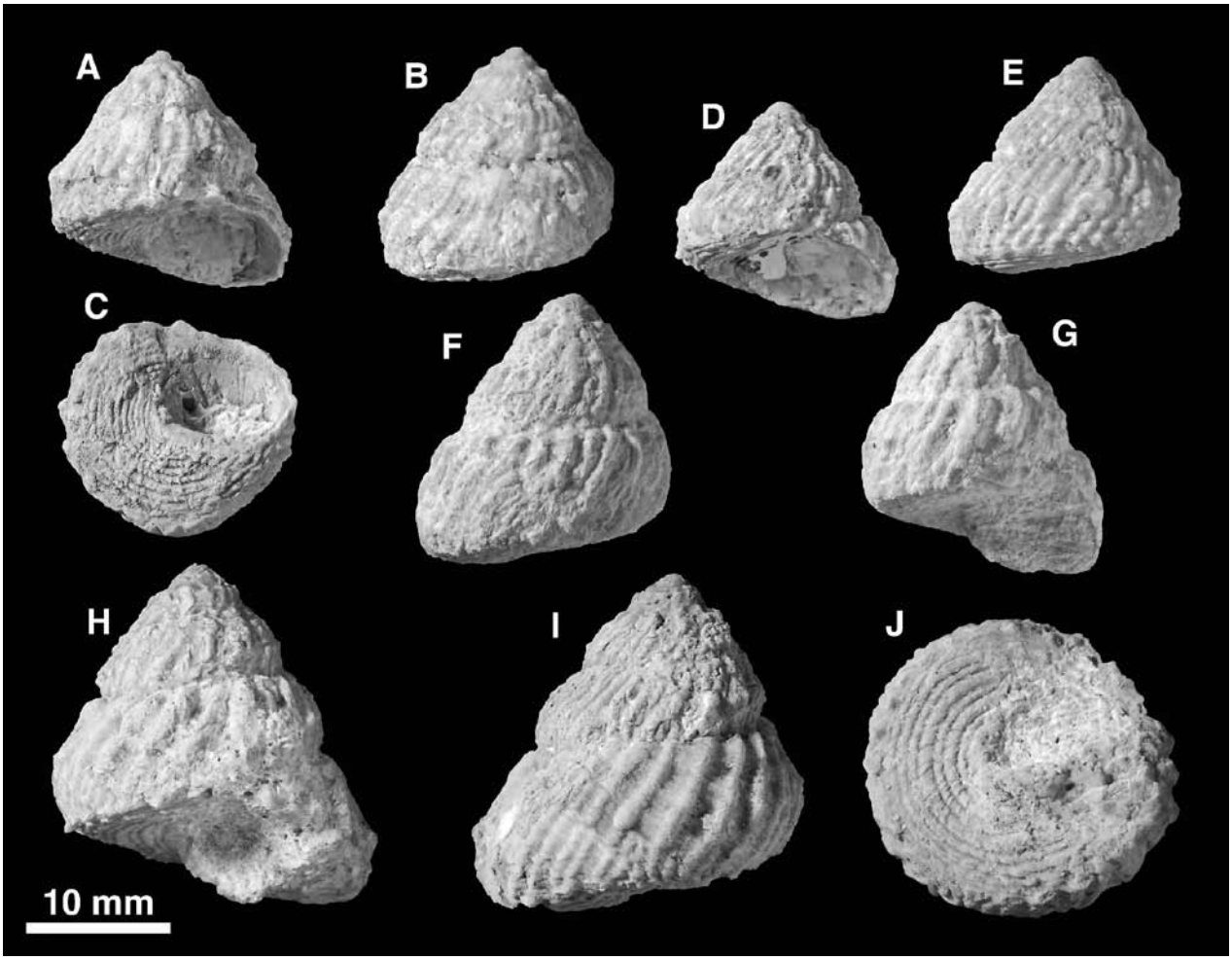

Fig. 2. ***Astralium ena*****, new species** from the Ena Limestone at Ena, Matsuzaki-cho, Kamo-gun, Shizuoka Prefecture, Japan. **A–C,** apertural, adapertural and basal views of paratype, NUM Fa456; **D, E,** apertural and adapertural views of paratype, NMNS PM65695; **F, G,** adapertural and apertural views of paratype, SPMN FL25008; **H–J,** apertural, adapertural and basal views of holotype, NMNS PM65696.

Description: Shell small, coniform, anomphalous, up to 23.8 mm high and 21.7 mm wide, as high as wide (width/height ration = 0.9–1.1). Spire conical, its height almost half of shell height. Spire angle 63°–84°. Protoconch all eroded. Teleoconch up to 5.5 whorls, straight- to concave-sided on early whorls, separated by linear suture and very narrowly shouldered in some specimens, while weakly convex and constricted above and below by impressed suture on later whorls. Teleoconch whorls ornamented with more or less irregularly arranged transverse axial ribs, sometimes bifurcating, dividing into two or more subordinate ones or intervening additional one, slightly noded near suture; number of ribs highly variable, counting 15 to around 40; some obscure spiral cords occur on adapertural part of penultimate whorl. Last whorl more or less angulated at middle, ornamented with opisthocline axial ribs same as those on early whorls in nature, 18 to over 40 in number, granulated or becoming rough on area above basal periphery, and finely tuberculated or spiny at basal periphery. Base angulated to subangulated at periphery, flat to slightly concave, ornamented with 7 to 10 rather thick spiral cords. Aperture oblique and low elliptical, parietal area covered with callus, columella evenly rounded. Operculum unknown.

Measurements: see Table 1.

Remarks: *Astralium* is very rare in fossil occurrence and constitutes a minor element of the Neogene and Quaternary warm-water marine molluscan assemblages in the Indo-Pacific region. Our extensive survey of literature shows that there are six named and four unnamed species from the Miocene beds, none from the Pliocene beds, and two species referable to the modern species and one unnamed species from the Pleistocene deposits (Table 2). *Astralium hayakawai* (Kanno, 1958) is the only species that has been recognized from the Miocene of Japan so far. Among them, *A. ena*, n. sp. is most similar to *Astralium verbeeki* Icke in Icke and Martin (1907) from a Late Miocene bed of Nias, Indonesia. In particular, smaller specimens of *A. ena*, n. sp. that bear an obscure shouldered edge on the last whorl show almost the same shell profile with *A. verbeeki* (Fig. 2A–E). In addition, both species share the surface sculpture that consists of many opisthocline, more or less clumsy axial ribs, and the presence of spiral cords on the base. However, the present new species is easily distinguished from *A. verbeeki* by its higher shell profile, more deeply impressed suture, thicker axial ribs and much number of spiral cords on the base. *Astralium ena*, n. sp. also resembles *Astralium waluensis* (Ladd, 1966) [= *Astraea* (*Calcar*) sp. A in Ladd, 1934] from the Lower Miocene Suva Formation in Fiji. In *A. waluensis* seven or eight opisthocline axial ribs consist of a bundle of much finer axial ribs and bear a broad-based hollowed spine each on them, while such axial ribs and spines are absent in the present new species. *Astralium* sp. illustrated by Dharma (2005) from the upper Miocene Nyalindung Formation in West Java is also similar to *A. ena*, new species. A comparison of the two species is pending for future study because the Nyalindung species has not been described formally yet.

Astralium ena, n. sp. is also similar to *Astralium biserialis* (Martin, 1884) from the Lower Miocene bed of Central Java, *Astralium hayakawai* (Kanno, 1958) from the Middle Miocene Hiranita Formation in the Chichibu basin, Japan and *Astralium* sp. 1 (Itoigawa et al., 1981) from the Lower to Upper Miocene Shukunohora Formation in the Mizunami basin, Japan. These three species are coniform and have a flattened base almost the same with the present new species, but the sculpture on the base in these three species consists of one or two spiral rows of fine granules, while it consists of 7 to 10 granular spiral cords in the new species.

Alf and Kreipl (2011) illustrated and gave shell characters for 20 named and one unnamed modern species from the Indo-Pacific. Among them, *A. ena*, n. sp. is most similar to *Astralium confragosum* (Gould, 1848). Meyer et al. (2005) demonstrated that *A. confragosum* is a morphologically and genetically distinct clade within the *Astralium rhodostomum* species complex, and endemic to the Society and Tuamotu Islands in the South Pacific. *Astralium confragosum* is characterized by its relatively small subconical shells that are as high as wide or slightly wider than high, shouldered whorls, fine and irregular opisthocline axial ribs, and the hollowed spines on the shouldered angle and basal periphery. In contrast, the new species is higher than wide in shell shape, and does not have hollowed spine at the shouldered angle as well as basal periphery.

The present new species is also similar to *Astralium haematragum* (Menke, 1829) distributed in Japan and Taiwan, and *Astralium rhodostomum* (Lamarck, 1822) widely distributed in the Northern Indo-West Pacific oceans. However, there are clear morphological differences between the new and the above two species in that the axial ribs are transverse between the upper and lower suture in the new species, while they consist of fine axial rugose ribs below the suture and much coarser axial spines or spiny costae above the suture and basal periphery in the extant species.

3. Acknowledgements

We wish to express our thanks to Merrs. Masahito Kadota (Kanagawa Prefectural Museum, Odawara), and Hayato Sano, Eisaku Hosoda, Yoshiharu Yabe and Nobutoshi Ishida (Izu Fossil Research Club of Matsuzaki-cho) who offered the specimens described in this study and kindly assisted us during the field work. We also thank Drs. Kazutaka Amano (Joetsu University of Education, Joetsu) and Yusuke Ando (Mizunami Fossil Museum) who provided detailed review of the manuscript.

Table 2. Neogene fossil occurrence of *Astralium* in the Indo-West Pacific.

Species	Original assignment	Formation	Area	Age	References
Astralium biserialis (Martin, 1884)	*Trochus* (*Polydonta*) *biserialis* Martin, 1884	unnamed bed	Central Java, Indonesia	Early Miocene	Martin, 1884; LeLoux & Wesselingh, 2009
Astralium waluensis (Ladd, 1966)	*Astraea* (*Astralium*) *waluensis* Ladd, 1966	Suva Formation	Fiji	Early Miocene	Ladd, 1934, 1966
Astralium sp. A	*Astralium* sp. 1	Shukunohora Formation	Mizunami, Japan	Early to Middle Miocene	Itoigawa et al., 1981
Astralium sp. B	*Astralium* sp. 2	Shukunohora Formation	Mizunami, Japan	Early to Middle Miocene	Itoigawa et al., 1981
Astralium proprium (Hatai & Kotaka, 1952)	*Astraea* (*Calcar*) *propria* Hatai & Kotaka, 1952	Heiroku Formation	North Korea	Middle Miocene	Hatai & Kotaka, 1952
Astralium hayakawai (Kanno, 1958)	*Astraea hayakawai* Kanno, 1958	Hiranita Formation	Chichibu, Japan	Middle Miocene	Kanno, 1958
Astralium verbeeki Icke, 1907	*Astralium* (*Pachypoma*) *verbeeki* Icke, 1907	not specified	Nias, Indonesia	Late Miocene	Icke & Martin, 1907; Skwarko & Sufiati, 1999
Astralium eniwetokensis (Ladd, 1966)	*Astraea* (*Astralium*) *eniwetokensis* Ladd, 1966	not specified	Eniwetok atoll, W. Pacific	Late Miocene	Ladd, 1966
Astralium sp. C	*Astralium* sp.	Nyalindung Formation	West Java, Indonesia	Late Miocene	Dharma, 2005
Astralium sp. D	*Astraea* (*Astralium*) sp. A	not specified	Eniwetok atoll, W. Pacific	Late Miocene	Ladd, 1966
Astralium rhodostomum (Lamarck, 1822)	*Astraea* (*Astralium*) *rhodostoma* (Lamarck, 1822)	not specified	Western Pacific Islands	Pleistocene	Ladd, 1966
Astralium sp. E	*Astraea* (*Astralium*) aff. *rhodostoma* (Lamarck, 1822)	not specified	Funafuti, Western Pafcific	Pleistocene	Ladd, 1966
Astralium haematragum (Menke, 1829)	*Astralium haematragum* (Menke, 1829)	raised beach deposits	Tateyama, Japan	Holocene	Yokoyama, 1924; Oyama, 1973

4. References

Alf, A., and K. Kreipl. 2011. The family Turbinidae: subfamilies Turbininae Rafinesque, 1815 and Prisogasterinae Hickman and McLean, 1990. In G. T. Poppe, and K. Groh, eds., A Conchological Iconography. Conchbooks. Hackenheim. p. 1–82, pls. 104–245.

Dharma, B. 2005. Recent and Fossil Indonesian Shells. ConchBooks. Hackenheim. 424 p.

Gould, A. A. 1848–1849. Descriptions of new species of shells, brought home by the U. S. Exploring Expedition. Proceedings of the Boston Society of Natural History 3: 83–85, 89–92, 106–108, 118–121, 140–144.

Gradstein, F. M., J. G. Ogg, M. D. Schmitz, and G. M. Ogg. 2012. The Geologic Time Scale 2012. Elsevier. Amsterdam. 2 vols., 1144 p.

Hatai, K., and T. Kotaka. 1952. On some Lower Miocene shells. Short Papers, Institute of Geology and Paleontology, Sendai (4): 70–86.

Icke, H., and K. Martin. 1907. Over tertiaire en kwartaire vormingen van het eiland Nias. Sammlungen des Geologischen Reichs-Museums in Leiden. Serie 1, Beiträge zur Geologie Ost-Asiens und Australiens 8 (3–4): 204–252, pls. 14–18.

Itoigawa, J., H. Shibata, H. Nishimoto, and Y. Okumura. 1981. Miocene fossils of the Mizunami group, central Japan. 2. Molluscs. Monograph of the Mizunami Fossil Museum (3-A): 1–53, pls. 1–52. [in Japanese]

Kadota, M. 2015. Reef-building corals from the Miocene Sakurada Formation of the Yugashima Group in Izu Peninsula. Shizuoka-Chigaku (112): 9–14. [in Japanese: title translated]

Kanno, S. 1958. New Tertiary molluscs from the Chichibu Basin, Saitama Prefecture, central Japan. Science Reports of the Tokyo Kyoiku Daigaku, Section C (Geology, Mineralogy and Geography) 6: 157–229, pls. 1–7.

Kase, T., S. Tomida, K. Inoue, and M. Kadota. 2020. New species of *Turbo* (*Marmarostoma*) (Gastropoda, Turbinidae) from the Miocene limestone in central Japan: a window into the Miocene marine biodiversity in the northeastern Philippines Sea. Paleontological Research 24: 14–25.
DOI: 10.2517/2019PR002

Ladd, H. S. 1934. Geology of Vitilevu, Fiji. Bernice P. Bishop Museum Bulletin 119: 1–263, pls. 1–44.

Ladd, H. S. 1966. Chitons and gastropods (Haliotidae through Adeorbidae) from the Western Pacific Islands. United States Geological Survey Professional Paper 531: 1–98, pls. 1–16.

Lamarck, J. B. de. 1822 in 1815–1822. Histoire naturelle des animaux sans vertèbres, présentant des charactères généraux et particulariers …tome 7. published by J. B. Lamarck. Paris. 711 p.

Leloux, J., and F. P. Wesselingh. 2009. Types of Cenozoic Mollusca from Java in the Martin Collection of Naturalis. NNM Technical Bulletin 11: 1–765.

Link, H. F. 1807. Beschreibung der Naturalien-Sammlung der Universität zu Rostock. 3te Abtheilung. Adler. Rostock. p. 101–165.

Martin, K. 1884. Systematischer Theil: Mollusca. I. Glossophora. A. Gastropoda. In K. Martin. 1883–1887. Palaeontologische Ergebnisse von Tiefbohrungen auf Java, nebst allgemeinen Studien ueber das Tertiaer von Java, Timor und einiger anderer Inseln. Sammlungen des Geologischen Reichs-Museums in Leiden, Serie l, Beiträge zur Geologie Ost-Asiens und Australiens 3: 43–184.

Menke, C. T. 1829. Verzeichniss der ansehnlichen Conchylien-Sammlung des Freiherrn von den Malsburg. H. Gelpke. Pyrmont. vi+123 p.

Meyer, C. P., J. B. Geller, and G. Paulay. 2005. Fine scale endemism on coral reefs: archipelagic differentiation in turbinid gastropods. Evolution 59: 113–125.
DOI: 10.1111/j.0014-3820.2005.tb00899.x

Misawa, Y., M. Kadota, and S. Matsui. 2007. Submarine topography, geology of the eastern part of the Suruga Bay and basement complex of the Izu Peninsula. Bulletin of the Institute of Oceanographic Research and Development, Tokai University (28): 1–12. [in Japanese with English abstract]

Okada, H. 1987. Calcareous nannofossil biostratigraphy and paleoenvironmental analysis of marine formations exposed in the South Fossa-Magna region. Fossils (43): 5–8. [in Japanese with English abstract]

Okada, H., N. Niitsuma, K. Kano, and S. Arai. 1986. Guide Book of Field Excursion to Subduction and Collision area, Shizuoka, Izu and Tanzawa. International Kaiko Conference. Tokyo. 36 p.

Oyama, K. 1973. Revision of Matajiro Yokoyama's type Mollusca from the Tertiary and Quaternary of the Kanto area. Palaeontological Society of Japan Special Papers (17): 1–148, pls. 1–57.

Rafinesque, C. S. 1815. Analyse de la Nature, ou Tableau de l'Univers et des Corps Organisés. Palermo. 224 p.

Skwarko, S. K., and E. Sufiati. 1999. Mollusca in Indonesian Cenozoic Biostratigraphy. Volume 3 (Second Edition). Gastropoda. Paleontology Section, Geology Division, Geological Research and Development Center. Bandung. 796 p.

Tomida, S., K. Inoue, M. Kadota, H. Sano, and E. Hosoda. 2017. *Tectus* sp. aff. *pyramis* (Born, 1778) (Gastropoda: Trochoidea) from the middle Miocene Yugashima Group of the Izu Peninsula, central Japan. Venus (Journal of the Malacological Society of Japan) 75: 88–92.
DOI: 10.18941/venus.75.1-4_88

Tomida, S., and M. Kadota. 2012a. A new species of *Turbo* (*Marmarostoma*) Gastropoda: Turbinidae) from the Miocene Yugashima Group of Izu Peninsula, central Japan. Venus (Journal of the Malacological Society of Japan) 70: 53–57.
DOI: 10.18941/venus.70.1-4_53

Tomida, S., and M. Kadota. 2012b. A fossil tropical giant conch *Strombus* (*Tricornis*) sp. (Gastropoda: Strombidae) from the Miocene Yugashima Group of Izu Peninsula, central Japan. Bulletin of the Mizunami Fossil Museum (38): 79–82. [in Japanese with English abstract]

Tomida, S., M. Kadota, and E. Hosoda. 2013. A fossil tropical giant gastropod *Tutufa* (Gastropoda: Bursidae) from the Miocene Yugashima Group of Izu Peninsula, central Japan. Bulletin of the Mizunami Fossil Museum (39): 65–68. [in Japanese with English abstract]

Tomida, S., and M. Kadota. 2014. *Turbo* (Gastropoda: Turbinidae) fossils from the middle Miocene of Izu Peninsula, central Japan, including the description of three new species. Paleontological Research 18: 67–76.
DOI: 10.2517/2014PR007

Tomida, S., H. Sano, and T. Kase. 2021. An additional new species of *Turbo* (*Marmarostoma*) (Gastropoda: Turbinidae) from the middle Miocene of the Izu Peninsula, central Japan. Paleontological Research 25: 375–378.
DOI: 10.2517/2021PR006

Tomida, S., K. Taguchi, H. Sano, and M. Kadota. 2019. An additional material of *Turbo* (Gastropoda: Turbinidae) with an *in situ* operculum from the middle Miocene Yugashima Group of the Izu Peninsula, central Japan. Bulletin of the Museum of Natural and Environmental History, Shizuoka 12: 1–4. [in Japanese with English abstract]

Yokoyama, M. 1924. Mollusca from the coral=bed of Awa. Journal of the College of Science, Tokyo Imperial University 45: 1–62, pls. 1–5.

Appendix

Astralium ena Tomida, Inoue and Kase, new species LSID: urn:lsid:zoobank.org:act:F712C866-9B44-4D1C-AE85-B43BF85C46FB

新称:エナウラウズガイ

This paper is dedicated to the memory of Professor Junji Itoigawa (1929–2021), who made a great contribution to the geology and paleontology of the Mizunami Group and also to the establishment of the Mizunami Fossil Museum.