

TETRAODONTIFORMES – puffers and allies

Fishes of Tetraodontiformes comprises 9 families, and, of these, only 2 families, *viz.*, Triacanthidae and Tetraodontidae, are hitherto recorded from the Mekong. During our field surveys in 2007–2013, we were able to collect fishes of the latter (Tetraodontidae) from the region. Rainboth *et al.* (2012: 111, pl. 117, fig. 2452) showed a photograph of a triacanthid fish *Tripodichthys oxycephalus* from the Hà Tiên River (a distributary of the Mekong) at Kiên Giang, Vietnam; some additional species of the Triacanthidae are also expected in the brackish estuaries of the Mekong.

The tetraodontid fishes, commonly known as puffers, usually have a soft, inflatable body, with numerous minute spinules (entirely naked in some). Pelvic fins, as well as fin spines, are absent. Teeth in jaws are fused and modified into 4 beak-like plates (*Tetraodon* means "four teeth" in Greek).

Many of the tetraodontid fishes are well known to have a strong poison "tetraodotoxin" in the body. Although the position of the poisonous parts varies depending on the species, hitherto it is not well studied in many of the species found in fresh- and brackish water areas of Southeast Asia. Nevertheless, the freshly-collected fish are sometimes seen at the markets in the Indochinese Mekong region [see photographs in *Pao suvattii* (p. 503) and *P. cochinchinensis* (p. 505)].

Many of the tetraodontid fishes are confined to marine waters, but some enter into, or spend their whole life in, the brackish- and/or fresh-water areas. About 15 species of this family were recorded from the Mekong; of these, more than



Arothron immaculatus, Bén Tre, Vietnam (aquarium photo: KS)

one-third (6 species) belong to a single genus *Pao* [previously misassigned to *Monotrete*, a junior synonym of *Leiodon* (see Kottelat, 2013c: 478–479)].

Carinotetraodon lorteti (Tirant, 1885)

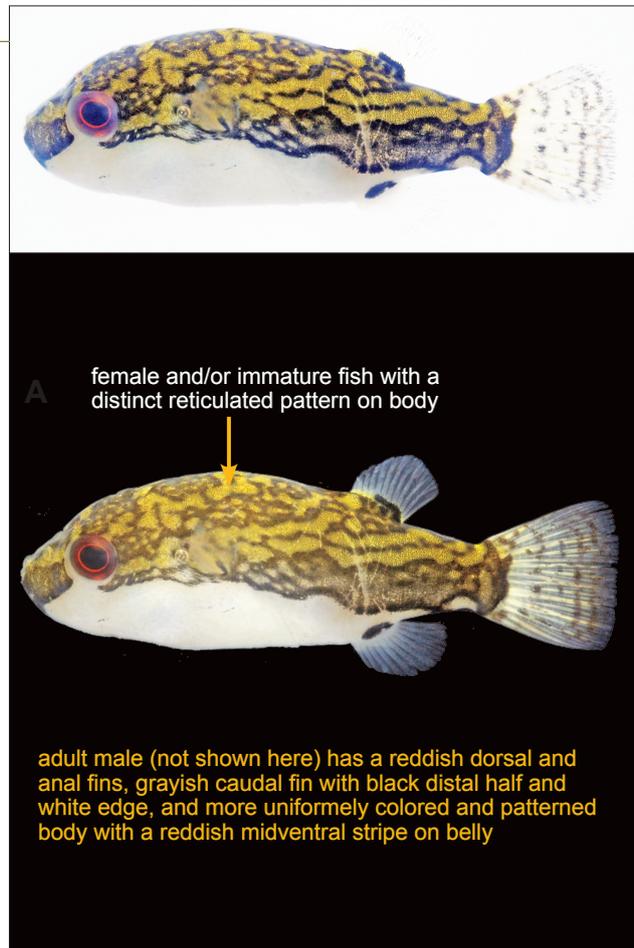
Family: Tetraodontidae (FC: 509)

Size: 5.4 cm SL (Kottelat *et al.*, 1993: 173).

Distribution: Mekong Basin in Cambodia and Vietnam; Chao Phraya Basin.

Notes: A small-sized species of puffers, found in brackish estuaries and adjacent freshwater areas. The photographed specimens shown here were collected from the Tonle Sap River (a tributary of the Mekong) in Phnom Penh, Cambodia.

Fishes of *Carinotetraodon* are small-sized freshwater puffers [largest size known is 55.4 mm SL in *C. salivator* (Tan, 1999: 354)], having mid-dorsal and mid-ventral cutaneous ridges in adult male, and distinct sexual dimorphism in adult coloration (Tan, 1999). The genus comprises 6 species from South and Southeast Asia (Britz & Kottelat, 1999a; Tan, 1999): *C. borneensis*, *C. imitator*, *C. irrubescens*, *C. lorteti*, *C. salivator*, and *C. travancoricus*. Of these, only a single species *C. lorteti* is known from the Indochinese Mekong (Tan, 1999: 350, fig. 5). The specimens shown here, as well as all other specimens of *C. lorteti* collected during our field surveys in 2007–2013 in the Mekong, appear to be immature fish or females (< 2.5 cm SL), having a distinct reticulated pattern on the body (see photos); adult males of *C. lorteti* have reddish dorsal and anal fins, a grayish caudal fin with black distal half and white edge, and a more uniformly colored/patterned body with a reddish midventral stripe on the belly (Kottelat *et al.*, 1993, pl. 82; Rainboth, 1996b: 225; Tan, 1999: 348, tab. 2). Its small size and compressed body with characteristic coloration readily distinguishes *C. lorteti* from the other Mekong puffers.



A female and/or immature fish with a distinct reticulated pattern on body

adult male (not shown here) has a reddish dorsal and anal fins, grayish caudal fin with black distal half and white edge, and more uniformly colored and patterned body with a reddish midventral stripe on belly

Lagocephalus lunaris (Bloch, 1801)

Family: Tetraodontidae (FC: 509)

Size: 50.0 cm SL (Yamada & Yagishita *in* Nakabo, 2013: 1741).

Distribution: Mekong Basin in Vietnam; Indo-West Pacific.

Notes: A large-sized species of puffers, found in coastal marine waters; it is also known to enter brackish estuaries. The photographed specimen shown here is a young, collected from a brackish estuary in an extensive mudflat at the Mekong Delta in Bạc Liêu, Vietnam.

Lagocephalus is readily distinguished from the other genera of the Mekong puffers by having sharply-contrasted bicoloration of the head and body, formed by a dark dorsal surface and a silvery white side and venter, a distinctive longitudinal skin fold on the lower side of the head and body, and an emarginate caudal fin (rather than truncate or rounded as in the other genera). The silvery white coloration of the venter is also found in *Auriglobus* (below), but *Auriglobus*, a genus of small-sized freshwater puffers reaching up to 10.6 cm SL (Roberts, 1982: 2, as *Chonerhinos*), has many more dorsal- and anal-fin rays, no raised skin fold on the ventral side of the head and body, and a truncate caudal fin. Matsuura (2001) recorded 7 species of *Lagocephalus* from the Western-Central Pacific region, and, of these, Kottelat (2013c) recognized only a single species, *L. lunaris*, in his checklist of inland water fishes of Southeast Asia.

Auriglobus nefastus (Roberts, 1982)

Family: Tetraodontidae (FC: 509)

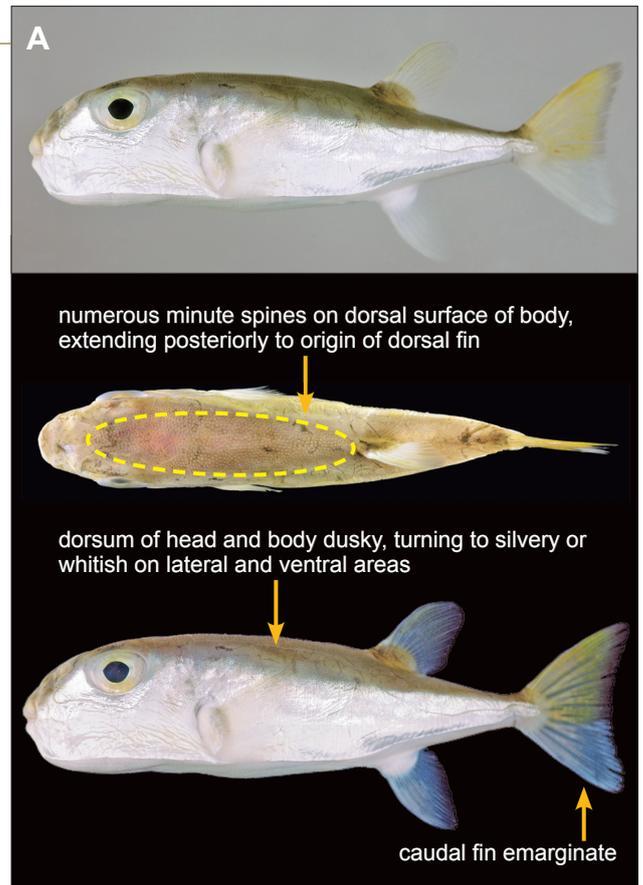
Size: 7.07 cm SL (Roberts, 1982: 11, as *Chonerhinos nefastus*).

Distribution: Mekong Basin in Laos, Thailand, Cambodia, and Vietnam; Malay Peninsula, Sumatra, and Borneo.

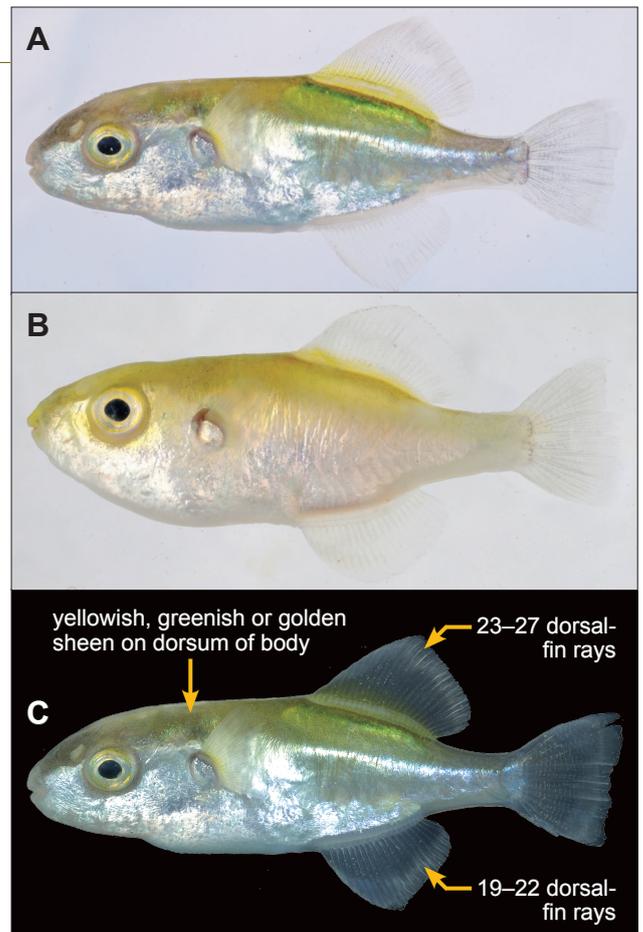
Notes: A small-sized species of freshwater puffers, found in slow-flowing rivers.

Puffers of *Auriglobus* are peculiar amongst the tetraodontids by having long-based dorsal and anal fins with 22–28 and 18–22 rays, respectively [Roberts, 1982 (as *Chonerhinos*)]; *Chonerhinos*, a similar looking genus with the long-based dorsal and anal fins, with 32–38 and 28–29 rays, respectively [Roberts, 1982 (as *Xenopterus*)]. *Auriglobus nefastus* appears to be only a single species of the genus found in the Mekong (see below), and is unique within the genus in having a projecting upper lip beyond the lower lip and an exposed portion of eyeball usually horizontally oval rather than rounded [Roberts, 1982 (as *Chonerhinos nefastus*)]. Its characteristic yellowish, light greenish, or golden coloration when alive readily distinguishes this species from the other Mekong puffers. The generic assignment follows Kottelat (1999, 2013c).

Vidthayanon (2008: 288) listed an additional species of the genus, *Auriglobus modestus*, in his checklist of fishes in the Mekong Delta, but it was an error (C. Vidthayanon, pers. comm.). Vidthayanon (2008: 288) also listed *Chonerhinos naritus* (as *Xenopterus naritus*) as a fish found in the Mekong Delta, but he did not confirm the voucher specimen from there actually (C. Vidthayanon, pers. comm.). Similarly, Rainboth *et al.* (2012) listed *C. naritus* (as *Xenopterus naritus*) in their book of fishes of the "Greater Mekong Ecosystem" (a term meaning the entire region directly affected by the Mekong), but they noted that the source of their record of it is "Bangkok in Smith, 1945"; Smith's (1945: 574) record of this fish was based on Bleeker's (1865) old record from "Siam" (Smith presumed that the locality was probably "Meanam Chao Phraya at Bangkok or Ayuthia"). Thus,



CTU-P-4631 (photo: LXT)



A and C) NUOL-P-739 (VP); B) IFREDD-P-1463 (photo: PT)

we were not able to locate any certain records of both *A. modestus* and *C. naritus* from the Mekong.

TETRAODONTIDAE

Takifugu oblongus (Bloch, 1786)

Family: Tetraodontidae (FC: 509)

Size: 26.3 cm SL (Kottelat *et al.*, 1993: 174).

Distribution: Mekong Basin in Vietnam; Indo-West Pacific.

Notes: A medium-sized species of puffers, found in coastal marine waters; it is also known to enter brackish estuaries.

Many fishes of *Takifugu* are confined to East Asian waters, and *T. oblongus* appears to be the only species widely distributed in the Indo-West Pacific, including the estuarine areas of the Mekong. Its characteristic pale-barred pattern on the dorsum readily distinguishes *T. oblongus* from the other Mekong puffers. Although Rainboth *et al.*, (2012) and Kottelat (2013c) recorded 4 additional congeners from South East Asia, *viz.*, *T. alboplumbeus*, *T. niphobles* [a junior synonym of *T. alboplumbeus*, see Matsuura (2017a)], *T. obscurus*, and *T. ocellatus*, all of these species are apparently not distributed southward beyond the South China Sea coasts of China and northern Vietnam.

Kottelat (2013c) pointed out that *Gastrophysus* (rather than *Takifugu*) is an available generic name for this group, described earlier than *Takifugu*; he stated, "The only way to continue to use *Takifugu* as a valid name would be to ask the ICZN to reverse precedence or to suppress *Gastrophysus*" (Kottelat, 2013c: 476). We here follow Jelks (2018), who used *Takifugu* as valid over *Gastrophysus*.

Chelonodontops patoca (Hamilton, 1822)

Family: Tetraodontiformes (FC: 509)

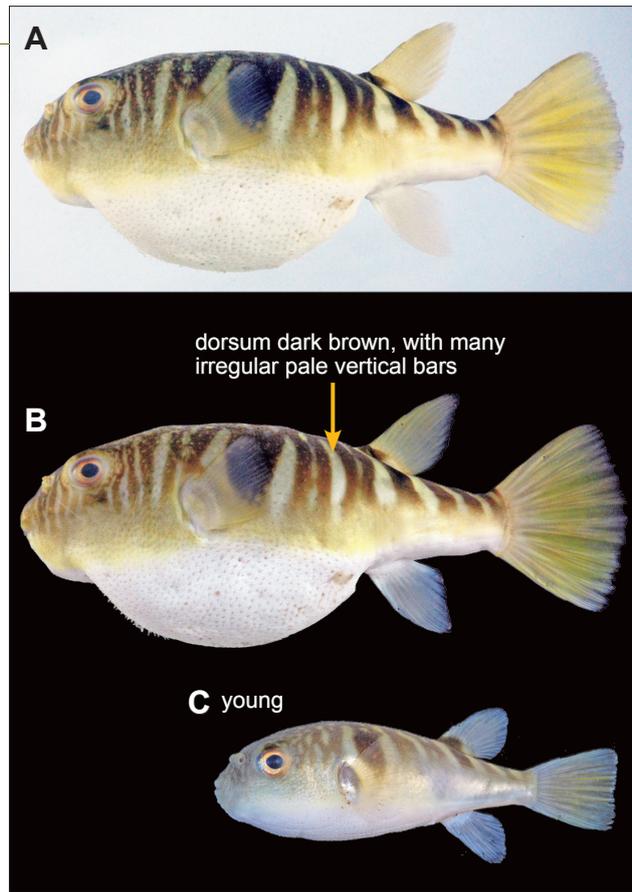
Size: 33 cm TL (Kottelat *et al.*, 1993: 173, as *Chelonodon patoca*).

Distribution: Mekong Basin in Vietnam; Indo-West Pacific.

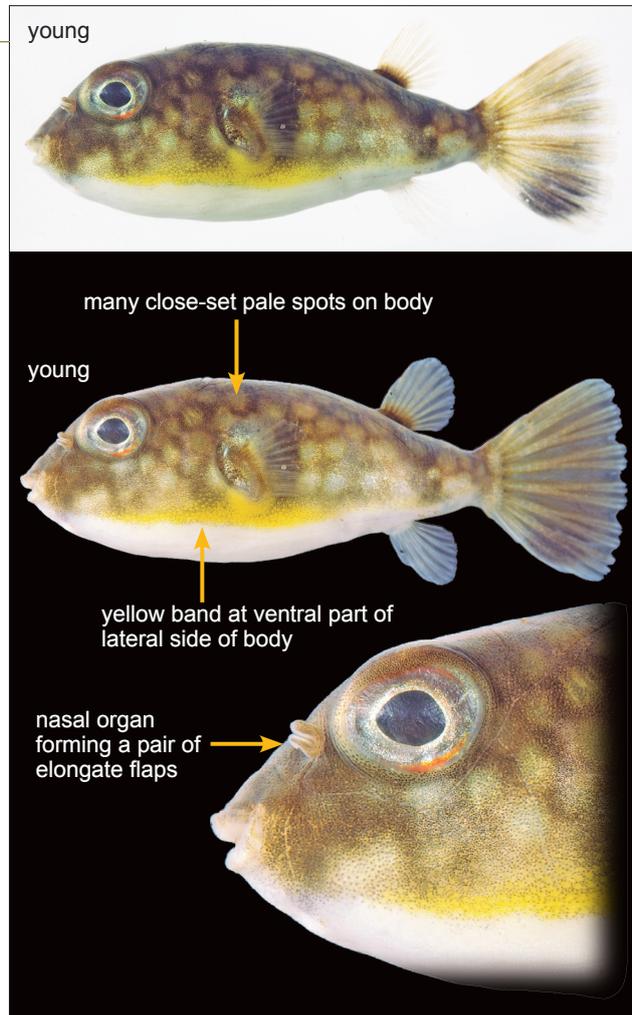
Notes: A medium-sized species of puffers, found in shallow coastal marine waters, brackish estuaries, and adjacent freshwater areas. Rainboth *et al.* (2012: 113, as *Chelonodon patoca*) recorded this species from the Mekong Delta, although we could not confirm it from the region during our field surveys in 2007–2013. The photographed specimen shown here is a young fish, collected from Phú Quốc Island, off southwestern coast of the Mekong Delta in Vietnam, where this species appears to be common in the mangrove areas.

This species had long been placed in *Chelonodon* by many fish researchers (*e.g.*, Kottelat, 1989, 1993; Rainboth *et al.*, 2012; Matsuura, 2002). Kottelat (2013c), however, indicated that *Chelonodon* is a junior synonym of *Leiodon*, a distinct genus comprising a single species *L. cutcutia*; thus Kottelat (2013c) assigned *C. patoca* to *Chelonodontops*, the oldest available name for the genus including this species.

Chelonodontops comprises 3 species, although only a single species *C. patoca* is known from Indo-West Pacific from India eastward to Indonesia (Matsuura, 2002, as species of *Chelonodon*); the other 2 similar-looking congeners (*C. laticeps* and *C. pleurospilus*) are confined to Madagascar and/or the east coast of South Africa. *Chelonodontops patoca* can be distinguished from the other Mekong puffers by having typically 8 anal-fin rays (*vs.* 9 or more in the other Mekong puffers), in addition to its characteristic color pattern, including a brownish dorsum and side of the body (usually tinged with yellow ventrally) with numerous close-set rounded pale spots, whitish venter, and 3 vague dusky bars on the body (at just behind the pectoral-fin base, below the dorsal fin, and the posterior end of the caudal peduncle).



A and B) CTU-P 4874 (photo: HVMM); C) CTU-P 1707 (photo: LXT)



Non-Mekong specimen, CTU-P 4331 (Phú Quốc Island, Vietnam, photo: LXT)

Dichotomyctere nigroviridis (Marion de Procé, 1822)

Family: Tetraodontidae (FC: 509)

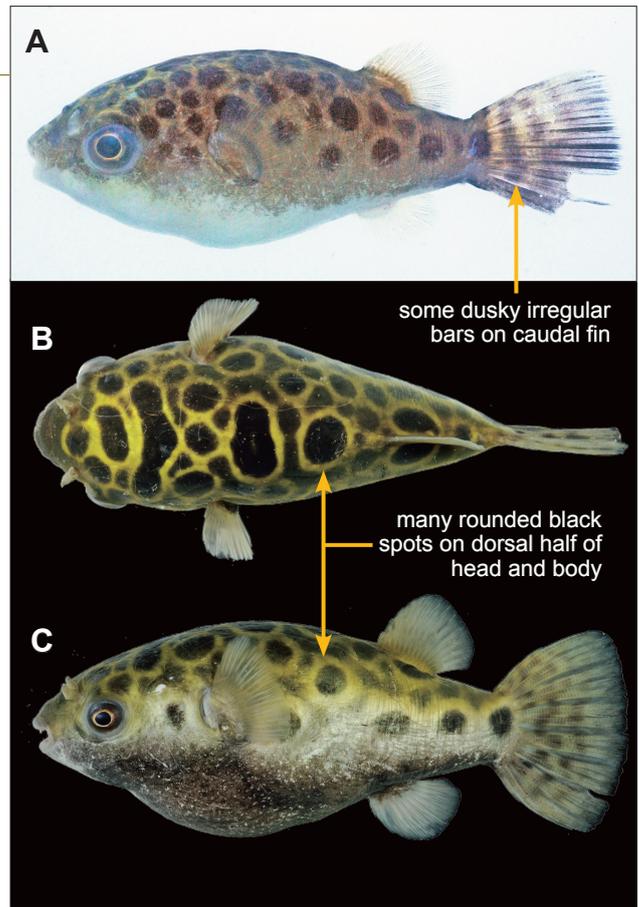
Size: 14.3 cm SL (Kottelat *et al.*, 1993: 174, as *Tetraodon nigroviridis*).

Distribution: Mekong Basin in Vietnam (and ?Thailand); coastal basins of Gulf of Thailand, Sundaland, Myanmar, and Sri Lanka.

Notes: A medium-sized species of puffers, found in brackish estuaries and adjacent freshwater areas of coastal basins; it is also commonly seen in aquarium fish trade. One of us (CG) recently got a specimen of this puffer from a local fisherman, who collected it from Mun River (a tributary of the Mekong) in Ubon Ratchathani, Thailand; the fisherman informed CG that the species was rarely collected there, although its origin needs to be confirmed (possibly an accidentally-introduced aquarium fish). Generic assignment follows Kottelat (2013c).

Five species of *Dichotomyctere* are known from the inland waters of Southeast Asia (Kottelat, 2013c), and, of these, at least 2 species (*D. nigroviridis* and *D. ocellatus*) have been reliably recorded from the Mekong. Some researchers have also recorded *D. fluviatilis* (as *Tetraodon fluviatilis*) from the Mekong (Kottelat, 1989a; Rainboth, 1996b; Vidthayanon, 2008), but it is presumed to be in error; Rainboth *et al.* (2012) did not list the species in their book of fishes of the "Greater Mekong Ecosystem."

Dichotomyctere nigroviridis somewhat resembles the other Mekong congener *D. ocellatus* (below), but has many rounded black spots on the dorsal half of the head and body, and some dusky irregular bars on the caudal fin.



A) Non-Mekong specimen (Koh Kong, Cambodia, IFREDI-P 6611, photo: PT); B and C) CTU-P 2589 (photo: LXT)

Dichotomyctere ocellatus (Steindachner, 1870)

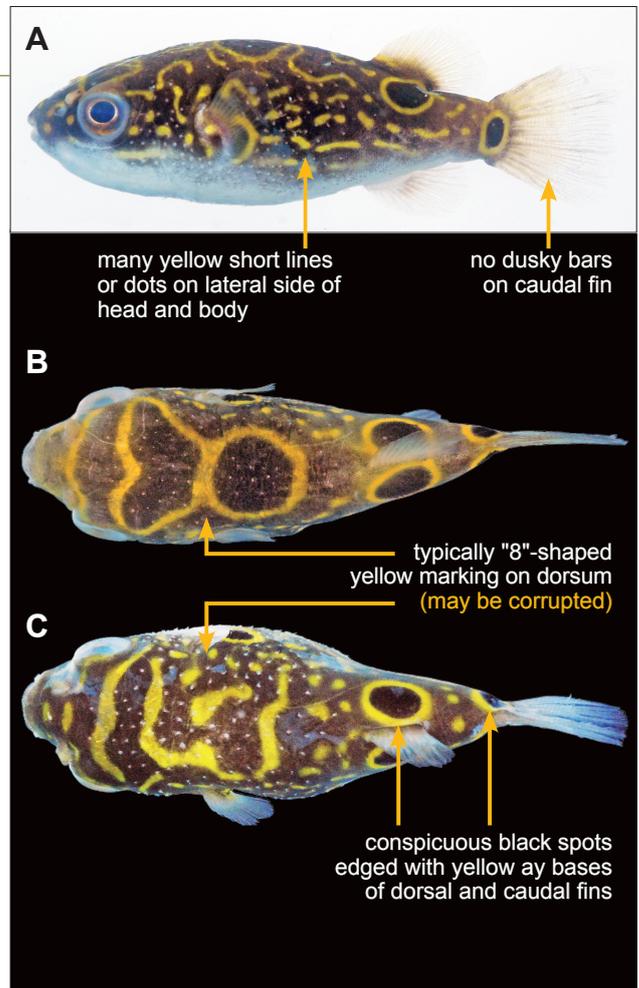
Family: Tetraodontidae (FC: 509)

Size: 5.9 cm SL (Kottelat *et al.*, 1993: 174, as *Tetraodon biocellatus*).

Distribution: Mekong Basin in Vietnam; coastal basins of Gulf of Thailand, Malaya, and Borneo.

Notes: A small-sized species of puffers, found in brackish estuaries and adjacent freshwater areas. During our field surveys in 2007–2013, we were not able to find any specimens from the Mekong; the photographed specimens shown here were collected from coastal basins in Sihanoukville, western Cambodia, where this species is common. Kottelat (1989a: 21, as *Tetraodon biocellatus*) and Rainboth (1996b: 225, as *Chelonodon biocellatus*) recorded this species from the Mekong. *Tetraodon biocellatus*, described from "Cochinchine" (more specified as "Vietnam: Thu-dau-mot" by Kottelat, 2013c: 476) by Tirant (1885), is a synonym of *D. ocellatus* (see Kottelat, 2013c). The generic assignment follows Kottelat (2013c).

Dichotomyctere ocellatus somewhat resembles *D. nigroviridis* (above) in body shape and coloration, but has more conspicuous ocelli below the dorsal-fin base and at the caudal-fin base, many irregular dashed yellowish lines and spots on the side of the head and body, and no distinct dusky markings on the caudal fin. Typically *D. ocellatus* has 8-shaped yellowish marking on the dorsal surface of the predorsal area (see photo B).



A) IFREDI-P 5992 (photo: PT); B) IFREDI-P 5997 (photo: PT); C) IFREDI-P 5999 (photo: PT)

TETRAODONTIDAE

Arothron immaculatus (Bloch & Schneider, 1801)

Family: Tetraodontidae (FC: 509)

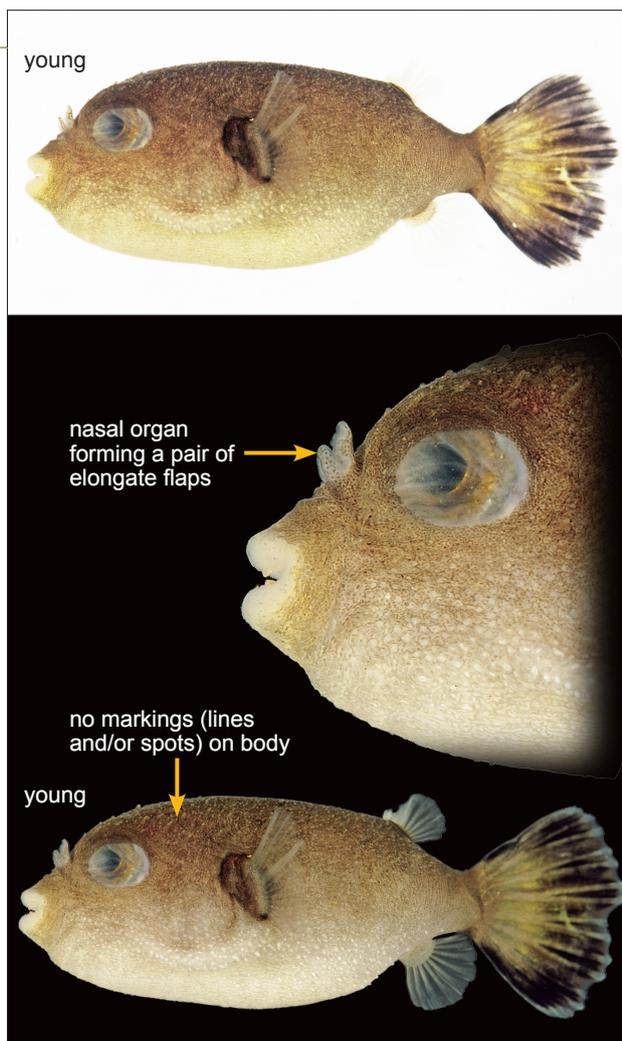
Size: 20.0 cm SL (Yamada & Yagishita *in* Nakabo, 2013: 1740).

Distribution: Mekong Basin in Vietnam; Indo-West Pacific.

Notes: A medium-sized species of puffers, found in shallow coastal marine waters; it commonly enters brackish estuaries in the juvenile stage. The photographed specimen shown here is a small young, collected from a small mangrove creek in B n Tre, Vietnam.

Arothron comprises 14 species (Matsuura, 2016, 2017b) from Indo-Pacific. Some species are known to enter brackish estuaries at least in early life stages, but the *Arothron* fauna in the Mekong is not yet well resolved. Although Rainboth *et al.* (2012: 113) listed 9 species of *Arothron* in their book of fishes of the "Greater Mekong Ecosystem" (a term meaning the entire region directly affected by the Mekong), they did not include any species with certain records from the Mekong; note that at least 5 of 9 species they listed (*A. firmamentum*, *A. leopardus*, *A. meleagris*, *A. nigropunctatus*, and *A. stellatus*) are the typical marine species, probably not expected to be in brackish estuaries, whereas the other 4 (*A. hispidus*, *A. immaculatus*, *A. mappa*, and *A. reticularis*), as well as *A. manilensis*, may occur. During our field surveys in 2007–2013, we confirmed only a single specimen of *A. immaculatus* (noted above) from the Mekong Delta.

Puffers of *Arothron* look similar to one another in general body shape, but many of them have species-specific coloration (Matsuura, 1994). *Arothron immaculatus* is similar to *A. manilensis* that is also expected to be found in the Mekong, but can be distinguished by having its immaculated coloration (*vs.* several dusky lines are on the head and body in *A. manilensis*).



CTU-P 5249 (photo: HVM)

Pao baileyi (Sontirat, 1985)

Family: Tetraodontidae (FC: 509)

Size: 12.0 cm SL (Kottelat, 2001a: 164, as *Monotrete baileyi*).

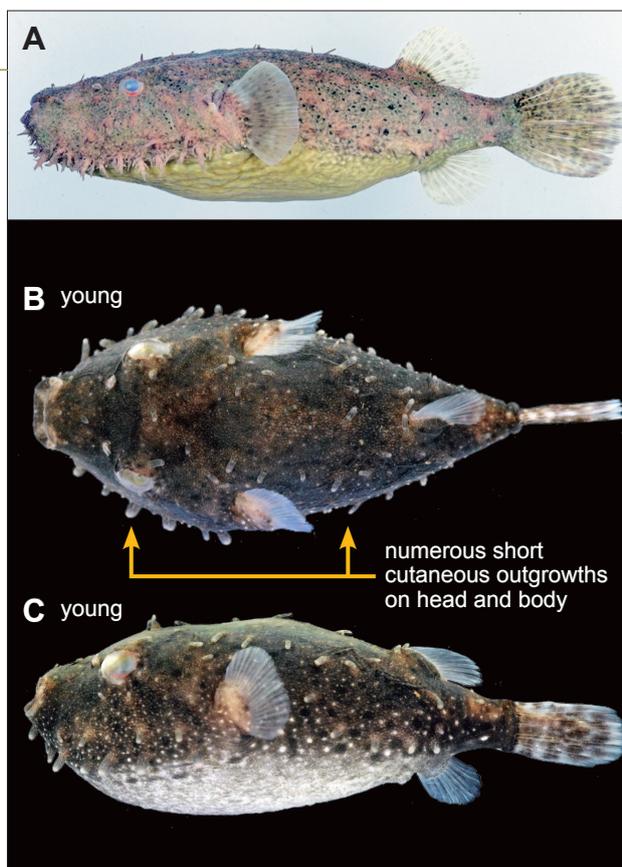
Distribution: Mekong Basin in Laos, Thailand and Cambodia.

Notes: A medium-sized species of freshwater puffers, found in rapids with rocky bottoms; it is frequently seen in aquarium fish trade. This species has been considered as rare since its original description (Sontirat, 1985), but one of us (CG) recently found that it can be fairly common locally in a particular habitat of the Thai Mekong; further field investigation of its habitat and ecological characteristics is being undertaken by CG. The generic assignment follows Kottelat (2013c).

Puffers of the genus *Pao* were assigned to the catch-all genus *Tetraodon* or *Monotrete* (*e.g.*, Rainboth, 1996b, as *Monotrete*; Kottelat, 2001a), until Kottelat (2013c) described the new genus *Pao* for this group. Although Kottelat (2013c) provisionally recognized 13 species from Southeast Asia in *Pao*, the genus clearly needs revision (see "Notes" of *Pao abei*, pp. 506–507). Of these, at least 6 species were confirmed to be from the Mekong, during our field surveys in 2007–2013.

Pao baileyi is peculiar within the genus by having numerous finger-like cutaneous outgrowths on head and body (Sontirat, 1989: 104, as *Tetraodon baileyi*; Kottelat, 2001a: 164, as *Monotrete baileyi*). These outgrowths on the head may be branched irregularly in large specimens (see, photo A).

This species was described at least 2 times as new with the same scientific name by Sontirat (1985, 1989); see also Kottelat (2013c: 479).



A) UNMF uncatalogued (photo: CG); B and C) IFREDI-P 5307 (photo: PT)



Pao suvattii (Sontirat & Soonthornsatit, 1985)

Family: Tetraodontidae (FC: 509)

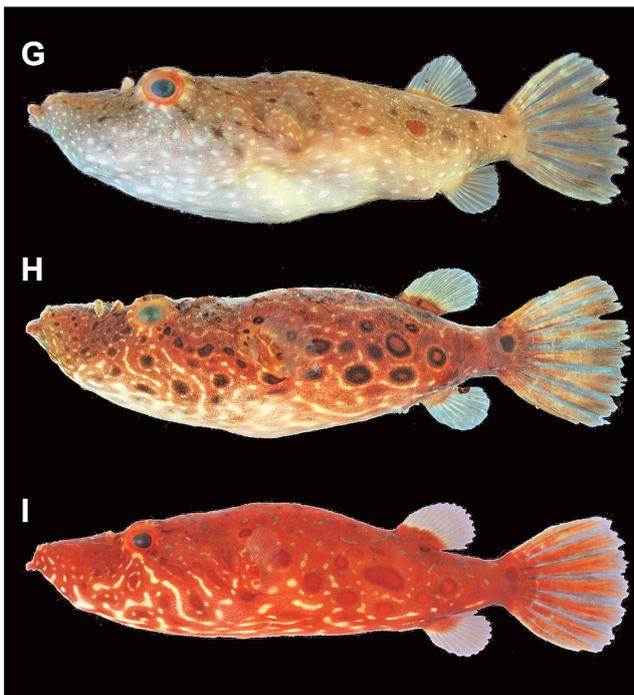
Size: 12.9 cm SL (NUOL-P 5154).

Distribution: Mekong Basin in Laos and Thailand.

Notes: A medium-sized species of freshwater puffers, found in large rivers with muddy bottoms. The generic assignment follows Kottelat (2013c).

Its peculiar appearance, including the upturned mouth, long and narrowly triangular snout, depressed head and body, and an arrowhead-shaped dusky marking behind the interorbital area, readily distinguishes *Pao suvattii* from the other Mekong puffers. As pointed out by Roberts (1998b: 228, as *Tetraodon suvattii*), *P. suvattii* is superficially similar to the African freshwater puffer *Tetraodon miurus* rather than the other puffers from Asia.

This characteristic species was named for Chote Suvatti, one of the pioneer ichthyologists in Thailand who worked with H.M. Smith, in honor of his contribution to the taxonomy of fishes of Thailand (Sontirat, 1989).



mouth upturned
snout long, narrowly triangular



arrowhead-shaped dusky marking behind interorbital space

A) Marketed fish, not preserved (Savannah, Laos, photo: KS); B) NUOL-P 2815 (photo: TP); C) NUOL-P 536 (photo: KS); D and F) NUOL-P 172 (photo: KS); E) NUOL-P 173 (photo: KS); G) NUOL-P 151 (photo: KS); H) NUOL-P 19 (photo: KS); I) NUOL-P 57 (photo: KS)

TETRAODONTIDAE

Pao fangi (Pellegrin & Chevey, 1940)

Family: Tetraodontidae (FC: 509)

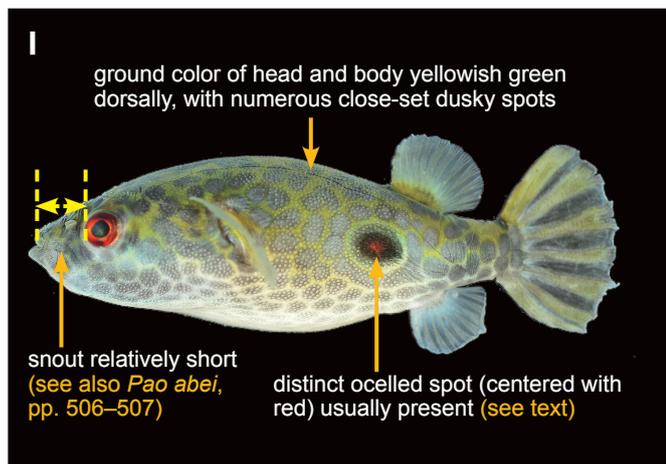
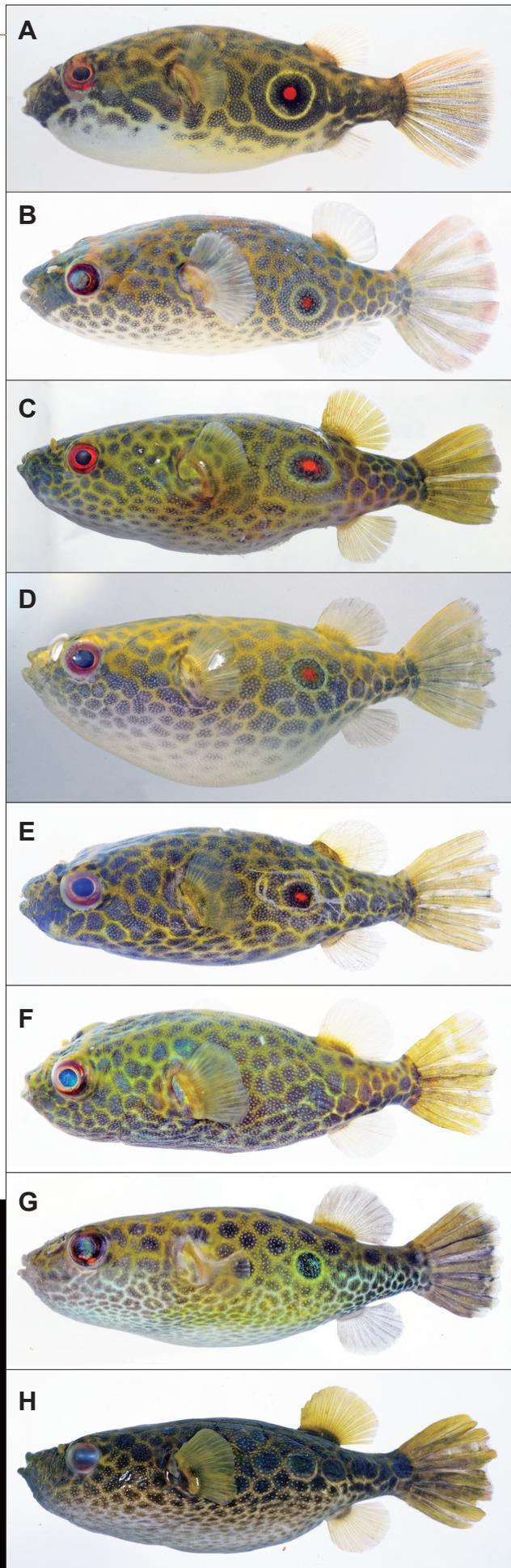
Size: 9.2 cm SL (Saenjundaeng *et al.*, 2013a: 78, as *Tetraodon palustris*).

Distribution: Mekong Basin in Laos, Thailand, Cambodia, and Vietnam; Chao Phraya Basin and ?peninsular Thailand.

Notes: A relatively small-sized species of freshwater puffers, found in marshes, swamps, and reservoirs with dense aquatic vegetation. The generic assignment follows Kottelat (2013c: 480).

Taxonomy of spotted puffers of the genus *Pao* in the Mekong is in a state of flux. For example, *Pao fangi* was treated by some previous researchers as a synonym of *P. leiurus* (e.g., Roberts, 1998b, as *Tetraodon leiurus*) or *P. cochinchinensis* (e.g., Kottelat, 2001a, as *Monotrete cochinchinensis*), but Saenjundaeng *et al.* (2013a) resurrected it as valid (as *Tetraodon fangi*). Subsequently Kottelat (2013c: 480) also treated *P. fangi* as valid following Saenjundaeng *et al.* (2013a), and, furthermore, considered that a congener from peninsular Thailand, *P. ocellatus*, is also a possible synonym of *P. fangi*. Saenjundaeng *et al.* (2013a) pointed out that *P. fangi* can be distinguished from *P. cochinchinensis* by having a shorter snout, although their *P. cochinchinensis* is possibly conspecific with *P. barbatus* (see "Notes" of *P. abei*, pp. 506–507).

Saenjundaeng *et al.* (2013a) described a new species *Tetraodon palustris* from the Mekong Basin in northern Thailand; the species was subsequently regarded as a junior synonym of *Pao brevirostris* by Kottelat (2013c: 479); we agree with his decision that these 2 are conspecific. According to Saenjundaeng *et al.* (2013a), their *T. palustris* is similar to *Pao fangi* (as *Tetraodon fangi*) in having no spinules on the dorsal surface of the snout, but has no ocellus on the body (vs. a distinct reddish-centered ocellus present in *P. fangi*). The condition of the ocellus in *P. fangi*, however, varies depending on the specimen; some have a distinct large ocellus (photos A and C), whereas the others have a smaller and sometimes poorly contrasted ocellus; note that the specimens in photo E (with a distinct ocellus = *fangi*-type) and F (with no ocellus = *palustris*-type), as well as some specimens with an intermediate condition, were collected together from a single reservoir in Battambang, Cambodia. The spinulate pattern on the head may be slightly different between these species in their figures (Saenjundaeng *et al.*, 2013, fig. 5), but the variation of this character actually overlaps between these 2 colormorphs. We thus conclude here that *T. palustris* is conspecific with (and a junior synonym of) *P. fangi*; this means that *P. brevirostris*, originally described by Benl (1957), is also a junior synonym of *P. fangi*, following Kottelat's (2013c) decision about synonymy of *P. brevirostris* and *P. palustris*. See also "Notes" of *P. abei*.



A) IFREDI-P 4222 (photo: PT); B) IFREDI-P 1008 (photo: PT); C) IFREDI-P 1786 (photo: PT); D) IFREDI-P 3555 (photo: PT); E) IFREDI-P 2228 (photo: PT); F) IFREDI-P 2227 (photo: PT); G) NUOL-P 1126 (photo: KS); H) NUOL-P 528 (photo: VV); J CTU-P 998 (photo: LXT)

Pao barbatus (Roberts, 1998)

Family: Tetraodontidae (FC: 509)

Size: 13.6 cm SL (Saenjundaeng *et al.*, 2013b: 78, as *Tetraodon barbatus*).

Distribution: Mekong Basin in Laos and Thailand.

Notes: A medium-sized species of freshwater puffers, found in rivers and lakes. The generic assignment follows Kottelat (2013c).

Pao barbatus, described by Roberts (1998b) from the middle and lower reaches of the Mekong, was considered as a junior synonym of *P. cambodgiensis* by subsequent researchers (e.g., Kottelat, 2001a, 2013c), but Saenjundaeng *et al.* (2013b) resurrected it as valid. According to Saenjundaeng *et al.* (2013b), *P. barbatus* can be distinguished from *P. cambodgiensis* by having no spinules on the caudal peduncle (vs. spinules are present on the upper part of the caudal peduncle in *P. cambodgiensis*) and a broader head (e.g., head width at preorbital 54.1–59.8% of the head length in *P. barbatus* vs. 48.7–52.9% in *P. cambodgiensis*). Although all our Lao (Luang Prabang and Savannakhet) and Thai (Ubon Ratchathani) specimens lack spinules on the caudal peduncle, the ratio of head width of some specimens falls into the range of *P. cambodgiensis* shown by Saenjundaeng *et al.* (2013b). We provisionally identify all of our Lao and Thai specimens as *P. barbatus* based only on its distribution pattern of spinules on the body. Further extensive research, including molecular analysis, is needed to clarify the taxonomic status of these 2 similar-looking, apparently allopatric species in the Mekong. Note that *Tetaodon cambodgiensis* Chabanaud, 1923 (= *Pao cambodgiensis*) is regarded here as a synonym of *P. cochinchinensis*, below.

Pao cochinchinensis (Steindachner, 1866)

Family: Tetraodontidae (FC: 509)

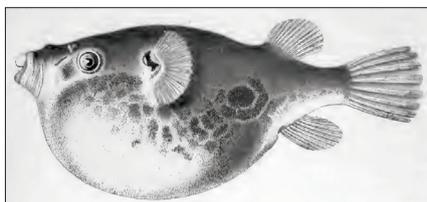
Size: 14.1 cm SL (Saenjundaeng *et al.*, 2013b: 81, as *Tetraodon cambodgiensis*).

Distribution: Mekong Basin in Cambodia and Vietnam.

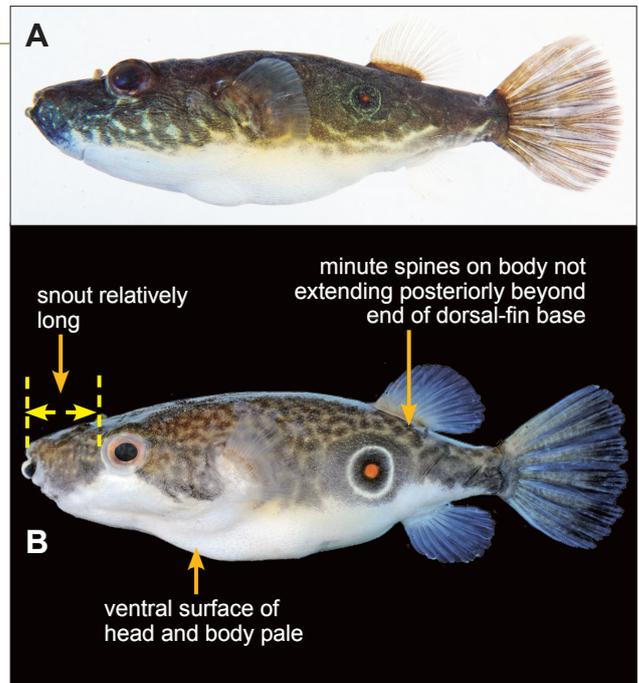
Notes: A medium-sized species of freshwater puffers, found in rivers and lakes. The generic assignment follows Kottelat (2013).

Pao cochinchinensis, described from "Cochinchina" (an old name for southern Vietnam), has been seriously confused with several nominal species of the genus, e.g., *P. abei* (and its possible synonym *P. turgidus*), *P. barbatus*, *P. fangi* (and its possible synonyms *P. brevisrostris* and *P. palustris*), and/or *P. leiurus* (e.g., Roberts, 1998b; Kottelat, 2001a, 2013; Saenjundaeng *et al.*, 2003a, b). *Tetaodon cambodgiensis* (= *Pao cambodgiensis*) is regarded here as a synonym of this species; see details in "Notes" of *P. abei*, next page.

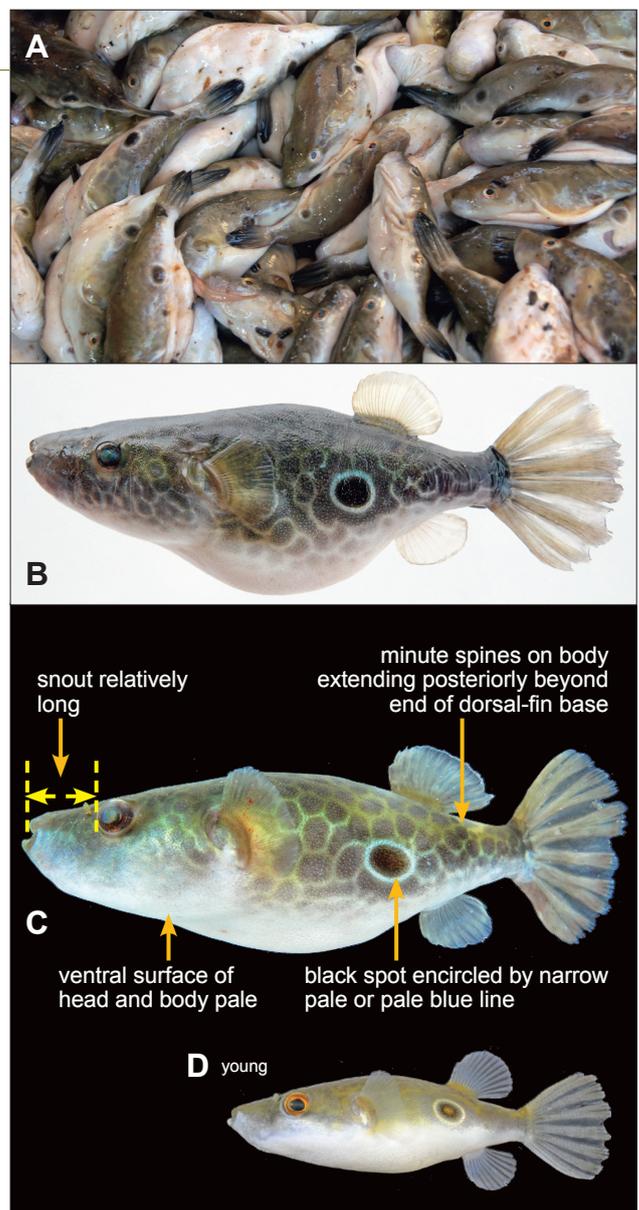
Pao cochinchinens greatly resembles the Mekong congener *P. barbatus* (above) in general appearance, but differs in having spinules on the caudal peduncle behind dorsal-fin base (Saenjundaeng *et al.*, 2013b, as *Tetraodon cambodgiensis*). As far as we know, these 2 similar-looking species are distributed allopatrically in the Mekong.



◀ Original figure of *Crayacion cochinchinensis* (= *Pao cochinchinensis*) (from Steindachner, 1866). Note that the lips appear to be turned up.



A) NUOL-P-4370 (photo: TP); B) NUOL-P-1413 (photo: KS)



A) Marketed fish, not preserved (Siem Reap, Cambodia, photo: KS); B) IFREDI-P-1814 (photo: PT); C) IFREDI-P-927 (photo: PT); D) IFREDI-P-1491 (photo: PT)

TETRAODONTIDAE

Pao abei (Roberts, 1998)

Family: Tetraodontidae (FC: 509)

Size: 18.5 cm SL (Kottelat, 2001a: 166, as *Monotrete turgidus*).

Distribution: Mekong Basin in Laos, Thailand, and Cambodia; Chao Phraya and Meklong basins.

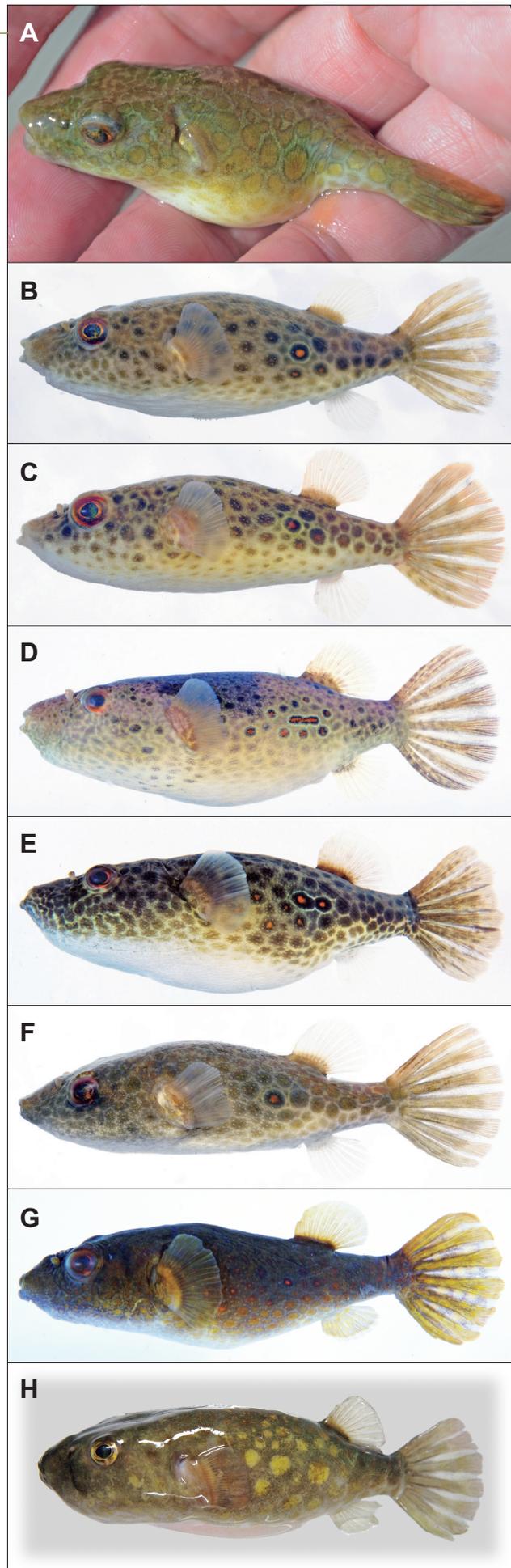
Notes: A medium-sized species of freshwater puffers, found in rivers and swift streams; it is common in upland areas. The generic assignment follows Kottelat (2013c).

Pao abei was originally described by Roberts (1998b, as *Tetraodon abei*) from the Mekong, Chao Phraya, and Meklong basins of Thailand and Laos (type locality: Xe Bangfai, Laos). In the description, Roberts (1998b: 228) stated that the species was immediately distinguished from "closely related" his *T. leiurus* (presumed to comprise *P. barbatus* and *P. cochinchinensis* recognized here) by having "entire dorsolateral surface of body with numerous pale spots uniformly distributed over a dark background." Subsequently Kottelat (2000) describe a new dark-spotted puffer *Monotrete turgidus* (= *Pao turgidus*) from Savannakhet Province of Laos; Kottelat (2001a: 165) stated that the species can be distinguished from the other Mekong congeners by having "adult without ocellus or larger black blotch under dorsal origin, but with several black spots on body with a paler (orange to red in life) central area."

During our field surveys in 2007–2013, we collected numerous specimens that can be identified as *P. abei* and/or *P. turgidus* from rivers and upland streams of the Mekong Basin in Laos and Thailand, as well as some from northern Cambodia. We were surprised by the fact that these puffers represent great variation in coloration of the head and body. Even in a single individual, they can change their coloration rapidly from paler background with dark spots (= *P. turgidus*-type) to a dark background with pale orange or yellow spots (= *P. abei*-type); such color variants are frequently found together in a single-netting collection (see photograph below). Since no other definitive characters differentiating these 2 species have been known, we here provisionally conclude that these 2 are conspecific; namely, *P. turgidus* is regarded here as a junior synonym of *P. abei*.

Within the Mekong puffers, *Pao abei* recognized here is similar to *P. fangi* (p. 504) in general appearance in particular its dusky spotted pattern (in the *P. turgidus*-type specimens) and spinulate area on the dorsal surface of the head, which does not extending anteriorly beyond a vertical line through the middle or anterior margin of the eye, but has a slightly longer snout (see

Freshly-collected fish of *Pao abei* (Ubon Ratchathani, Thailand, photo: KS)



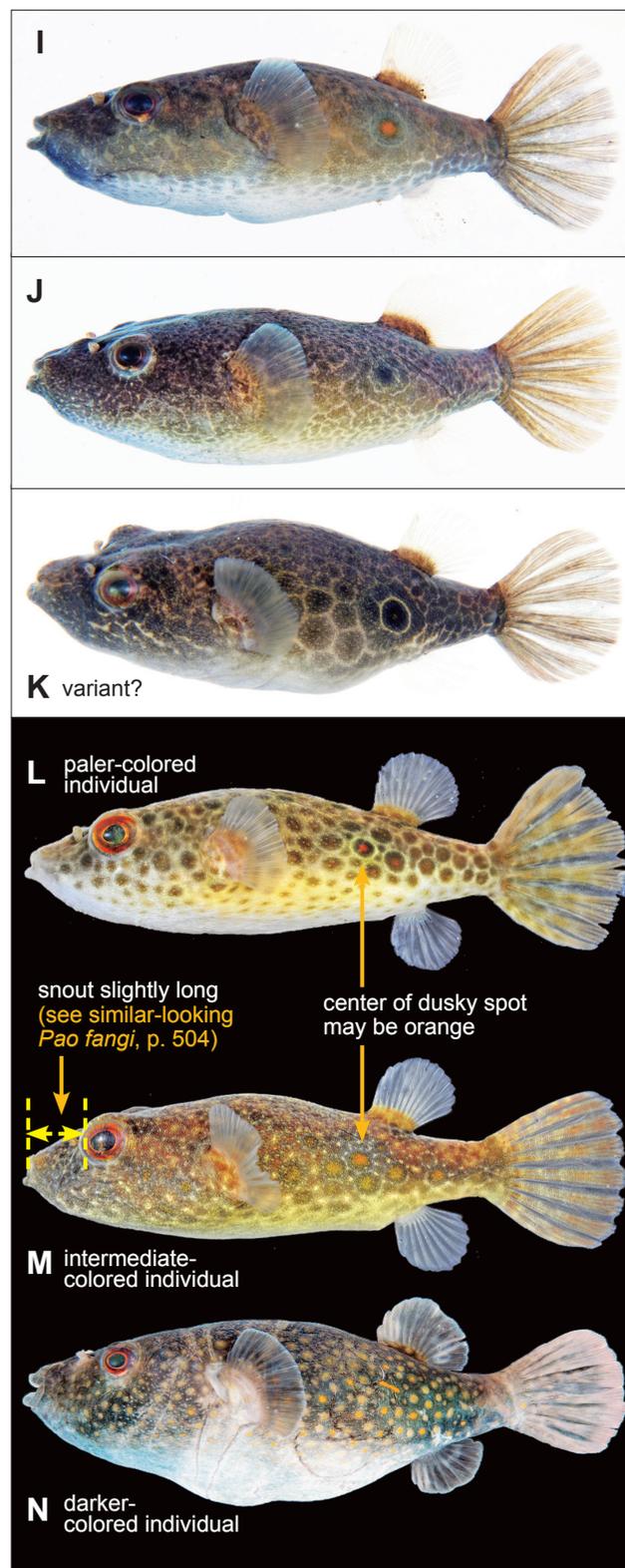
A) One of UNMF specimen (Ubon Ratchathani, Thailand, photo: KS); B) UNMF-P 1899 (photo: KS); C) UNMF-P 2029 (photo: KS); D) UNMF-P 3001 (photo: TP); E) UNMF-P 4522 (photo: TP); F) UNMF-P 1943 (photo: KS); G) UNMF-P 2572 (photo: TP); H) UNMF-P 456 (photo: PT)

also photographs of *P. fangi*, p. 504) and more or less paler body spots (usually dark brown, grayish brown, orange or yellowish, vs. black or gray in *P. fangi*). In the Mekong Basin, *Pao abei* is usually found in rivers and streams, whereas *P. fangi* most frequently inhabits marshes, swamps or reservoirs. We tentatively follow Tan & Kottelat (2009) that these Indochinese puffers of *Pao* are non-conspecific with similar-looking *Pao leiurus*, known from Java, Sumatra, and the Malay Peninsula. According to Tan & Kottelat (2009: 62–63, fig. 44, as *Monotrete leiurus*), their *P. leiurus* has "usually a pale brown unspotted patch in the upper part of the caudal peduncle and a broad pale brown band along the upper edge of the caudal fin"; these color patterns are not found in *P. abei* shown here. Note that we examined 3 specimens from the Bangpakong River in western Thailand (UNMF 8619, 8620, and 8621), that represent a similar color pattern with *P. leiurus* of Tan & Kottelat (2009) (*i.e.*, a pale brown patch in the upper part of the caudal peduncle, and a broad pale brown band along the upper edge of the caudal fin, as well as an ocellus with/without dull orange center below the dorsal-fin origin); spinulate pattern on the head and body of the Bangpakong specimens resemble that of *P. barbatus* redescribed by Saenjundaeng *et al.* (2013b).

Great variation in spotted pattern (not of a color tone) on the body of *Pao abei* is found in the population from the Nam Ou River (a tributary of the Mekong) in Luang Prabang, northern Laos (photos D, E, I–K, and N). For example, the specimen in photo K has close-set large dusky spots without a paler center on the body; it looks similar to the photographed specimen shown by Saenjundaeng *et al.* (2013a, fig. 4) as "*Tetraodon cochinchinensis*" rather than the typical *P. abei*. However, we identify this specimen as *P. abei* (rather than *P. cochinchinensis*), since it has no spinules on the dorsal surface of the head before a vertical line through the middle of the eye (see also comment on *T. cochinchinensis* of Saenjundaeng *et al.*, 2013a, below).

Note that the identification of *Pao cochinchinensis* has been seriously confused. The species was originally described by Steindachner (1866: 480, as *Crayacion cochinchinensis*) based on 2 specimens from "Cochinchina" (an old name for southern Vietnam). As far as we know, in southern Vietnam, only 2 species of *Pao* are known from the Mekong and Dong Nai basins: *P. cambodgiensis* of Saenjundaeng *et al.* (2013b, as *Tetraodon cambodgiensis*) and *P. fangi*. Although we did not examine the syntypes [that Kottelat (1998: 120) stated, "cannot be located in NMW"], Steindachner (1866) provided a good illustration in his original description of *C. cochinchinensis*; it is reproduced in p. 505. The fish in this original illustration looks similar to our specimen of *P. cochinchinensis* (= *T. cambodgiensis* of Saenjundaeng *et al.*, 2013b) (p. 505) in having relatively long snout (though the lips are turned up), a distinctive eye-sized black spot surrounding narrow pale ring, many close-set, irregularly-shaped dusky markings on the side of the head and body (sometimes faded in the Mekong specimens), and whitish abdomen. The other candidate, *P. fangi*, differs obviously from *C. cochinchinensis* of Steindachner (1866) in having a shorter snout and black spotted pattern entirely on the body (see photographs of *P. fangi*, p. 504). We thus identify our fish in p. 505 as *Pao cochinchinensis*. *Tetraodon cambodgiensis*, redescribed by Saenjundaeng *et al.* (2013b), is regarded here as a synonym of *P. cochinchinensis*.

The taxonomic status of "*Tetraodon cochinchinensis*" of Saenjundaeng *et al.* (2013a, figs 4 and 5A–B) is not clear; they did not state anything about the reason why they identified their specimens examined as *T. cochinchinensis*. Although their species resembles *P. barbatus* by having spinules on the dorsal surface of the snout (before a vertical line through the anterior margin of the eye) and no spinules on the caudal peduncle, it



appears to have a more robust body and a slightly shorter snout than the typical specimens of *P. barbatus* shown in p. 505; the coloration is more darkened and brownish than the latter. We also examined similar specimens from tributaries of the Mun River (itself a tributary of the Mekong), but could not reasonably differentiate those from typical *P. barbatus* due to their variation in body shape and coloration; actually, the ranges of % of snout length in head length of their *T. cochinchinensis* and *T. barbatus* shown by their papers (Saenjundaeng *et al.*, 2013a, b) are broadly overlapped. Further extensive research, including molecular analysis, is needed to clarify their taxonomic statuses.