

Validation of *Tetraodon barbatus* Roberts, 1998, a Freshwater Pufferfish (Family Tetraodontidae) from the Mekong River

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Abstract.– The freshwater pufferfish, *Tetraodon barbatus* Roberts, 1998, previously considered as a synonym of *Tetraodon cambodgiensis* Chabanaud, 1923, is validated. It differs distinctly from *T. cambodgiensis* by the combination of characters of that its caudal peduncle is smooth without small spinules and the head is broader (head width at preorbital, post orbital and nape: 54.1–59.8, 69.1–77.8 and 76.5–86.8 % head length (HL), respectively, in *T. barbatus* vs. 48.7–53.3, 60.2–64.3 and 68.5–74.3 %HL, respectively, in *T. cambodgiensis*).

KEY WORDS: *Tetraodon barbatus*, valid species, Mekong River

INTRODUCTION

Freshwater pufferfish of the genus *Tetraodon* Linnaeus, 1758 are widely distributed in Southeast Asia (Kottelat, 2001; Monkolprasit et al., 1997; Rainboth, 1996; Sontirat, 1989; Vidthayanon, 2008; Vidthayanon et al., 1997). Roberts (1998) reviewed the taxonomy of the freshwater pufferfish genus *Tetraodon* from Mekong basin, and also described *T. abei* and *T. barbatus* as two new species. Subsequently, Kottelat (2001) considered *T. barbatus* as junior synonym of *T. cambodgiensis*.

Recently, the authors have collected *T. barbatus* specimens from the same localities as the holotype and paratype in Thailand

and from the other places in the Mekong basin in Thailand, Laos and Cambodia. We also examined the syntype of *T. cambodgiensis* in the Museum National d' Histoire Naturelle (MNHN), Paris, France, and additionally collected new specimens of this species from Siem Reap and Stung Treng, Cambodia and Tram Chim, Tam Nong, Vietnam. Examination all of these specimens revealed that *T. barbatus* differs from *T. cambodgiensis* in some distinctive characters, sufficient to conclude that *T. barbatus* is a valid species of freshwater puffer fish from the Mekong basin distinct from *T. cambodgiensis*. The present study focuses on two aspects. The first re-describes the morphology of *T. barbatus*, whilst the second revalidates *T. barbatus* as a valid species based on the differences from *T. cambodgiensis* in terms of morphological features.

MATERIALS AND METHODS

The normal shape of the specimens (the proportions of the body when not puffed up) was used for the morphological study. Fin ray counts and measurements were manipulated with the left side of specimens. Point to point measurements were carried out with dial calipers, recording the data to the nearest 0.1 mm. Measurements of the standard length (SL), total length, dorsal fin base length, head length (HL), snout length, interorbital distance, eye diameter and mouth width, and the pectoral, dorsal, anal and caudal fin ray counts followed that of Dekkers (1975). In addition, the internasal distance, interopercular distance, head depths and head widths at the preorbital, postorbital and nape, interpectoral fin distance, prepectoral, predorsal and preanal fin lengths, pectoral, dorsal and anal fin base lengths, depth and width of body at middle base of the dorsal fin, and the caudal peduncle length, depth and width were all measured. The head subunit sizes were calculated in terms of the percent ratio of the HL (%HL). Meanwhile, the HL and measurements of the body parts were calculated as a percent ratio of the SL (%SL). The freshwater pufferfish specimens reported in this study are deposited in Kasetsart University Museum of Fisheries (KUMF), National Inland Fisheries Institute (NIFI) and Ubon Ratchathani Natural History Museum of Fisheries (UNMF).

RESULTS

Tetraodon barbatus Roberts, 1998 (Fig. 1a-d)

Tetraodon barbatus: Roberts, 1998: 230, fig. 4 (type locality: Huay Huang, 30 km. West of Chiang Khan, Loei Province, Thailand)

Monotreta cambodgiensis: Rainboth, 1996: 227, fig. 215

Monotreta cambodgiensis: Kottelat, 2001: 166, fig. 478

Material examined.— 24 specimens (18 adults and 6 juveniles). Mekong basin: KUMF 8801, 7, 86.4–96.2 mm SL, Ban Tha Lat, Amphoe Ban Phaeng, Nakhon Phanom Province, 18 March 2012, P. Saenjundaeng; KUMF 8802, 3, 60.1–72.8 mm SL, Ban Pha Tang, Amphoe Sangkhom, Nong Khai Province, 26 June 2010, P. Saenjundaeng; KUMF 8803, 1, 69.9 mm SL, Ban Kokmad, Amphoe Chiang Khan, Loei Province, 4 May 2012, P. Saenjundaeng; KUMF 8804, 1, 105.2 mm SL, Ban Hat Hae, Amphoe Chiang Khan, Loei Province, 3 April 2012, B. Hinumca; KUMF 8805, 1, 136.2 mm SL, Ban Pha Tang, Amphoe Sangkhom, Nong Khai Province, 4 April 2012, P. Saenjundaeng; KUMF 8806, 3, 36.9–85.4 mm SL, Ban Pha Tang, Amphoe Sangkhom, Nong Khai Province, 6 May 2010, P. Saenjundaeng; KUMF 8807, 2, 93.4 and 95.8 mm SL, Huay Huang, Ban Najan, Amphoe Chiang Khan, Loei Province, 28 July 2012, P. Saenjundaeng; KUMF 8808, 2, 111.2 and 123.2 mm SL, Amphoe Chiang Khan, Loei Province, 28 July 2012, P. Saenjundaeng; UNMF 07715, 1, 78.8 mm SL, Mouth of Mun River, Ban Dan Mai, Amphoe Khong Chiam, Ubon Ratchathani Province, 3 March 1999, C. Grudpun; NIFI 04686, 2, 96.2 and 102.2 mm SL, Nam Ngeum, Vang Viang, Lao PDR, 11 October 2011, C. Vidthayanon; NIFI 04685, 1, 124 mm SL, Stung Treng, Cambodia, 4 August 2007, C. Vidthayanon.

Diagnosis.— *Tetraodon barbatus* can be differentiated from *T. cambodgiensis* in having the following characters: caudal

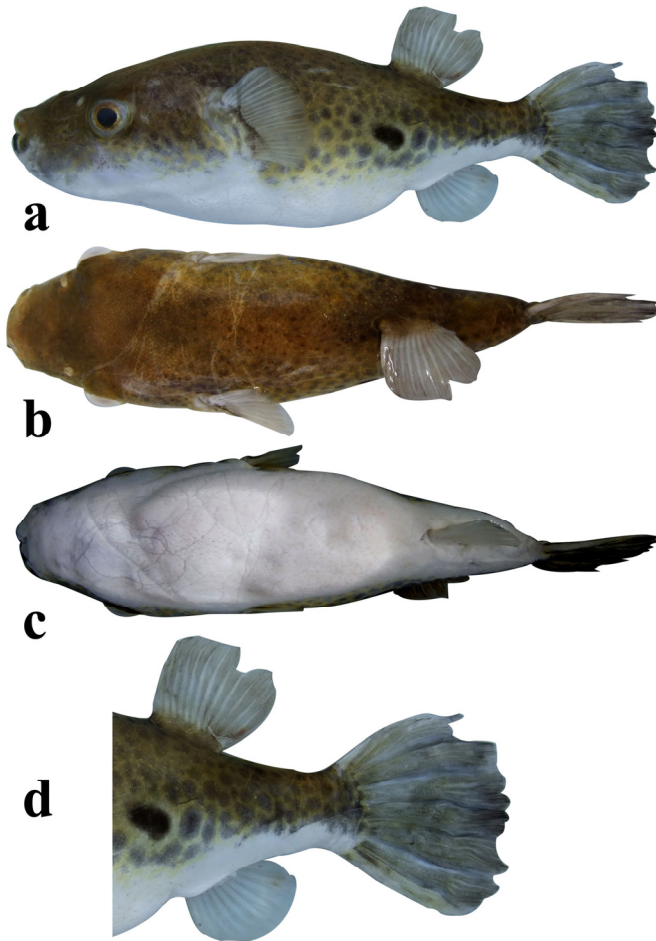


FIGURE 1. Fresh specimen of *T. barbatus* Roberts, 1998, KUMF 8808, 123.2 mm SL, Mekong river at Amphoe Chiang Khan, Loei Province: (a) lateral view, (b) dorsal view, (c) ventral view and (d) caudal peduncle without small spinules.

peduncle without small spinules or prickles (Fig. 1d), broader head (Table 1) (head width at the preorbital, post orbital and nape of 54.1–59.8, 69.1–79.7 and 76.5–86.8 %HL, respectively, in *T. barbatus* vs. 48.7–52.9, 60.2–67.6 and 68.5–75.0 %HL, respectively, in *T. cambodgiensis*).

Description.— Elliptical body, dorsal profile of head and body slightly convex, long blunted snout. In %HL: mouth width 25.2–

34.2, snout length 46.9–54.4, slightly large eye (diameter 15.2–20.1) protrudes laterally, visible from the ventral side of head, interorbital distance 52.0–64.7; internasal distance 33.5–41.5, preorbital head depth 45.6–58.9, width 54.1–59.8, postorbital head depth 56.9–70.1, width 69.1–79.7, head depth at nape 63.2–76.5, width 76.5–86.8. In %SL: head length 37.6–43.6, interpectoral fin distance 24.4–30.9, prepectoral fin length

TABLE 1. Meristic counts and the morphometric measurements, in terms of the %HL and %SL, of the specimens of *T. barbatus* and *T. cambodgiensis*

Characters	<i>Tetraodon barbatus</i> (n = 24) (Range and mean ± SD)	<i>Tetraodon cambodgiensis</i> (n = 9) (Range and mean ± SD)
Morphometric measurement as % HL		
Mouth width	25.2–34.2 (28.2 ± 2.3)	25.8–31.9 (29.3 ± 2.1)
Snout length	46.9–54.4 (51.6 ± 1.6)	46.9–51.3 (49.4 ± 1.7)
Eye diameter	15.2–20.1 (17.7 ± 1.3)	12.9–17.0 (15.1 ± 1.2)
Interorbital distance	52.0–64.7 (60.2 ± 3.3)	50.6–56.9 (53.7 ± 2.5)
Internasal distance	33.5–41.5 (35.7 ± 2.0)	31.1–39.7 (35.1 ± 2.9)
Head depth at preorbital	45.6–58.9 (52.9 ± 3.4)	43.9–50.5 (48.0 ± 2.3)
Head width at preorbital	54.1–59.8 (56.9 ± 1.9)	48.7–52.9 (51.6 ± 1.4)
Head depth at postorbital	56.9–70.1 (64.4 ± 4.0)	56.1–60.8 (58.4 ± 1.5)
Head width at postorbital	69.1–79.7 (73.9 ± 2.9)	60.2–67.6 (64.0 ± 2.5)
Head depth at nape	63.2–76.5 (72.0 ± 3.5)	62.3–67.6 (64.7 ± 2.0)
Head width at nape	76.5–86.8 (81.3 ± 3.5)	68.5–75.0 (72.0 ± 2.3)
Morphometric measurement as %SL		
Head length	37.6–43.6 (40.7 ± 1.6)	37.7–40.8 (39.2 ± 1.3)
Interpectoral fin distance	24.4–30.9 (27.3 ± 1.7)	21.8–25.1 (23.7 ± 1.0)
Prepectoral fin length	40.1–45.1 (42.5 ± 1.4)	38.1–42.4 (40.6 ± 1.3)
Predorsal fin length	69.6–75.4 (72.4 ± 1.4)	69.6–73.4 (71.9 ± 1.1)
Preal anal fin length	74.8–82.5 (78.5 ± 2.0)	76.8–80.6 (78.7 ± 1.2)
Pectoral fin base length	9.1–11.5 (10.5 ± 0.7)	9.6–11.5 (10.5 ± 0.6)
Dorsal fin base length	9.0–11.8 (10.4 ± 0.7)	9.5–11.7 (10.7 ± 0.7)
Anal fin base length	6.2–8.2 (6.9 ± 0.4)	6.4–8.4 (6.9 ± 0.6)
Body depth at middle base of dorsal fin	18.5–21.5 (20.1 ± 1.0)	19.4–22.0 (20.3 ± 0.8)
Body width at middle base of dorsal fin	16.5–21.5 (18.9 ± 1.5)	15.3–18.6 (17.2 ± 1.2)
Caudal peduncle length	14.5–17.7 (16.0 ± 1.0)	15.8–18.2 (16.9 ± 0.9)
Caudal peduncle depth	11.0–13.7 (12.3 ± 0.7)	11.9–14.1 (12.9 ± 0.8)
Caudal peduncle width	10.9–14.6 (12.9 ± 1.0)	10.2–13.7 (11.8 ± 1.2)
Meristic count		
Pectoral fin ray	i-ii 20–23	i-ii 20–22
Dorsal fin ray	i-ii 11–12	ii 12–13
Anal fin ray	i 9–10	i-ii 9–10
Caudal fin ray	ii 6 ii	ii 6 ii

40.1–45.1, predorsal fin length 69.6–75.4, preanal fin length 74.8–82.5, pectoral fin base length 9.1–11.5, dorsal fin base length 9.0–11.8, anal fin base length 6.2–8.2, body depth at middle of dorsal fin base 18.5–21.5, width 16.5–21.5, caudal peduncle length 14.5–17.7, depth 11.0–13.7, width 10.9–14.6. Covering area of spinules on dorsal surface between internasal to behind dorsal fin end, on lateral surface between nasal organ anterior margin and curve line behind dorsal fin end to anterior anal fin origin, on ventral surface between chin and anterior of vent.

Fin ray counts: pectoral i-ii 20–23, dorsal i-ii 11–12, anal i 9–10, caudal ii 6 ii

Colour.— Colour patterns of live specimens of *T. barbatus*. Middle sized, round ocellus with dark center on flank and light margin surrounding. Ventral surface of body evidently white. Dorsal and lateral surfaces yellow to brown background covered with small, round scattered-black spots. Lower lip generally has three black marks: first on middle part, two on lower lip sides. These marks visible from juvenile through adult stages. Some adult *T. barbatus* did not have

three black marks on lower lip. Lower lip usually grey. Pectoral and anal fins white, slightly hyaline. Dorsal and caudal fins are grey.

Geographic distribution.— *T. barbatus* is only known from the middle and lower Mekong basin (Roberts, 1998). The data from the field trips in Mekong basin of Thailand revealed that *T. barbatus* is not only found in Mekong mainstream but also in its larger tributaries, especially in places with rocky, sandy or muddy substrate. Moreover, *T. barbatus* inhabits rapids and is often found in the same habitat as *T. suvattii* and *T. baileyi*.

Comparative material

1. *Tetraodon cambodgiensis*: (Syntype plus eight specimens (8 adults and 1 juvenile)). Syntype from Museum National d'Histoire Naturelle, Paris, with catalog number MNHN 22-80 (Syntype of *T. cambodgiensis* Chabanaud, 1923): 1, 141.1 mm SL, Phnom Penh, Cambodia, 1921, A. Krempf; NIFI 04684, 2, 35.4 and 124.3 mm SL, Stung Treng, Cambodia, 9–11 March 2007, C. Vidthayanon; UNMF 07716, 5, 127.9–144.8 mm SL, Tonle sap lake fishing area, Phsar Leu (fresh market), Siem Reap, Cambodia, 11 March 2008, C. Grudpun; NIFI 04683, 1, 115.8 mm SL, Tram Chim, Tam Nong, Vietnam, 28 May 2007, C. Vidthayanon; NIFI 04694, 1, 109.6 mm SL, Tram Chim, Tam Nong, Vietnam, 12 July 2007, C. Vidthayanon.

2. *Tetraodon cochinchinensis*: (55 samples; 33 adults and 22 juveniles). NIFI 01544, 1, 48.2 mm SL, Ubonrat Dam, Khon Kaen Province, 13 February 1985, S. Soontornsathit; NIFI 03304, 1, 84.9 mm SL, Ubonrat Dam, Khon Kaen Province, 1–5 June 1987, P. Sodsook; NIFI 01520, 1, 64.8 mm SL, Ubonrat Dam, Khon Kaen Province, 12 February 1985, S. Soontornsathit; KUMF

8818, 1, 88.0 mm SL, Ubonrat Dam, Khon Kaen Province, 28 February 2012, M. Singhabud; NIFI 01546, 5, 46.8–81.6 mm SL, Ubonrat Dam, Khon Kaen Province, 13 February 1985, S. Soontornsathit; NIFI 01148, 8, 89.8–103.2 mm SL, Ubonrat Dam, Khon Kaen Province, 8–11 August 1977, J. Ratanathavee; KUMF 1658, 6, 67.2–88.9 mm SL, Nampong Irrigation Dam, 30 km North of Khon Kaen, 23 March 1971, P. Wongrat and Party; KUMF 8819, 2, 85.0–112.8 mm SL, Nam Pong river, Ban Hua Dong, Tambon Ban Kham, Amphoe Nam Pong, Khon Kaen Province, 28 February 2012, M. Singhabud; KUMF 8820, 1, 57.2 mm SL, Nam Pong river, Ban Kut Phang Khrua, Tambon Tha Krasoem, Amphoe Nam Pong, Khon Kaen Province, 8 March 2012, M. Singhabud; NIFI 00627, 2, 76.2 and 87.6 mm SL, Lampao Dam, Kalasin Province, 25 February 1978, N. Sugomol; KUMF 8821, 6, 70.2–82.6 mm SL, Lampao Dam, Ban Tha Ruea, Amphoe Yang Talat, Kalasin Province, 5 August 2012, P. Saenjundaeng; KUMF 8822, 3, 71.0–81.0 mm SL, Chi river, Ban Pak Pla Khao, Tambon Don Ong, Amphoe Pho Chai, Roi Et Province, 29 April 2012, P. Saenjundaeng; KUMF 8823, 8, 70.2–109.4 mm SL, Chi river, Ban Pak Pla Khao, Tambon Don Ong, Amphoe Pho Chai, Roi Et Province, 27 March 2012, S. Juntarasombat; KUMF 8824, 6, 61.2–96.2 mm SL, Chi river, Ban Non Krayom, Tambon Pho Chai, Amphoe Kok Pho Chai, Khon Kaen Province, 26 February 2012, M. Decha; KUMF 8825, 1, 67.8 mm SL, Chi River, Tambon Tha Phra, Amphoe Mueang, Khon Kaen Province, 6 March 2012, M. Singhabud; KUMF 1586, 2, 66.9 and 88.2 mm SL, Kwan Payao, 5 March 1924, H.M. Smith; KUMF 1656, 1, 54.3 mm SL, Kwan Payao, 21 October 1964, K.F. Lagler and Party.

DISCUSSION

Roberts (1998) accepted *T. cambodgiensis* and *T. cochinchinensis* as synonyms of *T. leiurus*. The data from the original description of *T. leiurus* in Bleeker (1851) gave the description of this species based on five specimens of 60-98 mm total length, collected from the sea and mouth of the river in Batavia (or Jakarta, Indonesia). The colour patterns were described as: dark and ruddy

upper part of the body without spots, yellow ventral part and yellow or ruddy fins. Bleeker (1852) redescribed *T. leiurus*, based on 11 specimens from Java, Sumatra and Borneo (five specimens of syntypes and six new specimens from Sumatra and Borneo), describing them as having a dark green body covered with round green spots (except the trunk), and a yellow or bronze ventral part. The first illustrated picture of *Cravacion* (= *Tetraodon*) *leiurus* by Bleeker (1865) also

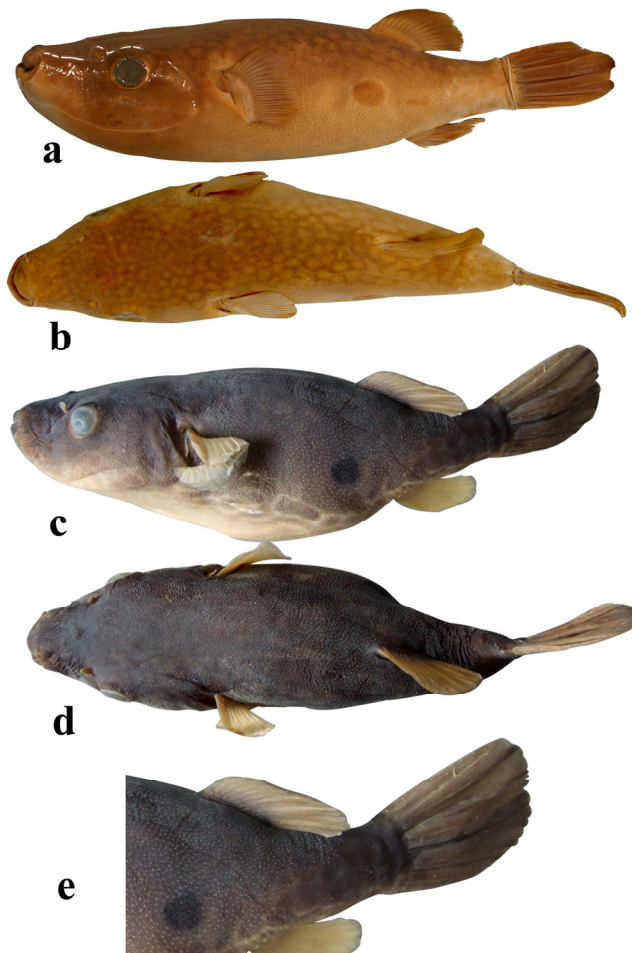


FIGURE 2. Preserved specimens of *Tetraodon cambodgiensis* Chabanaud, 1923, (a, b) syntype, MNHN 22-80, 141.1 mm SL, Phnom Penh, Cambodia, showing the (a) lateral view and (b) dorsal view; (c–e) NIFI 04684, 124.3 mm SL, Stung Treng, Cambodia, showing the (c) lateral view, (d) dorsal view and (e) upper part of caudal peduncle with small spinules.

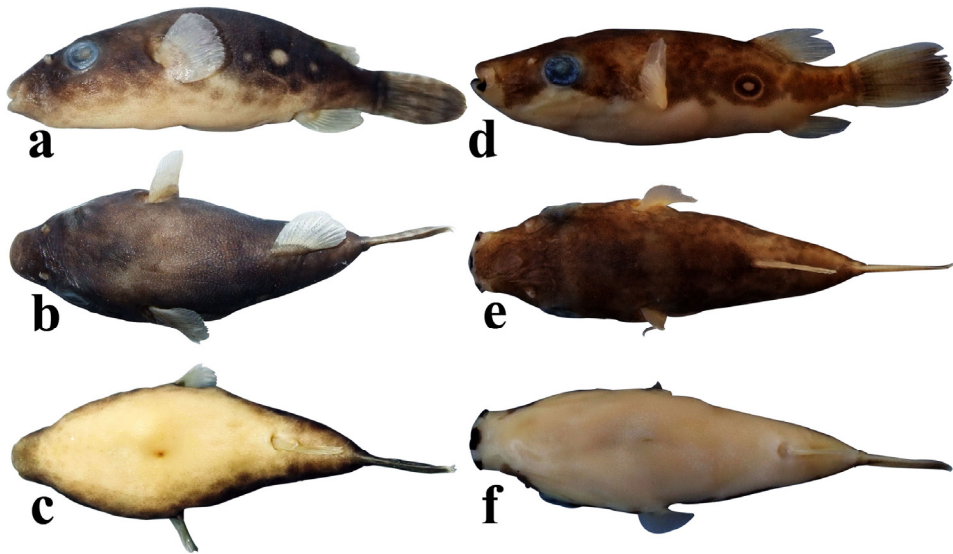


FIGURE 3. The juvenile stage of (a–c) *T. cambodgiensis* and (d–f) *T. barbatus*: (a–c) NIFI 04684 *T. cambodgiensis*, 35.4 mm SL, Stung Treng, Cambodia, showing the (a) lateral view, (b) dorsal view and (c) ventral view; (d–f) KUMF 8806 *T. barbatus*, 36.9 mm SL, Ban Pha Tang, Amphoe Sangkhom, Nong Khai Province, showing the (d) lateral view, (e) dorsal view and (f) ventral view.

gave a description, based on 19 specimens, of a dark green body covered with round black or dark green spots except for the trunk. The illustrated picture of *C.* (or *Tetraodon*) *leiurus* shows that the surface of the body has no ocellus and the covering area of spinules was between the internasal and the end of dorsal fin base. The colour patterns of *T. leiurus* in Bleeker (1851) differ from those in Bleeker (1852, 1865) in the presence of a dark or ruddy body without spots. Of course this discrepancy in colour appearance might be an artifact caused by inappropriate sample preservation, but in general the descriptions in Bleeker (1851, 1852 and 1865) demonstrated that the colour patterns of *T. leiurus* are different from *T. cambodgiensis* and *T. cochinchinensis*, which are found in the Mekong basin, in terms of having no large ocellus on the flank. Additionally, the

covering area of spinules in *T. cambodgiensis* is between the internasal and the upper part of caudal peduncle and so is evidently different from the covering area of spinules in *C.* (or *Tetraodon*) *leiurus* (Bleeker, 1865). Accordingly, it can be concluded that *T. cochinchinensis* and *T. cambodgiensis* are separate and valid species of freshwater pufferfish.

T. barbatus differs from *T. cochinchinensis* in having a longer snout (snout length 49.2–54.4 %HL in *T. barbatus* vs. 43.5–48.7 %HL in *T. cochinchinensis*). While *T. cambodgiensis* can be distinguished from *T. cochinchinensis* by having a slender body with a slightly longer snout (snout length 46.9–51.3 %HL in *T. cambodgiensis* vs. 43.5–48.7 %HL in *T. cochinchinensis*) and the caudal peduncle is covered with many spinules.

T. barbatus was considered as a synonym of *T. cambodgiensis* by Kottelat (2001) because they are similar in shape and colour patterns. However, examination of the syntype of *T. cambodgiensis* (Fig. 2a–b) and the specimens from Stung Treng (Fig. 2c–e), Siem Reap, Cambodia and Tram Chim, Tam Nong, Vietnam, revealed that the upper part of the caudal peduncle has many small spinules. On the other hand, the caudal peduncle of *T. barbatus* specimens is smooth without any tiny spinules. The distribution of spinules on the head and the body has been used for species identification in the genus *Lagocephalus* (Mohsin and Ambak, 1996) and it is evidently different between the genera *Takifuku* and *Tetractenos* (Matsuura, 2001).

With respect to the morphometric data of the head width at the preorbital, postorbital and nape, the head of *T. barbatus* is broader than in *T. cambodgiensis* (head width at preorbital, post orbital and nape: 54.1–59.8, 69.1–79.7 and 76.5–86.8 %HL, respectively, in *T. barbatus* vs. 48.7–52.9, 60.2–67.6 and 68.5–75.0 %HL, respectively, in *T. cambodgiensis*). The juvenile stage of *T. cambodgiensis* has a light grey lower lip and grey chin, lateral sides of trunk and ventral surface of the tail. The ocellus has no white margin (Fig. 3a–c). In contrast, the juvenile stage of *T. barbatus* exhibits three black marks on the lower lip, a clear white ventral surface of the body and the ocellus has a white margin (Fig. 3d–f). Consequently, it can be concluded that *T. barbatus* is a valid species of freshwater pufferfish in the Mekong basin.

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