

Juvenile morphology of three *Pseudogobius* species (Gobiidae) occurring in a mangrove estuary, southern Thailand

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Abstract: Morphological characteristics of three gobiid *Pseudogobius* species (*P. javanicus*, *P. sp. 1* and *P. sp. 2*) in their juvenile phases which collected in Sikao Creek, a mangrove estuary located in southern Thailand were described. Juveniles of them were distinguished from each other by the following characters: *P. sp. 1* ($n = 59$, 7.4–13.3 mm SL) with two distinctive large blotches located on dorsal and ventral sides symmetrically of caudal fin base; *P. sp. 2* ($n = 13$, 6.7–12.0 mm SL), with three blotches on caudal fin base; and *P. javanicus* ($n = 18$, 6.5–11.8 mm SL) with two distinctive large blotches on caudal fin base in asymmetrical, upper one close to the lateral midline of body. All of these *Pseudogobius* individuals were collected within creek, mainly at middle reach, whereas no individuals from the marine area off the creek mouth, suggesting that these species spend most of their life within the estuarine habitat.

Key words: Gobiidae, *Pseudogobius*, juvenile morphology, mangrove estuary

Gobioids are the most dominant fish group in Indo-Pacific mangrove estuaries, and because of the high species diversity and abundance, they have been considered to be one of important components of such estuarine ecosystem (Collette, 1983; Robertson and Duke, 1987; Blaber and Milton, 1990; Vidthayanon and Premcharoen, 2002; Tachihara et al., 2003). However, ecological information on mangrove estuarine gobioids in their juvenile phase is still limited to some species (e.g. *Eleotris* and *Butis* species) (e.g. Maeda and Tachihara, 2005; Yokoo et al., 2006), because juvenile morphology of mangrove estuarine gobioids for the other genus has not been studied to date, and thus their early developmental series are hardly identified to the species level. More detailed morphological studies of gobioid juveniles, therefore, are needed to clarify the species-specific utilization pattern of

each species in mangrove habitats (Yokoo et al., 2006), which contribute to better understanding of their roles within such estuarine ecosystem.

The gobioid genus *Pseudogobius* is widely distributed in the tropical- temperate Indo-West Pacific region (Larson, 2001). They reside in freshwater and estuarine habitats including muddy substrata, seagrass beds and mangroves. Morphological characteristics of *Pseudogobius* juveniles were not known except for two temperate estuarine species, *Pseudogobius olorum* (Neira and Miskiewicz, 1998) and *P. masago* (Dotu, 1958). The purpose of this study was to describe the characters of the *Pseudogobius* juveniles including two new types which collected in Sikao Creek, a mangrove estuary located in Trang Province, southern Thailand. Short comments on their distribution patterns are also given.

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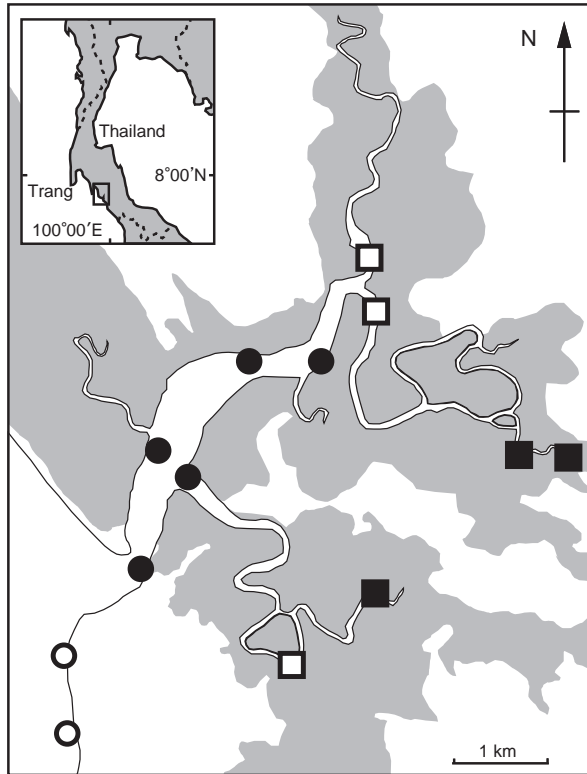


Fig. 1. Map of the sampling stations in Sikao Creek, Trang Province, southern Thailand. *Open circles*, marine area; *solid circles*, lower reach of creek; *open squares*, middle reach of creek; *solid squares*, upper reach of creek; *shaded area*, mangrove forest

Materials and Methods

This study was conducted in Sikao Creek, a mangrove estuary located in Trang Province, southern Thailand. Samplings were conducted at four areas: marine area (outside the creek) and lower reach (0.4–3.3 km from the mouth of the creek), middle reach (4.3–4.4 km) and upper reach (6.5–7.8 km) of the creek (Fig. 1), in August 1999, March, May, September and November 2000, and June 2002. A small seine net of 1 mm mesh [see Kanou et al. (2002)] was towed at about 1 m depth along the shoreline over a distance of 20 m. At each towing, net-mouth opening was constantly kept at 4 m, such covering the area of 80 m². In each area at each census time, two to five collections were made during low tide in daytime. Fish densities are expressed as the number of individuals per haul (per 80 m²) in this study. All samples were fixed in 10% formalin seawater in the field and later preserved in 70% ethanol in the laboratory.

Gobiid specimens collected were sorted out following Larson and Murdy (2001) and Nelson (2006), and then identified to the genus level following Larson (2001) and Larson and Murdy (2001). Although species comprising the genus *Pseudogobius* were given as a preliminary list by Larson (2001), a total number of species belonging to

this genus are uncertain yet and undescribed species may exist. Therefore, species identification of *Pseudogobius* specimens were based also on Day (1876), Herre (1940), Akihito and Meguro (1975), Kottelat et al. (1993) and Larson and Lim (2005) tentatively, and individuals with incomplete key-identification characters were identified by the series method of Leis and Trnski (1989). Measurements of body length and parts were made with a micrometer attached to a microscope and digital calipers, and illustrations of juveniles were done with the aid of camera lucida attached to a microscope. Terminology and methods for counts and measurements of morphological characters mainly followed Leis and Carson-Ewart (ed.) (2000).

The specimens examined in the study were deposited at the Museum of Tokyo University of Marine Science and Technology, MTUF-P(L)7206, 7254, 7345, 7355, 7378, 7458, 7490, 7491, 7497, 10654, 10720, 10736, 10742, 10757, 10779, 10786, 10788, 10792, 10806, 10833, 10855, 10878, 10880, 10908, 11187, 11291, 11298, 11303, 11307, 11341, 11344, 11403, 11599, 12248, 12354–12390, 12392, and 12393.

Results and Discussion

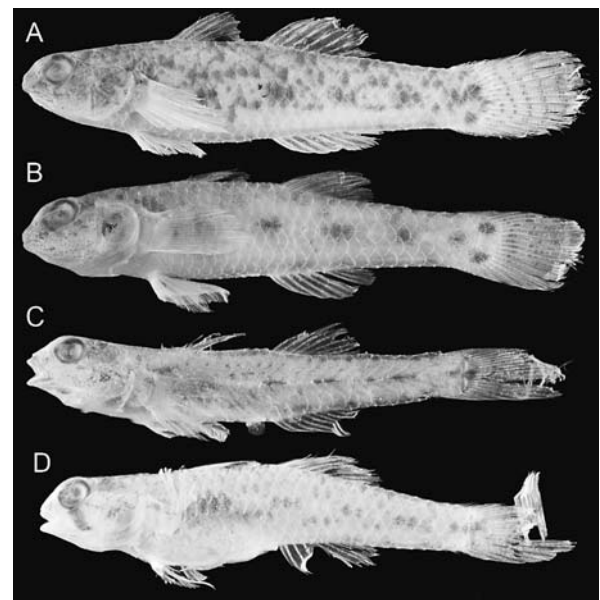
Identification. A total of 78 individuals of 9.2–29.2 mm SL were identified as *Pseudogobius* by having the combination of the following characters (Larson, 2001; Larson and Murdy, 2001): dorsal and anal fins separated from caudal fin; both dorsal fins separated from each other; segmented caudal fin rays 16; mouth small, subterminal, with rounded snout overhanging mouth; entire gut spirally coiled; body scaly; one pair of sensory pores present on snout. According to Larson (2001), *P. avicennia*, *P. javanicus*, *P. melanostictus* and *P. poicilosomus* are possibly distributed in this study area. Out of 78 *Pseudogobius* specimens collected in this study, 32 (13.0–29.2 mm SL) were identified as *P. javanicus* (Fig. 2A), based on pigmentation patterns on head, lateral side of body, and membrane of vertical fin rays. Although the remainders were not classified into *Pseudogobius* species listed preliminary by Larson (2001), they were divided into three types (*Pseudogobius* sp. 1–3) on the basis of the presence and/or absence of preorbital transverse band and pigmentation patterns of lateral side of body and caudal fin base. Pigmentation patterns of each type were as follows: *Pseudogobius* sp. 1 ($n = 22$, 11.9–25.2 mm SL, Fig. 2B): transverse band absent below eye, five large blotches present on lateral midline of body, and two blotches present on caudal fin base; *Pseudogobius* sp. 2 ($n = 8$, 13.0–14.0 mm SL, Fig. 2C): transverse band absent below eye, several melanophore blotches present on lateral midline of body, and three distinctive blotches present on caudal fin base; *Pseudogobius* sp. 3 ($n = 16$,

Table 1. Pectoral fin ray number of four described species and three types of *Pseudogobius* and three types of juveniles collected in Sikao Creek, Trang Province, southern Thailand from August 1999 to June 2002

	Number of pectoralfin ray	References
Adult		
<i>P. avicennia</i>	15–16	Larson and Lim (2005)
<i>P. javanicus</i>	14–16	This study, Akihito and Meguro(1975)
<i>P. melanostictus</i>	14–15	Larson and Lim (2005)
<i>P. poecilosomus</i>	14	Kottelat et al. (1993)
<i>P. sp. 1</i>	17	This study
<i>P. sp. 2</i>	15–16	This study
<i>P. sp. 3</i>	14–16	This study
Juvenile		
Type A	17–18	This study
Type B	15–16	This study
Type C	15	This study

9.2–14.0 mm SL, Fig. 2D): transverse band present below eye, several melanophore blotches present on lateral midline of body, and no distinctive blotch was observed on caudal fin base.

A hundred and twenty one juveniles (4.6–13.7 mm SL) possessed the combination of the characters being particular to the genus *Pseudogobius*. Of them, 91 individuals with melanophores on trunk and tail were subjected to the further analyses. They were divided into three types with distinctive pigmentation patterns on caudal fin base: type A ($n = 18$, 6.5–11.8 mm SL, Fig. 3A) with two distinctive large blotches located on dorsal and ventral sides symmetrically of caudal fin base; type B ($n = 59$, 7.4–13.3 mm SL, Fig. 3B) with three blotches on caudal fin base; type C ($n = 13$, 6.7–12.0 mm SL, Fig. 3C) with two distinct large blotches on caudal fin base in asymmetrical, upper one close to the lateral midline of body. Larger individuals of both types A and B (>11.3 mm SL) had preopercle sensory canal although incomplete. *Pseudogobius* sp. 1 and sp. 2 identified above in this study possessed the sensory canal on preopercle, although no *Pseudogobius* species of Larson (2001) possess the canal. Type A juvenile possessed two distinct blotches on dorsal and ventral sides of caudal fin base, and the number of pectoral fin rays was 17 or 18 (Table 1), these characters tallied with characters of *P. sp. 1*. Type B juveniles accorded with *Pseudogobius* sp. 2 by having three melanophore blotches on caudal fin base and 15 or 16 pectoral fin-rays in number (Table 1). Therefore, types A and B juveniles were identified as *Pseudogobius* sp. 1 and *Pseudogobius* sp. 2, respectively. Type C juveniles were distinguished from *P. avicennia* having numerous melanophores on the membrane of vertical fins (Herre, 1940), from *P. melanostictus* by absent of blotches on caudal fin base (Larson and Lim, 2005), and from *P. poecilosomus* and *Pseudogobius* sp. 3 by absent of transverse band below

**Fig. 2.** Specimens of four *Pseudogobius* species.

A *Pseudogobius javanicus*, MTUF-P(L) 11303, 27.1 mm SL;

B *Pseudogobius* sp. 1, MTUF-P(L) 12355, 23.9 mm SL;

C *Pseudogobius* sp. 2, MTUF-P(L)11403, 13.3 mm SL;

D *Pseudogobius* sp. 3, MTUF-P(L) 12385, 14.6 mm SL

eye (this study; Kottelat et al., 1993). On the other hand, because the pigmentation patterns and the numbers of fin rays of type C juveniles were consistent with those of *P. javanicus* collected in this study, type C was identified as *P. javanicus*.

Descriptions of *Pseudogobius* sp. 1 (Fig. 3A).
Morphology — Body moderate to elongate, body depth 14–16% SL; gut moderate to long, preanal length 47–55% SL; head moderate, head length 25–31% SL; eye moderate, eye diameter 28–30%HL; predorsal length 35–42%SL; caudal peduncle length 28–31% SL, depth 8–10% SL; snout length 16–19% HL. Jaws subequal,

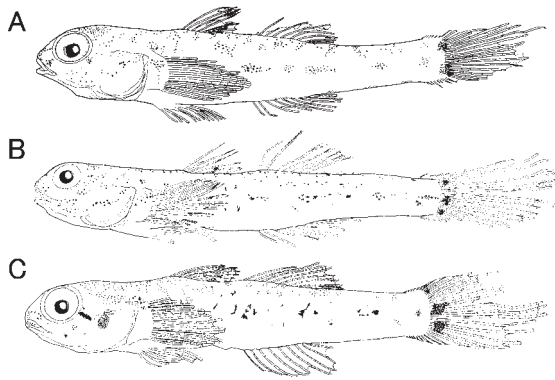


Fig. 3. Juveniles of three *Pseudogobius* species.
A *Pseudogobius* sp. 1 MTUF-P(L) 12360, 13.1 mm SL;
B *Pseudogobius* sp. 2 MTUF-P(L) 11931, 12.3 mm SL;
C *Pseudogobius javanicus* MTUF-P(L) 12370, 11.3 mm SL

upper jaw slightly projecting. Scales on lateral side present. Predorsal scales appearing first at 10.5 mm SL. Preopercle pores becoming complete at 11.3 mm SL. Scales on opercle appearing first at 11.3 mm SL.

Pigmentation — Melanophores scattered on such head regions as upper and lower jaws, lower jaw angle, snout, cheek, preopercle, upper part of opercle and isthmus; saddle-shaped pigmentation appearing on dorsal part of lateral side of body from anterior part of first dorsal fin to posterior part of caudal peduncle; five to six melanophore blotches appearing on lateral midline from under pectoral fin (not shown in the Figure) to posterior part of caudal peduncle; four blotches present on ventral part from anal fin base to caudal peduncle; two distinctive melanophore blotches present on caudal fin base, dorsal edge of dorsal blotch being on the upper second segmented caudal fin ray; transverse band present on membrane of first dorsal fin; melanophores scattered on second dorsal fin membrane. Melanophores present on pelvic fin base but disappearing at 11.0 mm SL.

Remarks — *Pseudogobius* sp. 1 differ from *Pseudogobius olorum* and *P. masago* in pigmentation patterns. The latter possess indistinctive blotches on caudal fin base and lack transverse band on first dorsal fin membrane.

Description of *Pseudogobius* sp. 2 (Fig. 3B).
Morphology — Body elongate to very elongate, body depth 9–14% SL; gut long, preanal length 50–56% SL; head moderate, head length 22–27% SL; eye moderate, eye diameter 26–30%HL; predorsal length 31–36%SL; caudal peduncle length 27–30% SL, depth 8–9% SL; snout length 17–22% HL. Jaws subequal, upper jaw slightly projecting. Scales on lateral side and predorsal area present. Preopercle pores present.

Pigmentation — Melanophores scattered on such head regions as upper and lower jaws, snout, cheek, preopercle, opercle and isthmus; scattered melanophores appearing on dorsal part of lateral side of body from anterior part of first

dorsal fin to posterior part of caudal peduncle; four to six melanophore blotches appearing on lateral midline from below second dorsal fin origin to posterior part of caudal peduncle; four blotches present on ventral part from anal fin base to caudal peduncle; three distinctive melanophore blotches present on caudal fin base; melanophores appearing on upper part of pectoral fin base; melanophores scattered on membrane of first dorsal fin. Melanophores on pelvic fin base appearing at 12.7 mm SL and disappearing at 13.3 mm SL.

Remarks — *Pseudogobius* sp. 2 can be distinguished from *P. olorum* and *P. masago* by having indistinctive blotches on the lateral side of body and three blotches on the caudal fin base.

Description of *Pseudogobius javanicus* (Fig. 3C).
Morphology — Body elongate, body depth 13–16% SL; gut moderate to long, preanal length 48–55% SL; head moderate, head length 26–30% SL; eye moderate, eye diameter 28–32%HL; predorsal length 34–40%SL; caudal peduncle length 27–31% SL, depth 9–11% SL; snout length 12–20% HL. Jaws subequal, upper jaw slightly projecting. Scales on lateral side of tail present and expanding to trunk at 7.5 mm SL. Predorsal scales appearing first at 8.9 mm SL.

Pigmentation — Melanophores scattered on such head regions as upper and lower jaws, snout, cheek, preopercle, opercle and isthmus; distinctive blotches present on preopercle and opercle; scattered melanophores appearing on dorsal part of lateral side of body from anterior part of first dorsal fin to posterior part of caudal peduncle; five to six melanophore blotches appearing on lateral midline from under pectoral fin (not shown in the Figure) to posterior part of caudal peduncle; four blotches present on ventral part of anal fin base to caudal peduncle; two distinctive melanophore blotches present on caudal fin base, dorsal edge of dorsal blotch being on the upper fourth segmented caudal fin ray; melanophores appearing on upper part of pectoral fin base; transverse band present on membrane of first dorsal fin; melanophores scattered on second dorsal fin membrane. Melanophores on isthmus disappearing at 10.6 mm SL.

Remarks — Juveniles of *P. javanicus* are distinguishable from *P. olorum* and *P. masago* on the basis of melanophore pattern. The latter possess indistinctive blotches on caudal fin base and lack transverse band on first dorsal fin membrane.

Occurrence patterns. In the present study, all of the *Pseudogobius* individuals were collected within Sikao Creek, while no individuals from the marine area (Table 2), suggesting that they spend their entire life cycles within the estuary system. Neira and Potter (1992) have also pointed out that estuarine gobiids such as *P. olorum* typically spend their juvenile and adult life in a restricted area within estuaries, and the demersal and adhesive eggs

Table 2. Number of individuals per haul of four species of *Pseudogobius* collected at four areas in Sikao Creek, Trang Province, southern Thailand from August 1999 to June 2002

	Upper reach	Middle reach	Lower reach	Marine area
<i>P. javanicus</i>	0.5	5	0.1	-
<i>P. sp. 1</i>	0.1	3.1	-	-
<i>P. sp. 2</i>	0.2	1.3	0.3	-
<i>P. sp. 3</i>	-	1.2	<0.1	-

enabled them to reduce the potential loss from the estuary with the seaward flow.

Within mangrove estuaries, distribution patterns in early life stages of species of the genus *Acentrogobius* (Yokoo et al., unpublished data), *Butis* (Yokoo et al., 2006) and *Eleotris* (Maeda and Tachihara, 2005) were different even among closely related species. In contrast, *Pseudogobius* juveniles occurred mainly at the middle reach area within Sikao Creek. Further studies are needed to clarify the mechanisms which allowing their coexisting within such a restricted area.

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