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## ***Tiburonia granrojo* n. sp., a mesopelagic scyphomedusa from the Pacific Ocean representing the type of a new subfamily (class Scyphozoa: order Semaestomeae: family Ulmaridae: subfamily Tiburoniinae subfam. nov.)**

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**Abstract** Submersible observations off Japan, Hawaii, and California, USA, at depths of 645–1497 m, have revealed a previously undescribed species of large semaeostome scyphomedusa. These observations were made from 1993 to 2002. The medusa, *Tiburonia granrojo* n. sp. is sufficiently different from other species in the family Ulmaridae to justify the creation of a new subfamily (Tiburoniinae). This subfamily and species are distinct in overall bell morphology and color, lacking any marginal tentacles, and having four to seven short, thick oral arms that extend beyond the bell margin. The entire medusa, including the mesoglea, is a deep red. A new key to the subfamilies of the Ulmaridae and large subunit rRNA sequence information for *T. granrojo* are provided. That new species of this size and mass are still being discovered in the deep waters of the world suggests that deep-water species remain undescribed.<sup>1</sup>

### **Introduction**

The class Scyphozoa consists of four orders (Coronatae, Semaestomeae, Stauromedusae, and Rhizostomeae). Only the Coronatae and Semaestomeae are considered to be pelagic medusae, with the Stauromedusae represented by benthic species and the Rhizostomeae usually

shallow water or epibenthic in nature. The pelagic scyphomedusae can be divided into two groups on the basis of their typical habitat (Larson 1986): neritic (living over the continental shelf) or oceanic (occurring beyond the continental shelf). The oceanic habitat can be further divided by depth into different zones (epipelagic, mesopelagic, bathypelagic, abyssopelagic, and hadalpelagic). Regardless of habitat, little is known about the biology and ecology of scyphomedusae. Our operations in the deep sea (at MBARI and at JAMSTEC) continue to reveal new information about the life history of scyphomedusae, but even in nearshore waters, this knowledge is incomplete. There are currently only three semaeostome genera (*Deepstaria*, *Poralia*, and *Stygiomedusa*) known to be mesopelagic. Each of these is monotypic and unusual in size and morphology. In this paper, we will describe a fourth mesopelagic species that represents a new species, genus, and subfamily in the order Semaestomeae. This species was first recognized as something novel during a JAMSTEC expedition to Sagami Bay (35°00'00"N; 139°22'00"E) in 1996 (see Table 1), when an individual was photographed by Dr. T. Toda between 1196 and 1227 m. A video malfunction onboard the "Shinkai 2000" precluded both the capture of the specimen on video and the determination of the exact depth of observation. It was called the finger-foot jelly (*yubiashi-kurage*), but a taxonomic description was not possible with only a few images extant. A MBARI expedition to Gumdrop Seamount (37°27'11"N; 123°27'22"W) in 1998 provided more footage (stills and video), and, at this time, the species was given the common name of gumdrop jelly. The deep red pigmentation, bulky bell, varying number of oral arms, and the absence of marginal tentacles clearly distinguish it from the other subfamilies within the Ulmaridae.

### **Materials and methods**

*Tiburonia granrojo* is described based on video footage from a high-resolution color video camera (Sony DXC 3000) fitted with a surface-controlled, 5.5–40 mm zoom lens that provides

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telephoto, wide-angle, and macro-imaging capabilities. The camera is mounted on the remotely operated vehicle (ROV) "Tiburon", and the video signal is conveyed to the surface support vessel (R.V. "Western Flyer") through optical fibers at the core of the ROV's tether. At the surface, the video signal was viewed on a high-resolution monitor and recorded on digital BetaCam tape. The observer's comments and descriptions were recorded on the audio track of the videotape. After each dive, this information was transcribed into a database and cross-referenced with data on depth, temperature, salinity, and oxygen concentration. Because of the maneuverability of the ROV, it was possible to view undisturbed *in situ* specimens of this scyphomedusa from virtually all angles. For gelatinous pelagic invertebrates, morphological information acquired in this way is often superior to that which can be obtained from preserved material. Since that initial observation, we have gone back through the MBARI and JAMSTEC video archives and have found additional observations starting in 1993 (Table 1). Further video of HDTV or digital BetaCam footage collected using the ROVs "HyperDolphin" (JAMSTEC), "Ventana" (MBARI), and "Tiburon" (MBARI) was referred to for this species description.

Materials for the present study were collected in 7.5-l "detritus samplers", designed for the gentle capture of delicate material in midwater (Youngbluth 1984). The ROV pilot positioned the vehicle so that the open cylinder of the sampler enclosed the medusa, then the sliding doors at either end were closed by hydraulic rams. Because of the large size of all but one of the observed medusae, only pieces of the medusae were collected (targeting the bell margin and the oral arms) for morphological and molecular analysis. One complete specimen was collected on 23 April 2001 and is considered the holotype specimen (deposited in the California Academy of Sciences—CASIZ 162748) with the other fragments comprising partial paratype samples (Table 1).

Tissue samples for molecular analysis were collected with the ROV "Tiburon" (23 February 2000) and either frozen at  $-80^{\circ}\text{C}$  or pressed onto FTA paper (Whatman Bioscience). The 28S rRNA gene was amplified and then sequenced directly and cloned and then sequenced. In both cases, the results from multiple

polymerase chain reactions or plasmid DNAs from two to five individual clones were sequenced both individually and as a pooled group.

## Results

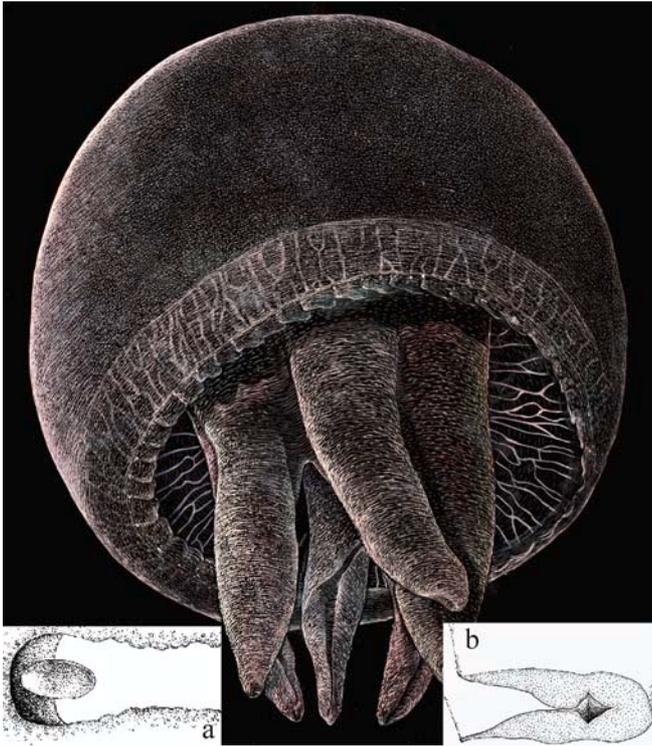
### Electronic supplementary material

Supplementary material (still images, video clips, molecular methodology, and results) is available for this article at <http://www.mbari.org/midwater>. Figure 1 is an artist's rendering of the medusa based on this material.

- Order Semaestomeae
- Family Ulmaridae Haeckel, 1879 (Haeckel 1879)
- Tiburoniinae subfam. nov.
  - Diagnosis. Scyphomedusae with no marginal tentacles and four to seven thick oral arms that extend beyond the bell margin.
  - Type genus. *Tiburonia* gen. nov.
  - Etymology. The subfamily name comes from the ROV "Tiburon", which was the vehicle used by D. Clague during a seamount expedition in 1998 when detailed video and photographic documentation were obtained.
- *Tiburonia* gen. nov.
  - Diagnosis. Scyphomedusa with no marginal tentacles and four to seven thick oral arms that extend beyond the bell margin. This genus has a bell diameter up to 75 cm. Coloration is a deep red

**Table 1** *Tiburonia granrojo*. Observations in the eastern Pacific and Hawaii using MBARI ROVs "Ventana" (V) and "Tiburon" (T) and in the western Pacific using JAMSTEC ROVs "Kaiko" (10K) and "HyperDolphin" (HD) as well as the "Shinkai 2000" (2K)

Date	Vehicle and dive no.	Latitude	Longitude	Depth (m)	Temp ( $^{\circ}\text{C}$ )	Salinity (PSU)	Oxygen ( $\text{ml l}^{-1}$ )	No. of oral arms
3 Aug 1993	V537	36°42'47"N	122°03'14"W	746	4.9	34.32	0.17	6
14 Jun 1996	2K873	35°00'00"N	139°22'00"E	1196–1227	NA	NA	NA	6
14 Oct 1997	T047	36°41'56"N	122°02'20"W	907	4.1	34.36	0.22	NA
21 May 1998	T088, Gumdrop Seamount	37°27'11"N	123°27'22"W	1390	2.8	34.46	NA	6
14 Jul 1998	V1436	36°42'14"N	122°02'46"W	745	4.6	34.35	0.15	NA
23 Mar 1998	V1581	36°42'04"N	122°02'46"W	748	4.6	34.32	NA	NA
23 Apr 1999	10K115	39°10'00"N	144°07'00"E	1036	3.2	34.32	NA	6
23 Apr 1999	10K115	39°10'00"N	144°07'00"E	1375	2.6	34.46	NA	6
23 Feb 2000	T108 (paratype)	36°35'02"N	122°30'58"W	1497	2.8	34.46	1.19	6
21 Mar 2000	T119, Pioneer Seamount	37°24'07"N	123°24'00"W	1428	2.9	34.45	1.08	6
23 Mar 2000	T121, Taney Seamount	37°23'50"N	123°24'25"W	992	3.8	NA	1.22	6
27 Mar 2001	T267, Hawaii	22°25'52"N	157°58'08"W	804	4.7	34.	0.58	6
28 Mar 2001	T268, Hawaii	21°28'26"N	158°23'49"W	990	4.0	34.46	0.75	4
23 Apr 2001	V1964 (holotype)	36°42'02"N	122°03'18"W	844	4.3	34.52	0.3	4
21 Mar 2002	T410	36°19'48"N	122°54'04"W	881	4.4	34.10	0.15	7
26 Apr 2002	HD101	40°25'54"N	144°31'36"E	1146	3.2	34.35	0.7	4
30 Apr 2002	HD104	39°30'00"N	144°15'05"E	1042	2.8	34.4	0.7	6
30 Apr 2002	HD104	39°30'00"N	144°15'05"E	1057	2.8	34.4	0.7	6
2 May 2002	HD106	38°05'00"N	142°48'50"E	790	3.3	34.26	0.7	6
2 May 2002	HD106	38°05'00"N	142°48'50"E	916	3.1	34.35	0.7	NA
2 May 2002	HD106	38°05'00"N	142°48'50"E	933	3.1	34.35	0.7	6
18 May 2002	T425, Davidson Seamount	35°43'34"N	122°43'30"W	1366	2.8	34.51	NA	6



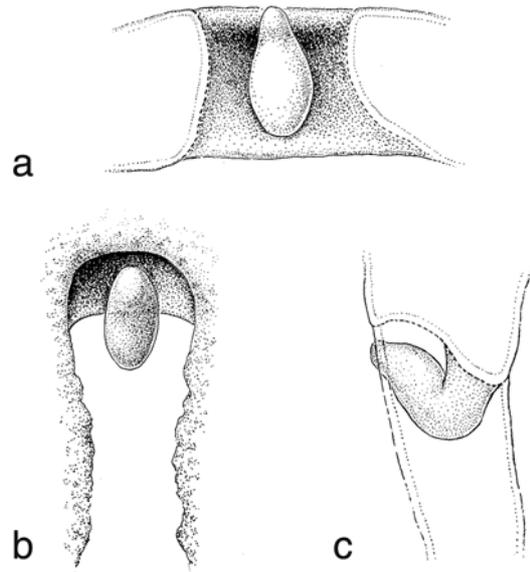
**Fig. 1a, b** *Tiburonia granrojo*. Artist's rendering of medusa based on 2 h of video footage and examination of the holotype: **a** dorsal view of rhopalia which are found between most of lappets and **b** cross-section of oral arm reveals a salmon steak-like morphology. Number of oral arms ranges from four to seven with no correlation with overall bell diameter

throughout; the oral arms are thick at the base, tapering to a blunt tip. The genus is monotypic.

- Type species. *granrojo* sp. nov.
- Etymology. The genus name comes from the ROV “Tiburon”, which has been used for the majority of observations of this new genus. The genus name is feminine.
- *granrojo* sp. nov.
  - Type material. Holotype collected by the ROV “Ventana” dive 1964 on 23 April 2001; 36°42′02″N; 122°03′18″W; time of collection: 17:13:34 UMT; depth of collection: 855 m.

#### Examination of material

In addition to the characters used in the key below, the new subfamily Tiburoniinae is characterized by a dark reddish brown coloration to the entire medusa, including the mesoglea, four to seven oral arms (Table 1), between 24 and 50+ lappets, and rhopalia between the lappets (but occasionally every other lappet with no noticeable pattern). The rhopalia can be difficult to see as they have an “elbow joint” that bends and can hide the rhopalia from view (Fig. 2). The number of ostia ranges from four [for the four-armed specimen (holotype collected 23 April 2001)] to seven for the seven-armed specimen. The bell and oral arms



**Fig. 2a–c** *Tiburonia granrojo*. **a** Direct view of rhopalia from dorsal view (**b**) of rhopalia. **c** Rhopalia can be difficult to detect as the rhopalium is somewhat recessed and can bend along an “elbow joint”

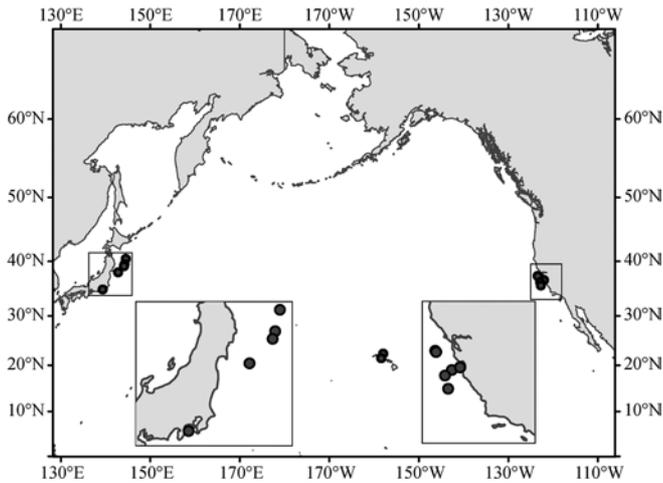
are thick yet the entire medusa deflates readily with the mesoglea disappearing upon preservation. The lappets are covered on the exumbrellar and subumbrellar surfaces with nematocyst warts. The bell reaches up to 75 cm in diameter and the exumbrella is covered with nematocyst warts. The nematocysts appear to be all heterotrichous microbasic euryteles; however, only two specimens (the holotype and paratype) have been examined. Thus far, all specimens have been found at depths of 745–1498 m.

After the initial sighting, we have found this species off Japan, Hawaii, and in several areas off California. A search through the MBARI database (<http://www.mbari.org/~jana/VIMSEExternal/VIMSOOverview.htm>) located 12 additional sightings from March 1993 to May 2002 (Table 1). Most of these had been identified as *Poralia* sp., which it superficially resembles. Nine additional specimens were identified in the JAMSTEC midwater database under the name “finger-foot medusa” (Table 1), giving this species a North Pacific distribution (Fig. 3). All specimens have been found in temperatures of 2.7–4.9°C and salinities of 34.1–34.5 PSU, with oxygen contents of 0.15–1.22 ml O<sub>2</sub> l<sup>-1</sup>.

A total of 1044 bases have been sequenced from the LSU rRNA gene and have been deposited in GenBank (AY149900) and provided as an electronic supplement.

#### Family Ulmaridae (Larson 1986)

Gastric cavity with peripherally radiating canals (either simple or branched) that join the marginal ring canal. Oral arms either broad and curtain-like or narrow and



**Fig. 3** *Tiburonia granrojo*. North Pacific distribution indicating location of each sighting. Sightings reflect the focus of MBARI and JAMSTEC investigations to date

tapering; lips usually with nematocyst-lined papillae or digitata. Gonads either inverted or everted. Tentacles either marginal or subumbrellar or absent.

Key to subfamilies:

- 1a. With tentacles (2)
- 1b. Without tentacles (5)
- 2a. Gonads inverted (3)
- 2b. Gonads everted (4)
- 3a. Gonads separate, horseshoe shaped (Aureliinae)
- 3b. Gonads contiguous and forming ring (Poraliinae)
- 4a. Tentacles marginal (Ulmarinae)
- 4b. Tentacles subumbrellar (Sthenoniinae)
- 5a. Gastrovascular canals variably thickened, forming netlike anastomoses that peripherally decreased in size. Length of oral arms several times that of bell height (Stygiomedusinae)
- 5b. Gastrovascular canals uniformly thin, forming netlike anastomoses of fairly equal size. Length of oral arms less than three times bell height (6)
- 6a. five thin oral arms contained within the bell margin (Deepstariinae)
- 6b. four to seven thick oral arms extending beyond the bell margin (Tiburoniinae).

## Discussion

This large and impressive scyphozoan has been observed in three areas in the North Pacific (Japan, Hawaii, California), suggesting a wide distribution. This novel semeanostome medusae superficially resembles *Poralia* sp. in coloration and in habitat, but the lack of any marginal tentacles, the much larger bell, and the varying oral arm number clearly distinguishes it from the subfamilies Poraliinae, Aureliinae, Ulmarinae, and Sthenoniinae.

Russell and Rees (1960) redefined the family Ulmaridae to include species without marginal tentacles when *Stygiomedusa fabulosa* was described. There is

currently one species of *Stygiomedusa*, as *S. stauchi* Repelin, 1967 (Repelin 1967) has been combined with *S. fabulosa* (Harbison et al. 1973) and both are synonyms for *Stygiomedusa gigantea* Browne, 1910 (Browne 1910; Larson 1986). This genus is characterized by four oral arms, each reaching > 1 m in length, and a bell morphology resembling a wide-brimmed hat. *S. gigantea* is viviparous, and the young have 20 or 21 marginal sense organs and ~60 marginal lappets (Russell 1959). We have never observed any gonadal development in *Tiburonia granrojo*, and the bell morphology lacks the wide “brim” of *S. gigantea*. We do know that the oral arms are much shorter than those of *S. gigantea*. Coloration of the two genera is similar (brownish red), as is the variable shape of the ostioles. Both genera appear to have marginal sense organs between every lappet or every other lappet, with no obvious pattern. *S. gigantea* has 15 to 20 radial canals that form a network of anastomoses that narrow as they approach the periphery. The radial canals of *T. granrojo* do not narrow, but remain uniformly thin. This, in addition to the length of the oral arms and the difference in basic bell morphology, separates these two genera.

*Deepstaria enigmatica* was described by Russell (1967) based on an initial collection by the submersible “Deepstar” at 723 m in the San Diego Trough. Since then, an additional species, *Deepstaria reticulum* Larson et al., 1988 (Larson et al. 1988), has been described. This species is reddish brown rather than the transparent white typical of *D. enigmatica*. *D. reticulum* was collected off Bermuda at 915 m depth and has been seen off Monterey, California, only once (23 November 2002 at 1400 m). It has a short, thick manubrium and eight rhopaliar lappets. *D. enigmatica* has been observed many times off Monterey, California, and twice off Japan (Lindsay et al. 2001). The clear color, long manubrium, five slender oral arms, and bell morphology clearly distinguish the Deepstariinae from the newly described subfamily Tiburoniinae.

The characteristics defined in this paper clearly justify the erection of a new species, genus, and subfamily within the family Ulmaridae. As explorations of the deeper regions of the world’s oceans continue, we will undoubtedly continue to find new species and learn more about the ecology and natural history of these unusual and ecologically significant medusae.

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