Juvenile Morphology and Occurrence of Two Sillaginid Fishes, *Sillago intermedius* and *S. sihama*, in a Surf Zone, Southwestern Thailand

Prasert Tongnunui[1*] Mitsuhiko Sano[2] and Hisashi Kurokura[3]

ABSTRACT

Juveniles of sillaginid fishes were collected from the surf zone of Rajamangala Beach at Sikao Bay, Trang, southwestern Thailand, between May 2003 and April 2004. These juveniles were identified as *Sillago intermedius* (n=3,195; 6.4–69.1 mm in standard length, SL) and *S. sihama* (n=3,280; 5.7–109.0 mm SL). The former was easily distinguishable from the latter by having a series of systematic blotches of melanophores on the mid-lateral part of the body. The ontogenetic changes in the body proportion and caudal skeleton were similar between the two species. Both species occurred year-round, with a peak abundance in January for *S. intermedius*, and from November to January for *S. sihama*. The occurrence throughout the year of the two species indicates that the sandy surf zone is a critical habitat for their population.

Key words: juveniles, *Sillago intermedius*, *Sillago sihama*, Thailand

INTRODUCTION

Sandy-beach surf zones are considered to be a nursery area or important juvenile habitat for several fishes (Brown and McLachlan, 1994; Macpherson, 1998; Rose and Lancaster, 2002). Surf zones usually contain high densities and large biomass of zooplankton and epi-and hyperbenthos such as mysids and gammaridean amphipods, providing an abundant food source for juvenile fish (Inoue *et al*., 2005; 2008). In addition, the abundance of larger predators is often observed to be lower in surf zones than in offshore and deeper waters, probably resulting in

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[1] Department of Marine Science, Faculty of Science and Fisheries Technology, Rajamangala University of Technology Srivijaya, Sikao, Trang 92150, Thailand.

[2] Department of Ecosystem Studies, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan.

[3] Department of Global Agricultural Sciences, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan.

[*] Corresponding author, Tel: 66 (75) 204064, Fax: 66 (75) 204064, e-mail: prasert65@hotmail.com

reduced predation risk for small fish in surf zones (but see Nakane *et al*., 2009).

Juveniles of some fish species of the genus *Sillago*, including *S. intermedius* and *S. sihama*, have been reported to be a typical resident of surf zones (Weng, 1986; Kato *et al*., 1996; Suda *et al*., 2002; Ikejima *et al*., 2003; Inoue *et al*., 2008). Surf zones may be therefore a nursery or important juvenile habitat for *Sillago* species. However, there have been few studies on the seasonal occurrence of *Sillago* juveniles in surf zones. Furthermore, in spite of their popularity as a common inhabitant of surf zones and other inshore areas, the morphological information on *Sillago* larvae and/or juveniles is still limited to a few species (Ueno *et al*., 1958; Kinoshita, 1988; Oozeki *et al*., 1992; Kato *et al*., 1996).

The objective of the present study was to identify and describe juveniles of *Sillago* species occurring in a surf zone in Thailand, and to investigate their seasonal occurrence patterns in relationship to growth.

MATERIALS AND METHODS

Juveniles of sillaginid species were captured from a surf zone at Rajamangala Beach, Sikao Bay, southwestern Thailand (Fig. 1), using a small seine net (10 m wide, 1 m deep, and 1 mm×1 mm square mesh, with a 4.5 m long central purse-bag). Sampling was conducted monthly at flood tide (water depth about 1 m),

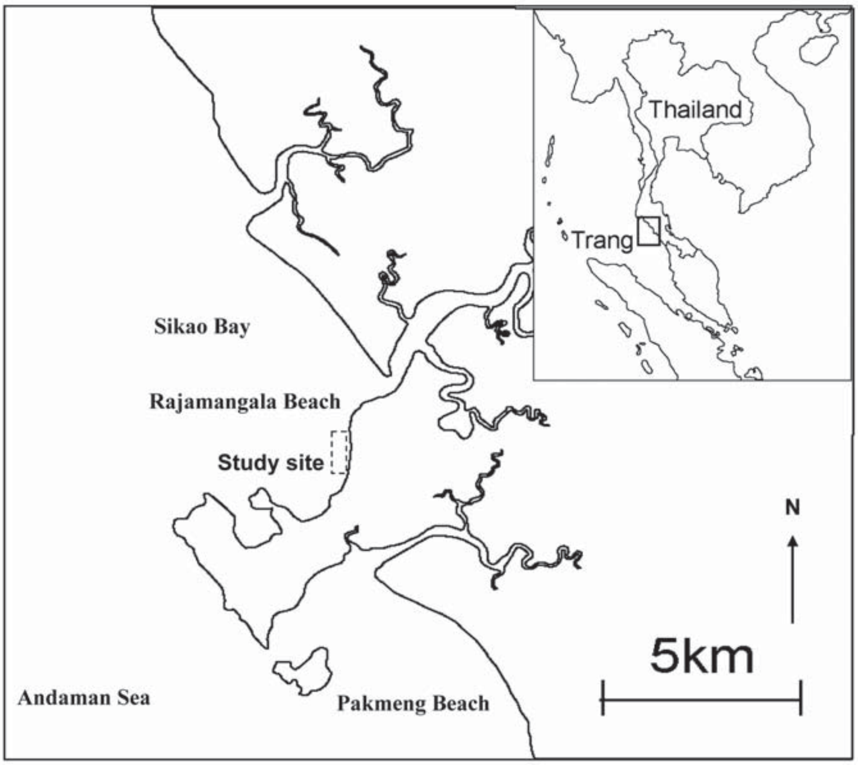

Figure 1 Map of the study site at Rajamangala Beach, Sikao Bay, Trang, southwestern Thailand.

between 6:00 and 9:00 A.M., from May 2003 to April 2004. The net was towed about 50 m along the shoreline five times per day on each of five consecutive days of each month. Specimens were fixed in 10% formalin in the field and later transferred to 5% formalin for preservation.

Sillaginid specimens collected in the samples were sorted on the basis of the identification guide of Leis and Trnski (1989), Neira *et al*., (1998), and McKay (1999). After sorted specimens of the genus *Sillago* were identified into species (*Sillago intermedius* or *S. sihama*), the standard length (SL) of each specimen was measured to the nearest 0.01 mm. Morphological observations were made on 70 specimens for *Sillago intermedius* and 71 for *S. sihama* (6.90–26.40 and 7.30–27.10 mm SL for *S. intermedius* and *S. sihama*, respectively). The following body parts were measured: head length (HL), pre-anal length, body depth, upper jaw length, snout length, eye diameter, caudal peduncle length and depth, and pelvic fin length (see terminological description in Leis and Trnski, 1989). In this study, the snout tip was standardized at the anterior tip of the cranium and percentages of body-part lengths to SL or HL used. Comparison between the mean measured body parts in % of SL or HL in each of the two species was carried out by mean of the Mann-Whitney U test (Steel and Torrie, 1981)

The ontogenetic changes in caudal skeleton of the two species were observed using specimens cleared and stained following the method of Potthoff (1984). External and internal illustrations were made with the aid of a binocular digital camera (Motic Images Advanced 3.2).

RESULTS

Identification

Sillaginid specimens identified in this study possessed the following characters, all characteristic of the genus *Sillago* (Leis and Trnski, 1989; Neira *et al*., 1998; McKay, 1999): 32–39 myomeres (11–17+19-24), small and elongate head, slightly compressed body, anus located midway along body, weak head spination, and a unique melanophore series along ventral and dorsal midlines. Using these characters, 6,475 specimens were determined as *Sillago* in this study. Based on a size series examination, the specimens were divided into two groups, Type A (n=3,195, 6.4–69.1 mm SL) (Fig. 2) and Type B (n=3,280, 5.7–109.0 mm SL) (Fig. 3), relating to the presence (Type A) or absence (Type B) of a series of systematic blotches of melanophores on the mid-lateral part of the body . The relative growth of body parts measured in this study was similar between the two types (Fig. 4). Although the early development of the caudal skeleton was similar between the two types (Fig. 5), the specimens larger than 47.0 mm SL clearly showed the different features. In a type A specimen of 48.0 mm SL, epural 3 had been reduced (Fig. 5D), but not in type B specimens (Fig. 5H).

Based on the species description in McKay (1999), Type A was either *Sillago aeolus* or *S. intermedius*. However, the numbers of dorsal (D) and anal (A) soft fin rays in Type A

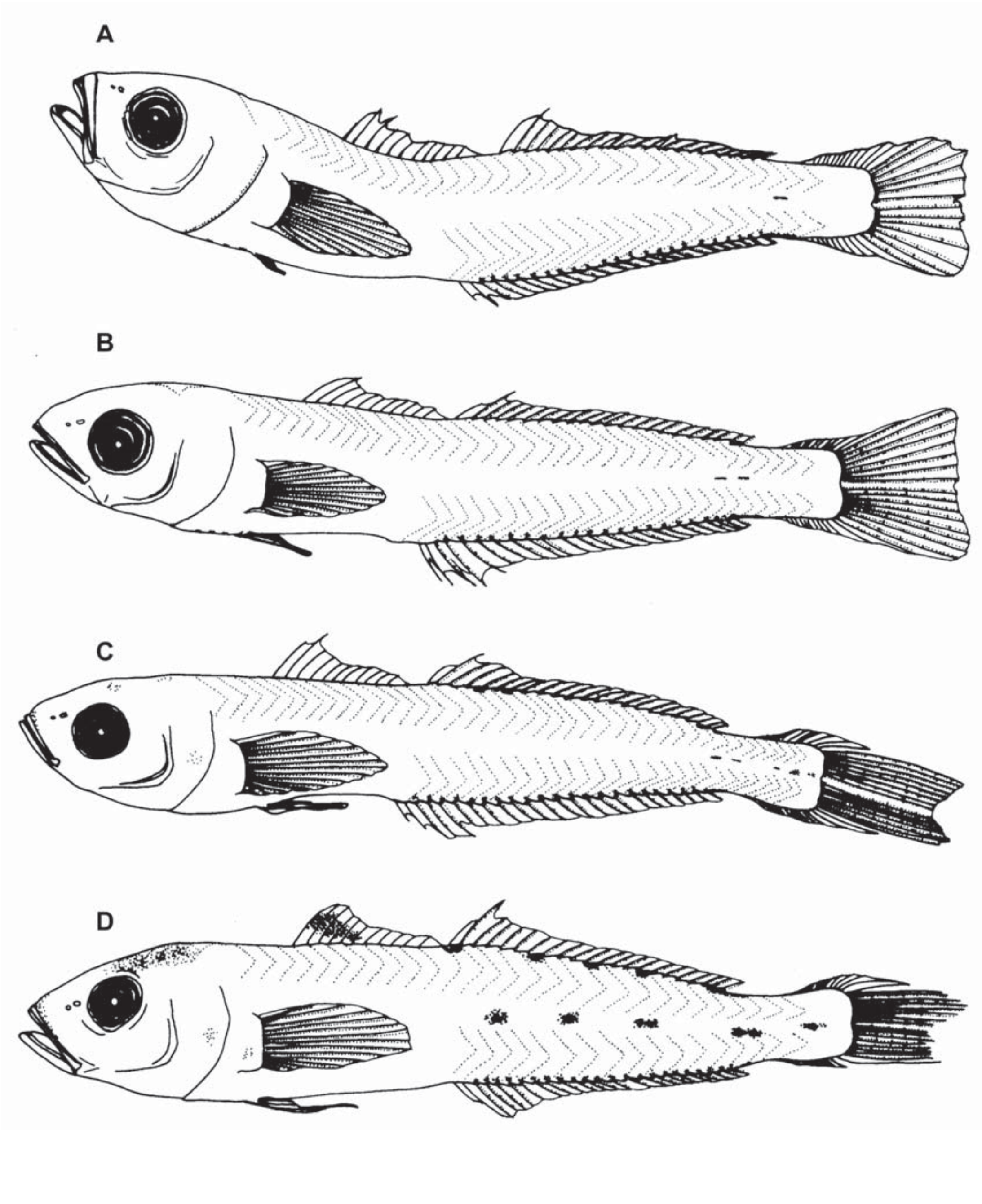

Figure 2 Juvenile development of *Sillago intermedius* collected from the surf zone at Rajamangala Beach, Sikao Bay. A) 7.3 mm SL; B) 9.6 mm SL; C) 12.8 mm SL; D) 16.7 mm SL.

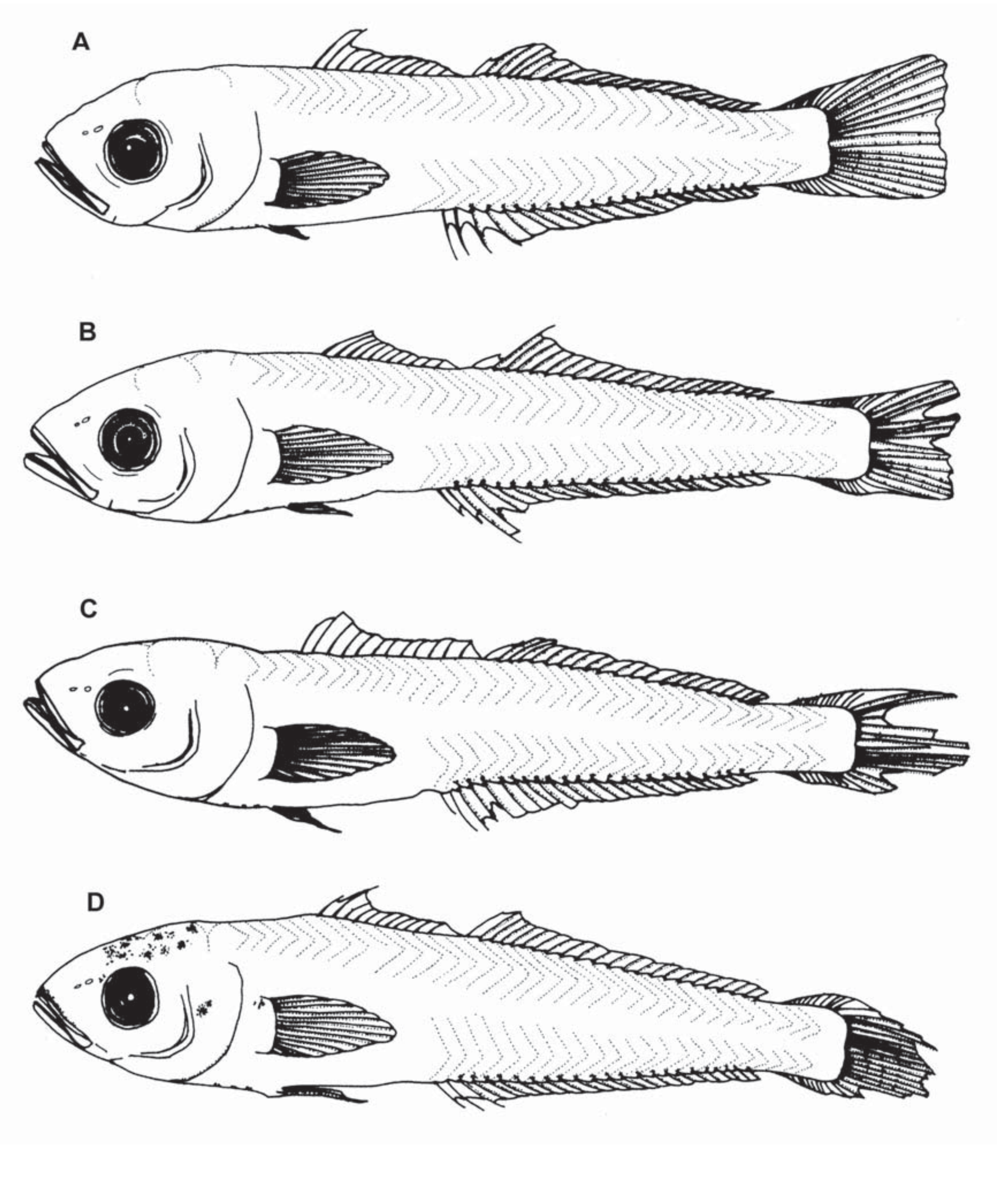

Figure 3 Juvenile development of *Sillago sihama* collected from the surf zone at Rajamangala Beach, Sikao Bay. A) 7.6 mm SL; B) 9.3 mm SL; C) 12.2 mm SL; D) 16.8 mm SL.

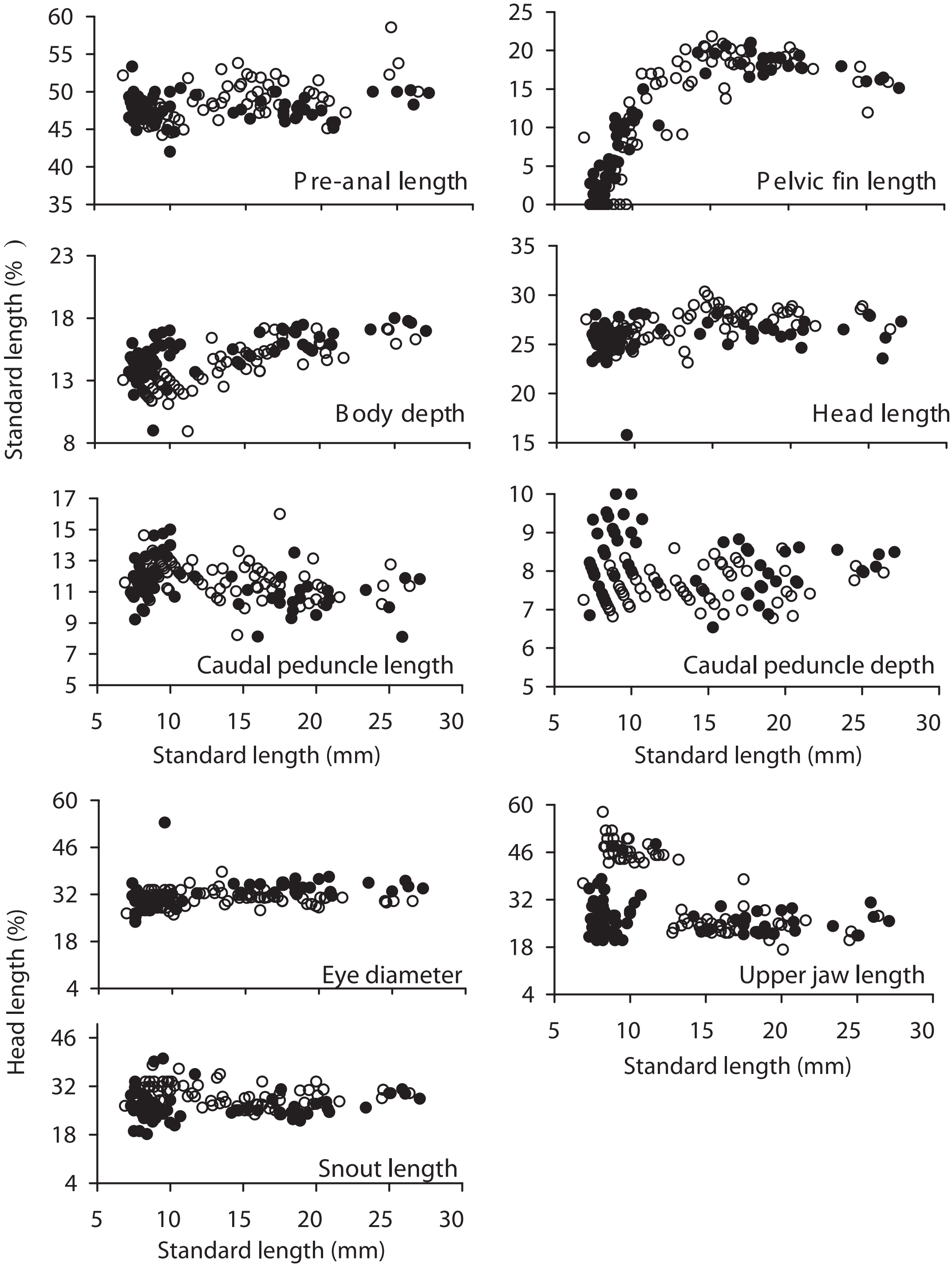

Figure 4 Body proportions of *Sillago intermedius* (Ë%) and *S. sihama* (Ï%) collected from the surf zone at Rajamangala Beach, Sikao Bay.

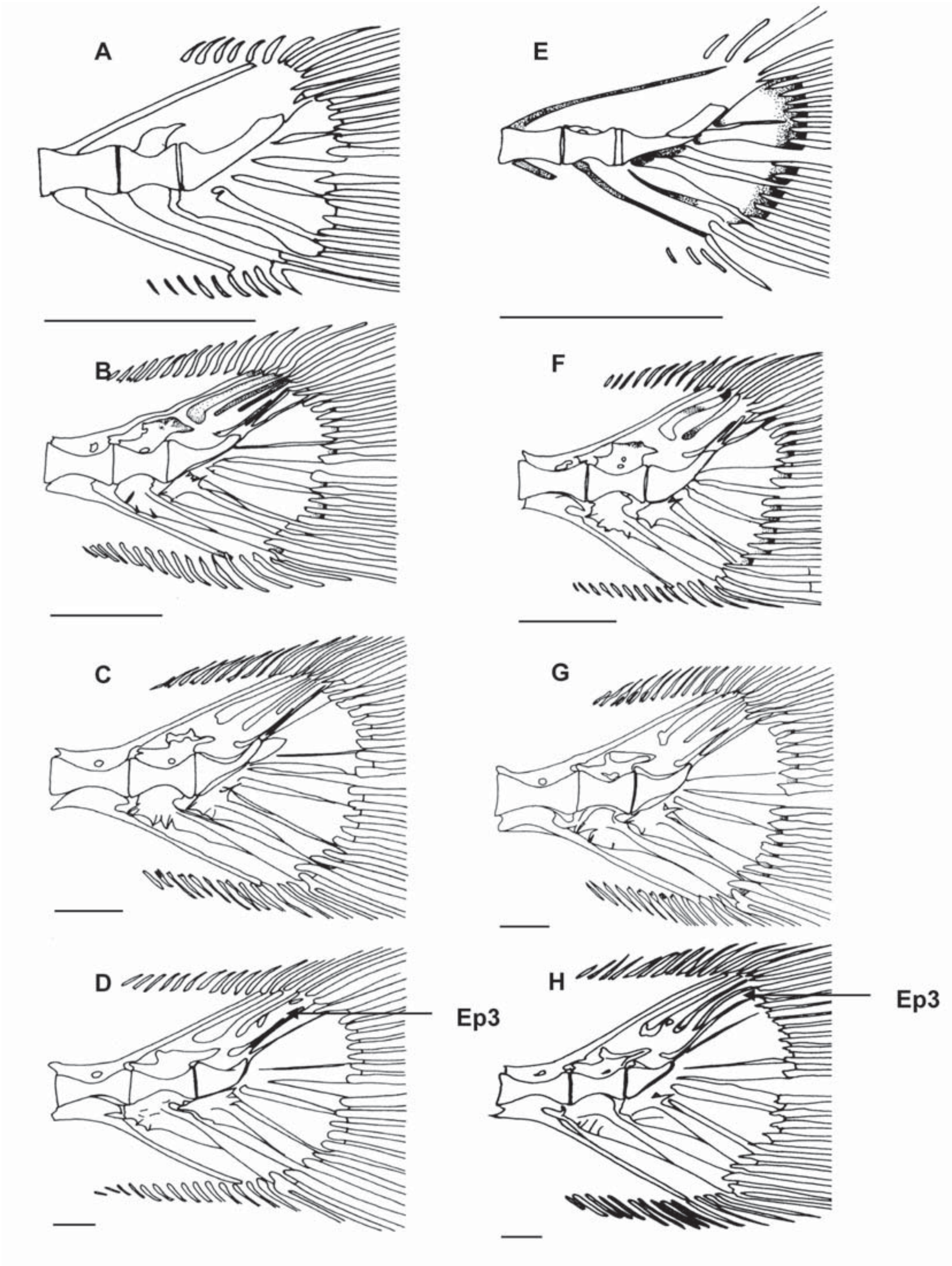

Figure 5 Development of the caudal skeleton (left lateral view) in juveniles of *Sillago intermedius* (A–D) and *S. sihama* (E–H). A) 8.8 mm SL; B) 16.6 mm SL; C) 27.7 mm SL; D) 47.9 mm SL; E) 8.4 mm SL; F) 15.5 mm SL; G) 27.0 mm SL; H) 47.8 mm SL. Ep. 3 shows epural 3. Scale bars indicate 0.5 mm.

were in complete accordance with those in *S. intermedius* (D 20–22 and A 20–21 for *S. intermedius* vs. D 18–20 and A 17–19 for *S. aeolus*). Therefore, the specimens of type A were identified as *S. intermedius* (Fig. 2). The external morphology and the counts of dorsal and anal soft fin rays in Type B best fit to the description of *S. sihama* (see Kato *et al*., 1996), and thus the specimens of Type B were considered to be *S. sihama* (Fig. 3).

Description of juveniles

Sillago intermedius (Figs. 2, 4) — Dorsal-fin rays XI+I, 20–22, anal-fin rays II+20-21, total myomeres 32–39.

Body elongate, depth 8.9–17.2% SL; gut long, pre-anal length 44.2–58.5% SL; head moderate to large, length 23.1–30.3% SL; caudal peduncle length 8.2–16.0% SL, depth 6.7–8.9% SL; pelvic fin length 0–21.9% SL; eye moderate to small, diameter 25.9–38.7% HL; snout length 23.8–38.1% HL; upper jaw length 17.2–57.9% HL. Values of body depth, pelvic fin length, eye diameter, and snout length relative to SL or HL increased with body size, whereas other morphometric characters remained constant throughout the size range examined in this study. Pelvic fin appeared at 7–9 mm SL specimens. Pelvic fin length increased by 12 mm SL and became stable at around 20% SL thereafter. Epural 3 in the caudal skeleton had been reduced at a specimen of 48 mm SL (Fig. 5D).

All specimens examined in this study possessed a single row of melanophores along the ventral midline of the tail, and a series of melanopores midlaterally on the caudal peduncle. Larger juveniles developed pigments on the head, the first dorsal-fin membrane, the dorsal midline of the trunk and tail, and midlaterally on the tail.

Sillago sihama (Figs. 3, 4) — Dorsal-fin rays XI +I, 20–23, anal-fin rays II+20-23, total myomeres 32–39.

Body elongate, depth 8.9–18.0% SL; gut long, pre-anal length 42.0–53.3% SL; head moderate to large, length 15.8–28.2% SL; caudal peduncle length 8.1–15.0% SL, depth 6.5–10.0% SL; pelvic fin length 0–21.0% SL; eye moderate to small, diameter 23.8–53.3% HL; snout length 18.2–40.0% HL; upper jaw length 20.0–48.4% HL. Values of body depth, pelvic fin length, eye diameter, and snout length relative to SL or HL increased with body size, whereas other morphometric characters remained constant throughout the size range examined in this study. Pelvic fin appeared at 7–10 mm SL specimens. Pelvic fin length increased by 12 mm SL and became stable at around 20% SL thereafter. Epural 3 in the caudal skeleton had not been reduced at a specimen of 48 mm SL (Fig. 5H).

Statistical comparison between the mean measured relative growths of the two species revealed significant difference for values of body depth ($z=-3.835$, $P<0.05$), head length ($z=-3.941$, $P<0.05$), caudal peduncle depth ($z=-4.819$, $P<0.05$), pelvic fin length ($z=-2.736$, $P<0.05$) and snout length ($z=-5.796$, $P<0.05$) and upper jaw length ($z=-3.214$, $P<0.05$). No significant difference for pre-anal length, caudal peduncle length and eye diameter.

All specimens examined possessed a single row of melanophores along the ventral midline of the tail. Larger juveniles developed pigments on the head, although they did not have pigments on the dorsal midline of the trunk and tail, and on the midlateral part of the tail.

Seasonal occurrence

Monthly changes in the mean number of juveniles per haul (150 m2) of the two species are shown in Fig. 6. The monthly occurrence indicates that juveniles of both species occurred at the beach throughout the year, with a peak abundance in January for *S. intermedius*, and from November to January for *S. sihama*. Juvenile *S. sihama* were much more abundant than *S. intermedius* every month except January. The body size of the specimens ranged from 6.4 to 69.1 mm SL for *S. intermedius*, and 5.7 to 109.0 mm SL for *S. sihama* (Fig. 7). Almost all specimens of both species (98.3 and 96.3% in *S. intermedius* and *S. sihama*, respectively) fell within the size class of 5.7 to 40.0 mm SL. Small juveniles of *S. intermedius*, and small and large juveniles of *S. sihama* were collected in most months, whereas large juveniles of *S. intermedius* were only captured between February and June (Figs. 8, 9).

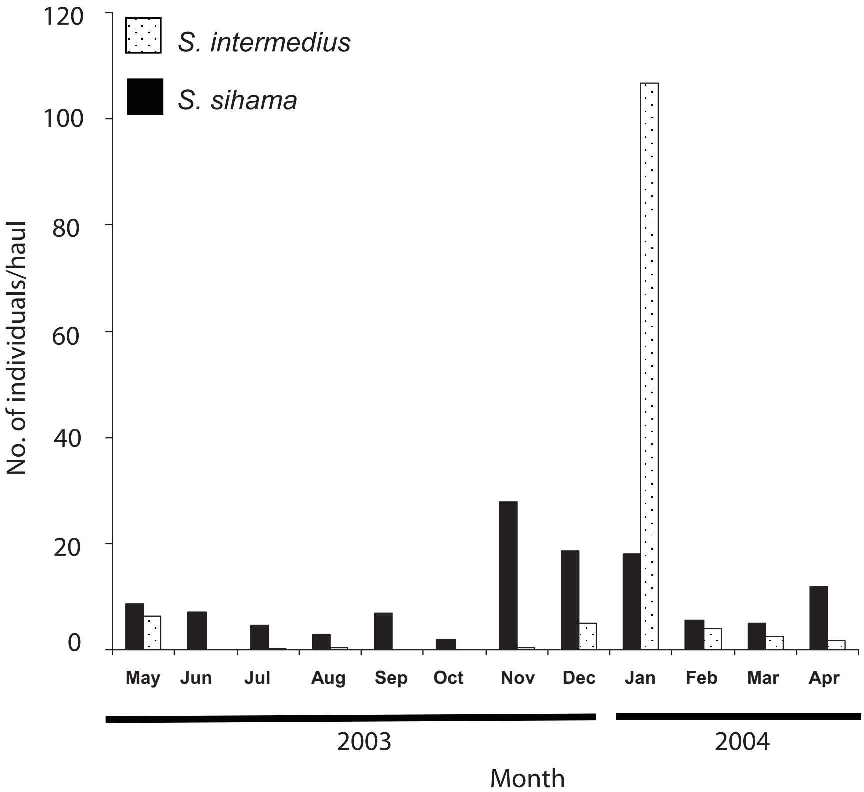

Figure 6 Monthly changes in mean number of juveniles per haul (150 m2) in *Sillago intermedius* and *S. sihama* collected at Rajamangala Beach, Sikao Bay, from May 2003 to April 2004.

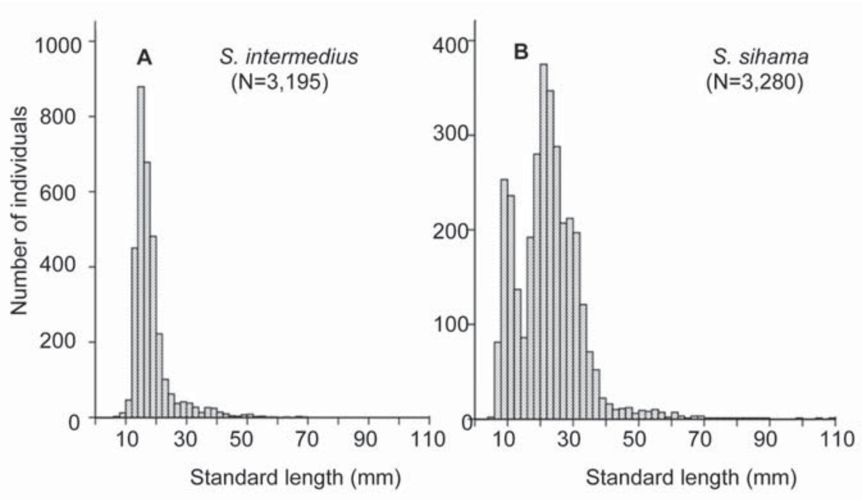

Figure 7 Length frequency distributions of juvenile *Sillago intermedius* (A) and *S. sihama* (B) collected at Rajamangala Beach, Sikao Bay, from May 2003 to April 2004.

DISCUSSION

Results of this study indicated that juveniles of *Sillago intermedius* and *S. sihama* occurring in the surf zone in southwestern Thailand were easily distinguished from each other by the occurrence of melanonophores on the mid-lateral line. The former species developed a short bar of melanophores on the mid-lateral line of the caudal peduncle, such a melanophore bar being absent in the latter species. Although the two species were not distinguishable from one another using morphometric characters, it was suggested here that melanophore distribution patterns are an important character to separate between juveniles of the two species. Our findings in morphometrics and melanophore distributions of *S. sihama* were congruent with those of conspecific juveniles (8.6–22.9 mm SL) collected in the Phillipines (Kato *et al*., 1996).

In addition to the two *Sillago* species, juveniles of *S. aeolus* have been reported to be distributed in the coastal area of the study location (Ikejima *et al*., 2003). *S. aeolus* has melanophores on the mid-lateral part of their body, like *S. intermedius* (McKay, 1999), but the former was distinguished from the latter by having lower numbers of soft dorsal and anal fin rays (McKay, 1999; Kato *et al*., 1996).

The present study showed that juvenile *S. intermedius* and *S. sihama* occurred year-round, peaking in the dry season (November–January) at Rajamangala Beach. The peak occurrence of *Sillago* species in a surf zone in the Philippines was observed in the dry season from November to April (Kato *et al*., 1996). In addition, juvenile *Sillago ciliata*, *Sillago analis*, and *Sillago maculata* were found only in warm months of the year at Moreton Bay, Queensland, Australia (Weng, 1986). The dry season of southwestern

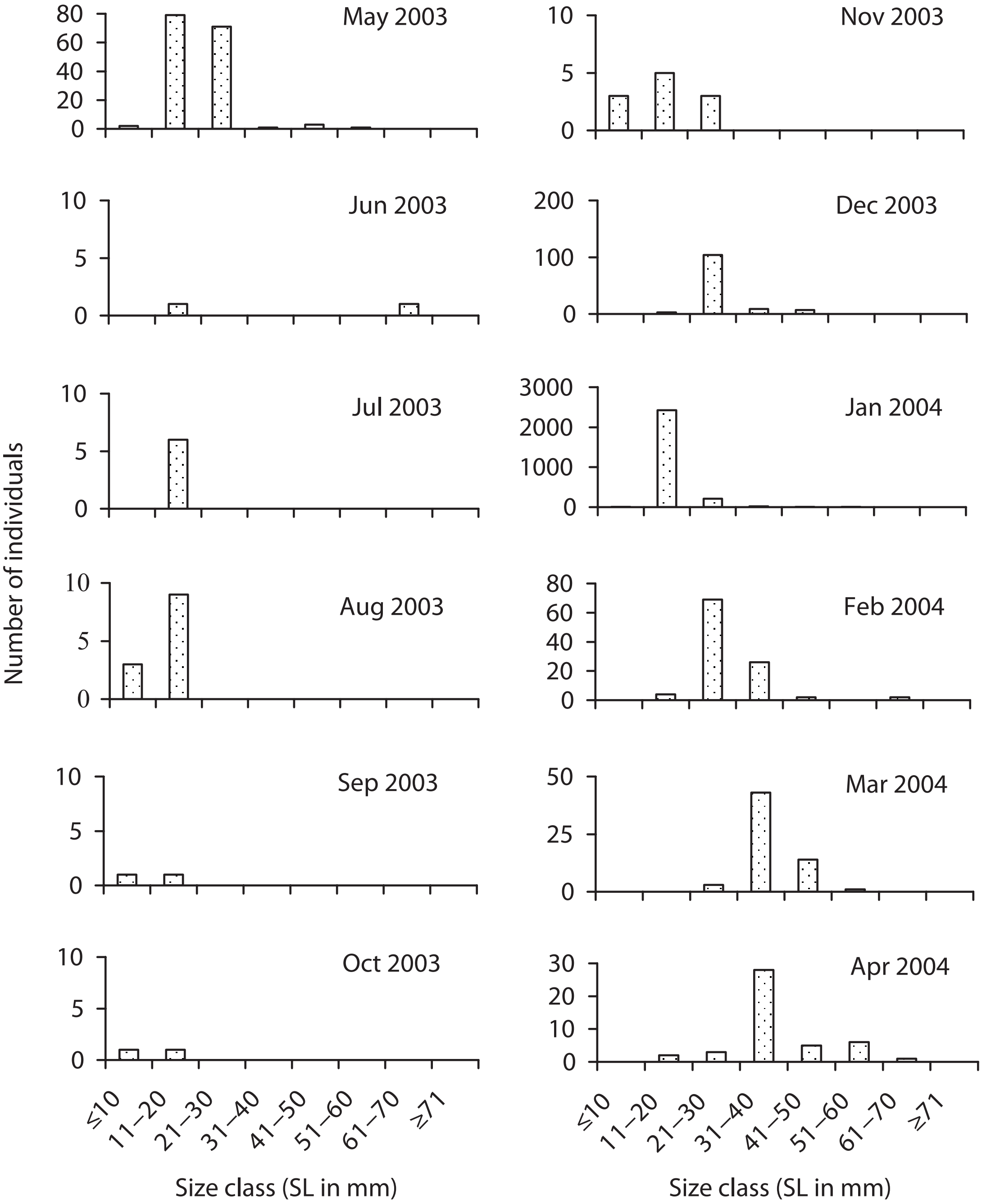

Figure 8 Monthly length frequency distributions of juvenile *Sillago intermedius* collected at Rajamangala Beach, Sikao Bay, from May 2003 to April 2004.

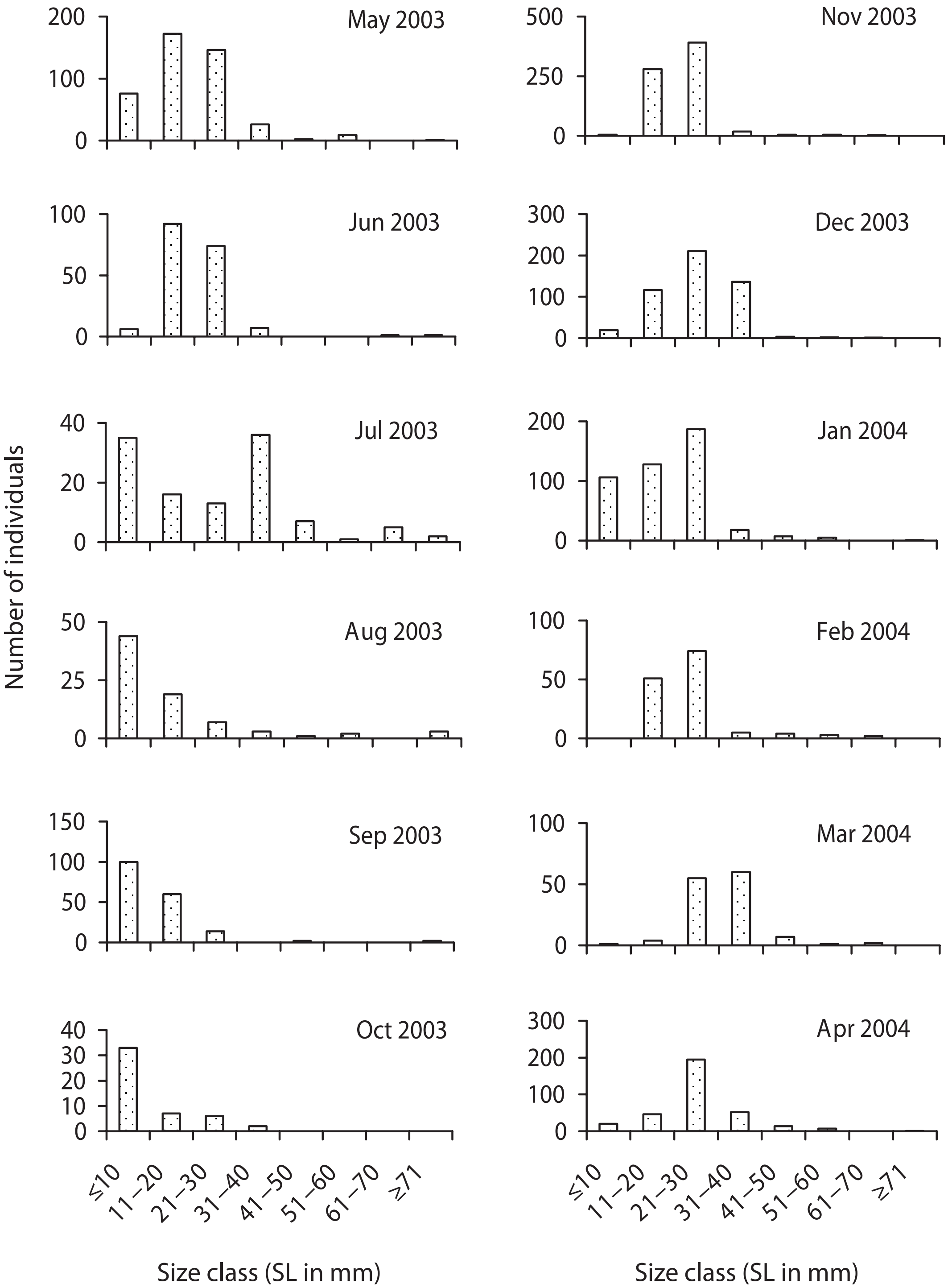

Figure 9 Monthly length frequency distributions of juvenile *Sillago sihama* collected at Rajamangala Beach, Sikao Bay, from May 2003 to April 2004.

Thailand is effected by northeast wind blow; the wave action on the beach is low. The environmental conditions in the dry season and/ or warm season, therefore may be suitable for sillaginid juveniles.

In the present study site, the size frequency distribution showed that both small and large juveniles of *S. sihama* occurred throughout the year, whereas larger juveniles of *S. intermedius* were found only during February and June. This phenomenon suggests that the surf zone of the study beach is more suitable as a juvenile habitat for *S. sihama* rather than for *S. intermedius*.

Although a great number of juveniles of the two species were collected in the surf zone of Rajamangala Beach, most were small juveniles less than 45 mm SL. The lengths of *S. intermedius* never reached 70 mm SL, and those of *S. sihama* rarely exceeded 70 mm SL. Similar findings have been reported in the two species captured from the surf zone in the Philippines (Kato *et al*., 1996). In addition the fishing ground of the two species in this study site (Sikao Bay) is located deeper area. This suggests that both species display an ontogenetic habitat shift from surf zones to offshore and deeper waters. Such size-related movement has been described in other sillaginid species (Hyndes *et al*., 1996; Fowler *et al*., 2002), indicating that shallow nearshore habitats, including surf zones, may function as nursery areas for several sillaginid species (Beck *et al*., 2001).

CONCLUSIONS

The characteristics using in identification between the juvenile of *Sillago intermedius* and *S. sihama* is a systematic blotches of melanophores on the mid-lateral part of the body. The *Sillago intermedius* present that one character and easy to distinguish from the *S. sihama*. The ontogenetic changes in the body proportion and caudal skeleton were similar between the two species. Both species occurred year-round, with a peak abundance in January for *S. intermedius*, and from November to January for *S. sihama*.

ACKNOWLEDGMENT

Thanks are due to John M. Fitzpatrick for helpful comments on the manuscript. Special thanks to colleagues of the Laboratory of Global Fisheries Science, The University of Tokyo and the Department of Marine Science, Faculty of Science and Fisheries Technology, Rajamangala University of Technology Srivijaya, for their help in collecting the specimens. All merits of this paper are dedicated to Pratthana Tongnunui.

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