Bull. Natn. Sci. Mus., Tokyo, Ser. A, 17(3), pp. 157–164, September 22, 1991

Redescription of a Rare Pufferfish, *Arothron carduus* (CANTOR, 1849) (Teleostei: Tetraodontidae)

By

Keiichi MATSUURA

Department of Zoology, National Science Museum, Tokyo

and

Junji OKUNO

Faculty of Marine Science and Technology, Tokai University, Shimizu

Abstract A rare pufferfish, *Arothron carduus* (CANTOR, 1849), is redescribed on the basis of the holotype and two additional specimens. It differs from other species of *Arothron* by the combination of many longitudinal black lines on the body, irregular black lines and spots on the caudal fin, and a yellow ventral region. It is known only from Penang Island in the eastern Indian Ocean and the Ryukyu Islands in the Pacific.

Pufferfishes of the genus *Arothron* are widely distributed in tropical regions of the Indo-Pacific. As in other genera of pufferfishes it is difficult to separate *Arothron* species by using morphometric characters, because meristic counts overlap in many species and pufferfish specimens are often distorted by preservation. This situation has led previous authors to distinguish *Arothron* species primarily by color. The species of this genus, however, show much color variation in relation to growth and geographical populations, resulting in many synonymous names for color variants of single species (e. g., *A. stellatus*). This situation has made it difficult to study the systematics of the genus, although revisional studies have recently been made to clarify the relationships of several species (RANDALL, 1985 for *A. immaculatus* and *A. manilensis*; SU & TYLER, 1986 for *A. meleagris* and *A. nigropunctatus*).

Arothron carduus was originally described as *Tetrodon carduus* by CANTOR (1849) on the basis of a single specimen collected at Penang Island, lying off the west coast of the Malay Peninsula. Because the specimen was preserved only as a skin from the right side of the body, it has been difficult for subsequent authors to evaluate its taxonomic status. Although BLEEKER (1859, 1861) did not examine the specimen of *T. carduus*, he included it under *Arothron* in his list of the fishes of the East Indies. BLEEKER (1865, 1866) subsequently placed it in the genus *Crayracion*. GÜNTHER (1870) examined CANTOR's specimen and concluded that it was probably a color variant of *Tetrodon immaculatus* BLOCH et SCHNEIDER, 1801. Since GÜNTHER (1870) regarded *T. carduus* as a variety of *T. immaculatus*, the former name has not been used by subsequent authors and no additional specimens have ever been reported.

A second specimen of this apparently rare pufferfish was collected by the first author at Ishigaki-jima Island, one of the Ryukyu Islands in 1973. At first it was thought to be an undescribed species, because of its having many longitudinal black lines on the body, unlike other congeneric species. A subsequent search for additional material to help clarify its taxonomic status resulted in a third specimen being found as a fish lantern in a souvenir shop on Hachijo-jima Island, one of the Izu Islands, Japan, while the junior author was making a survey of that island's fish fauna in 1990. A survey of the literature indicated that the specimens from Ishigaki-jima and Hachijo-jima islands were probably conspecific with *Tetrodon carduus* CANTOR. This has been confirmed by a comparison of them with the holotype of *T. carduus*, which itself is a valid species even though it has not appeared in any publication since GÜNTHER (1870) placed it under the synonym of *A. immaculatus* (actually GÜNTHER's *immaculatus* was *manilensis*).

The detailed description that follows reestablishes the validity of *Arothron carduus* (CANTOR) on the basis of the three specimens now available.

Methods

The methods for counts and measurements followed those of DEKKERS (1975) except for the following: the eye diameter was taken as the largest diameter of the exposed eyeball. Radiographs were used to count the number of vertebrae and to observe features of the skull. The distribution of spinules on the body was determined using a binocular microscope, and confirmed by radiographs. Pectoral ray counts include the uppermost rudimentary ray. Osteological characters of the skull were examined by removing the skin and muscle from the right side of the head. Except when otherwise stated, proportional measurements are based on the Ryukyu Islands specimen, because the holotype and the Hachijo-jima Island specimen are in poor condition. Institutional abbreviations follow LEVITON *et al.* (1985).

Generic Allocation of *Tetrodon carduus* CANTOR, 1849

Tetrodon carduus is referred to the genus *Arothron* because of its combination of the following characters: a single lateral line on the side of the body reaching to the base of the caudal fin, two nasal tentacles on each nostril clearly bifurcated to the base, and the sphenotic not extending laterally beyond the frontal edge. Two fleshy tentacles or lobes on each nostril are also seen in *Chelonodon* and *Tetraodon*, but these genera differ from *Arothron* by a greater lateral projection of the sphenotic. *Chelonodon* further differs from *Arothron* in having a bifurcation of the lateral line above the anal fin. In all Asiatic species of *Tetraodon*, the nasal organs are divided distally into two lobes, but are tube-like at the base, unlike *Arothron* (DEKKERS, 1975). Our observations on some African species, also referred to *Tetraodon*, showed that they have two fleshy tentacles on each nostril as in *Arothron*, but also usually have a

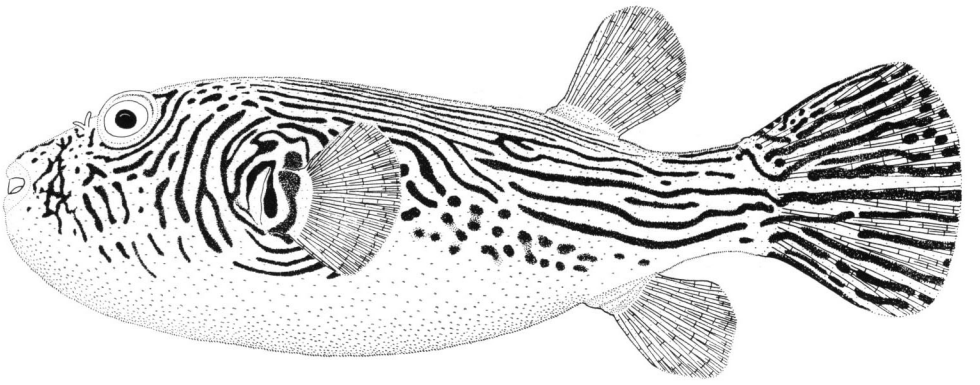

Fig. 1. *Arothron carduus*, HUMZ 35438, 194.6 mm SL, Ryukyu Islands.

lower lateral line branch such as in *Chelonodon*.

Arothron carduus (CANTOR, 1849)

[New Japanese name: Nagare-moyofugu]

(Figs. 1–5)

Tetrodon carduus CANTOR, 1849, p. 1357 (original description; West Malaysia, sea of Pinang).
Arothron carduus: BLEEKER, 1859, p. 202 (listed); BLEEKER, 1861, p. 68 (listed).
Crayracion carduus: BLEEKER, 1865, p. 66 (description after CANTOR, 1849); BLEEKER, 1866, p. 36 (listed).

Specimens examined. Holotype, BMNH 1860.3.19: 591, 110.9 mm SL (139.5 mm in total length), skinned specimen (right side of body only), Penang Island (= Pinang), eastern Indian Ocean, Dec. 1842; HUMZ 35438, 194.6 mm SL (243.1 mm TL), Ishigaki-jima I., Ryukyu Is., 10 m depth, gill nets, 24 July 1973; NSMT–P 34460, 342 mm SL (435 mm TL), obtained at Hachijo-jima I., Izu Is., Japan, but possibly imported from the Philippines (see below).

Description. Dorsal rays 10–11 (11 in holotype); anal rays 9–10 (9 in holotype); pectoral rays 18–19 (19 in holotype); caudal rays 11 (uppermost and lowermost rays unbranched); vertebrae 8+11=19. Body oblong, slightly compressed, dorsal profile gently arched. Head length 2.5 in SL; snout short, blunt, snout length 5.1 in SL. Mouth terminal, surrounded by thin lips. Interorbital space flattened, bony interorbital width 2.2 in head. Eye diameter 7.0 in head. Nasal organ located anteromedial to eye; two nasal tentacles divided to base on each nostril, anterior and posterior tentacles almost equal in size. Head and body covered with small spinules except on posterior of caudal peduncle, and around mouth, eye, gill opening, and dorsal and anal fin bases (Fig. 2). Caudal peduncle compressed, depth 2.9 and length 2.2 in head. Dorsal and anal fins rounded, origin of dorsal anterior to that of anal;

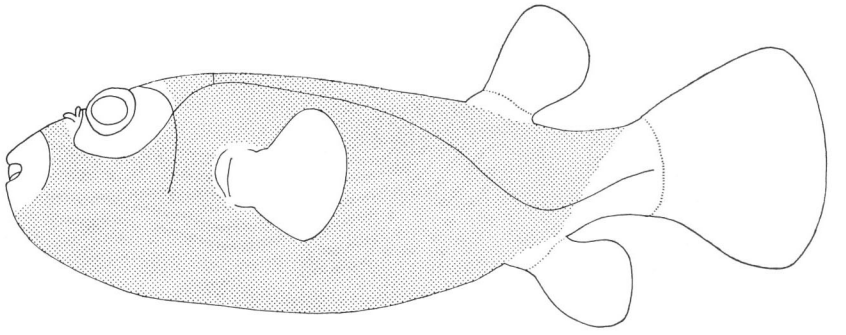

Fig. 2. Lateral line system and distribution of spinules (shaded) in *Arothron carduus*.

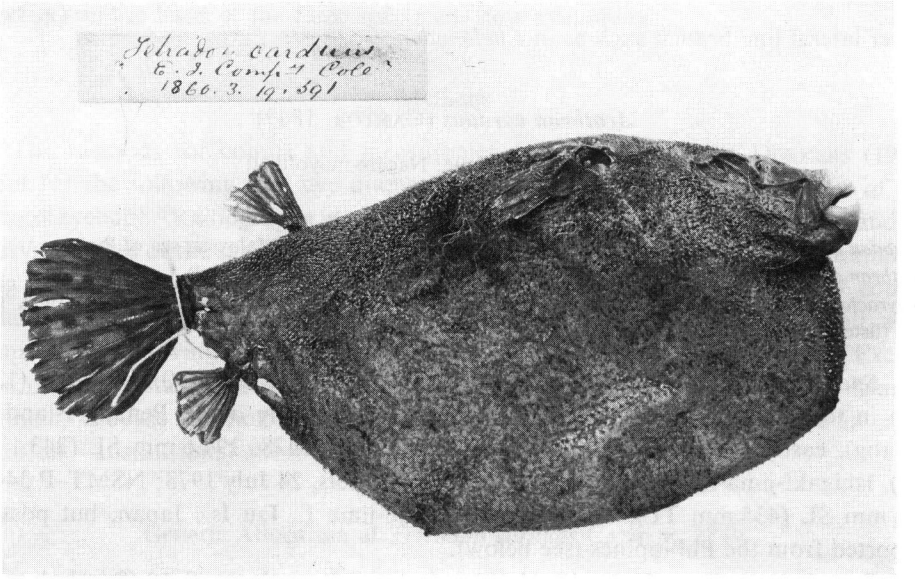

Fig. 3. Holotype of *Arothron carduus*. BMNH 1860. 3.19: 591, 110.9 mm SL, Penang Island.

longest dorsal and anal fin rays both 2.3 in head; distance from snout to dorsal origin 1.4 in SL (1.2 in SL in holotype); distance from snout to anal origin 1.2 in SL (1.1 in SL in holotype). Pectoral fin rounded; longest ray 3.5 in head. Caudal fin rounded, relatively long, its length 1.5 in head. A single lateral line passing along body from caudal fin base to above gill opening, where it branches into two lines; one crossing over nape to meet with the opposite element, the other encircling eye and coursing down to level with the lower edge of the gill opening (Fig. 2). A separate lateral line system just posterior to mouth is not connected with its opposite element.

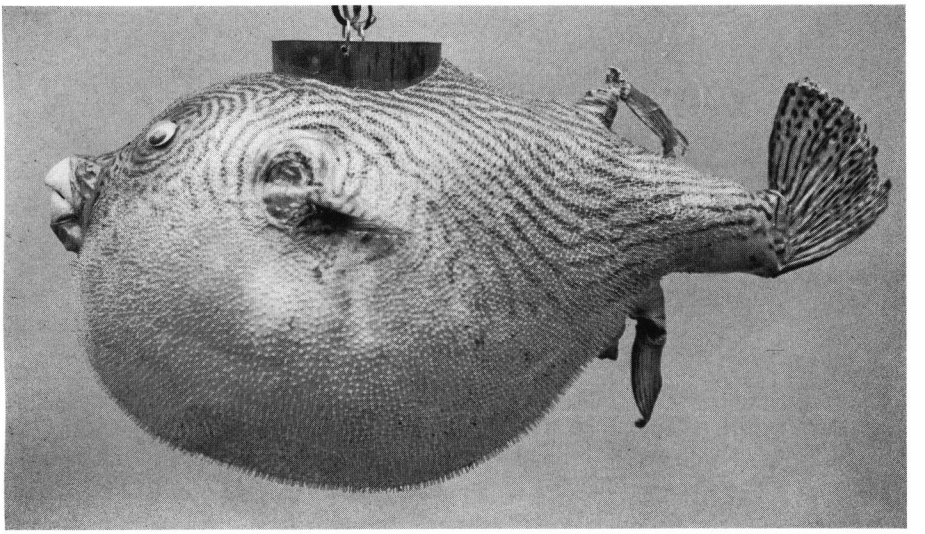

Fig. 4. *Arothron carduus*, NSMT–P 34460, 342 mm SL, obtained at Hachijo-jima Island, Izu Islands, but possibly from the Philippines.

Color of fresh specimen: lateral and dorsal sides of head and body white with many black lines; these lines encircling eye and gill opening; several small black spots scattered on ventrolateral part between pectoral and anal fins; ventral side of head and body yellow; pectoral fin dusky yellow; dorsal and anal fins yellowish-brown; caudal fin white with many irregular longitudinal black lines and black spots; outer surface of nasal tentacle white with black pigments, inner surface pink.

Color in alcohol: head and body light gray with many black lines; color pattern formed by black lines and spots as in fresh specimen; pectoral, dorsal and anal fins dusky yellow; outer surface of nasal tentacle blackish, inner surface white.

Notes on the Holotype. CANTOR (1849) stated that his specimen measured 6 inches (15.2 cm) TL, but it is now approximately 14 cm TL. This discrepancy is most likely due to shrinkage of the skin following preparation. Because the holotype comprises skin only, it is impossible to reconstruct proportional dimensions. However, the fins were sitill in relatively good condition, enabling exact fin ray counts. The nasal tentacles were missing, except for the proximal parts, which showed clear bifurcation to the base as found in other species of *Arothron*. The distribution of spinules on the body was the same as that found in the two additional specimens. All of the fins were rounded. The color of the head and body was yellowish-brown, slightly paler on the ventral side. Longitudinal black lines running from the interorbital region to the caudal peduncle numbered 6 to 7 above the gill opening (CANTOR stated that the number of lines was 12 on the back). Several black spots were scattered on the ventrolateral region between the gill opening and the anal fin. The pectoral, dorsal and anal fins were yellowish-brown, as was the caudal fin which

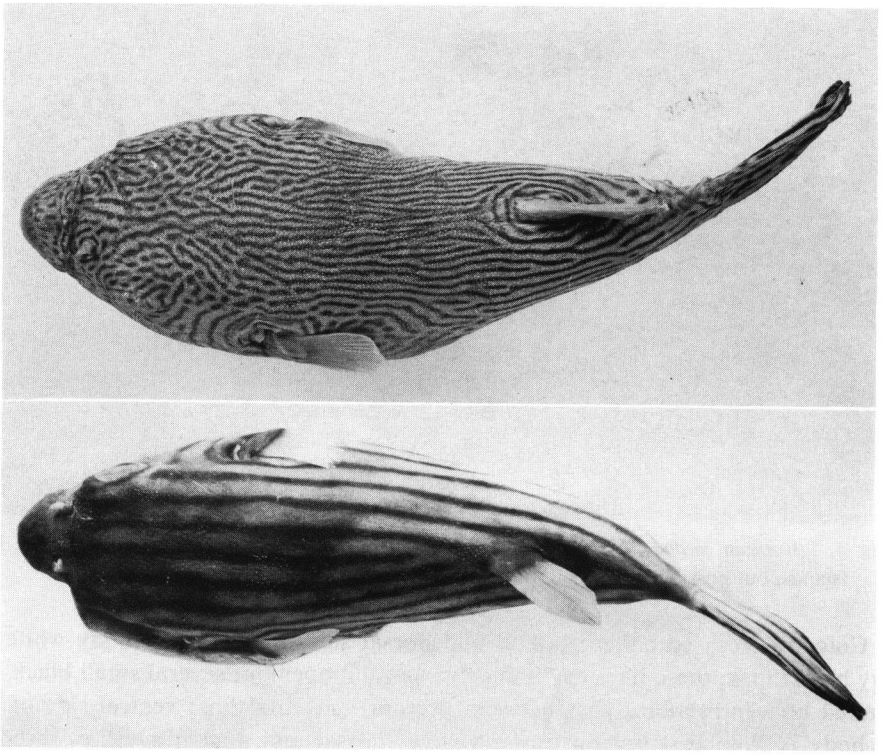

Fig. 5. Dorsal view of two species of *Arothron*. Top, *A. carduus*, HUMZ 35438, 194.6 mm SL; bottom, *A. manilensis*, NSMT-P 23649, 90 mm SL.

also had several longitudinal black lines and black spots.

Remarks. CANTOR's (1849) color description of the holotype almost agrees with that of the Ryukyu Islands specimen, but he stated "Head and back dark yellow-ochre with a number of longitudinal, slightly serpentine black lines continued to the caudal; ..." In our specimens the head and back do not show any trace of ochre. This suggests that *A. carduus* exhibits color changes with growth, as is also found in *A. stellatus*, in which the dorsolateral side of the body is reddish-orange with many black spots in young specimens but white with many small black spots in adults.

BLEEKER (1865) recognized *A. carduus* as distinctive from *A. manilenis* by its many longitudinal black lines on the body, irregular black lines on the cheek, black spots on the flank, and black vermiculations on the caudal fin. GÜNTHER (1870) synonymized *A. carduus* with *A. manilensis*, although he noted that in the former the caudal fin was not edged with black, which is a diagnostic character of the latter. *A. carduus* is similar to *A. manilensis* in having many longitudinal lines on the body, but the number of lines is much larger in the former (Figs. 5, 6). In addition to this, *A. carduus* is clearly different from *A. manilensis* in color of the caudal fin and abdomen:

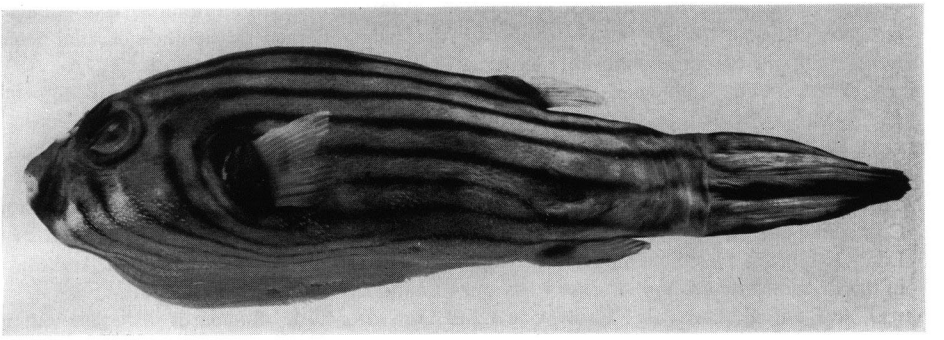

Fig. 6. *Arothron manilensis*, NSMT–P 23649, 90 mm SL, Gilbert Islands.

irregular black lines and spots but no black edge on the caudal fin in *A. carduus* (Fig. 1), whereas no black lines or spots but a black edge on the caudal fin in *A. manilensis* (Fig. 6). In addition the abdomen is yellow in *A. carduus* but pale without yellow tinge in *A. manilensis*.

The Hachijo-jima Island specimen is the largest of the three available specimens. According to the shop keeper where the specimen was obtained, it was possibly imported from the Philippines, but there was no exact information about the collection locality. Similarly, information on the fresh color of the Hachijo-jima Island specimen was not available, but it still retained a color pattern similar to that of the preserved Ryukyu Islands specimen. Judging from the collection localities of the holotype and the additional specimens, this species is probably distributed in the tropical regions of the Indo-West Pacific.

Acknowledgments

We thank the following persons for the loan of the specimens: Jim CHAMBERS and Gordon HOWES (BMNH) and Kunio AMAOKA (HUMZ). Helpful comments on the manuscript were made by Graham S. HARDY of Minoo City and James C. TYLER (USNM). This study was supported by a grant-in-aid from the Ministry of Education, Science and Culture, Japan (no. 02640589).

Literature Cited

BLEEKER, P., 1859. Enumeratio specierum piscium hucusquein Archipelago indico observatarum, adjectis habitationibus citationibusque, ubi descriptiones earum recentiores reperiuntur, nec non speciebus Musei Bleekeriani Gengalensibus, Japonicis, Capensibus Tasmanicisque. *Act. Soc. Sci. Indo-Neerl.*, **6**: i–xxxvi+1–276.

——— 1861. Ietes over de vischfauna van het eiland Pinang. *Versl. Akad. Amsterdam*, **12**: 64–80.

——— 1865. Atlas ichthyologique des Indes Orientales Néêrlandaises, publié sous les auspices du Gouverment colonial néêrlandais. Tome V. Baudroies, Ostracions, Gymnodontes, Balistes. 152 pp., 38 pls.

——— 1866. Synonyma Balistidorum, Ostracionidorum, Gymnodontidorumque Indo-archipelagicorum hucusque observatorum revisa, adjectis habitationinus citationibusque ubi descriptiones figuraque eorum recentiores reperiuntur. *Ned. Tijdschr. Dierk*, **3**: 20–40.

CANTOR, T. E., 1849. Catalogue of Malayan fishes. *J. Asiat. Soc. Bengal*, **18**: i–xii+983–1443, pls. 1–14.

DEKKERS, W. J., 1975. Review of the Asiatic freshwater puffers of the genus *Tetraodon* LINNAEUS, 1758 (Pisces, Tetraodontiformes, Tetraodontidae). *Bijidr. Dierk.*, **45**: 87–142.

GÜNTHER, A., 1870. Catalogue of the Fishes in the British Museum. Catalogue of the Physostomi, Containing the Families Gymnodontidae, Symbranchidae, Muraenidae, Pegasidae, and of the Lophoboranchii, Plectognathi, Dipnoi, Ganoidei, Chondropterygii, Cyclostomata, Leptocardii, in the British Museum. Vol. 8. xxv+549 pp. London.

LEVITON, A. E., R. H. GIBBS, Jr., E. HEAL & C. E. DAWSON, 1985. Standards in herpetology and ichthyology: Part I. Standard symbolic codes for institutional resource collections in herpetology and ichthyology. *Copeia*, **1985**: 802–832.

RANDALL, J. E., 1985. On the validity of the tetraodontid fish *Arothron manilensis* (PROCÉ). *Japan. J. Ichthyol.*, **32**: 347–354.

SU, J., & J. C. TYLER, 1986. Diagnoses of *Arothron nigropunctatus* and *A. meleagris*, two extremely polychromatic Indo-Pacific pufferfishes (Pisces: Tetraodontidae). *Proc. Acad. Nat. Sci. Philad.*, **138**: 14–32.