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Description of a new midwater medusa, *Tiaropsidium shinkaii* n. sp. (Leptomedusae, Tiaropsidae)

MINORU KITAMURA, DHUGAL J. LINDSAY & HIROSHI MIYAKE

Marine Ecosystem Research Group, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2–15 Natsushima-cho, Yokosuka, Kanagawa 237–0061, Japan

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Abstract: A new species, *Tiaropsidium shinkaii* (Leptomedusae, Tiaropsidae) is described based on a single specimen collected by submersible from the midwater zone of Sagami Bay, Pacific coast of Japan. The presence of compound sense organs, four radial canals, and two kinds of tentacles indicate that the present specimen is a member of the genus *Tiaropsidium* within the family Tiaropsidae. Of the currently described *Tiaropsidium* species, the present specimen resembled *T. roseum* most closely as the number of long tentacles was four. However, it was distinguishable from *T. roseum* by (1) deep umbrella, (2) thick jelly, (3) sinusoidal gonads located on distal portion of radial canals, (4) presence of baso-abaxial projection on each tentacle bulb, and (5) black pigmentation in interradial portion of inner wall of stomach. This is the seventh species in the genus *Tiaropsidium*.

Key words: new species, *Tiaropsidium shinkaii*, Leptomedusae, Tiaropsidae, midwater

Introduction

Since the introduction of crewed submersibles, remotely operated vehicles (ROV) and other sampling devices, it has become apparent that the species diversity of mid and deep water jellyfishes is high. Pugh described many new siphonophore species based on specimens collected using submersibles (e.g. Pugh & Harbison 1987, Pugh & Youngbluth 1988). In the Atlantic, Larson et al. (1991) reported the presence of many undescribed species from observations using a submersible. Recently, Gili et al. (1998, 1999) described several new species collected by moored sediment traps in the Mediterranean Sea. The manuscripts of Pugh et al. illustrate the effectiveness of submersibles as devices enabling taxonomic studies on midwater cnidarians. In order to examine a suite of morphological characters in detail, selective and individual sampling of such fragile jellyfishes is the ideal.

Submersible-based studies on jellyfishes in Japanese waters have been mostly observational records (Pérès 1959, Toyokawa et al. 1998, Lindsay et al. 1999, 2004, Miyake et al. 2002), methodology for faunal studies with associated observational records (Hunt & Lindsay 1999), and an observational record of feeding by *Atolla* sp. (Hunt & Lindsay 1998). Taxonomic reports on deep sea jellyfishes around Japan are mainly old papers based on plankton net samples (e.g. Bigelow 1913, Uchida 1928, 1947), but recently Matsumoto et al. (2003) described a new midwater scyphomedusa from studies using submersibles.

In the present study, we describe a new species of midwater leptomedusa collected using the submersible *Shinkai 2000*, from southeast of Hatsushima Island, Sagami Bay, Pacific coast of Japan. Crewed submersibles and ROVs are effective platforms not only for taxonomic but also for ecological studies. For ecological studies, identification of species through observation rather than collection is often necessary. Hence, we also describe the macro-morphology and swimming behavior of the present species *in situ* as a guide to species identification in the field.

Materials and Methods

A living specimen was collected from southeast of Hatsushima Island, Sagami Bay (35°00′N, 139°14′E), on November 9, 2002. Sampling was achieved using a suction sampler (Hunt et al. 1997) from the crewed submersible *Shinkai 2000*, operated by the Japan Marine Science & Technology Center (JAMSTEC). The dive number was 2K1409, and the observer was M. Kitamura. Bottom depth

Corresponding author: Minoru Kitamura; e-mail, kitamura@jamstec.go.jp; Tel: +81-46-867-9527; Fax: +81-46-867-9525

at the dive point was 1200 m, and the depth of collection was 439 m. Before collection, the swimming behavior of the present specimen was observed directly and recorded *in situ* on Sony Digital Betacam videotapes, which are stored at the Computer and Information Department, JAMSTEC (Dive 2K1409, 1/6–6/6). Physico-chemical environmental parameters at the sampling depth were determined using a SeaBird SBE19 CTD attached to the submersible on the dive. After collection, the specimen was fixed and preserved in a 5% buffered formalin-seawater solution. For nematocyst observations, the distal part of a long tentacle was cut off before fixation and a squash preparation of the tentacle was made. Preservation liquid for the nematocyst preparation was 5% formalin/5% glycerin-seawater. Morphological observations and measurements of the medusan body and nematocysts were carried out under a dissecting and a phase-contrast microscopes, respectively. Terminology used in this study follows that of Bouillon (1999) and Mariscal (1974).

Taxonomic Description

Family Tiaropsidae Boero, Bouillon & Danovaro, 1987
Genus *Tiaropsidium* Torrey, 1909
Tiaropsidium shinkaii n. sp.

(Figs. 1–6)

Material examined. Holotype, collected from Sagami Bay (35°00′N, 139°14′E), 439 m depth, on Nov. 9, 2002. The holotype is deposited in the National Science Museum, Tokyo (NSMT-Co1406).

Description. Umbrella deep (Fig. 1A), 24.3 mm in width and 24.8 mm in height. Jelly tender, thick at apex but thin at margin, 3.2 mm and 0.6 mm respectively. Four radial canals straight and narrow (Fig. 2). Manubrium short, about one fifth of umbrella height; attached to each of four radial canals (Fig. 3A); cruciform in transverse section, with four recurved lips. Length of attached portion about equal to half of manubrium height. Stomach pointed centrally at base. Color of outer surface of manubrium white; interradial portion of inner wall of stomach black (Fig. 3B). Numerous horizontal furrows running along inner wall of stomach. Gonads, white, elongated and sinusoidal, about half length of radial canals, located on distal half of radial canals but not reaching umbrella margin. Two kinds of tentacles present, four long and 62 tiny. Former located perradially and coiled two or three times at base in preserved condition. Each of long tentacles with large, globular tentacle bulb, with associated small baso-abaxial projection (Fig. 4A). Tentacle bulbs with two brownish-pigmented areas inside (Fig. 4A). At perradial umbrella margin, jelly projected downward (Fig. 4A, B). Each tentacle bulb located on adaxial side of jelly projection (Fig. 4B). Only one type of nematocyst (microbasic mastigophore; Fig. 5) recognized on long tentacles. Undischarged capsules ellipsoid in shape, 12 μm in length and 2.1–2.8 μm in width. Tiny

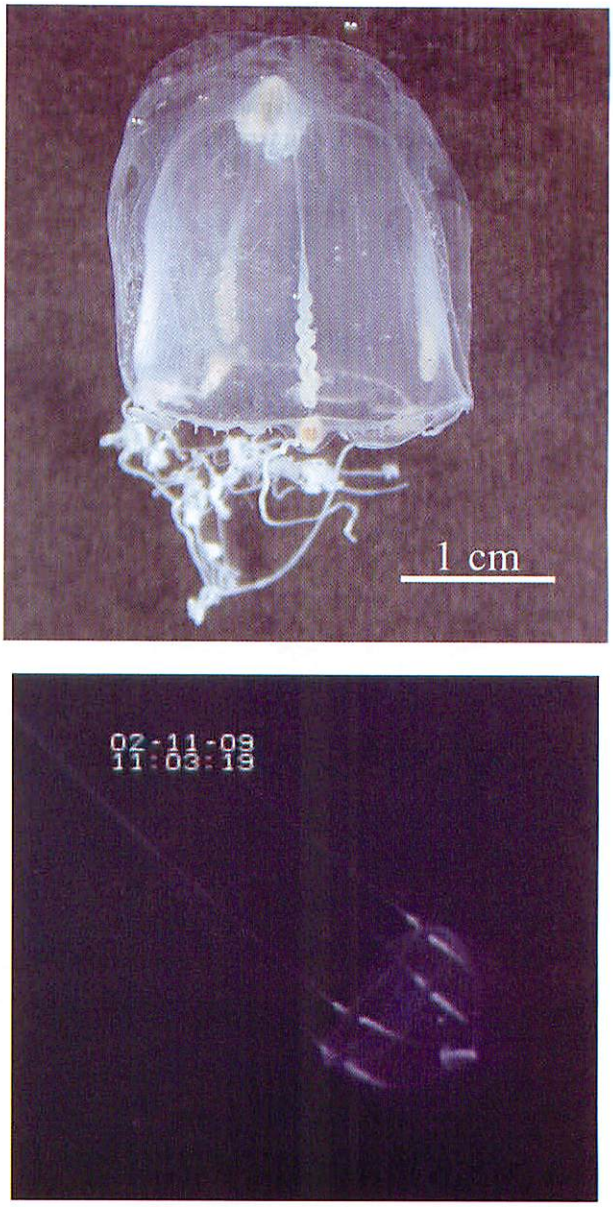

Fig. 1. *Tiaropsidium shinkaii* n. sp. A: Preserved specimen, in the lateral view. B: Live specimen, filmed from *Shinkai 2000* (439 m depth).

tentacles not coiled, with slightly wider bases; all similar in length, from 0.4 to 0.6 mm. Number of tiny tentacles: three to five between tentacle bulbs and sense organs, seven to nine between successive sense organs, 14 to 18 in total in each quadrant. Eight compound sense organs, two in each quadrant, located on the velar side of the umbrella margin. Each sense organ with open vesicle and ocellus. Each vesicle, a small invagination of velum, opening toward umbrella cavity (Fig. 6A–C). Ocellus located on outer side of vesicle, round in lateral view, while round, triangular or square with rounded corners in oral view, black in color. Ring canal narrow. Velum not overly developed, 1.8 mm in width.

Type locality. Sagami Bay.

Geographical distribution. Known only from the type locality.

Etymology. The specific name, *shinkaii*, is derived from the name of the crewed submersible '*Shinkai 2000*' operated by the Japan Marine Science & Technology Center (JAMSTEC). *Shinkai* also means 'deep sea' in Japanese.

Habitat. The major water mass at the depth of collection was classified as Intermediate Kuroshio Water (IKW; Fujimura & Nagata 1991), a subset of North Pacific Inter-

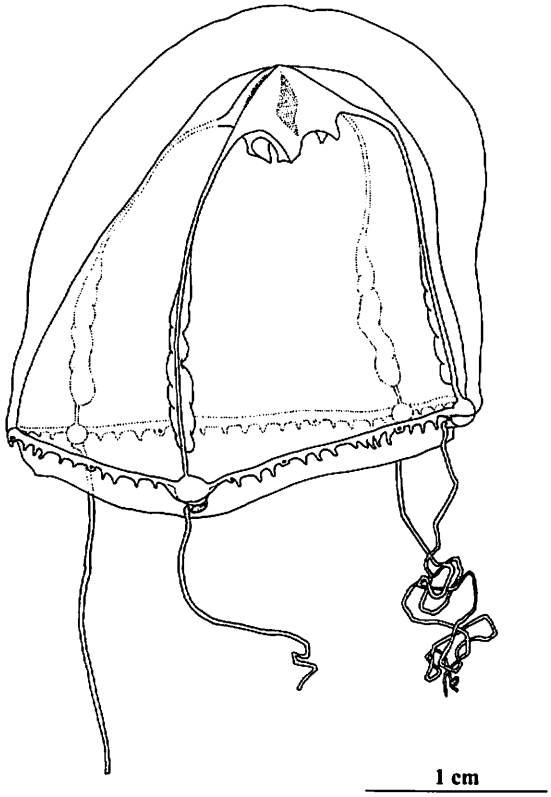

Fig. 2. *Tiaropsidium shinkaii* n. sp. Lateral view. Scale bar=1 cm.

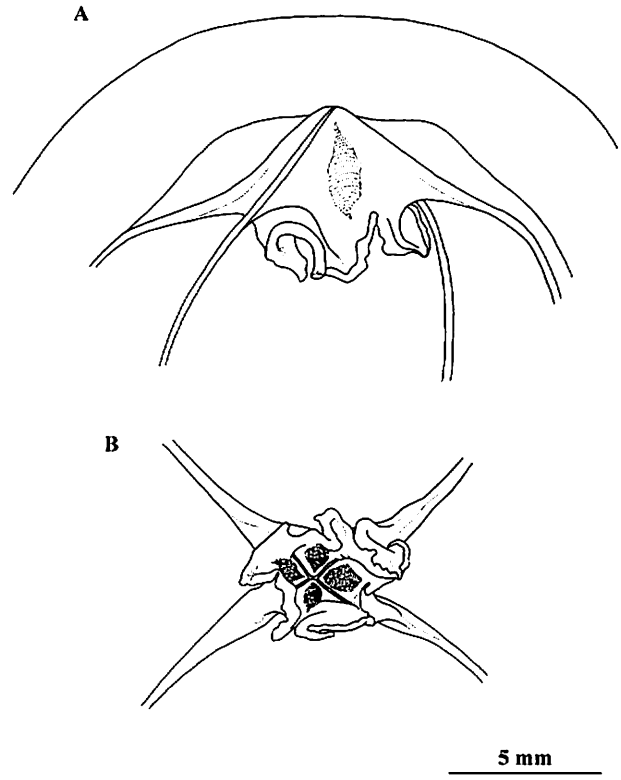

Fig. 3. *Tiaropsidium shinkaii* n. sp. Manubrium in the lateral view (A) and the oral view (B). Scale bar=5 mm.

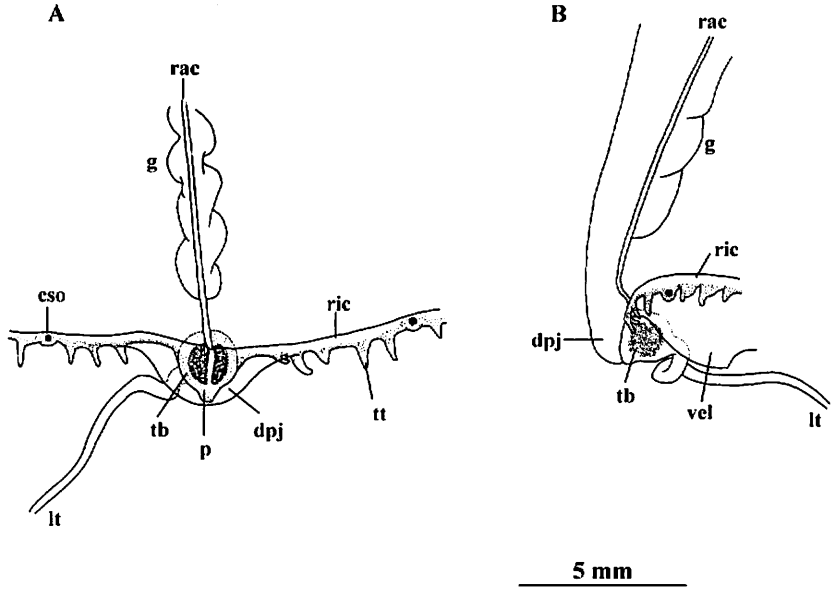

Fig. 4. *Tiaropsidium shinkaii* n. sp. Umbrella margin near tentacle bulb in the lateral view (A) and tentacle bulb in the lateral view (B). Velum is not drawn in Fig. 4A. Abbreviations: dpj, downward projection of jelly; cso, compound sensory organ; g, gonad; lt, long tentacle; p, baso-abaxial projection of tentacle bulb; rac, radial canal; ric, ring canal; tb, tentacle bulb; tt, tiny tentacle; vel, velum. Scale bar=5 mm.

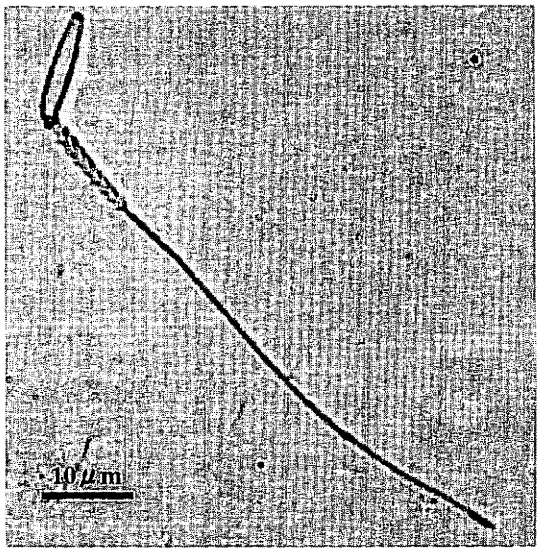

Fig. 5. *Tiaropsidium shinkaii* n. sp. Nematocyst from long tentacle. Scale bar = 10 μm.

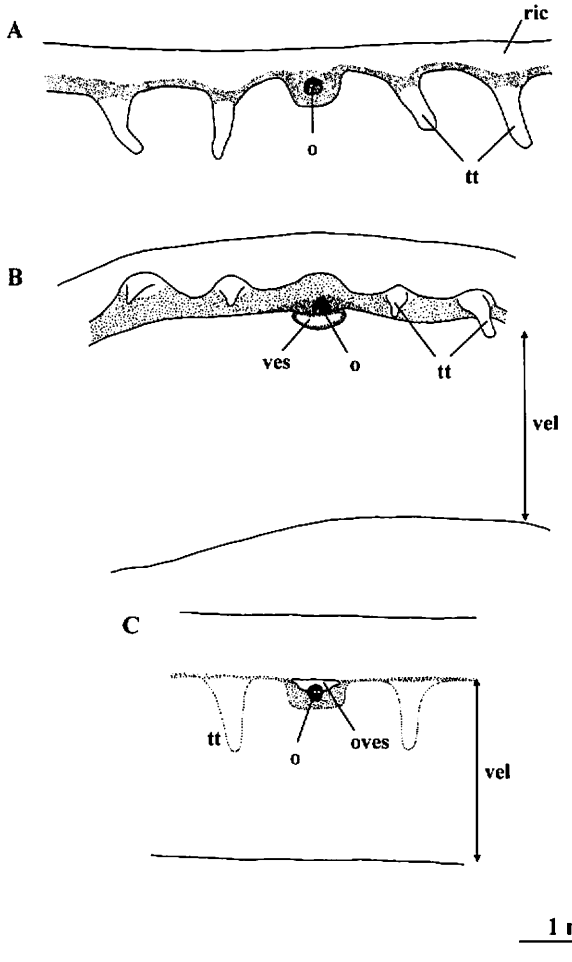

Fig. 6. *Tiaropsidium shinkaii* n. sp. Compound sense organ and row of tiny tentacles in the lateral view (A), the oral view (B) and schematic drawing of opening of the vesicle viewed from the umbrella cavity (C). Abbreviations: o, ocellus; oves, opening of vesicle; ric, ring canal; tt, tiny tentacle; ves, vesicle. Scale bar = 1 mm.

mediate Water (NPIW; Talley 1993). The collection depth (439 m) was located within the salinity minimum layer formed by the IKW. Physico-chemical environmental parameters at the collection depth were as follows: temperature, 6.6°C; salinity, 34.29; sigma-t, 26.91.

Macro-morphology and swimming behavior in situ *as a guide to species identification in the field.* The umbrella was deep, as high as wide. The manubrium, four gonads, four tentacle bulbs and four long tentacles were prominent and whitish (Fig. 1B). The manubrium had a short stomach with slightly recurved lips. The gonads were sinusoidal and located on the distal half of the radial canals. The proximal portions of the gonads were narrower. The tiny tentacles and compound sense organs were not recognizable in the NTSC video record from the *Shinkai 2000*. Swimming of the present specimen was slow and continuous with bell pulsing at 0.6 Hz. Contraction of the umbrella during swimming occurred primarily near the margin. When the medusa was swimming, the long tentacles were very extended, 13 times as high as the umbrella height, and were dragged behind the medusa.

Discussion

The present specimen has compound sense organs, each of which is comprised of an ocellus and a statocyst (only open vesicles were recognized in the present specimen), indicating that it belongs to the family Tiaropsidae, which includes three genera, *Tiaropsis*, *Tiaropsidium*, and *Octogonade*. Of the three genera, *Tiaropsis* has only one type of tentacle, while the others have two types, long tentacles and rudimentary ones. One of the characters distinguishing between the genera *Tiaropsidium* and *Octogonade* is the number of radial canals. Species included in the former genus, except *T. polyradiatum*, have four canals while those in the latter genus have eight. The present specimen has two types of tentacles, and four radial canals, relegating it to the genus *Tiaropsidium*.

At present, six species in the genus *Tiaropsidium* have been described, *T. atlanticum* Russell, 1956, *T. japonicum* Kramp, 1932, *T. kelseyi* Torrey, 1909, *T. mediterraneum* (Metschnikoff, 1886), *T. polyradiatum* Kramp, 1965, and *T. roseum* (Agassiz & Mayer 1899) (see Kramp 1961, Boero et al. 1987, Bouillon & Boero 2000). Morphological differences between *Tiaropsidium* species, including our present specimen, are shown in Table 1. The number of long tentacles is one of the more important characters for distinction of *Tiaropsidium* species. The present material resembles *T. roseum* because of the presence of four long tentacles, but has the following different characters: (1) a deep umbrella, (2) thick jelly at the apex, (3) sinusoidal gonads located on the distal part of the radial canals, (4) baso-abaxial projection of tentacle bulbs and perradial gelatinous projections at umbrella margin near the tentacle bulbs, (5) black pigmentation in interradial portion of inner wall of stomach. As concerns (1), although the specimens of *T. roseum* de-

Table 1. Comparisons between the different species of the genus *Tiaropsidium*.

Species	Umbrella	Size in mm	Number of long tentacles and shape of tentacle bulbs	Number of tiny tentacles in each quadrant	Gonads	Number of compound sense organs	Color	Distribution	References
Tiaropsidium atlanticum Russell, 1956	Flatter than hemisphere with fairly thick jelly	60 wide	Probably 24, with elongated swollen bulbs	Probably 18	Linear, along middle 3/4 of radial canals	Probably about 48	Interradial walls of stomach and long tentacles black	English Channel; dwelling depth unknown	1
Tiaropsidium japonicum Kramp, 1932	Watch-glass shaped with thin jelly	18 wide	8, with large and swollen bulbs	12~14	Linear, along almost entire length of radial canals	16	Unknown	Sagami Bay, east of Cook Strait; midwater	2, 3
Tiaropsidium kelseyi Torrey, 1909	Somewhat conical, three times as broad as high	50 wide	8, with elongated bulbs	About 10	Curtain-like, much folded, along entire length of the radial canals	8	Manubrium, canals, gonads and tentacles faint yellow	West coast of North America; midwater	4
Tiaropsidium mediterraneum (Metschnikoff, 1886)	Globular with thick jelly	5 high, 7 wide	2 opposite perradially, another 2 perradial portions of umbrella margin had small bulbs	5	Elongated, along distal 2/3 of radial canals	8	Gonads, stomach and tentacle bulbs yellowish-grey	Messina; dwelling depth unknown	5
Tiaropsidium polyradiatum Kramp, 1965	Flattened with thin jelly	30 wide	Apparently 24~32, no description about bulbs	More than 2	Along entire length of radial canals	More than 8	Unknown	Nicobars; dwelling depth unknown	3
Tiaropsidium roseum (Agassiz & Mayer, 1899)	Flattened with thin jelly	15 wide	4, with broad bulbs	7	Elongated oval, near stomach, somewhat longer than 1/3 of radial canals	8	Entoderm of stomach ocher-yellow to dull-red	Fiji Islands, Malayan Archipelago, Mauritius, Nicobars, north of Papua New-Guinea, off Sydney, east of New Zealand, Benguela Current, California; surface layer	3, 6~12
Tiaropsidium shinkaii n. sp.	Deep, jelly thick at apex	24.8 high, 24.3 wide	4, each bulb with baso-abaxial projection	13~19	Sinusoidal, distal part of radial canals	8	Outer wall of manubrium, gonads, tentacles white; interradial portions of inner wall of stomach black	Sagami Bay; midwater (439 m)	Present study

References: 1) Russell (1956); 2) Kramp (1932); 3) Kramp (1965); 4) Torrey (1909); 5) Metschnikoff (1886); 6) Agassiz & Mayer (1899); 7) Maas (1909); 8) Brown (1916); 9) Boero, Bouillon & Danovaro (1987); 10) Bouillon & Barnett (1999); 11) Pagès, Gili & Bouillon (1992); 12) Alvariño & Kimbrell (1987)

scribed by Agassiz & Mayer (1899), Brown (1916), Kramp (1958) and Boero et al. (1987) had a hemispherical umbrella, they were too young to be compared with the present material. These specimens were 2.5 mm in umbrella height, 3 mm, 5–8 mm and 1.5 mm in umbrella diameter, respectively.

Tiaropsidium roseum has previously been collected from surface waters in the Indian and Pacific Oceans, Malayan Archipelago (surface, Maas 1905), Mauritius (128–0 fathoms, Brown 1916), Nicobars (surface, Kramp 1958), Benguela Current (93–0 m, Pagès et al. 1992), Fiji (surface, Agassiz & Mayer 1899), a coralline island off the north coast of Papua New-Guinea (Boero et al. 1987), and California (70–0 m, Alvariño & Kimbrell 1987). There have been two other reports of collection from the Pacific Ocean (off Sydney, 3000 m wire out, Kramp 1965; east of New Zealand, sampling details unknown, Bouillon & Barnett 1999), but the exact depths of collection are unclear. Although there are two records from ambiguous depths, it is probably safe to assume that *T. roseum* is a surface species. The present material, however, was collected from 439 m depth. The black pigmentation in the stomach wall, which may function to mask any bioluminescence produced by ingested prey, allows us to infer that the present species is a true member of the midwater fauna. Among the previously described species of the genus *Tiaropsidium*, only *T. atlanticum* that probably dwells the midwater had black pigmentation in the stomach wall.

Uchida (1965) described *Tiaropsis rosea* (=*T. roseum*) collected from Misaki, Sagami Bay, but his description and figure seems only to be a quotation of Mayer (1910). We hesitate to classify his specimen as *T. roseum* because his description was very brief and the material has been lost.

Kramp (1932) described *T. japonicum* based on two specimens collected from Sagami Bay, at about 600 m depth. Although both our present specimen and *T. japonicum* were collected from the midwater layer of Sagami Bay, the former is easily distinguishable from the latter by having (1) eight compound sense organs, (2) four long tentacles, (3) a deep umbrella, and (4) sinusoidal gonads located on the distal half of the radial canals. The present specimen is 24.3 mm in width, while Kramp's *T. japonicum* materials were nearly the same size, 18 mm. The above-mentioned morphological differences are, therefore, considered to be interspecific rather than ontogenetic.

From the above-mentioned morphological and distributional differences, we conclude that a new species in the genus *Tiaropsidium* should be established to accomodate the present material.

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