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FIRST FAUNAL RECORD OF LARVAL AND JUVENILE GOBIES (Actinopterygii: Gobiiformes) IN THE KA LONG ESTUARY, NORTHERN VIETNAM

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ABSTRACT

Gobies are dominant in terms of both species diversity and abundance in estuarine habitats, but little is known about their early developmental stages in the coastal waters of Vietnam. To examine species diversity of goby larvae and juveniles, monthly collections were carried out using a small seine net from the Ka Long estuary in the northernmost Vietnamese coast, from September 2014 to August 2015. A total of 1,334 goby fishes of 20 species or more in three families (Butidae, Oxudercidae and Gobiidae) were caught, including nine unidentified species. This is the first record of gobies at early developmental stages from an estuary in Vietnam. The family Oxudercidae was the most abundant in terms of total species, and *Gobiopterus chuno* was the most frequent species in the study area. The goby specimens collected were mostly postflexion larvae and juveniles, ranging from 2.3 mm to 99.1 mm in body length. The size of nine dominant gobies was around 10 mm body length. In the study site, goby fishes are from tropical, subtropical and temperate zones, suggesting this goby fauna can display transitional biodiversity from tropical to temperate waters.

Keywords: Early developmental stages, Ka Long estuary, gobies, biodiversity, transitional zone.

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INTRODUCTION

Gobiiformes consists of over two thousand species, which show varied life history characteristics (Nelson et al., 2016). In estuarine environments of the Indo-Pacific coasts, this order is dominant in terms of species and abundance (Tachihara et al., 2003; Tran & Ta, 2014; Nguyen et al., 2019a). However, only a few studies have investigated the occurrence of estuarine gobies at early developmental stages (Maeda & Tachihara, 2005, 2014; Tran et al., 2015, 2018b; Yokoo et al., 2006). In Vietnam, this order has 99 species, inhabiting marine, brackish and freshwater habitats, and many of them are commercial importances (Nguyen, 2005).

Recently, early stages of several fish species have been examined from estuaries in northern Vietnam (Tran & Ta, 2016; Tran et al., 2016a, 2017a, 2018c, 2019b–c; Nguyen et al., 2019b), but a few works on gobies have been carried out (Tran et al., 2015, 2018b, 2019a; Tran, 2018). These studies propose the importance of estuaries for the early stages of fish. The Ka Long estuary, located on the northernmost coast of Vietnam, has a large tidal flat area, which shows a potential role as nursery grounds for many fish species (Tran et al., 2012, 2014, 2016b, 2017b, 2018a, 2019a; Nguyen et al., 2017, 2019b). The occurrence of subtropical fish in the Ka Long estuary might suggest that this ichthyofauna can be a transition of biodiversity from tropical to temperate waters (Tran et al., 2012, 2014, 2018a; Nguyen et al., 2019b). Accordingly, this study first examined the species composition of gobies at early developmental stages from an estuary in northern Vietnam, which could provide more evidence to support the above transitional zone suggestion.

MATERIALS AND METHODS

Study area. We investigated the Ka Long estuary, which is located on the northernmost Vietnamese coast on the Gulf of Tonkin (Fig. 1). Ten sampling stations located along the shoreline of the Ka Long estuary and its adjacent marine area, the surf zone site (St. S10: outside of the estuary) were selected (Fig. 1).

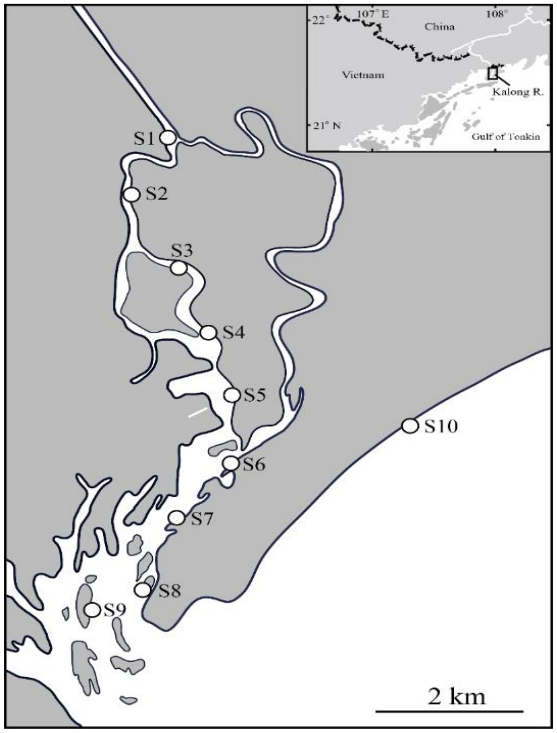

Figure 1. Chart showing stations (S1 to S10) where samples of goby larvae and juveniles were collected in the Ka Long estuary

Sampling and catch analysis. A small seine net (1 × 4 m, 1 mm mesh-aperture) (Kinoshita et al., 1988) was towed at a depth of 0.2–1.0 m along the shoreline over a distance of 50 m (2 minutes). A day's collection usually consisted of one to three hauls at each estuarine bank water station every month from September 2014 to August 2015. All samples were fixed in 5% formalin (1 formalin: 19 water) in the field and later preserved in 70% ethanol in the laboratory.

In total, 20,758 fish specimens were collected at the 10 sampling stations. A total of 1,334 goby individuals were sorted out from specimens under a 10–40x magnification dissecting microscope (Nikon 103044). The sorted specimens were identified to the lowest possible taxonomic

level based on characters listed in various studies of gobies of the Indo-Pacific region (Jeyaseelan, 1998; Kendall, 2011; Okiyama, 2013; Termvidchakorn & Hortle, 2013). The standard length (SL), body depth (BD) and head length (HL) were measured to the nearest 0.1 mm with digital callipers or with a micrometre attached to the above microscope by developmental stages (Kendall et al., 1984). Terminology of morphometric measurements and meristic counts used in the present study followed Nakabo (2002): D1 (first dorsal fin), D2 (second dorsal fin), A (anal fin), P1 (Pectoral fin), and P2 (Pelvic fin).

RESULTS

Species composition of goby larvae and juveniles

A total of more than 20 species in 3 families of gobies were identified (Fig. 2 and Tables 1, 2). The dominant family in terms of the number of species was the Oxudercidae family. Numerically, *Gobiopterus chuno* was the most abundant, accounting for 62.1% of the total number of specimens. *Pseudogobius* sp. was ranked second, followed by *Acanthogobius flavimanus*, *Silhouettea* sp., and *Rhinogobius similis* (Table 1). Based on morphology and melanophores, nine taxa could be identified into genus levels in the study site. They were small in size and at early development (Table 1).

In the identified species, eleven species are distributed in all three environments (marine, brackish and freshwater), and twelve were amphidromous fish, which migrate between rivers and the sea (Froese & Pauly, 2021). The number of tropical, subtropical and temperature fishes in the Ka Long estuary area was 7, 4 and 4, respectively (Table 1).

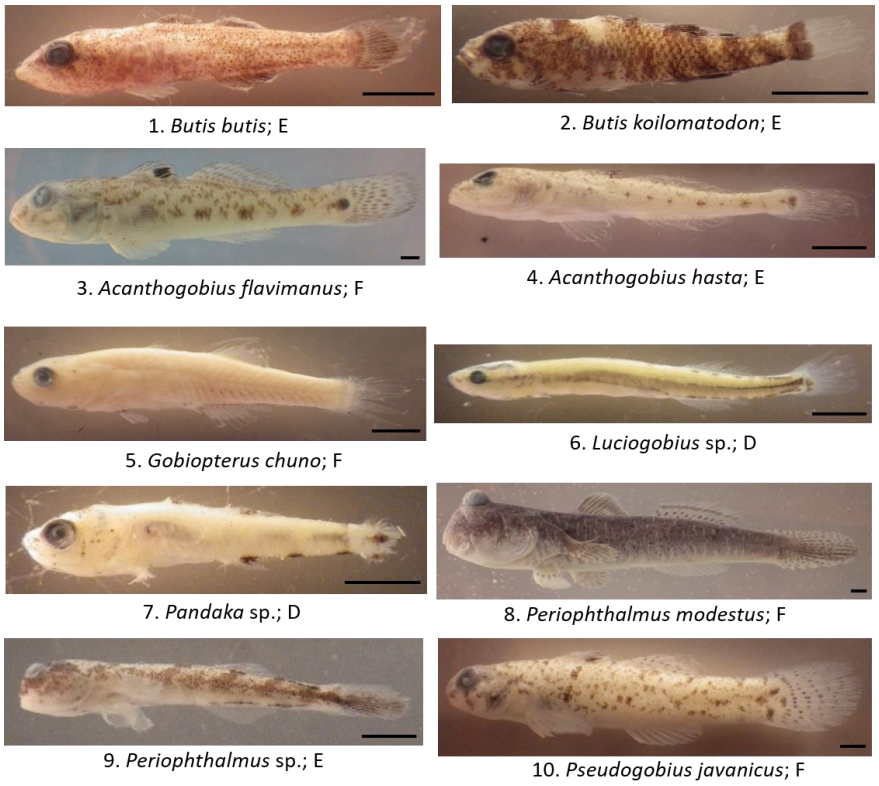

Figure 2. The larvae and juveniles of gobies collected in the bank waters around the Ka Long estuary, northern Vietnam, from September 2014 to August 2015. Scale bar = 2 mm. Developmental stage: C = flexion larval stage, D = post-larval stage, E = juvenile; F = adult

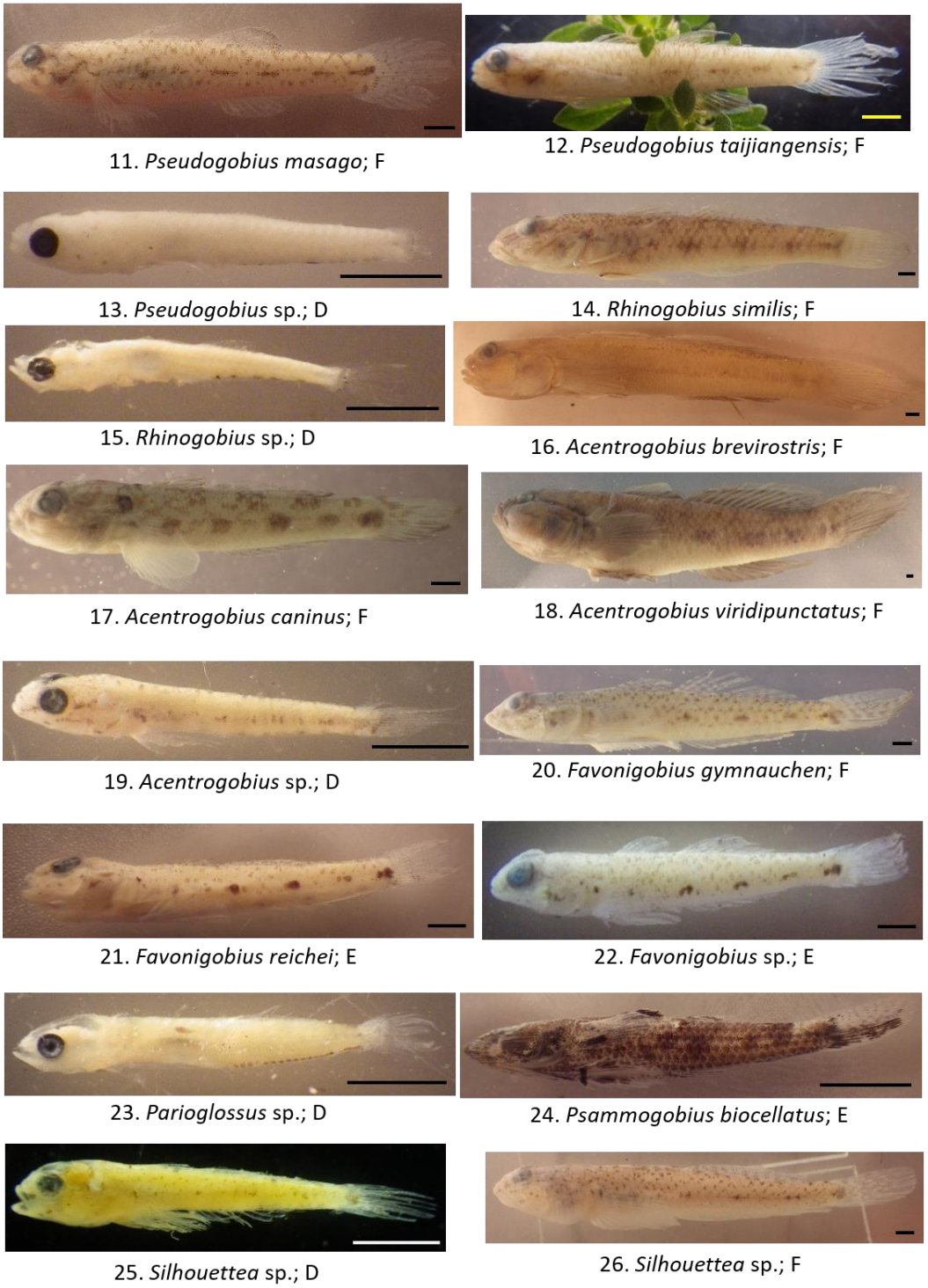

Figure 2. The larvae and juveniles of gobies collected in the bank waters around the Ka Long estuary, northern Vietnam, from September 2014 to August 2015. Scale bar = 2 mm. Developmental stage: C = flexion larval stage, D = post-larval stage, E = juvenile; F = adult (next)

Table 1. The occurrence of goby larvae and juveniles in the bank waters of Ka Long estuarine bank, northern Vietnam, from September 2014 to August 2015

Family and species	% of total number of specimens	SL (mm)	Developmental Stage	Habitat/Life history types/Climate (Froese & Pauly, 2021)
Butidae				
Butis butis (Hamilton, 1822)	0.1	8.2–9.4	E	MFB/Am/Tr
B. koilomatodon (Bleeker, 1849)	0.1	11.3	E	MFB/Am/Tr
Oxudercidae				
Acanthogobius flavimanus (Temminck & Schlegel, 1845)	6.4	9.5–40.8	D, E, F	MFB/Am/T
A. hasta (Temminck & Schlegel, 1845)	0.2	11.5–23.3	D, E	MFB/Am/T
Gobiopterus chuno (Hamilton, 1822)	62.1	2.3–15.5	D, E, F	FB/Am/Tr
Luciogobius sp.	0.1	11.6	D	
Pandaka sp.	2.9	4.5–8.0	C, D	
Periophthalmus modestus Cantor, 1842	0.1	41.5–41.7	F	MFB/Am/St
Periophthalmus sp.	0.6	8.7– 9.8	D, E	
Pseudogobius javanicus (Bleeker, 1856)	1.2	6.7–25.2	D, E, F	MFB/Am/Tr
P. masago (Tomiyama, 1936)	0.5	6.9–22.9	D, E, F	B/St

P. taijiangensis Chen, Huang & Huang, 2014	0.4	13.5–27.7	D, E, F	B/St
Pseudogobius sp.	7.9	5.0–7.6	D	
Rhinogobius similis Gill, 1859	4.7	6.4–42.4	D, E, F	B/T
Rhinogobius sp.	0.3	6.0–7.0	D	
Gobiidae				
Acentrogobius brevirostris (Günther, 1861)	0.7	21.6–65.7	E, F	F/NF
A. caninus (Valenciennes, 1837)	0.1	28.7	F	MFB/Am/Tr
A. viridipunctatus (Valenciennes, 1837)	0.2	74.65–99.1	F	MFB/Am/Tr
Acentrogobius sp.	0.1	7.1	D	
Favonigobius gymnauchen (Bleeker, 1860)	1.5	6.8–39.2	D, E, F	MFB/Am/St
F. reichei (Bleeker, 1854)	0.3	13.1–21.3	E	MFB/Am/Tr
Favonigobius sp1.	2.8	12.0–34.1	E	
Parioglossus sp2.	0.3	6.4–7.4	D	
Psammogobius biocellatus (Valenciennes, 1837)	0.3	8.2–9.4	E	MFB/Am/Tr
Silhouettea sp.	6.0	6.0–30.1	D, E, F	

Note: Devlopmental stage: C = flexion larval stage, D = post-larval stage, E = juvenile; F = adult. Habitats: B = brackish, F = freshwater, M = marine. Life history types: Am = amphidromy. Climate zone: Tr = tropical, St = Subtropical, T = temperate, NF = no information.

Table 2. Morphometric and meristic count values for goby larvae and juveniles in the Ka Long estuary, northern Vietnam

Species	BD/BL (%)	HL/BL (%)	D1	D2	A	P1	P2
B. butis	18.18	30.91	VI	I, 8	I, 8	18	I, 5
B. koilomatodon	21.28	32.73	VI	I, 8	I, 7	20	I, 5
A. flavimanus	16.13-18.38	27.03-8.23	VIII	I, 13-14	I, 11-12	16-19	I, 5
A. hasta	14.08-14.29	25.82-6.76	IX	I, 17	I, 14	20	I, 5
G. chuno	12.15-27.74	6.68-32.94	IV-V	8-9	11-12	14-15	I, 5
Luciogobius sp.	12.79	22.09	I, 14	N	I, 15	14	I, 5
Pandaka sp.	11.86-21.67	12.77-7.27	V-VI	6-7	6-7	14-16	I, 5
P. modestus	28.50-28.65	17.80-7.84	XIV	I, 12	I, 11	14	I, 5
Periophthalmus sp.	15.0-26.67	10.42-5.24	IV	I, 9	I, 10	14	I, 5
P. javanicus	20.11-27.18	17.46-9.02	VI	I, 7	I, 7	14-15	I, 5
P. masago	12.0-20.38	13.10-7.20	VI	I, 7	I, 7	14-15	I, 5
P. taijiangensis	24.30-25.0	16.87-7.31	VI	I, 7	I, 7	14-15	I, 5
Pseudogobius sp.	12.50-19.05	10.23-5.48	VI	I, 7	I, 7	12-13	I, 5
R. similis	15.34-22.20	21.25-4.70	VI	I, 8	I, 8-9	17-18	I, 5
Rhinogobius sp.	12.34-27.84	21.25-4.70	VI	I, 8	I, 8-9	15-18	I, 5
A. brevirostris	16.0-17.18	26.57-27.0	VI	I, 11	I, 10	16	I, 5
A. caninus	18.95	26.84	VI	I, 9	I, 8	18	I, 5
A. viridipunctatus	23.57	21.66	VI	I, 9	I, 9	18	I, 5
Acentrogobius sp.	15.48	26.79	VI	I, 9	I, 9	15	I, 5
F. gymnauchen	13.28-4.92	18.34-22.10	VI	I, 9	I, 9	15-18	I, 5
F. reichei	14.21-5.38	20.34-24.04	VI	I, 9	I, 9	17-18	I, 5
Favonigobius sp1	14.25-6.13	20.42-26.11	VI	I, 9	I, 9	17-18	I, 5
Parioglossus sp2	12.90-3.04	27.80-27.95	IV	I, 16	I, 15-16	0	0
P. biocellatus	14.21	21.58	VII	9	I, 8	18	I, 5
Silhouettea sp.	11.36-15.64	23.47-28.49	VI	I, 10	I, 11-12	15	I, 5

Note: N: no second dorsal fin in this genus. Bold number: incomplete adult complement of fin rays.

Developmental stages and sizes of goby larvae and juveniles

Fishes collected in this estuary were composed of flexion and postflexion larvae, juveniles, and adults. No preflexion larvae were collected. Specimens of the two species included flexion larvae in addition to the postflexion larvae and juveniles (i.e., *Gobiopterus chuno* and *Pandaka* sp.) and the specimens of twelve species are adults (Table 1). Nine unidentified species were mainly at flexion and postflexion larvae (Table 1). Body length ranged from 2.3 to 99.1 mm (Table 1). Length frequency distributions according to developmental stages of nine dominant species were present in Figure 3. Fish around 10 mm BL were mainly postflexion larvae. The specimens of five species were postflexion larvae, juveniles or adults, and all *Pseudogobius* sp. were postflexion larvae, while all *Favonigobius* sp. were juveniles (Fig. 3).

Ratios of body depth and head length to the body length for all species and their fin spine and ray counts are present in table 2. *Luciogobius* has only one dorsal fin ray, being different from other species in the study area. The pelvic fin rays are I, 5 in all species, except for *Parioglossus* sp. in which it has not appeared yet. In common, the first dorsal fin rays are VI (Table 2). Anal and pectoral fin rays are not fully completed at postflexion larvae in six and seven species (Table 2).

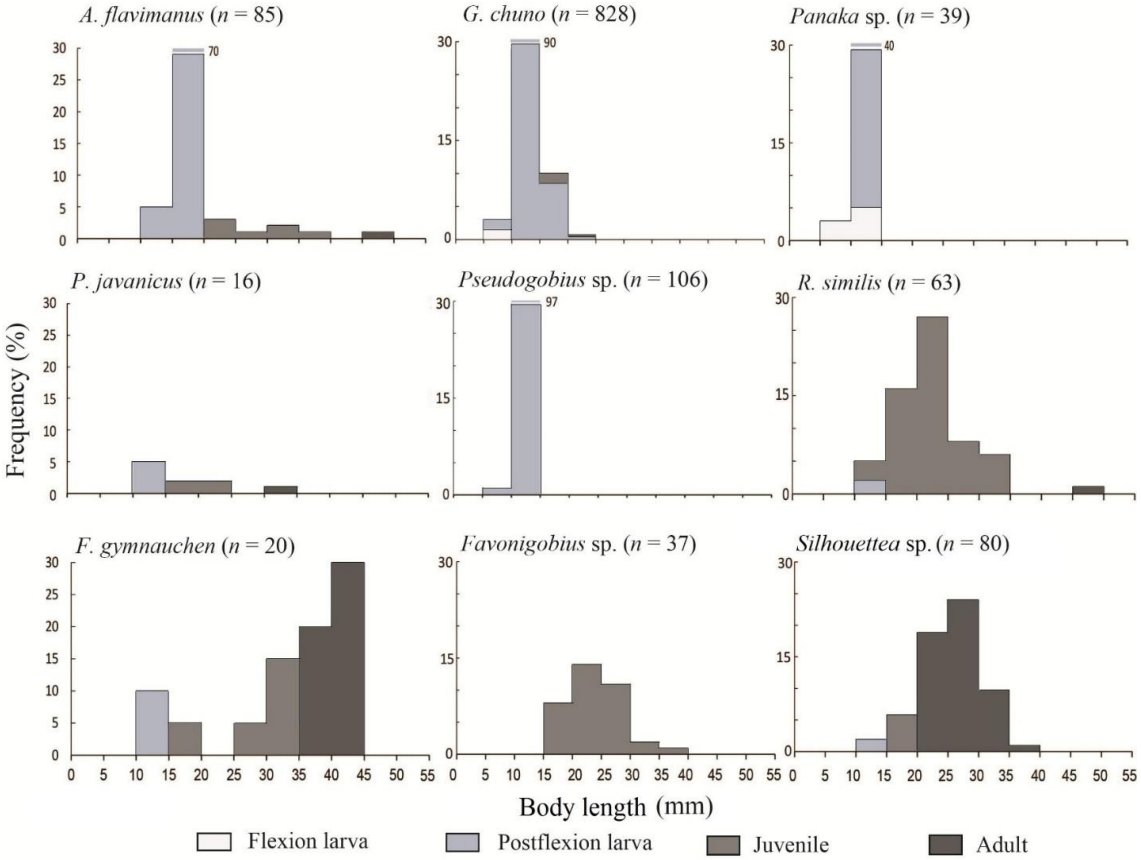

Figure 3. Length frequency (body length - BL) of larvae and juveniles of gobies collected in bank waters of the Ka Long estuary area, from September 2014 to August 2015

DISCUSSIONS

Tropical gobies were dominant in the study site, but some subtropical and temperate species could be recorded herein (Table 1). The goby community in bank waters of the Shimanto estuary, southern Japan seems more diverse than the current fauna (25 species or more vs. 20 species or more) (Fujita et al., 2002). Five shared species were found between the two estuaries (i.e., *Acanthogobius flavimanus*, *Favonigobius gymnauchen*, *Periophthalmus modestus*, *Pseudogobius masago* and *Rhinogobius similis*), which are all subtropical and temperate fishes (Froese & Pauly, 2021). In addition to goby, the early stages of Ayu (*Plecoglosus altivelis*) and Japanese seabass (*Lateolabrax maculatus*), the two subtropical fish, are distributed in the study site (Tran et al., 2012, 2014, 2017b, 2018a; Nguyen et al., 2019b). Compared with the goby fauna in the bank waters of the Tien Yen estuary (about 60 km southward), where 13 species or more were collected from October 2015 to April 2016 (Tran, 2018), and all the identified species are tropical fish (i.e., *Acentrogobius viganensis*, *Brachygobius aggregatus*, *Gobiopterus brachypterus*, *Pseudogobius javanicus* and *Redigobius bikolanus*) (Froese & Pauly, 2021). The difference in species composition by the climate zone amongst the above three estuaries additionally supports the fact that the fish community from the Ka Long estuary can reveal transitional biodiversity from tropical to temperate waters (Tran et al., 2019b). Further investigations in other fish taxa in this estuary might provide more information about this transition trait.

Acanthogobius flavimanus and *Rhinogobius similis* were within the top five abundant species in both the Ka Long and Shimanto estuaries (Table 1, Fujita et al., 2002). Similar to *Gobiopterus chuno* in the Ka Long estuary, *Acanthogobius flavimanus* was the most abundant in the Shimanto estuary (Table 1). The abundance of *Gobiopterus chuno* in the present study is consistent with *Gobiopterus brachypterus* in the Tien Yen estuary (Tran, 2018).

Many amphidromous and estuarine fishes collected from the Ka Long estuary area were postflexion larvae and juveniles (Table 1) indicating that this area could be a temporal habitat during their movement between marine and freshwater environments. This is consistent with the occurrence of gobies in an estuary in Okinawa, Japan (Maeda & Tachihara, 2014) and in the Tien Yen estuary, northern Vietnam (Tran, 2018). Ta et al. (2020) reported a number of amphidromous fishes at the adult stage in the Ba Che and Tien Yen Rivers, northern Vietnam, indicating the importance of these two estuaries for migratory fishes. There are few pelagic larvae of gobies collected from the bank waters of the Ka Long estuary, hence further field works in the centre of the current as well as using other fishing gears to collect more adults will understand the larval movement in this estuary and could determine its importance as a nusery ground for gobies.

The unidentified species were primarily at the flexion and postflexion larval stages (Table 1), which lack well-defined species diagnostic characters. Also, few morphological descriptions of goby in northern Vietnam (Tran et al., 2018b) or nearby areas might be difficult to the identification. In fact, gobies are diverse in the number of species amongst teleosts (Nelson et al., 2016) and their indistinguishable ontogeny could be one of the taxonomic problems. Thus, morphological description and photos of goby larvae and juveniles from the Ka Long estuary, as present in this study, will be valuable and important for further works on the taxonomy and developmental biology of gobies in Vietnamese waters. In addition, applying novel techniques such as DNA barcoding, which has been utilized to identify many Vietnamese fish species (Pham et al., 2019), will clearly confirm taxonomic levels of gobies at early developmental stages in Vietnam.

CONCLUSION

A total of more than 20 species of gobies from three families were determined along the bank waters of the Ka Long estuary area, northern Vietnam. Collections were mostly postflexion larvae and juveniles, ranging from 2.3 to 99.1 mm in body length. The goby fauna shows transitional biodiversity from tropical to temperate waters although the tropical fishes are still dominant.

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