



## Clarifying the identity of the Japanese Habu-kurage, *Chironex yamaguchii*, sp. nov. (Cnidaria: Cubozoa: Chiropodida)

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### Abstract

Here we describe the new species *Chironex yamaguchii* (Cnidaria: Cubozoa) from the Ryukyu Archipelago, Japan. This highly venomous cubomedusa, commonly referred to as Habu-kurage in Japan, is the culprit for several fatalities in Japanese waters. The scientific name adopted for this species in the literature is *Chiropsalmus quadrigatus*, but our taxonomic investigations show that this represents a case of mistaken identity. In fact, Habu-kurage is a close relative of *Chironex fleckeri*, which is particularly interesting because the latter has a reputation for being the most venomous animal known. Differences in the shape of the pedalial canal bend, the number of tentacles, and bell size distinguish the two species. In addition to Japan, *Chironex yamaguchii* is widely distributed in the Philippines.

**Key words:** Habu-kurage, Okinawa, *Chironex*, *Chiropsalmus quadrigatus*, *Chiropsoides*

### Introduction

The coastal beaches of the islands of Okinawa and the surrounding Ryukyu Archipelago (i.e., Ishigaki, Iriomoto, Miyako, and Kumei) are plagued every summer (from July to the end of September) by a highly venomous box jellyfish. It is known among local people as “Habu-kurage” in Japanese or in the Okinawan dialect as “Irah” or “Igoh” (Yamaguchi 1982), and encounters between this jellyfish and humans have led to at least three confirmed deaths, in which envenomation led to cardiac arrest in systole and respiratory failure with acute pulmonary edema (Okinawa Prefectural Institute for Health and Environment 1999). Several studies have addressed questions on the development of this animal (Kawamura *et al.* 2003; Oba *et al.* 2004) and its venom function and composition (Nagai *et al.* 2002; Sakanashi *et al.* 2002; Koyama *et al.* 2003; Nagai 2003; Noguchi *et al.* 2005). The scientific name adopted for the Habu-kurage in these works has been *Chiropsalmus quadrigatus* Haeckel, 1880. Our investigations, however, show that this identification is erroneous and we rectify the problem here. In particular, Habu-kurage is a species of *Chironex*, a genus represented so far by only a single species, *Chironex fleckeri* Southcott, 1956, from tropical Australia. *Chironex fleckeri* is infamous for its high toxicity, and its reputation as the most venomous animal known (Williamson *et al.* 1996) makes its close relationship with the Habu-kurage particularly interesting.

## Systematic account

Phylum Cnidaria Verrill, 1865

Subphylum Medusozoa Peterson, 1979

Class Cubozoa Werner, 1973

Order Chiropoda Haeckel, 1880

Family Chiropidae Haeckel, 1880

Genus *Chironex* Southcott, 1956

*Chironex yamaguchii*, sp. nov.

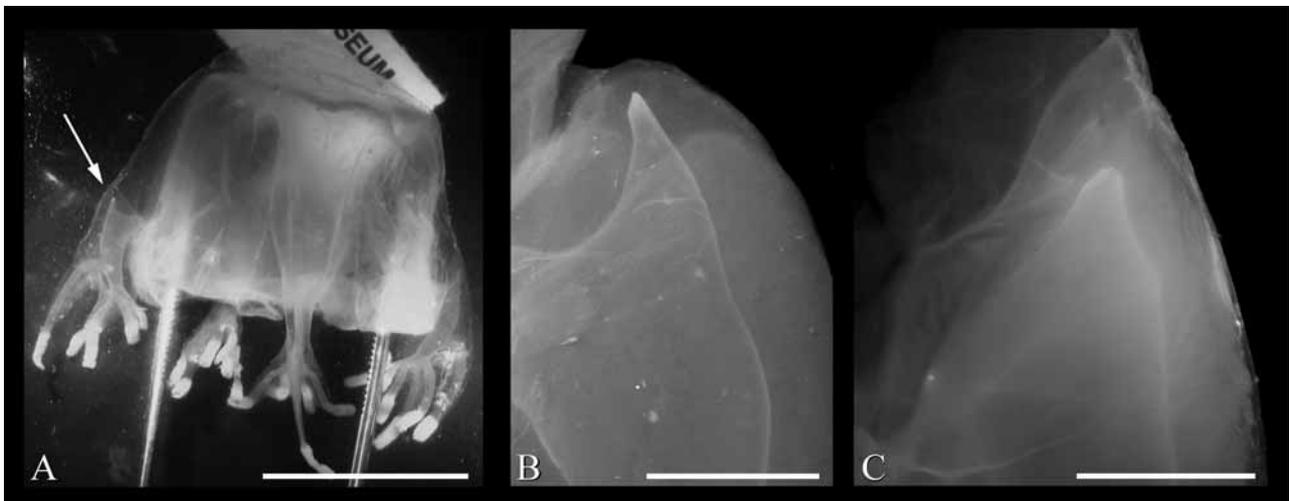
Figures 1C, 2A–K

*Chiropsalmus quadrigatus*: Mayer (1910: 516–517, Philippine records); Light (1914a: 291–295); Light (1914b: 197); Mayer (1915: 171); Mayer (1917: 190; Fig. 4); Light (1921); Stiasny (1927: 213–217, Philippine records); Thiel (1928: 16, remarks, Fig. 6); Stiasny (1931: 139); Yamaguchi (1982); Fenner (1997: Okinawa and Philippine records); Nagai *et al.* (2002); Sakanashi *et al.* (2002); Kawamura *et al.* (2003); Koyama *et al.* (2003); Nagai (2003); Oba *et al.* (2004); Noguchi *et al.* (2005).

*Chironex* n. sp. B: Gershwin (2006a).

non *Chiropsalmus quadrigatus* Haeckel, 1880 [now *Chiropsoides quadrigatus* (see Gershwin 2006b)].

**Abbreviations.** National Museum of Natural History, Smithsonian Institution: USNM; Queensland Museum, Brisbane: QM; Bell height in mm: BH—measured from velarial turn-over to the top of the bell; interradial bell width in mm: IRW; maximum number of tentacles per pedalium: NT.



**FIGURE 1.** Comparison between the pedalial canal bend of *Chironex fleckeri* (B; QM G322755) and *Chironex yamaguchii*, sp. nov. (C; USNM 1121555); the location of the pedalial canal bend at the proximal end of the pedalium is indicated in A (*Chironex fleckeri*; QM G322298). Note the sharp tip as well as the concave slope of the bend (“upswept corniculum”) in *Chironex fleckeri*; in *Chironex yamaguchii* the slope is more gradual and the tip of the bend less sharp (“volcano-like”). Scale bars: 1cm.

**Material examined.** *Holotype*: USNM 1121554, female with fully developed gastric saccules and oocytes, 92 mm BH, 80 mm IRW, NT 6, Ishigaki Island, Ryukyu Archipelago, Okinawa Prefecture, Japan, 24 September 2007.

*Paratypes*: USNM 1121555, female with fully developed gastric saccules but oocytes not fully developed, 90 mm BH, 85 mm IRW, NT 6, Ishigaki Island, Ryukyu Archipelago, Okinawa Prefecture, Japan, 24 September 2007; USNM 1121556, 70 mm BH, 60 mm IRW, NT 7, initially fixed in EtOH and subsequently transferred into formalin, gastric saccules fully developed, Okinawa Island, 26° 20.9' N 127° 45' E, 19 September 1988; QM G317050, juvenile preserved in EtOH, 20 mm BH, 16 mm IRW, NT 5, Nakagusuku, Okinawa Island, 18 July 1992.

*Other material*: Mayer's Philippine lots USNM 27911 and 27915, Subig Bay, Luzon; USNM 27913, Cataingan Bay, Masbate; USNM 27914, Pujada Bay, Mindanao; USNM 27916, Panabutan Bay, Mindanao; USNM 27917 and 27918, Mansalay Bay, Mindoro; USNM 28691, Ulugan Bay, Palawan; USNM 28692 and 28696, Malcochim, Linapacan Strait, Palawan; USNM 28694 and 28697, Bolinao Bay, Luzon; USNM 28695 and 28701, San Miguel Bay, Luzon; USNM 28698, Tilik Bay, Lubang Island, Mindoro; USNM 28700, Hamilo Point, Luzon; USNM 38019 Taytay, Palawan [lots USNM 27912, 28693, 28699, and 38016 could not be located]; 232 unregistered specimens collected from 1978 to 1996 by Y. Araki, M. Yamaguchi, and the first author at Ginowan Marina, Ginowan Tropical Beach, Chatan Beach, and Motobu Port (Okinawa Island), and Sukuji Beach on Ishigaki Island; QM G317051, Kana Beach, Ginoza, Okinawa Island.

**Type locality.** Ishigaki Island, Ryukyu Archipelago, Okinawa Prefecture, Japan.

**Etymology.** The specific name honors Prof. Masashi Yamaguchi, who has contributed much to an understanding of Japanese cubozoans and the early life history of *Chironex fleckeri*.

**Diagnosis.** *Chironex yamaguchii*, **sp. nov.**, has a maximum bell height of about 110 mm (about 1/2 to 1/3 that of its congener *Chironex fleckeri*); up to nine tentacles per pedalius (versus up to 15 in *Chironex fleckeri*); proximal pedalius canal bend volcano-shaped (Fig. 1B) (in contrast to the "upswept corniculum" in *Chironex fleckeri*; Fig. 1B).

**Description.** Chirodropid medusae with smooth exumbrella (Fig. 2A), maximum BH about 110 mm (average about 60 mm) and maximum IRW about 95 mm. Pedalia claw-like, each bearing up to nine tentacles, but usually only seven; proximal pedalius canal bend volcano-shaped *sensu* Fenner (1997) (Fig. 1C). Extended trailing tentacles in life appearing flat and broad as in *Chironex fleckeri*; up to nine tentacles per pedalius with lavender-colored nematocyst bands. Upon contraction, or in preserved specimens, tentacles tending to be thicker and rounded, like sausage-links (Fig. 2B). Manubrium cruciform with four narrow, lanceolate lips (Fig. 2C); about 2/3 to 3/4 as long as bell height. Gastric phacellae V-shaped in each corner of stomach as in most other chirodropids (Fig. 2A); gastric cirri simple and unbranched (Fig. 2D). Gastric saccules (superior gonads) cock's-comb shaped/grape-cluster-like and opaque in mature specimens (Fig. 2E). Development of gonads following sequence described for *Chironex fleckeri* by Barnes (1966). Gastric saccules developing from small, smooth, kidney-shaped bulges at ceiling of subumbrella into large, grape-cluster-like swellings by elongation and successive addition of numerous swellings until they occupy much of subumbrellar cavity. Perradial lappets smooth, broad, triangular, extending almost to subumbrellar edge of velarium (Fig. 2F). Four perradial muscular brackets (frenulae) brace the right-angle connection from tip of rhopalial niche to 3/4 the distance between velarial turnover and its margin (Fig. 2G). Each frenulum consisting of a single, thick gelatinous sheet (Fig. 2G). Velarial canals numerous and highly branched, as in *Chironex fleckeri* (Fig. 2H, 2I). Each of the four rhopalia bearing a set of six eyes, with the two median possessing prominent lenses and the four lateral ones adjacent to the lens eyes being pigment pits and slits (Fig. 2J). Statolith oval, transversally mounted at base of rhopalium (Fig. 2J). As in other chirodropids, rhopalial niche ostium dome-shaped with a single upper covering scale (Fig. 2K); rhopalial niche located in a triangular depression of exumbrella (Fig. 2K). The cnidome of *Chironex yamaguchii* and its transformation throughout the course of development was described in detail based on specimens from Japan by Oba *et al.* (2004; as *Chiropsalmus quadrigatus*).

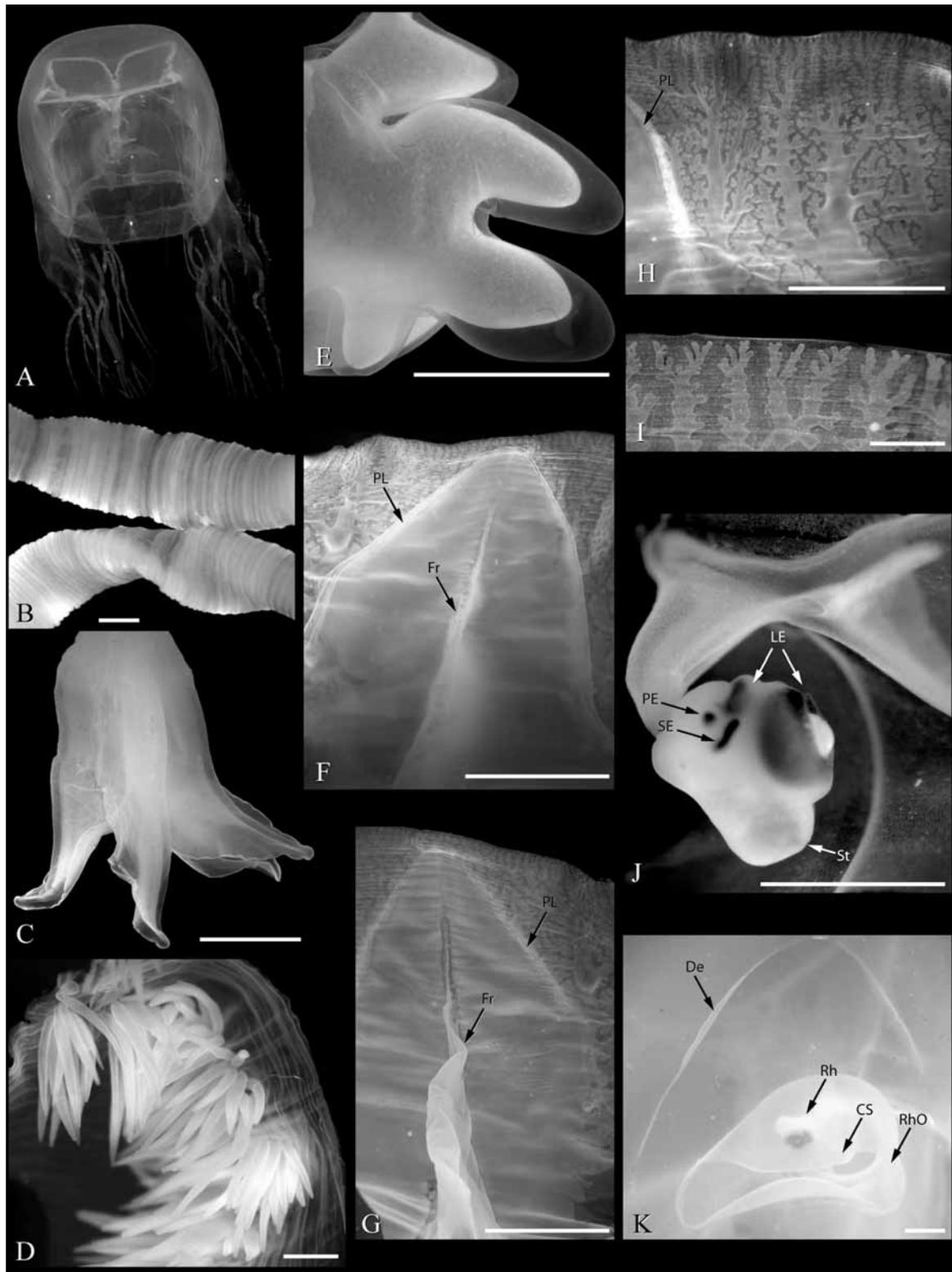
**Remarks.** Earlier misidentifications of *Chironex yamaguchii* can be attributed to Mayer's (1910: 516–517) redescription of this species, under the name *Chiropsalmus quadrigatus* Haeckel, 1880, from the Philippines. *Chiropsoides quadrigatus* (Haeckel, 1880: 447, as *Chiropsalmus quadrigatus*) was described from Burma and is easily distinguishable from *Chironex yamaguchii*. Members of the genus *Chiropsoides*

have laterally compressed pedalia and their gastric saccules are long, finger-shaped and smooth, whereas the pedalia in *Chironex* are claw-like and the gastric saccules in mature specimens are cock's-comb shaped/grape-cluster-like. Both Thiel (1928) and Stiasny (1937) noted the discrepancies between Mayer's description of what he thought was *Chiropsoides quadrigatus* from the Philippines and Haeckel's original description of the species from Burma. Stiasny (1937) nevertheless believed that the descriptions pertained to the same species. Rather than rectifying this taxonomic problem, he provided yet another redescription of *Chiropsoides quadrigatus* (as *Chiropsalmus quadrigatus*) by reconstructing the species from Haeckel's (1880) and Mayer's (1910) descriptions, as well as a specimen from the Maldive Archipelago. By doing so he perpetuated the confused identity of the chirodropids from the Philippines and, ultimately, from Japan.

Our examinations of Mayer's (1910) material at the National Museum of Natural History, Smithsonian Institution, revealed that the specimens belong to the genus *Chironex*, and they agree in their morphological characteristics with material examined from Japan. Specimens from the Philippines appear to be a developmental series displaying numerous stages in the maturation process from juvenile to adult in *Chironex yamaguchii*. Mayer (1910: 516, Fig. 331) depicted two stages in the development of *Chironex yamaguchii*, even though he did not explicitly state so. The oral view of the stomach shows the well-developed, cock's-comb shaped gonads typical of *Chironex*, whereas the side view of the animal depicts an immature specimen that has not yet fully developed. There is little doubt that what Mayer observed was a species of *Chironex*. Since *Chironex* was not described until some 45 years later (Southcott 1956), he did not recognize his mistake and believed that he had an opportunity to add to the arguably insufficient original description of *Chiropsoides quadrigatus* (see Gershwin 2006b, for discussion).

Morphological differences between *Chironex fleckeri* and *Chironex yamaguchii* are few, and the shape of the pedalian canal bend seems to be the most reliable character to distinguish the two. However, we believe that they represent different species, and geographic distance among the collection sites of *Chironex fleckeri* and *Chironex yamaguchii* lends additional credibility to this interpretation. In addition to morphological differences and allopatric distributions of *Chironex fleckeri* and *Chironex yamaguchii*, we observed a strong genetic differentiation among the two. We calculated uncorrected pairwise distances among mitochondrial COI sequences from the Ishigaki type material of *Chironex yamaguchii* (GenBank nos. FJ665180 and FJ665182) and an unvouchered specimen of *Chironex fleckeri* from Weipa, Queensland, Australia (GenBank no. FJ665182). Both sequences of *Chironex yamaguchii* were identical, but differed from *Chironex fleckeri* by 16.7%.

In a medical thesis, Fenner (1997) identified close affinities between *Chironex fleckeri* and the deadly venomous chirodropid known from both Japanese and Philippine waters. Dr. Fenner's familiarity with morphological characters of the latter was garnered through correspondence with Y. Araki and the first author of this manuscript, and his study of Mayer's specimens. He also pointed out the distinguishing feature of the pedalian canal bend, but did not describe it as a new species. He noted many more fatalities related to jellyfish envenomations in the Indo-West Pacific. Future sampling will probably lead to additional records of *Chironex* species or probably even new, distinct species. In general, there appears to be a tendency for morphological conservativeness in Cubozoa and probably Medusozoa in general. Given these considerations, future studies may show that Philippine and Japanese specimens of *Chironex yamaguchii* represent two distinct species, but our current data do not support such an interpretation.



**FIGURE 2.** *Chironex yamaguchii*, sp. nov. A. juvenile specimen (bell height approximately 5 cm) displayed at Enoshima Aquarium, Japan; B. preserved tentacles; C. manubrium with four lips; D. gastric cirri; E. gastric saccules; F. perradial lappet as seen from below the subumbrellar opening; G. perradial lappet and frenulum as seen from inside the subumbrellar cavity; H. velarial canals; I. tips of velarial canals; J. rhopalium; K. rhopalial niche (note the triangular depression around the niche). Scale bars: 1 mm (B, D, I, J, K), 1 cm (C, E, F, G, H); CS: covering scale; De: triangular shaped depression; Fr: frenulum; LE: lens eye; PE: pit eye; PL: perradial lappet; Rh: rhopalium; RhO: rhopalial niche ostium; SE: slit eye; St: statolith. All photographs except A and B are taken from paratype USNM 1121555; B is taken from the holotype.

## Acknowledgements

We are grateful to M. Yamaguchi and Y. Araki for facilitating the first author's studies at the University of the Ryukyus and the Okinawa Prefectural Institute for Health and Environment in Okinawa, to K. Masato for providing type material, to A. G. Collins for photographs and helpful comments on this work, and to M. Ekins for facilitating the second author's investigations in the QM collections. Funding was provided through a US National Science Foundation Assembling the Cnidarian Tree of Life Grant, the PADI Foundation, and a Japanese Government Monbukagakusho Scholarship. Two anonymous reviewers provided helpful comments that greatly improved an earlier version of this manuscript.

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