

CHAPTER 3

RESULTS

1. Taxonomic study

1.1 The shrimp-associated gobiid fishes

In this study, the gobiid fishes living in association with the alpheid shrimps were collected from four stations on Khang Khao Island (A, B, C and D) and one station on Sichang Island (SMaRT). Twelve species of goby belonging to four genera, *Cryptocentrus* Valenciennes, *Amblyeleotris* Bleeker, *Ctenogobiops* Smith, and *Myersina* Herre, were found in this study.

Ctenogobiops and *Myersina* are recorded for the first time in the Thai waters. There are three species found to be new to science, two of *Cryptocentrus* and one of *Amblyeleotris*. One of the two species of *Myersina* could not as yet been identified. List of the shrimp-associated gobies found in this study are shown in Table 2.

Artificial key to species of gobies associated with alpheid shrimps found in this study.

1a	Second dorsal fin with less than 12 soft rays.....	2
1b	Second dorsal fin with more than 12 soft rays.....	10
2a	Gill opening extending below the point between eye and preoperculum. Gill membrane united across isthmus.....	3
2b	Gill opening extending below the point behind preopercular angle.....	4

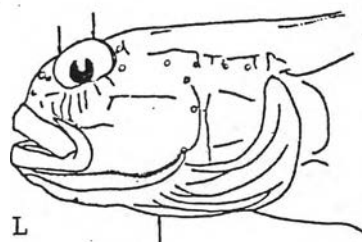
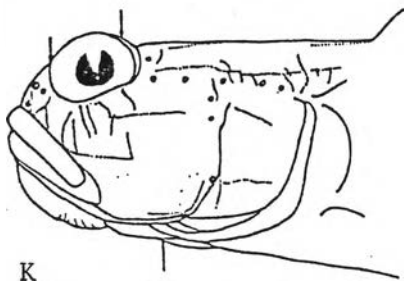
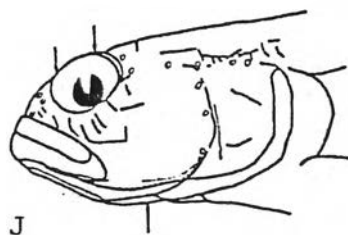
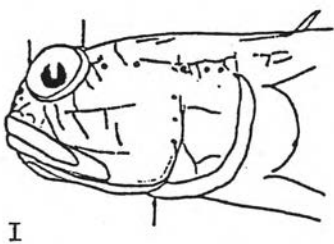
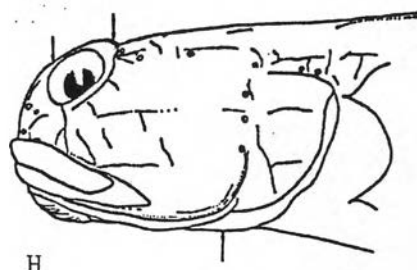
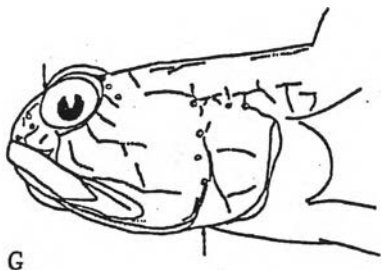
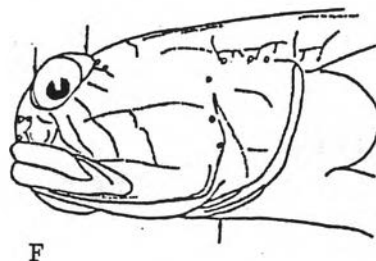
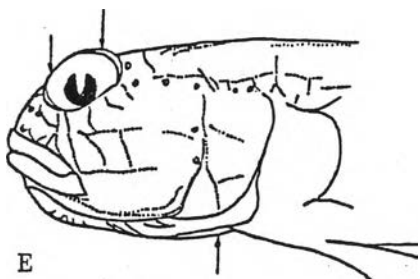
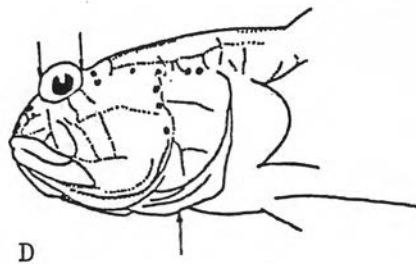
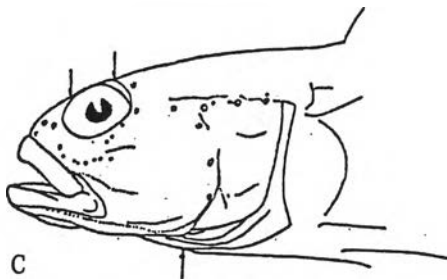
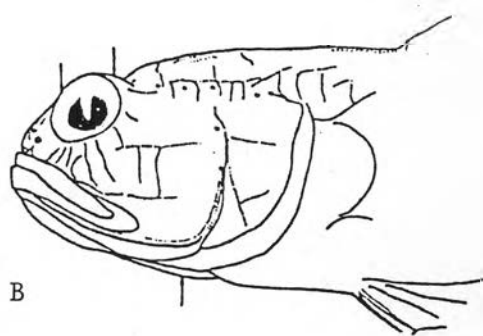
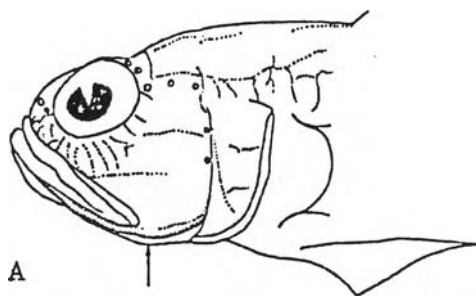
- 3a Caudal fin truncate, longer than head...*Myersina macrostoma*
- 3b Caudal fin round, as long as head.....*Myersina* sp.A
- 4a Sensory line on head well developed.....5
- 4b Sensory line on head poorly developed *Ctenogobiops pomastictus*
- 5a Scales in longitudinal series more than 65.....6
- 5b Scales in longitudinal series less than 65
..... *Cryptocentrus caeruleomaculatus*
- 6a Anal fin with 10 to 11 soft rays.....7
- 6b Anal fin with 9 soft rays.....8
- 7a Head with many pink spots surrounded by blue ocelli
.....*Cryptocentrus singaporensis*
- 7b Head with oblique broken parallel dark blue streak on cheek
and operculum.....*Cryptocentrus cyanotaenia*
- 8a Body with transverse bands or many dark spots.....9
- 8b Body without transverse band or spots but sometimes with many
transverse blue stripes and patches of pale colour on head,
Head and pelvic fin with many blue spots.*Cryptocentrus cinctus*
- 9a Body with 7 unequal transverse bands. Head, second dorsal
fin and anal fin with many tiny yellow lines.*Cryptocentrus* sp.1
- 9b Body with many size of irregular dark spots. Two distinct
longitudinal spots at mouth angle*Cryptocentrus* sp.1
- 10a Second dorsal fin with more than 13 soft rays, pelvic fins
united and frenum well developed.....11
- 10b Second dorsal fin with 13 soft rays, pelvic fins seperated
and frenum poorly developed.....*Amblyeleotris* sp.1
- 11a Second dorsal fin with 15 soft rays, first dorsal fin with
prominent black marking.....*Amblyeleotris fontanesii*
- 11b Second dorsal fin with 18 soft rays, first dorsal fin without
black marking but post ocular with prominent longitudinal
marking.....*Amblyeleotris gymnocephala*

Table 2 List of the gobiid fishes and alpheid shrimps found at Khang Khao and Sichang Islands

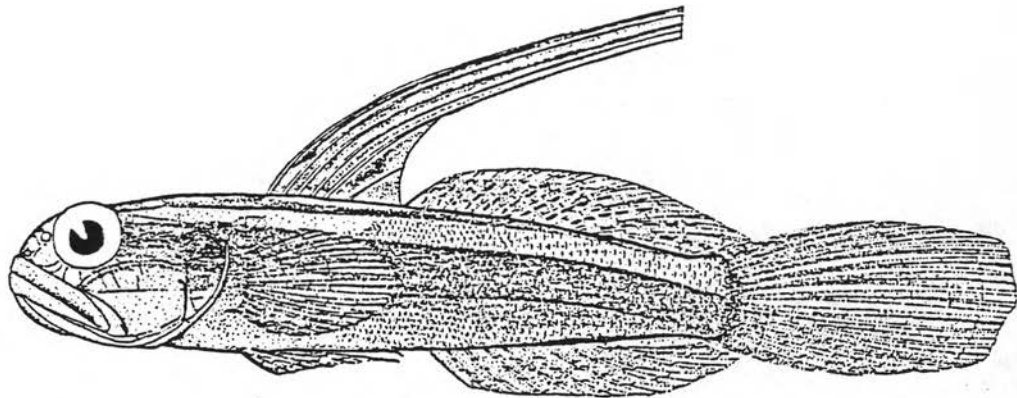
Given code name	Scientific name	St.A	St.B	St.C	St.D	St.SMART	Remark
Gobies							
A	<i>Cryptocentrus cinctus</i> (Herre)	+	+++	-	-	-	dark form
B	<i>Cryptocentrus</i> sp.1	+	+++	++	+	+	
C	<i>Cryptocentrus cinctus</i>	+	++	+	+	+	yellow form
D	<i>Cryptocentrus singaporensis</i> (Herre)	+	++	-	-	+++	
E	<i>Cryptocentrus</i> sp.2	++	++	-	-	++	
F	<i>Cryptocentrus cinctus</i> (Herre)	+	++	-	-	-	patchy form
G	<i>Cryptocentrus caeruleomaculatus</i> (Herre)	+++	++	++	-	+++	
H	<i>Amblyeleotris gymmocephala</i> (Bleeker)	+	+++	-	+	++	
I	<i>Amblyeleotris</i> sp.1	-	++	+	-	-	
J	<i>Ctenogobiops pomastictus</i> Lubbock et Polunin	-	+	-	-	-	
K	<i>Cryptocentrus cyanotaenia</i> (Bleeker)	-	-	-	-	+	
L	<i>Amblyeleotris fontanesii</i> (Bleeker)	+	-	-	-	-	
M	<i>Myersina macrostoma</i> (Herre)	-	-	-	-	++	
N	<i>Myersina</i> sp.A	+	-	-	-	+	
Alpheid shrimps							
α	<i>Alpheus bellulus</i> Miya and Miyake	+	+++	++	+	++	
β	<i>Alpheus djiboutensis</i> De Man	+++	++	+	-	+++	
γ	<i>Alpheus</i> sp.1	+	++	+	+	+	
δ	<i>Alpheus rapacida</i> ?	-	-	-	-	+	
ε	<i>Alpheus</i> sp.A	-	-	-	-	+	
ζ	<i>Alpheus distinguencus</i> De Man	-	-	-	-	+	
η	Uncollected alpheid shrimp	+	+	-	-	+	

Fig. 7 Canal pores and sensory papillae.

- A. *Myersina macrostoma*,
- B. *Myersina* sp.A
- C. *Ctenogobiops pomastictus*
- D. *Cryptocentrus caeruleomaculatus*
- E. *Cryptocentrus singaporensis*
- F. *Cryptocentrus cyanotaenia*
- G. *Cryptocentrus cinctus*
- H *Cryptocentrus* sp.1
- I *Cryptocentrus* sp.2
- J *Amblyeleotris* sp.1
- K *Amblyeleotris fontanesii*
- L *Amblyeleotris gymmocephala*

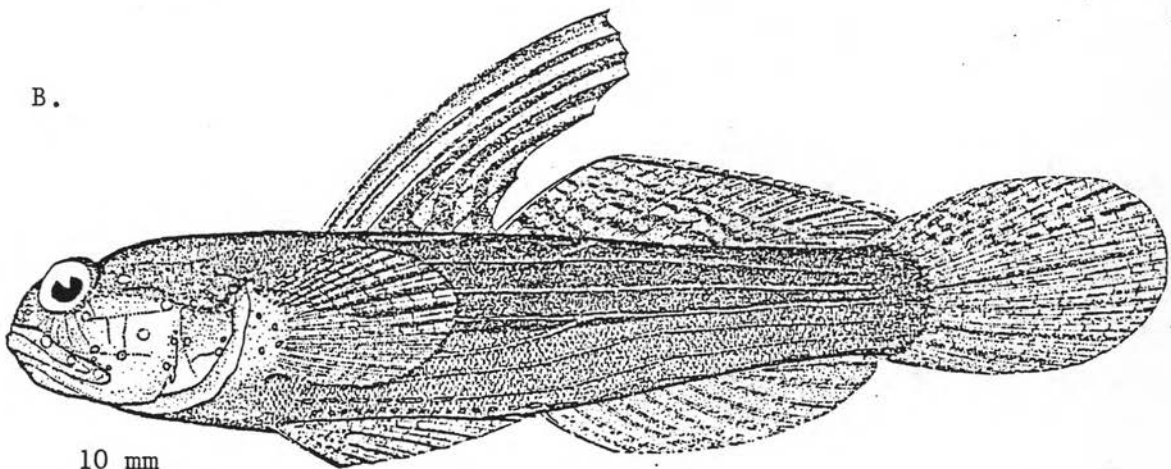


A.



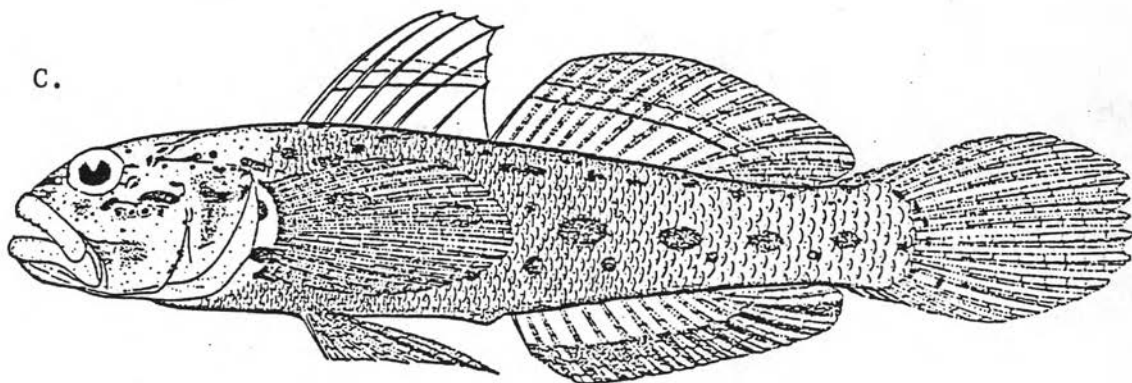
10 mm

B.



10 mm

C.



10 mm

Fig. 8. A. *Myersina macrostoma*, male, 37 mm SL.

B. *Myersina* sp.A, male, 65 mm SL.,

C. *Ctenogobiops pomastictus*, female, 57.5 mm SL.

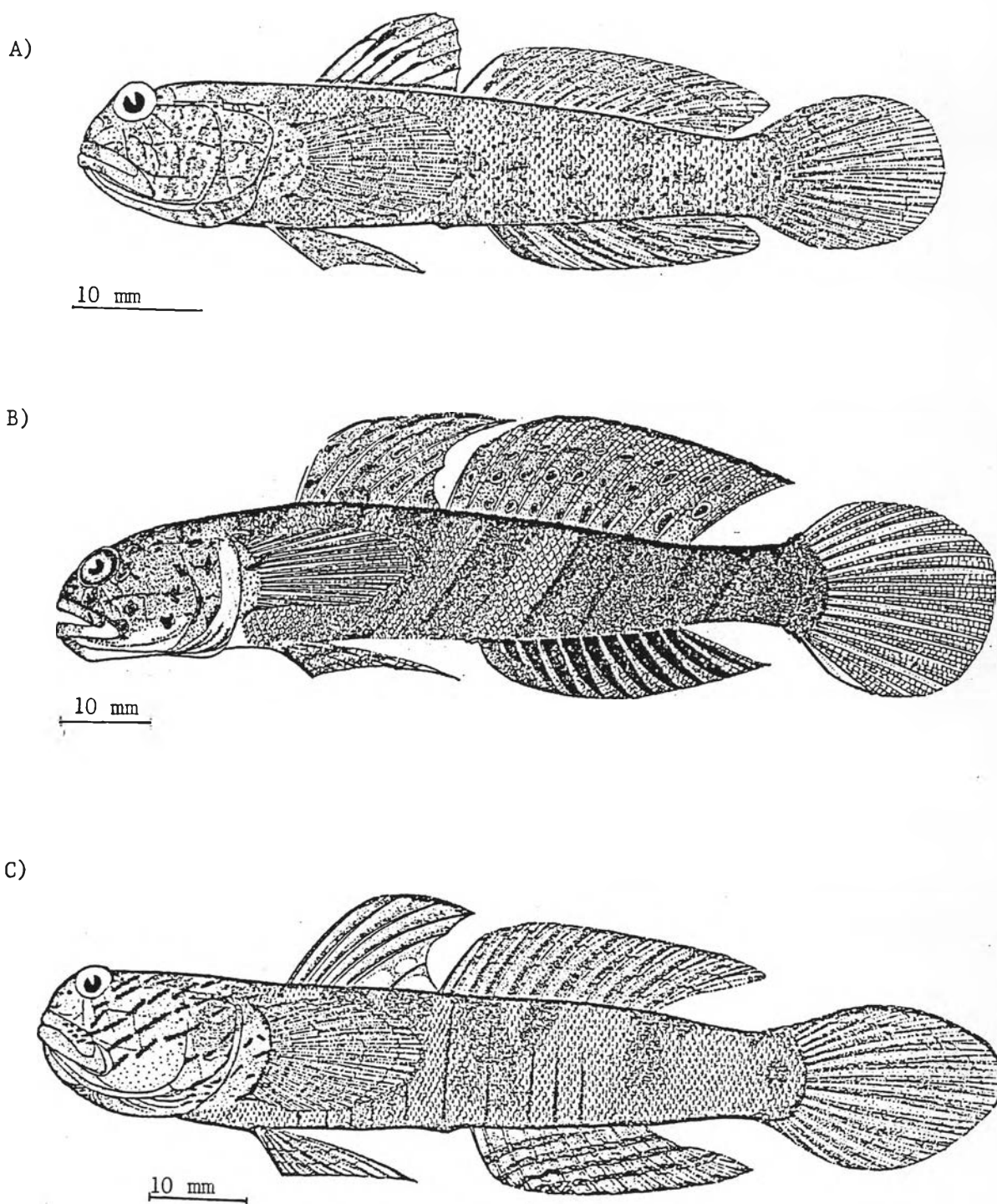


Fig. 9 A. *Cryptocentrus caeruleomaculatus*, male, 54 mm SL.

B. *Cryptocentrus singaporensis*, male, 75 mm SL.

C. *Cryptocentrus cyanotgenia*, female, 78 mm SL.

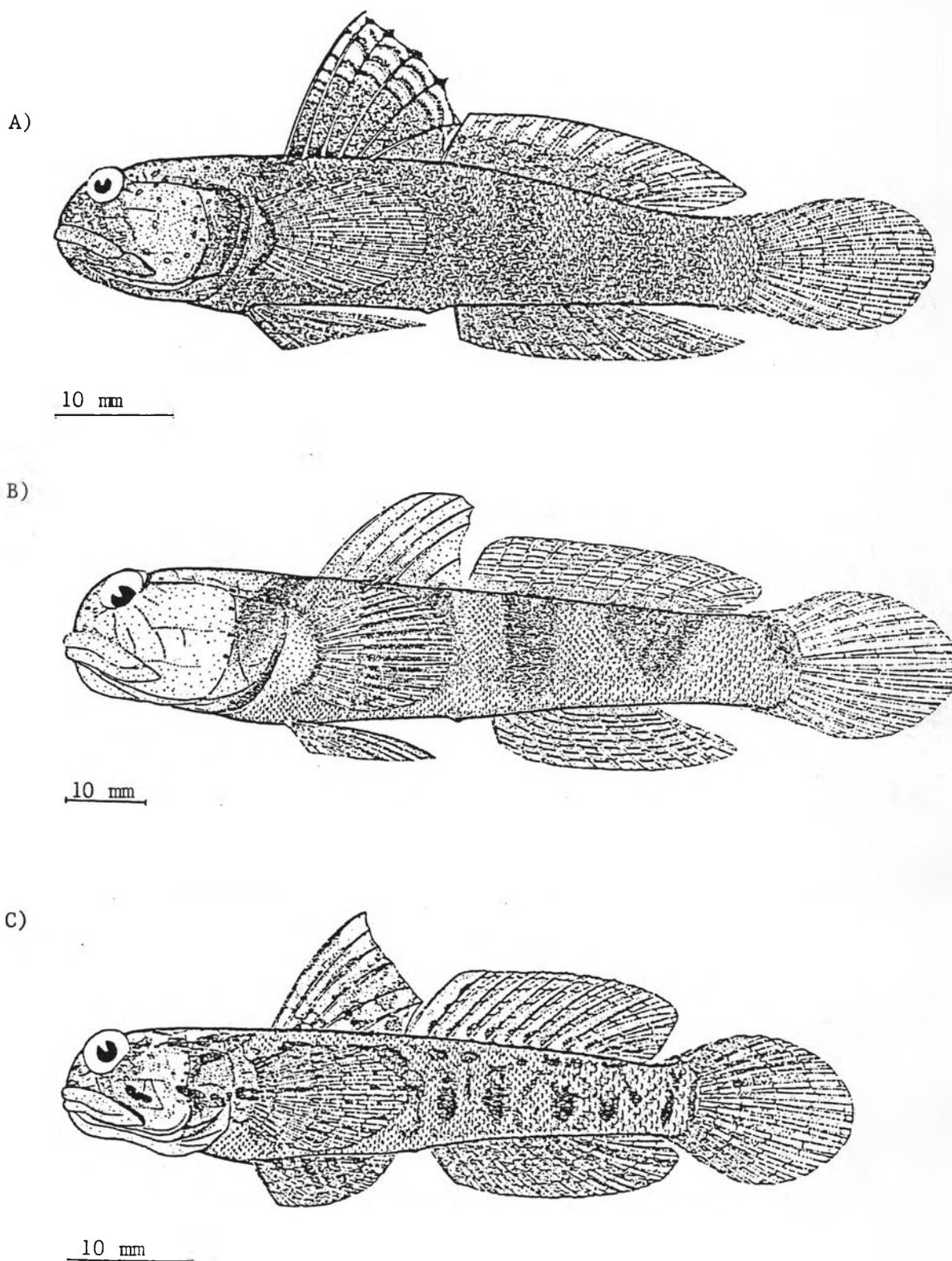
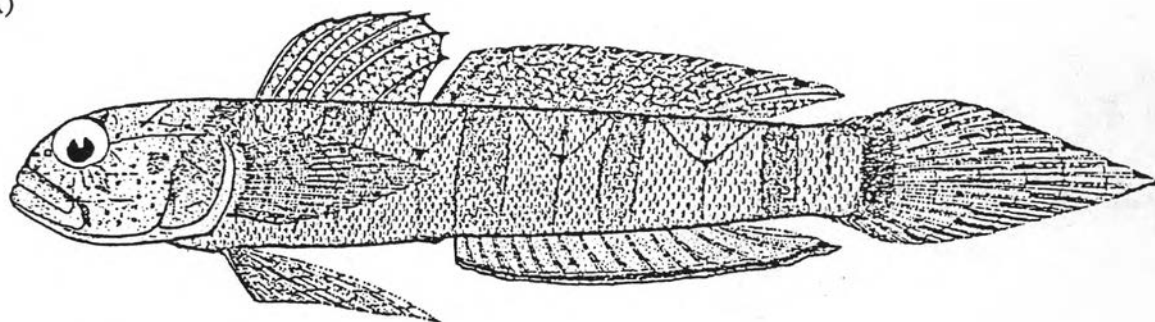


Fig. 10 A. *Cryptocentrus cinctus*, male, 60 mm SL.

B. *Cryptocentrus* sp.1, male, 93 mm SL.

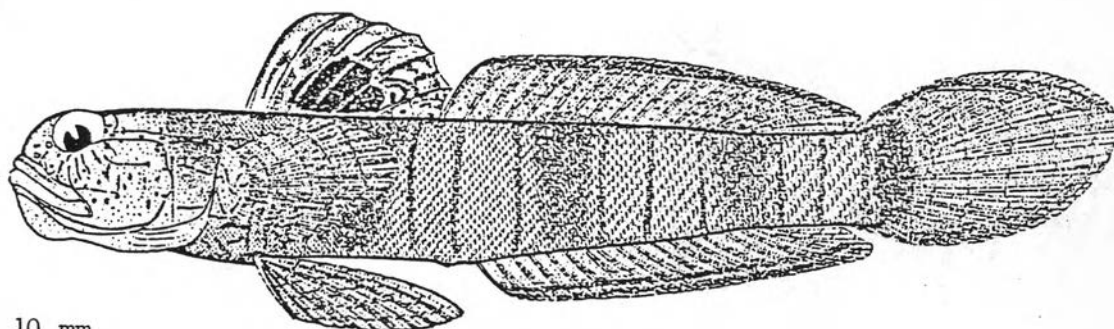
C. *Cryptocentrus* sp.2, female, 50.5 mm SL.

A)



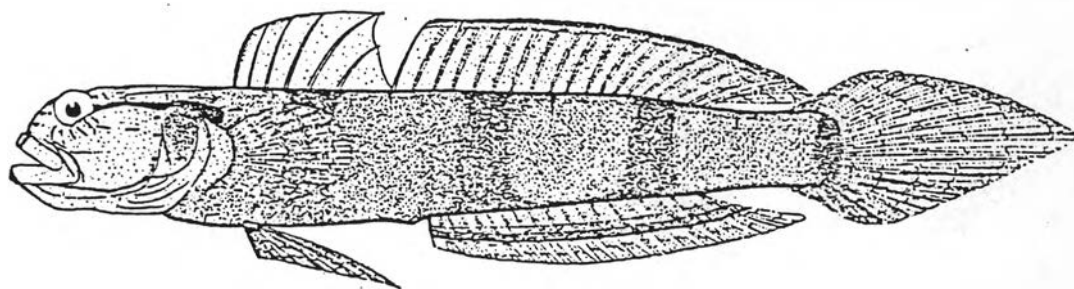
10 mm

B)



10 mm

C)



10 mm

Fig. 11 A) *Amblyeleotris* sp. 1, female, 74 mm SL.

B) *Amblyeleotris fontanesii*, female, 130 mm SL.

C) *Amblyeleotris gymmocephala*, female, 106.5 mm SL.

Myersina macrostoma Herre

Figures 7A and 8A

Myersina macrostoma : Herre, 1934 : 90

Akihito and Meguro, 1978 : 295

Hoese and Lubbock, 1982 : 53

Akihito, Hayashi and Yoshino, 1984 : 259(P1.244)

Meristic counts : D VI-I, 10 ; A I, 9 ; P₁ 16 ; P₂ I, 5 ; LR 55-60 ;

TR 28 ; Pred. S 0

Description : Head large, with large eye 3.0 in head and a big oblique mouth. Gill membranes connected across isthmus under a point between eye and posterior preopercular margin. Canal pores and sensory papillae on head well developed. Anterior interorbital (C) and posterior oculoscapular (K' & L') canal pores absent (Fig.7A). First dorsal fin high, greater than body depth, with some rays prolonged. Caudal fin truncate in male and obtusely rounded in female. Scale cycloid. Body scales reduced, with scales extending forward in wedge from end of base of first dorsal fin to behind pectoral base. Head and belly naked.

Colour in life specimen, head and body light brown. A dark brown spot covering upper half of operculum. A bright blue longitudinal line curving up from mouth, the point below middle of eye, to operculum. A dark board brown stripe extending from eye to base of caudal fin. Back of body dark. First dorsal fin purple with an elongate black mark covering membrane between first two dorsal spine from just above base, fading dorsally. Second dorsal fin with 3-4 rows of red oval spot, upper margin yellow. Anal fin dusky purple. Caudal fin dusky

purple, with yellow and red stripe run alternative in lower part.
Pectoral fins clear. Pelvic fin dusky purple.

Habitat : *Myersina macrostoma* is associated with *Alpheus distinguendus* and another species alpheid shrimp which could not be collected. At Station SMaRT, they were found mostly at the depth of 1-6 m below low tide level and 10-15 m at station A on Khang Khao Island. The substratum of both stations were muddy sand. Single individual was always seen at each burrow. They were usually seen hovering about 5-10 cm above shelter holes.

Size : Maximum length examined 39.3 mm SL., 54.5 mm TL.

Distribution : Philippines, Japan and Gulf of Thailand.

Remarks : *Myersina macrostoma* can be easily distinguished from other *Myersina* by caudal fin which truncate and long in *M. macrostoma* while point or round in other *Myersina*.

Myersina sp.A

Figures 7B and 8B

Meristic counts : D VI-I, ; A I, 9 ; P₁ 17 ; P₂ I, 5 ; LR 90 ; TR 34 ;
Pred. S 0

Description : Head and body moderately compressed, body elongate. Interorbital space narrow. Mouth large, jaw nearly equal, lower jaw slightly protruding and extending to position in line with third way from eye to preopercle. Gill opening wide, gill membranes united across the isthmus. Canal pore and sensory papillae fairly developed (Fig. 7B). Preopercular canal pore without pore N.

First dorsal fin high, greater than body depth, 2nd or 3rd spines longest. Second dorsal fin shorter than body depth. Origin of anal fin at point below 2nd soft ray of second dorsal fin. Caudal fin round, as long as head. Pectoral fin round posteriorly, reaching line vertically midway between 6th ray of first dorsal fin and origin of second dorsal fin. Pelvic fin long, reaching anus; fin united, frenum normally developed. Scales on body all cycloid, embedded. Head and belly naked.

Colour in life specimen, head and body brown on the upper half and creamy below. Body with 8 narrow longitudinal orange lines from behind head to caudal base, some of the lines touch and join each other which made them appeared as branched. The front parts of yellow lines below pectoral fins replaced by several distinct elongate yellow spots. Head and anterior part of the body with many light orange spots. First dorsal fin on 2nd and 3rd interspinous membranes largely yellow and with two curved yellow bands across last spine, the rest of fin bluish grey and darker near tip of fin. Second dorsal fin, lower half with sandwich wave of orange at the middle and blue streaks running posteriorly oblique downward, upper half part with the same streak but running upward; outer margin yellow. Caudal fin light yellow, upper half with series of blue spots running along interspinous membrane and arranged to blue lines alternating with orange lines on the lower half. Anal fin coloured as the low part of the body. Pectoral fin hyaline. Pelvic fins creamy with orange fin rays.

Habitat : *Myersina* sp.A was found from Khang Khao Island at station A, and Sichang Island at station SMaRT, where it was muddy sand bottom,

depths of 8-12 m. This species lived associated with *Alpheus* sp.1 and another species of uncollected alpheid shrimps. Only a single specimen was observed in each burrow. It was always hovering about 5 cm above burrow entrance.

Size : Maximum length examined 74.7 mm SL., 94.4 mm TL.

Distribution : Gulf of Thailand

Remarks : *Myersina* sp.A is similar to *Cryptocentrus crocatus* Wongratana, 1975 both the general body form and colouration, but some character such as apperance of canal pores and pattern of sensory papillae on the head is closed to *Myersina nigrivirgata* Akihito & Meguro, 1983. Presumbly *Myersina* sp.A is possible to be *C. crocatus* (which should be changed to *Myersina crocata*). Because of the original description of *C. crocatus* did not give the characteristics of canal pores and sensory papillae. Hence, these undescribed characters should be studied in the holotype of *C. crocatus* to confirm.

Ctenogobiops pomastictus Lubbock et Polunin

Figures 7C and 8C

Ctenogobiops pomastictus : Lubbock et Polunin, 1977 : 506

Yoshino and Senou, 1983 : 5

Akihito, Hayashi and Yoshino, 1984 : 261

(Pl.244)

Meristic counts : D VI-I 11 ; A I, 11 ; P₁ 17 ; P₂ I, 5 ; LR 56 ;

TR 18 ; Pred. S 0

Description : Head and body moderately compressed, body elongate, Interorbital space narrow. Mouth rather large, lower jaw extending below center of eye. Gill opening rather wide, extending forward below a point slightly behind margin of preoperculum. Sensory papillae on head poorly developed (Fig.7C)

First dorsal fin as high as body depth, 2nd or 3rd spine longest. Anal fin slightly shorter than second dorsal fin, its origin at a point below 1st soft ray of second dorsal fin. Caudal fin lanceolate as long as head. Pectoral fin rounded posteriorly, reaching approximately to position in line with base of third soft-dorsal ray. Pelvic fin united, frenum normally developed. Scales cycloid anteriorly, ctenoid laterally below third or fourth dorsal spine, increasingly ctenoid posteriorly. Head and belly naked.

Colour in life specimen, head and body pale brownish gray with four series of brown spots ; upper most series from nape along dorsal body contour ; second from upper margin of preopercle, lowermost series running on the lower flank of body, consisting of nine small round brown spots. Head with three nearly horizontal rows of brown spots ; uppermost consisting of three spots, arranged along upper margin of cheek and opercle ; second from lower margin of eye to upper end of two spots on base of pectoral fin ; last running posteriorly from posterior margin of upper jaw. A golden diagonal band on nape. Some golden specks on side of head and belly. Snout with dark brown V-shaped marking. Pectoral fin hyaline with a bright white spot. Dorsal fins hyaline with a yellow median stripe, margin pale blue. Pelvic fin membrane becoming dark along inner rays. Caudal fin hyaline with some pale yellow spots on base.

Habitat : *Ctenogobiops pomastictus* was found only from Khang Khao Island, at station B, at edge of coral zone, depths of 3-5 m with the substratum of coarse sand packed with coral debris. This species was found associated with *Alpheus djiboutensis* and *A. bellulus*. It was usually observed sharing the shelter burrow with another one of the same species. It was commonly found leaving its burrow and moved to the surrounding area or to another burrow.

Size : Maximum length examined 56 mm SL., 71.9 mm TL.

Distribution : Australia (Great Barrier Reef), Japan, Thailand (Gulf of Thailand and Andaman Sea).

Remarks : *Ctenogobiops pomastictus* can be easily distinguished from other gobies found in this study by sensory papillae on the head which less developed in *Ct. pomastictus*

Cryptocentrus caeruleomaculatus (Herre)

Figures 7D and 9A

Mars caeruleo-maculatus : Herre, 1933 : 22

Herre, 1934 : 87

Cryptocentrus octofasciatus : Tomiyama, 1936 : 80-81

Mars caeruleo-maculatus : Koumans, 1953 : 21

Yanagisawa 1978 : 278

Cryptocentrus octofasciatus : Akihito, Hayashi and Yoshino, 1984 :
257 (Pl. 243)

Merictic counts : D VI-I, 10 ; A I, 9 ; P₁ 16 ; P₂ I, 5 ; LR 65 ;
TR 20 ; Pred. S O

Descriptions : Head roundish, body elongate and moderately compressed. Interorbital space very narrow, snout obtuse. Mouth rather large slightly oblique, maxillary extending posteriorly to the position nearly quarter way from eye to preopercle. Gill opening rather wide, extending to a point below anterior part of opercle. Canal pore and sensory papillae on head fairly noticeable developed (Fig. 7D).

First dorsal fin lower than body, 2nd or 3rd spine longest. Second dorsal fin as first one. Anal fin as high as second dorsal fin, rounded posteriorly, its origin at a point below 2nd soft ray of second dorsal fin. Caudal fin round, a little shorter than head. Pectoral fin round posteriorly, nearly reaching to position in line with anus. Pelvic fins united, frenum normally developed.

Scales on the anterior half of body small and cycloid becoming larger and ctenoid posteriorly. Head naked.

Colour in life specimen, body dusky olive with 7 or 8 indistinct dark brown transverse bands. Reddish brown speckles on cheek and opercle. Four dark short bars along the middle of body. Many small blue spots on the body. First dorsal fin partially yellow, on the basal half thick vermillion spots, and on the distal half a dusky longitudinal band of the same colour. On the basal half of second dorsal fin pale dusky vermillion spots with yellow background, and along the upper quarter a band of the same colour. Five dark brown bar alternating with yellow bars, inclined backward and downward, across anal fin. Caudal fin pale yellow background with vermillion spots. Pectoral fin semi-transparent. Pelvic fin dusky with four pale vermillion spots arranged longitudinally across pelvic disc.

Habitat : *C. caeruleomaculatus* was found at Sichang and Khang Khao Islands. It was presented in all station excepted station D on Khang Khao Island. It was found along the coral community of station A and at the edge of the coral zone of stations B and C. It was always found near coral heads where substrate was fine sand packed with shell or coral fragments. At station SMaRT, it was found from intertidal zone to sublittoral zone where substratum was fine sand packed with shell fragment. The maximum depth at which they occurred did not exceed 5m below low tide level. This species was found associated with *Alpheus djiboutensis* and *Alpheus* sp.A. It was always found guarding the burrow entrance and its activities were observed to occur near the burrow entrance.

Size : Maximum length examined 52 mm SL., 67 mm TL..

Distribution : Philippines, Japan, Thailand

Remarks : *Cryptocentrus caeruleomaculatus* can be easily distinguished from other *Cryptocentrus* by colouration, notably numerous blue spots on head and body of *C. caeruleomaculatus*.

Cryptocentrus singapurensis (Herre)

Figures 7E and 9B

Smilogobius singapurensis : Herre, 1936 : 13

Cryptocentrus leptocephalus : Smith, 1945 : 554

Smilogobius singapurensis : Kouman, 1953 : 26

Smith, 1959 : 188

Cryptocentrus leptocephalus : Wongratana, 1975 : 8

Cryptocentrus singaporensis : Yanagisawa, 1978 : 271

Akihito, Hayashi and Yoshino, 1984 :

258 (Pl. 243)

Meristic counts : DVI-I ; A I, 10 ; P₁ 18 ; P₂ I, 5 ; LR 75 ; TR 28 ;
Pred. S, 0 ; Gill rakers 4-5+9

Description : Head round, body elongate. Interorbital space very narrow, snout obtuse. Mouth slightly oblique, jaws subequal with lower jaw reaching to a point below the posterior part of eyes. Gill opening rather wide, extending to a point below anterior part of opercle. Canal pores and sensory papillae on head shown in Fig. 7E.

First dorsal fin higher than body, 3rd or 4th spine longest. Second dorsal and anal fins as high as body. Caudal fin round and oblong, as long as head. Pectoral fin rounded posteriorly, nearly reaching to a line vertically through the origin of second dorsal fin. Pelvic frenum normally developed. Scales on body all cycloid. Head naked. Belly scaly.

Colour in life specimen, body creamy with 7 or 8 reddish brown transverse bands running a little obliquely downward and forward. Head and nape ornated with red spots, surrounding by 3-5 small blue spots. Many small blue spots running along back. In male, dorsal fins with many red spots encircled with blue line, and a red stripe along their distal edges ; anal fin dark blue or black with a red longitudinal stripe at the distal part. Posterior part of body, form dark blue or black band at anal fin. In female, dorsal fin with red transverse stripes, parallel to fin rays, and a red stripe along their distal edges anal fin creamy with red

transverse stripes, the distal part with a yellow longitudinal stripe. Colouration on dorsal fin and anal fin show remarkable differences between sexes. Pectoral fin pale creamy. Pelvic fin pale olive - creamy with red longitudinal stripes.

Habitat : In this study, *Cryptocentrus singapurensis* lived associated with *Alpheus djiboutensis*, *A. distinguensis*, *Alpheus* sp.1 and *Alpheus* sp.A. At station SMaRT, they typically occurred where fine sand packed with shell fragment, gravel on fine sand, and coralline rock on fine sand. They were found from intertidal zone to 3m below low tide level. At station A, this species was found living with *A. djiboutensis* where the habitat was with limestone rock on fine sand at fore-reef zone (intertidal). At station B and C, this species was found living with *A. djiboutensis* in coarse sand packed with coral debris at the edge of coral zone, 3-5 m deep. They were always seen guarding the burrow entrance.

Size : Maximum length examined 86 mm SL., 110 mm TL.

Distribution : Singapore, Japan, Gulf of Thailand

Remarks : In each burrow, besides the shrimps, only one *Cryptocentrus singapurensis* was found and there was no evidence that this species lived in pair. *Cryptocentrus singapurensis* can be easily distinguished from other *Cryptocentrus* by colouration, notably red spots which surrounding by small blue spots on head and nape of *C. singapurensis*.

Cryptocentrus cyanotaenia (Bleeker)

Figures 7F and 9C

Gobius cyanotaenia : Bleeker, 1853 : 475

Gunther, 1861 : 71

Cryptocentrus cyanotaenia : Fowler, 1928 : 413

Cryptocentrus wehrleri : Fowler, 1937 : 256

Smith, 1945 : 552

Cryptocentrus cyanotaenia : Koumans, 1953 : 32

Munro, 1967 : 497

Wongratana, 1975 : 6

Meristic counts : D VI-I, 10 ; A I, 10 ; P₁ 18 ; P₂ I, 5 ; LR 86-105 ;
TR 25-36 ; Pred. S 32

Description : Large elongate *Cryptocentrus*, head and body moderately compressed. Mouth large and slightly oblique, maxillary extending posteriorly to position in line with nearly mid-way from eye to preopercle. Interorbital space narrow. Gill opening rather wide, extending forward ventrally to a point below anterior margin of opercle. Canal pore and sensory papillae fairly developed. Posterior otic pore (G) absent (Fig. 7F).

First dorsal fin slightly higher than body, 3rd or 4th spine longest. Second dorsal fin slightly shorter than first. Anal fin as high as second dorsal fin, rounded posteriorly, its origin at a point below 2nd soft ray of second dorsal fin. Caudal fin oblong and round. Pectoral fin round posteriorly, reaching to the position

in line with anus. Pelvic fin rather long, reaching anus ; pelvic fins united, frenum normally developed. Scales all cycloid and embedded. Head partially scaled. Belly and abdomen naked.

Colour in life specimen, this species has many types of colour pattern. It can change its colour very quickly. In this study, this species can be separated into 2 main groups. First is of normal colour pattern and second is of yellow colour pattern. In normal group, colour background greenish yellow with six unequal saddle red-brown blotches. Head with 7 oblique prominent blue broken streaks, upper lip with many blue spots. Prepectoral region and gill membrane also spotted with blue. Membrane of first dorsal fin vertically barred with red and green but with pink and yellow in second dorsal fin. Caudal with upper posterior edge of fin yellowish, longitudinally alternating with violet and blue lines on membrane between rays. Anal fin yellow, distally with 4-5 violet longitudinal stripes. Outer most darker and confined to edge of fin, each stripe bordered above and below by a thin blue streak. Pelvic fin dark violet and finely dotted with blue.

In yellow group, all of the body bright yellow but with blue broken streaks on head and violet longitudinal stripes, which presented in normal group, appeared to red in yellow group.

In some specimens there are twelve equidistant vertical thin blue streaks on the body, which is absent in other specimens. The two groups can be further separated into two sub-group, on the basis of the presence or absence of these blue streaks. This phenomena is the same as in *Cryptocentrus cinctus*.

Habitat : *Cryptocentrus cyanotaenia* was found only at Sichang Island (Station SmaRT) on intertidal and sublittoral zone, depths of 3m, with substratum of fine sand covered with gravel. This species was found associated with *Alpheus rapacida*? and *A. bellulus*. They were always seen guarding the burrow entrance and never move for a long time far from the burrow.

Size : Maximum length examined 96 mm SL., 123.5 mm TL.

Distribution : Gulf of Thailand, Java, West New Guinea, East Indies

Remarks : *Cryptocentrus cyanotaenia* can be easily distinguished from other *Cryptocentrus* by colouration, notably 7 oblique blue broken streaks on head of *C. cyanotaenia*.

Cryptocentrus cinctus (Herre)

Figures 7G and 10A



Smilogobius cinctus : Herre, 1936 : 12

Cryptocentrus cinctus : Akihito, Hayashi and Yoshino, 1984 : 257
(Pl. 243)

Cryptocentrus flavus : Akihito, Hayashi and Yoshino, 1984 : 258
(Pl. 243)

Meristic counts : DVI-I, 10 ; A I, 9 ; P₁ 17 ; P₂ I, 5 ; LR 75-78 ;
TR 26-29 ; Pred. S 0

Description : Head round, body elongate and moderately compressed. Interorbital space very narrow, snout obtuse. Mouth large, maxillary extending posteriorly to the position half way from eye to preopercle.

Gill opening rather wide, extending to a point below anterior part of opercle. Canal pore and sensory papillae fairly developed. Posterior otic pore (G) absent (Fig. 7G).

First dorsal fin higher than body, 3rd or 4th spine longest. Second dorsal fin slightly shorter than first, anal fin shorter than second dorsal fin, its origin at a point below 2nd soft ray of second dorsal fin. Caudal fin round, shorter than head. Pectoral fin round posteriorly, reaching a vertical line at origin of second dorsal fin. Pelvic fin rather long, reaching nearly anus ; pelvic fins united, frenum normally developed.

Scales on body all cycloid. Head naked, the median part of nape, pectoral base with scales. Thorax and belly scaly.

Colour in life specimen, body and head dark brown, cheek pale. Head and anterior part of body with many small bright blue spots. First dorsal fin reddish brown with many light blue spots, at distal part. Spots arranged on zic-zac narrow white streaks. Second dorsal fin brown, darker at base, margin yellow ; many blue spots on basal half and arranged to light blue transverse stripes on the distal half. Caudal hyaline, connecting membrane yellow alternating with vermilion longitudinal stripes. Anal fin dark brown, fin rays with bright blue streaks and spots near base. Pectoral fin hyaline with many light blue spots. Pelvic fin dark brown with numerous tiny blue spots.

In this study, three types of colour pattern in *Cryptocentrus cinctus* were found. From earlier study of Nakaone & Manthachitra (1986), they were named as, 'A', 'C' and 'F'. 'A' was normal type which was described earlier 'C' was yellow type, which all of the

body was bright yellow with bright blue spots on head, body and fins similar to the first one. 'F' was yellowish brown colour background with 3-4 dark brown unequal bands. Furthermore, each type could be separated into two groups. First, the body with 10-12 equidistant vertical thin blue streaks. Second, without vertical streaks. The yellow colour pattern and vertical streaks same as in *C. cyanotaenia*

Habitat : *Cryptocentrus cinctus* was found at Khang Khao and Sichang Islands. It was found on the sandy bottom surrounding the coral zone where the substratum was coarse sand packed with coral and shell fragment, with the depth of 3-6 m. This species was found associated with *Alphus bellulus*, *C. cinctus* was always seen living in pair and also with pair of *A. bellulus*. Pairs with different colour pattern were usually found. They always guard the burrow entrance and their activities occurred around the burrow.

Size : Maximum length examined 61 mm SL., 77 mm TL.

Distribution : Singapore, Japan, Gulf of Thailand

Remarks : *Cryptocentrus cinctus* can be easily distinguished from other *Cryptocentrus* by colouration, notably many blue spots on head of *C. cinctus*.

Cryptocentrus sp.1

Figures 7H and 10B

Meristic counts : D VI-I, 10 ; A I, 9-10 ; P₁ 18 ; P₂ I, 5 ; LR 75-80 ; TR 32-35 ; Pred. S 35

Description : Big head with elongate body and moderately compressed. Interorbital space very narrow, snout obtuse. Mouth large, maxillary reaching to position in line with nearly half way from eye to preopercle. Gill opening rather wide, extending to a point below preopercle angle. Canal pore and sensory papillae less developed. Posterior otic (G), posterior oculoscapular (K' & L') and peopercular pore reduced, absent or present but very small (Fig. 7H).

First dorsal fin as high as body, 2nd or 3rd spine longest. Second dorsal fin as first. Anal fin shorter than second dorsal fin, its origin at a point below 2nd soft ray of second dorsal fin. Caudal fin round, slightly shorter than head. Pectoral fin round posteriorly, reaching a line vertically midway from 6th ray of first dorsal fin to origin of second dorsal fin, pelvic fin rather long, reaching nearly to anus ; fins united, frenum normally developed.

Scale on body all cycloid. Head partially scaly, embedded. Thorax and belly scaly.

Colour in life specimen, head and body creamy with 7 unequal and somewhat oblique brown bands ; first running oblique from upper part of opercle to origin of first dorsal fin ; second below 3rd to 5th ray of first dorsal fin ; third is short, below 6th ray of first dorsal fin to origin of second dorsal fin ; fourth below 2nd to 5th soft ray of second dorsal fin ; fifth short, below 7th to 8th soft ray of second dorsal fin ; sixth oblique running anteriorly downward and fuse with fifth band, to form V shaped band ; last on caudal peduncle. Head and anterior part of body with many broken tiny yellow lines. First dorsal fin light brown with blue lines. Second dorsal

fin brown with many longitudinal yellow wavy lines, upper margin colourless. Caudal fin brown, membrane with longitudinal blue alternating with yellow streaks. Anal fin brown, with longitudinal blue alternating with vermillion streaks. Pectoral hyaline at middle part. Pelvic fin brown with many yellow and blue spots.

Two other colour patterns of this species were found in this study. First with very dark brown body and head (almost black). The other yellow throughout the head and body but the specimen rarely found.

Habitat : *Cryptocentrus* sp.1 was found at Khang Khao and Sichang Island. It was most abundant at station B on Khang Khao Island, at the sandy bottom surrounding coral zone, depths of 5-8 m below low tide level. The substratum was coarse sand packed with coral and shell fragments. This species found associated with *Alpheus bellulus* and *Alpheus* sp.1. It was usually seen singly but sometimes occurred in pairs. It always guarded the burrow entrance and its activities were confined to the area around the burrow entrance.

Size : Maximum length examined 93 mm SL., 114mm TL.

Distribution : Thailand

Remarks : *Cryptocentrus* sp.1 is similar to *C. fasciatus* (Playfair, 1866). It can be distinguished from *C. fasciatus* by colouration, notably the position of bands on the body, and development of sensory papillae on head in which *Cryptocentrus* sp.1 is less develop than *C. fasciatus*

Cryptocentrus sp.2

Figures 7I and 10C

Meristic counts : D VI-I, 10 ; A I, 9 ; P₁ 17 ; P₂ 15 ; LR 75-85 ; TR 23-25 ; Pred. S 0

Description : Head round, body elongate, moderately compressed. Interorbital space very narrow, snout obtuse. Mouth large, maxillary reaching to position in line with nearly half way from eye to preopercle. Gill opening rather wide, extending posteriorly to a point below posterior part of preopercle. Canal pore and sensory papillae fairly developed (Fig 7I).

First dorsal fin as high as body, first spine longest. Second dorsal fin slightly shorter than first. Anal fin slightly shorter than second dorsal fin, its origin at a point below midway between 1st and 2nd soft ray of second dorsal fin. Caudal fin round, slightly shorter than head. Pectoral fin round posteriorly, reaching in line with origin of second dorsal fin. Pelvic fin long, reaching to genital papillae ; fins united, frenum normally developed. Scales on body all cycloid. Head naked. Thorax and belly scaly, embedded.

Colour in life specimen, head and body light brown with ten patchy brown bands, darker on dorsal and paler on ventral. Six to eight short dark brown bars along middle of body. Head with many light blue spots and three horizontal rows of prominent dark brown longitudinal spots ; upper most consisting of 4-5 spots, arranged along upper margin of cheek and opercle ; second with 2-3 spots running posteriorly from middle of cheek to middle of

opercle ; last on posterior part of mouth. Pectoral fin hyaline, with a dark brown longitudinal spot at base. First dorsal fin hyaline with three board dark band running across fin ray. Second dorsal fin hyaline with brown streaks on each fin ray. Caudal fin hyaline, membrane with longitudinal yellow streaks alternating with vermillion. Anal fin dark brown. Pelvic fin with sandwich transverse band of vermillion (middle) and blue alternating with yellow bands. Yellow colour pattern also found for this species. A specimen of the yellow form was caught and after kept in aqurium for 3-4 hours, its colour changed to the normal colour pattern. That specimen was a female.

Habitat : *Cryptocentrus* sp.2 was found at Khang Khao(stations A and B) and Sichang Islands, at the area sunounding coral zone, depth of 3-10m. Substratum of the area closed to coral zone consisted of course sand packed with coral fragment, whereas the area at the depths of 8-10m consisted of muddy sand. This species live associated with *Alpheus* sp.1, *A. bellulus* and an uncollected species. It was found singly and always seen guarding the burrow entrance.

Size : Maximum length examined 68 mm SL., 85 mm TL.

Distribution : Gulf of Thailand, Japan (Yoshino per. comm.)

Remarks : *Cryptocentrus* sp.2 is similar to *C. cinctus* (Herre, 1936). It can be distinguished from *C. cinctus* by colouration. In *Cryptocentrus* sp.2, colour background is creamy with many irregular marking on the body but in *C. cinctus*, colour background is uniformly reddish brown.

Amblyeleotris sp.1

Figures 7J and 11A

Meristic counts : D VI-I, 13 ; A I, 14 ; P₁ 18 ; P₂ I, 5 ; LR 82-85 ; TR 24 ; Pred. S 0

Description : Head round, body elongate, compressed. Interorbital space very narrow, snout obtuse. Mouth oblique, jaw nearly equal, lower jaw reaching a point below posterior part of pupil. Gill opening very wide, extending anteriorly to a point below half way between the posterior margin of eye and margin of preopercle. Canal pores and sensory papillae on head fairly developed (Fig. 7J).

First dorsal fin as high as body, 4th spine longest. Second dorsal fin slightly shorter than first. Anal fin as high as second dorsal fin, its origin at a point below 2nd soft ray of second dorsal spine. Caudal fin oblong, slightly longer than head. In male, caudal fin lanceolate but pointed in female. Pectoral fin rather pointed posteriorly, reaching to a point below origin of first dorsal fin. Pectoral fin separated, connecting membrane present at base, frenum absent.

Scales on anterior part of body small, cycloid, larger and ctenoid posteriorly. Head and belly naked.

Colour in life specimen, head and body creamy, back olive creamy, with six transverse orange band bordered by golden lines. Inter-banding space with transverse golden lines, on midline with upside-down golden triangle, with broken golden line connected between each side of triangle base to upper part of the band at that

side, at half of connecting line with enlarge golden spots ; on upper quarter of inter-banding line also with enlarge golden spots. Head with many tiny yellow and blue spots, longitudinal orange brown spot above posterior part of maxillary. B', C and D pore with reddish-orange. Upper part of posterior of eye dark brown with short dark brown bar ; dorsal golden line running from middle part of upper margin of cheek to midway from eye to first dorsal fin. All fins yellow. Interspinous membranes of first, second dorsal fins and upper part of caudal fin with numerous small pale yellow circle centered with orange dots. Upper margin of first dorsal fin with blue and pinkish-red streaks. Upper margin of second dorsal fin with pinkish-red spots on longitudinal wavy blue streaks. Caudal fin ; upper margin with some pattern similar to second dorsal fin but arranged longitudinally ; half way to upper margin with dark longitudinal blue spots ; lower half of lower margin with longitudinal pinkish-red spots circled with grey-blue line. Anal fin, lower margin with longitudinal sandwich of board orange (middle) and thin greyish-blue streaks.

Habitat : *Amblyeleotris* sp.1 was found only at Khang Khao Island (Stations B & C), could be considered as a rare species of this area. It was found on sandy bottom surrounding coral zone, where it was coarse sand packed with coral fragments. This species was found associated with *Alpheus bellulus*. Behaviour closely resembled that of *A. fontanesii* and *A. gymnocephala*.

Size : Maximum length examined 72 mm SL., 99 mm TL.

Remarks : *Amblyeleotris* sp.1 is similar to *A. latifasciata* Polunin & Lubbock, 1979. It can be distinguished from *A. latifasciata* by

the number of soft anal rays which are 13 in *A. latifasciata* while 14 in *Amblyeleotris* sp.1 and by colouration, notably the golden marking between each band on the body in *Amblyeleotris* sp.1 but absent in *A. latifasciata*

This species was first collected from Chuang Island, Sattahip, further down on the eastern part of the Gulf of Thailand and after also found at Sak, Lan, Phai and Manwichai Islands which is closer to Sichang Island as well.

Amblyeleotris fontanesii (Bleeker)

Figures 7K and 11B

Gobius fontanesii : Bleeker, 1852 : 764

Gunther, 1861 : 74

Cryptocentrus fontanesii : Herre, 1927 : 242

Biat luzonicus : Herre, 1927 : 246

Cryptocentrus fontanesii : Koumans, 1953 : 89

Wongratana, 1975 : 10

Meristic counts : D VI-I, 15 ; A I, 16 ; P₁ 19 ; P₂ I, 5 ; LR 110 ; TR 31 ; Pred. 5 23

Description : Larger size among other species of *Amblyeleotris*, with elongated body, snout blunt. Interorbital narrow, mouth moderately large and slightly oblique, maxillary extending forward ventrally to position half way between eye and posterior margin of preopercle. Canal pore and sensory papillae shown in Fig. 7K.

First dorsal fin as high as body, 3rd or 4th spine longest. Second dorsal fin and anal fin equally high, shorter than first dorsal fin. Origin of anal fin at a point below 1st soft ray of 2nd dorsal fin. Caudal fin round and oblong, as long as head. Pectoral fin round posteriorly, reaching to the position between 6th spine of first dorsal fin and origin of second dorsal fin. Pelvic fin long, reaching anterior of anal fin ; pelvic fins united, frenum normally developed. Scales cycloid anteriorly, becoming ctenoid posteriorly with larger size. Anterior scales on upper part of body embedded.

Colour in life specimen, head and body light brown with five dark brown transverse bands. In the space between each band, with three bright yellow stripes running across the body. Snout darker; head with scattered small bright yellow spots. In some specimens, chin with a small black spot on each side. First dorsal fin dusky with a large black mark on middle of fin, surrounded with bright yellow striped, margin orange. Second dorsal fin reddish brown, scattered with orange spots; margin with bright blue and dark reddish brown stripes. Caudal fin pale yellow or orange, upper margin and lower margin with sandwich of two bright blue and an orange stripes. Anal fin pale yellow with sandwich of three bright blue and two reddish brown stripes at lower margin. Pelvic fin dark, membrane dark blue and fin rays reddish brown. Pectoral fin colourless.

Habitat : *Amblyeleotris fontanesii* was found only at Khang Khao Island (Station A) where it was muddy sand bottom, depth of 8-12 m. This species was found associated with *Alphens* sp.1. Only single fish observed in each burrow. It usually guarded burrow entrance or moved to adjacent burrows for a few minutes then moved back.

Size : Maximum length examined 127 mm SL., 163 mm TL.

Distribution : Philippines, Obimajor, Ambon, Celebes, Java, Sumatra, Japan and Gulf of Thailand.

Remarks : *Amblyeleotris fontanesii* can be easily distinguished from other *Amblyeleotris* by soft dorsal fin rays and colouration, notably black marking on first dorsal fin of *A. fontanesii*

Amblyeleotris gymnocephala (Bleeker)

Figures 7L and 11C

Gobius gymnocephalus : Bleeker, 1853 : 473

Gunther, 1861 : 792

Day, 1889 : 249

Cryptocentrus gymnocephalus : Smith, 1932 : 82

Smith, 1945 : 555

Koumans, 1953 : 92

Fowler, 1982 : 1306

Wongratana, 1975 : 11

Meristic counts : D VI-I, 18 ; A I, 18 (19) ; P₁ 15 ; P₂ I, 5 ;

LR 118, TR 35 ; Pred. S 0

Description : Large elongate *Amblyeleotris*, head and body moderately compressed. Mouth rather large, gape oblique, maxillary extending posteriorly to the position in line with middle of eye. Interorbital space narrow. Gill opening moderately wide, extending forward ventrally to position half way between eye and posterior margin of preopercle. Canal pore and sensory papillae shown in Fig. 7L.

First dorsal fin as high as body, 5 th dorsal spine longest. Second dorsal fin as high as first. Anal fin slightly shorter than second dorsal fin, its origin at a point below 2nd soft ray of second dorsal fin.

Caudal fin oblong and pointed. Pectoral fin round posteriorly, reaching to position between 6 th spine of first dorsal fin and origin of second dorsal fin. Pelvic fin rather long, reaching to genital papillae ; pelvic fins united, frenum normally developed.

Scales cycloid anteriorly, ctenoid posteriorly with larger size. Head partially scaled, but scales partly embedded.

Colour in life specimen, head and body olive creamy with five dark reddish brown bands. Interspace between 2nd-3rd-4th and 5th bands with short dark stripes running from back to upper quarter of the body. Anterior part of upper lip with thin reddish brown stripes. Chin reddish brown. Gill membrane orange. A prominent longitudinal dark brown postocular band along the supraopercular groove. Double lines of blue and orange (blue lower) running from mid posterior edge of eye to origin of first dorsal fin. First dorsal fin creamy, margin with reddish brown. Second dorsal fin creamy, margin with double stripes of blue (inner) and reddish brown (outer). Caudal fin creamy, upper margin with reddish brown line, connecting membrane of lower part blue alternated with reddish brown. Upper half of anal fin creamy, three longitudinal stripes of blue reddish brown and black running through middle of fin ; outer half transparent. Pelvic fin dark. Pectoral fin dusky.

Habitat : *Amblyeleotris gymnocephala* was found at Sichang and Khang

Khao Islands on the sandy bottom somewhat away from coral zone, with the depth of 6-10m. At Sichang Island, station SMaRT, the substratum was muddy sand whereas at station B on Khang Khao Island was coarse and packed with coral and shell fragments. This species was found associated with *Alpheus bellulus* and *Alpheus* sp.1 Behaviour closely resembled *A. fontanesii*.

Size : Maximum length examined 105 mm SL., 139 mm TL.

Distribution : Hong Kong, Java, Burma, Madras and Gulf of Thailand,

Remarks : Coloration of this species varied. Some specimens collected from depths of 25m, found to have the whole body dark reddish brown without visible marking. However after kept in aquarium for three days, the colour changed to normal.

1.2 The gobies-associated alpheid shrimps

In this study, the alpheid shrimps living in association with gobiid fishes were collected from Khang Khao and Sichang Islands. Six species of alpheid shrimps belonging to the Brevirotris Group of the genus *Alpheus* Fabricius were collected in this study. However, one species was found but specimen could not be collected. List of the alpheid shrimps living in association with the gobiid fishes found in this study is shown in Table 2.

Artificial key to species of alpheid shrimps associated with gobies found in this study.

- 1a Large chela with transverse groove behind dactylus.....2
- 1b Large chela without transverse groove behind dactylus *Alpheus* sp.1

- 2a Rostrum carina extending posteriorly to mid-dorsal carapace..3
- 2b Rostrum carina extending posteriorly to base of orbital hood.4
- 3a Carapace and abdomen with transverse band. In male, small
chela is sub-balaenicap shape.....*Alpheus rapacida* ?
- 3b Carapace and abdomen without transverse band, abdomen with
longitudinal streaks. In male, small chela is true balaenicep
shape.....*Alpheus distinguendus*
- 4a Carapace and abdomen with transverse bands.....5
- 4b Carapace and abdomen without transverse band but scattered
numerously with spots of various shape.....*Alpheus* sp.A
- 5a Band colour olive green.....*Alpheus djiboutensis*
- 5b Band colour brownish purple.....*Alpheus bellulus*

Alpheus sp.1

Figures 18A-C and 19A

Description : Rostrum acute reaching near end of first antennular article. Rostral carina extending posteriorly to mid-dorsal carapace. Orbitorostral grooves moderately deep. First and third antennular articles sub-equal, second article 2.8 times as long as broad. Stylocerite acute, reaching nearly end of first antennular article. Scapocerite with strong lateral spine, reaching beyond antennules. Carpocerite reaching tip of antennular peduncle.

Large chela without transverse groove behind dactylus. Small chela nearly equal fingers, normal shaped in male.

Carpal articles of second pereopod with ratio ; 10 : 10 : 4
: 4 : 6.5

Fig. 12 Important characteristics of some species of alpheid
shrimps. Bars indicated 10 mm .

A, B, C Large chela, small chela and second leg of *Alpheus* sp.

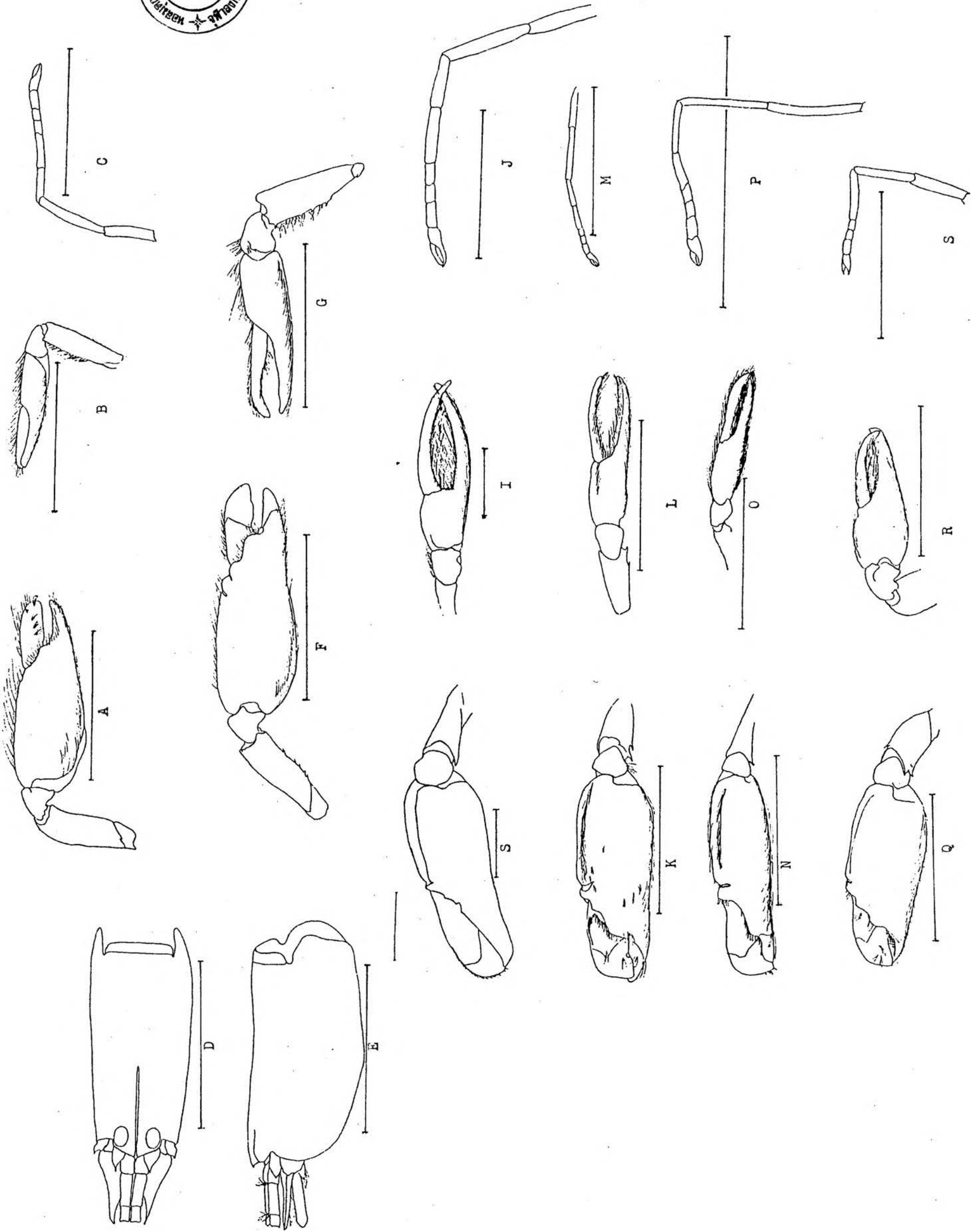
D, E, F, G dorsal view, lateral view of carapace, large chela
and small chela of *Alpheus rapacida* ?

H, I, J Large chela, small chela and second leg of
Alpheus distinguendus

K, L, M Large chela, small chela and second leg of
Alpheus sp. A

N, O, P Large chela, small chela and second leg of
Alpheus djiboutensis

Q, R, S Large chela, small chela and second leg of
Alpheus bellulus



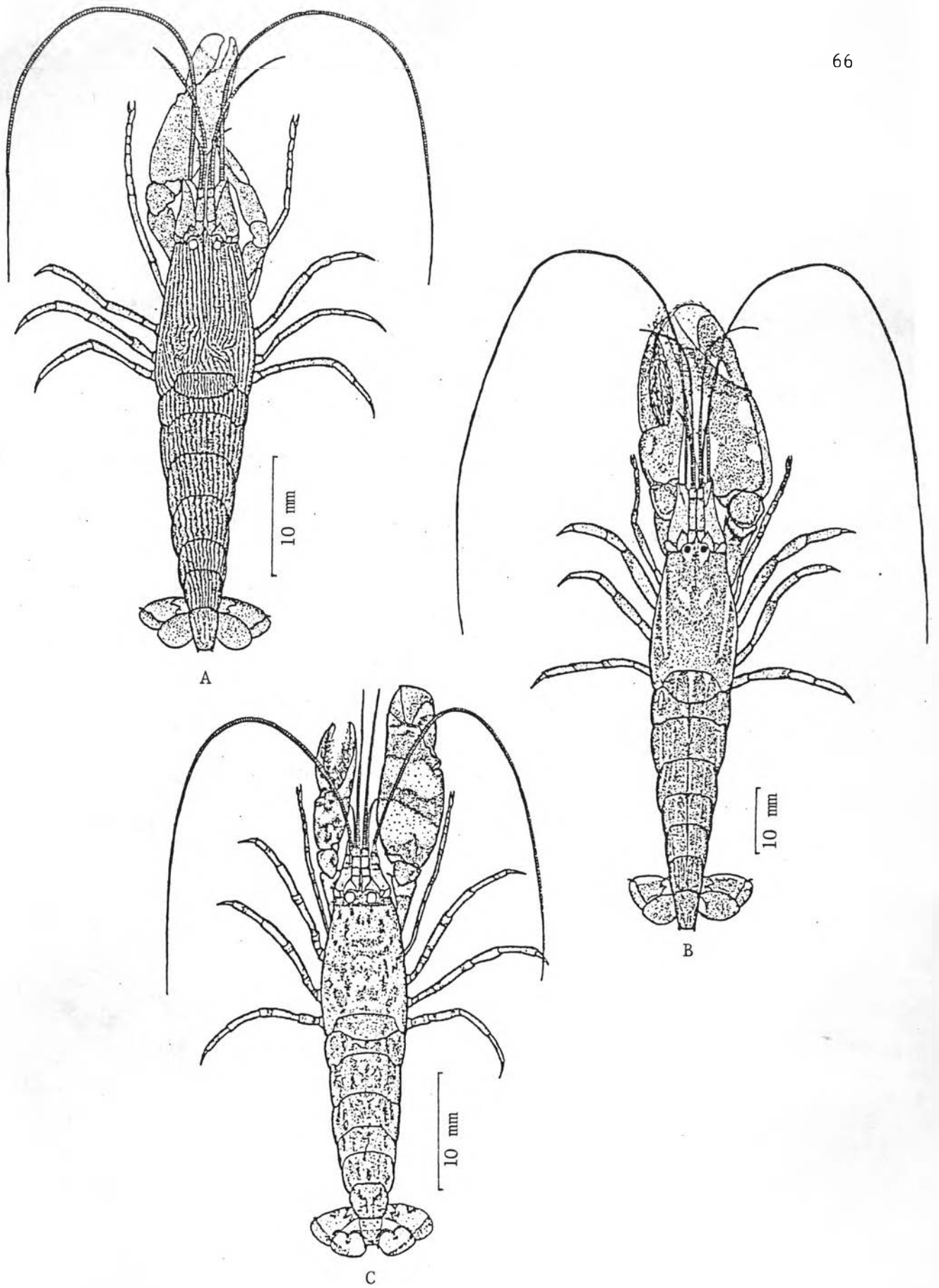


Fig. 13 A. *Alpheus* sp.1 female, 12 mm CL.
 B. *Alpheus distinguendus*, male, 17.5 mm CL.
 C. *Alpheus* sp.A, male, 11 mm CL.



Fig. 14 Picture of live *Alpheus rapacida*?(male)

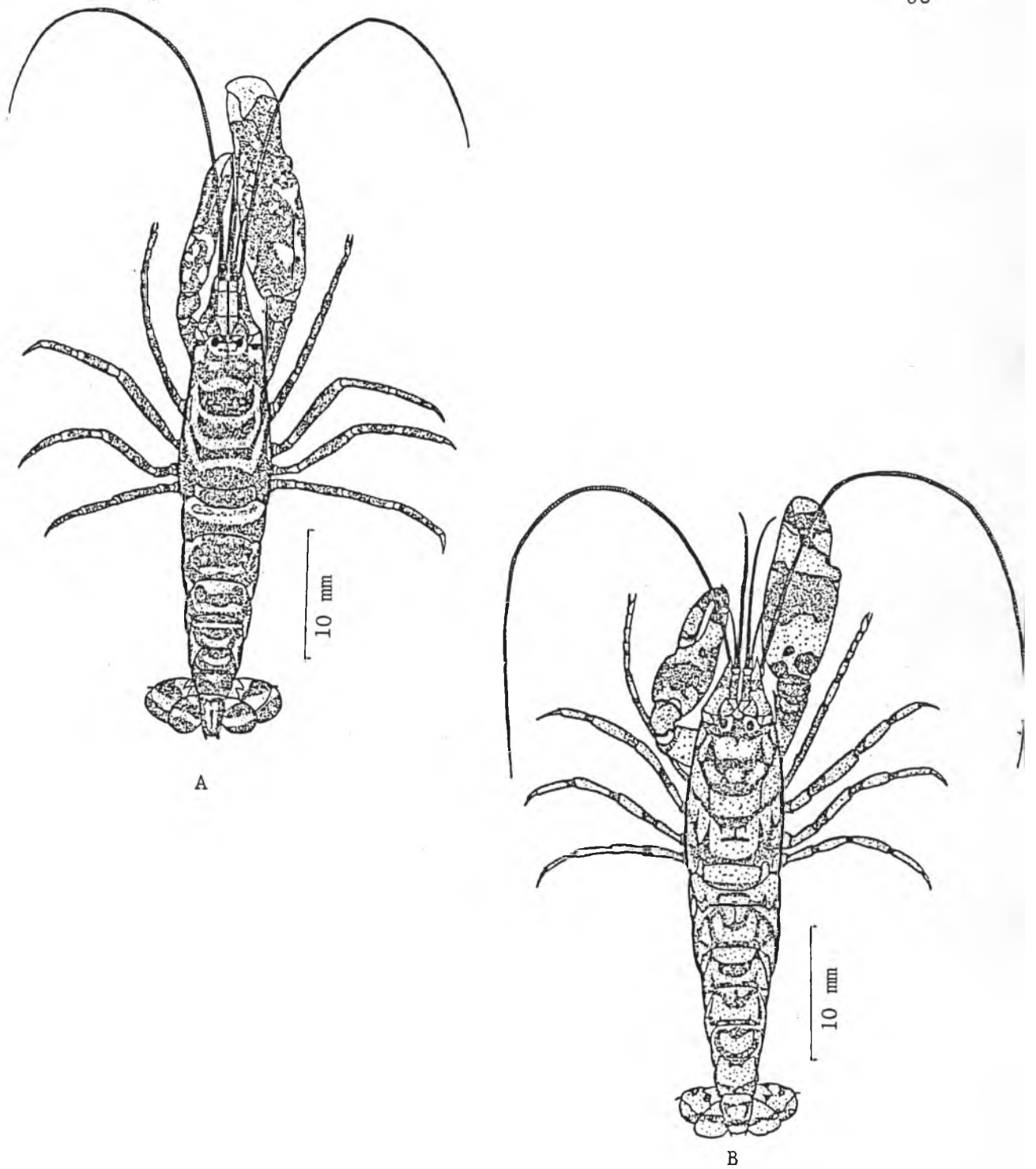


Fig. 15 A. *Alpheus djiboutensis*, female, 12.5 mm CL.
B. *Alpheus bellulus*, male, 12 mm CL.

Third leg, dactylus spatulated instead of styliform; merus unarmed.

Colour in life specimen, ground colour of entire animal, vermilion. Carapace and abdomen with thin longitudinal wavy transparent lines. Antennules colour prominent dark vermilion. Large chela vermilion, white at half margin of dactylus. Small chela vermilion, tip of finger white. Walking legs vermilion with transparent angles. Tail fans transparent scattered with vermilion.

Habitat : *Alpheus* sp.1 was collected from Khang Khao and Sichang Islands, at sublittoral zone, depths of 4-12 m, where substratum of the shallower part with coarse sand packed with shell and coral fragments, whereas the deeper part with muddy sand. The goby-partners of this species are *Cryptocentrus* sp.2, *Amblyeleotris fontanesii*, *A. gymnocephala* and *Myersina* sp. A. *Alpheus* sp.1 always form a shallow depressor extending on the bottom surface from the burrow entrance.

Size : Maximum total length (carapace & body) examined 35 mm.

Distribution : Gulf of Thailand

Remarks : *Alpheus* sp.1 can be distinguished from other *Alpheus* by its unique colouration. In *Alpheus* sp.1 ground colour is vermilion with longitudinal wavy transparent lines while in other *Alpheus*, colouration of the body usually with transverse bands.

Alpheus rapacida ? De Man

Figures 18D-G and 20

Alpheus rapacida : Banner & Banner, 1966 : 119

Banner & Banner, 1982 : 161

Description : Rostrum acute reaching midway of first antennular article. Rostral carina extending posteriorly to nearly mid-dorsal carapace. Orbitorostral grooves moderately deep. First and third antennular article subequal, second article 2.5 times as long as broad. Stylocerite acute, reaching end of first antennular article. Scapocerite with strong lateral spine, reaching end of first antennular article. Scapocerite with strong lateral spine, reaching beyond antennules, carapocerite reaching tip of antennular peduncle.

Large chela with a slight transverse groove behind dactylus. Small chela with dactylus longer than palm, sub-balaeniceps shaped.

Colour in life specimen, ground colour of entire animal, dark olive green. Carapace and abdomen with posteriorly curved yellowish white streaks running across the body, streaks at posterior end of carapace and fourth abdominal segment prominent. Large chela dark olive green with three irregular yellowish white bands, half margin of dactylus pinkish. Small chela same as large. Walking legs dark blue joints of each articles orange. Tail fan dark blue with three transverse orange bands.

Habitat : *Alpheus rapacida*? was found at Sichang Island, station SMaRT, on the sandy and rocky bottom of intertidal zone, especially sandy gravel bottom surrounded by limestone rock plate. The goby-partners

were found to be *Cryptocentrus singaporensis* and *C. cyanotaenia*. This species did not form a shallow depression as in *A. bellulus*.

Size : Maximum total length examined 40 mm.

Distribution : Gulf of Thailand

Remarks : The only one specimen of this species which was found in this study was kept in the aquarium for several months. Unfortunately, this specimen was lost. Hence, taxonomic study was based on its molted exoskeleton and its photograph which is insufficient for definite identification. From many characters observed, this species might be *Alpheus rapacida* De Man.

Alpheus distinguensus De Man

Figures 18 H-J and 19B

Alpheus distinguensus : Banner & Banner, 1982 : 157

Description : Rostrum acute reaching midway of first antennular article. Rostrum carina extending posteriorly to mid-dorsal carapace; orbitorostral groove moderately deep. First and third antennular article subequal, second article four times as long as broad. Stylocerite with strong lateral spine, reaching beyond antennules, carpal article reaching tip of antennular peduncle.

Large chela with transverse groove behind dactylus. Small chela with dactylus longer than palm, balaeniceps shaped.

Carpal articles of second pereopod with ratio, 10:10:4:3:5

Third leg, dactylus spatulated and unarmed.

Colour in life specimen, ground colour of entire animal, green. Carapace creamy laterally, with two streaks dorso-laterally. Abdomen with longitudinal creamy streaks. Large chela green, sometimes with two irregular white bands, half margin of fingers yellow. Small chela same as the large. Second pereopod purple-grey with yellow angle and colourless at base. Walking legs colourless, joints of each articles yellow, and purple grey at distal part of first article. Tail fan green, scattered with yellow.

Habitat : *Alpheus distinguendus* was found at Sichang Island, station SMaRT, in intertidal to sublittoral zone, maximum depth of 5m below low tide level, with substratum of fine sand to muddy sand packed with shell fragments. The goby-partners were found to be *Cryptocentrus singapurensis* and *Myersina macrostoma*.

Size : Maximum total length examined 62 mm.

Distribution : Australia, Japan, Gulf of Thailand

Remarks : *Alpheus distinguendus* can be easily distinguished from other *Alpheus* by large chela (Fig. 18)

Alpheus sp.A

Figures 18 K-M and 19C

Description : Rostrum acute reaching midway of first antennular article. Rostral carina, high and narrow, reaching posteriorly to

base of orbital hoods. Orbitorostral groove moderately deep. First and third antennules subequal, second article 2.2 times as long as broad. Stylocerite acute, reaching end of first antennular article. Scapocerite with strong lateral spine, reaching beyond antennules, carpuocerite reaching tip of antennular peduncle.

Large chela with transverse groove proximally to dactylus. Small chela with equal fingers, sub-balaeniceps shaped.

Carpal articles of second pereopod with ratio ; 10:9:3:3:4

Third leg, dactylus spatulated, merus unarmed.

Colour in life specimen, ground colour of entire animal, yellowish white scattered with irregular green to brown blotches. Large chela yellowish white with four irregular cross bands. Small chela same as large. Walking legs yellowish white with reddish brown and green spots. Tail fan yellowish white with reddish brown spots on upper margin, half lower margin with irregular cross-green band.

Habitat : *Alpheus* sp.A. was found at Sichang Island, station SMaRT, from intertidal to sublittoral zone, maximum depths of 4m below low tides level, with substratum of fine sand packed with shell fragments. This species of *Alpheus* always found in pair. The goby-partners were found to be *Cryptocentrus singaporensis* and *C. caeruleomaculatus*

Size : Maximum total length examined 36 mm.

Distribution : Gulf of Thailand

Remarks : : *Alpheus* sp.A is similar to *A. rapax* Fabricius 1798. It can be distinguished from *A. rapax* by colouration. In *Alpheus* sp.A

body is scattered with numerous irregular blotches whereas *A. rapax* has irregular band on the body.

Alpheus sp.A were commonly found at the norther part of Samet Island, Rayong, depths of 4-6 m.

Alpheus djiboutensis De Man

Figures 18 N-P and 21A

Alpheus djiboutensis : Banner and Banner, 1982 : 180

Description : Rostrum subacute reaching near end of first antennular article. Rostral carina extending posteriorly to orbital hood, orbitorostral grooves moderately deep. First and third antennular articles subequal, half as long as second article. Stylocerite acute, reaching end of first antennular article. Scapocerite with strong lateral spine, reaching beyond antennules, carpocerite reaching tip of antennular peduncle.

Large chela with narrow transverse groove proximal to dactylus. Small chela with dactylus longer than palm, sub-balaeniceps shaped in male but not markedly broadened with setiferous crests.

Carpal articles of second periopod with ratio ; 10:7:3:3:4

Third leg, dactylus spatulated, merus unarmed.

Colour in life specimen, ground colour of entire animal, transparent yellow. On carapace, abdomen and tail fan with irregular olive green pattern arranged symmetrically. Posterior end of carpace with orange cross band. Antennular olive green. Large chela olive

green, half margin of fingers white to yellow and inner half dark olive green ; with subequal yellowish white spots on palm. Small chela olive green with unequal yellowish white spots. Walking legs greenish blue with yellow bands on each angle.

Habitat : *Alpheus djiboutensis* was found from Khang Khao and Sichang Island, from intertidal to sublittoral zone. At station SMaRT, found on sandy beach with substratum of fine sand packed with shell fragments. At station A, found on reef flat with substratum of coarse sand packed with coral and shell fragments, and on reef edge with substratum of coarse sand packed with shell fragments. This species usually found single, but some rare occasions found in pair. The goby partners were found to be *Cryptocentrus singaporensis*, *C. caeruleomaculatus*, *C. cyanotaenia* and *Ctenogobiops pomastictus*. This species did not form shallow depression.

Size : Maximum total length examined 41 mm.

Distribution : Red Sea, Australia, Gulf of Thailand.

Remarks : *Alpheus djiboutensis* can be easily distinguished from other *Alpheus* by colouration, notably orange cross band on posterior end of carapace of *A. djiboutensis*.

Alpheus bellulus Miya and Miyake

Figures 18 O-S and 21 B

Alpheus bellulus : Miya & Miyake, 1969 : 307

Description : Rostrum triangular, reaching nearly to end of first

antennular segment ; rostral carina sharp, extending posteriorly beyond base of orbital hood. Carpocerite reaching to tip of antennular peduncle ; scapocerite with strong lateral spine markedly extending forward as far as tip of antennular peduncle.

Large chela marked with a transverse groove near articulation of dactylus. Small chela without such a groove ; fingers high, shutting together, not excavated internally ; dactylus usual in female, while sub-balaeniceps shaped in male.

Carpal articles of second perioopod with ratio, 10:9:2:2:4

Third perioopod, dactylus spatulated instead of styliform ; merus unarmed.

Colour in life specimen, ground colour of entire animal, yellowish white on carapace, abdomen and tail fan with irregular bright brownish purple arranged symmetrically. Antennules vermilion. Large chela, distal half of each finger pure white, but proximal half brownish or bluish purple : palm brownish purple on the inner surface, merging to bluish purple on outer surface. Small chela same colouration as large, except distal half of each finger bluish purple.

Habitat : *Alpheus bellulus* was found at Khang Khao and Sichang Island, at the area surrounding coral zone, with substratum of coarse sand packed with coral fragments or shell fragments. This species was always found in pairs. Its burrow was guarded by gobies, *Cryptocentrus* sp.1, *C. cinctus*, *Amblyeleotris gymnocephala*, *Cryptocentrus* sp.2, *Amblyeleotris* sp.1, *C. cyanotaenia* and *Ctenogobioys pomastictus*. This species always form a shallow depression extending on the bottom

surface from the burrow entrance.

size : Maximum total length examined 43 mm.

Distribution : Japan, Thailand

Remarks : *Alpheus bellulus* can be easily distinguished from other *Alpheus* by colouration, notably brownish purple band on carapace and body of *A. bellulus*.

2. Field survey

2.1 Basic environmental parameters

At any time, temperature, salinity, dissolved oxygen and pH did not vary too much between the sampling stations, nor between surface and bottom conditions (Table 3). The differences of temperature and salinity in each month, ranged from 26.5–31.0°C and 19.0–31.0 ppt. Dissolved oxygen and pH, vary slightly in each month. Average dissolved oxygen was 5.3±0.5 ppm and pH was 8.03±0.10.

2.2 Distribution of gobiid fishes and alpheid shrimps found at five stations A, B, C, D and SMaRT

The results from monthly census of the associations between gobiid fishes and alpheid shrimps at Khang Khao Island are presented in Table 4 and summarized in Fig.16. These results showed that the associations were abundant at station B both in number and species diversity (58 pairs and 12 combinations). *Cryptocentrus caeruleomaculatus* - *Alpheus djiboutensis* were most numerous (20 pairs). At station A, the associations were relatively high in number (43

Table 3 Environmental parameters at four stations on Khang Khao Island.
During the periods from September 1985 to February 1986*

Date	Station/level**	Depth (m)	Temperature (°C)	Salinity (‰)	D.O.(ppm.)	pH
1/9/85	A _s	1.0	28.8	30.6	5.1	8.05
	A _b	5.8	28.6	30.6	5.3	8.01
	B _s	1.0	28.9	30.7	5.2	8.06
	B _b	5.4	28.8	30.7	5.0	7.99
	C _s	1.0	29.0	30.7	5.3	8.02
	C _b	6.2	28.9	30.6	5.7	8.08
	D _s	1.0	28.8	30.3	5.2	7.97
	D _b	5.9	28.8	30.0	5.5	7.95
12/10/85	A _s	1.0	27.0	30.0	5.2	7.90
	A _b	5.2	27.0	31.0	5.0	7.95
	B _s	1.0	27.0	30.0	5.2	7.91
	B _b	5.5	27.0	30.0	5.2	7.85
	C _s	1.0	27.0	30.0	5.1	7.95
	C _b	6.0	27.0	30.0	3.6	7.90
	D _s	1.0	26.5	30.1	5.7	7.94
	D _b	6.3	27.0	30.1	4.6	7.86
3/11/85	A _s	1.0	29.0	19.0	5.2	8.04
	A _b	5.5	29.0	23.5	5.3	8.09
	B _s	1.0	31.0	23.8	5.2	8.09
	B _b	5.9	30.0	24.5	5.3	7.98
	C _s	1.0	29.0	24.5	5.1	8.04
	C _b	6.3	31.0	24.0	5.4	8.05
	D _s	1.0	29.0	24.5	5.2	8.10
	D _b	5.6	29.0	24.9	5.4	8.08
1/2/86	A _s	1.0	26.5	28.5	5.9	8.21
	A _b	5.5	26.5	29.0	5.4	8.28
	B _s	1.0	27.0	28.5	5.95	8.14
	B _b	6.0	27.0	29.0	5.95	8.11
	C _s	1.0	27.5	28.0	6.0	7.95
	C _b	6.5	27.0	28.5	5.7	7.96
	D _s	1.0	26.5	27.5	6.2	8.16
	D _b	5.5	27.0	27.5	6.0	8.18

Remark * not recorded on December 1985 and January 1986

** Two levels were measured for each station; Surface (s) and bottom (b)

Table 4 Monthly appearance of the combinations between gobiid fishes and alpheid shrimps from census lines of four stations on Khang Khao Island.

During the periods from September 1985 to February 1986.

Combinations	Date	Station																Totals
		1/9/85				12/10/85				2/11/85				1/2/86				
		A	B	C	E	A	B	C	E	A	B	C	D	A	B	C	D	
<i>C. cinctus</i> (A)	Aa	1	1	0	1	-	-	1	-	2	1	0	0	0	0	0	0	7
↓	Aaa	0	0	0	0	-	-	0	-	1	0	0	0	0	0	0	0	1
<i>A. bellulus</i> (a)	Aaco	0	0	0	0	-	-	0	-	1	1	0	0	0	0	0	0	2
↓	AaE	0	0	0	0	-	-	0	-	0	2	0	0	0	0	0	0	2
<i>C. cinctus</i> (A)	ABB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	AAEB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>Cryptocentrus</i> sp.1 (B)	Ba	0	3	2	0	-	-	1	-	4	0	4	0	0	2	1	0	17
↓	Baa	0	1	1	0	-	-	1	-	0	0	4	0	0	1	3	2	13
<i>A. bellulus</i> (a)	Bbaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	BY	0	0	0	1	-	-	0	-	0	0	1	0	0	0	0	0	2
<i>Cryptocentrus</i> sp.1 (B)	BYT	0	1	0	0	-	-	0	-	0	0	0	0	0	0	0	0	1
↓	BEYY	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>Alpheus</i> sp.1 (γ)	BEYY	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	DB	3	1	0	0	-	-	0	-	0	6	3	0	0	0	0	0	15
<i>C. singapurensis</i> (D)	DBB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	DBBB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>Cryptocentrus</i> sp.2 (E)	Ea	0	8	0	0	-	-	0	-	0	0	0	0	0	0	0	0	8
↓	Eaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>A. bellulus</i> (a)	Eaao	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	EY	0	0	0	0	-	-	0	-	0	1	0	0	0	1	0	0	2
<i>Cryptocentrus</i> sp.2 (E)	EYT	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	EYYT	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>Alpheus</i> sp.1 (γ)	EYYT	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	GA	0	0	0	0	-	-	0	-	0	1	0	0	0	0	0	0	1
<i>C. caeruleopunctatus</i> (G)	Gaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	GGaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>A. bellulus</i> (a)	GGaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	GB	24	7	0	0	-	-	2	-	8	10	0	0	5	3	2	0	61
<i>C. caeruleopunctatus</i> (G)	GBB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	GBBB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>A. djiboutensis</i> (B)	GBBB	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	Ha	0	0	0	0	-	-	0	-	0	1	0	0	0	1	0	0	2
<i>A. gymnocephala</i> (H)	Haaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	1	1
↓	MHaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>A. bellulus</i> (a)	MHaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	HY	0	0	0	0	-	-	0	-	0	1	0	0	0	1	1	0	3
<i>A. gymnocephala</i> (H)	HYT	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	BEYY	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>Alpheus</i> sp.1 (γ)	BEYY	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
↓	Ia	0	0	0	0	-	-	1	-	0	0	0	0	0	0	0	0	1
<i>Amilyeleotris</i> sp.1 (I)	Iaa	0	0	0	0	-	-	1	-	0	2	0	0	0	0	0	0	3
↓	Iaaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
<i>A. bellulus</i> (a)	Iaaa	0	0	0	0	-	-	0	-	0	0	0	0	0	0	0	0	0
Total		28	22	3	2	-	-	7	-	15	27	13	0	5	5	8	3	142

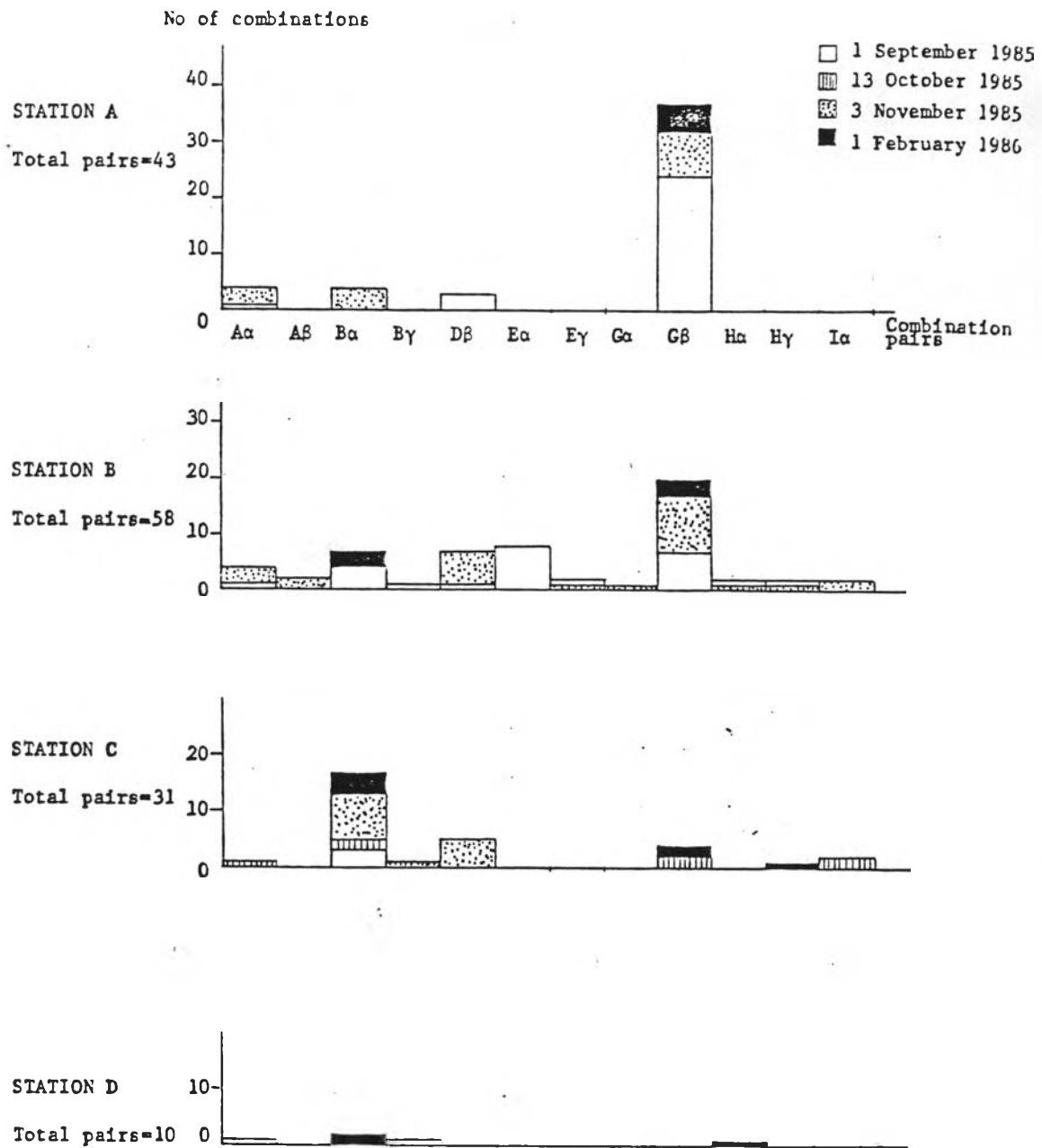


Fig. 16 Cumulative occurrence of the combinations between gobiid fishes and alpheid shrimps at four stations on Khang Khao Island

A-C. *cinctus* ; B-*Cryptocentrus* sp.1 ; D-C. *singaporensis* ;
 E-*Cryptocentrus* sp.2 ; H-A. *gymnocephala* ; I- *Amblyeleotris* sp.1 ;
 α -A. *bellulus* ; β -A. *djiboutensis* ; γ -*Alpheus* sp.1

pairs) but species diversity relatively low (4 combinations). The associations were moderate at station C both in number and species diversity (31 pairs and 7 combinations). The associations were rarely found at station D (10 pairs and 4 combinations).

From the line census technique, not all of the gobiid fishes and alpheid shrimps were found along the line. Therefore, general surveys of the area at every stations were carried out as well as the station on Sichang Island (station SMaRT). List of gobiid fishes and alpheid shrimps found are summarized in Table 2. The results from this general survey showed that the associations between gobiid fishes and alpheid shrimps were abundant at station B and station SMaRT. At station B, the gobiid fishes *Cryptocentrus* sp.1 and *C. cinctus* were most numerous. Most of them were living in association with *Alpheus bellulus*. At station SMaRT, *C. singaporensis* and *C. caeruleomaculatus* were most numerous and most of them were living with *A. djiboutensis*.

The habitat at the five stations of the study area can be categorized into 5 types;

1. Shallow sandy areas of intertidal zone which is represented by station SMaRT.
2. Shallow sandy areas of intertidal zone covered with rubble which is represented by station SMaRT and station A.
3. Semi-microatoll along the reef flat which is represented by station A.
4. Sandy bottom of the inner part of the areas surrounding coral zone which is represented by station A, B, C and D.



5. Outer part of the areas surrounding coral zone with muddy bottom which is represented by station A and SMaRT. The occurrences of different species of gobiid fishes and alpheid shrimps in five types of habitat are summarized in Table 5. Most of the gobiid fishes and alpheid shrimps were found from the depth of 0-7.5m, particularly at the inner part of the areas surrounding coral zone.

3. Field study

3.1 Population structure of the associations between gobiid fishes and alpheid shrimps at stations B and SMaRT

At station B, the associations between gobiid fishes and alpheid shrimps could be found nearly all over the 25m x 25m quadrat area (Fig.17). It is to be noted that the associations were found more towards at the inner half of the quadrat which is closer to the coral zone. When the quadrat were divided into 5 sub-quadrats (5m x 25m) parallel to the shore line the observed numbers of each animal in each sub-quadrat were found to be decreasing when moving a way from the shore, excepted for *Alpheus* sp.1, *Cryptocentrus* sp.2 and *Amblyeleotris gymmocephala* which found to be increasing in the first three sub-quadrats before decreasing in last two (Fig.18). Within 25m x 25m quadrat, the highest density of burrow within 25m² sub-quadrat was 15 burrows. The combination between *Cryptocentrus* sp.1 and *Alpheus bellulus* was found to be 45% and the most numerous of all the combinations. All combinations of species between gobiid fishes and alpheid shrimps are summarized in Table 6.

At station SMaRT, the associations also found occurred all over the area of the quadrat and the results are presented in

Table 5 Habitats of gobiid fishes and alpheid shrimps found at Khang Khao and Sichang Islands

Organism	Habitat*					Depth		
	1	2	3	4	5	Intertidal	0-7.5	>7.5
Gobiid Fishes								
<i>M. macrostoma</i>				+	+		+	+
<i>Myersina</i> sp.A					+			+
<i>Ct. pomastictus</i>				+			+	
<i>C. caeruleomaculatus</i>	+	+	+	+		+		
<i>C. singapurensis</i>	+	+		+		+		
<i>C. cyanoaenia</i>		+		+		+		
<i>C. cinctus</i>				+			+	
<i>Cryptocentrus</i> sp.1				+			+	
<i>Cryptocentrus</i> sp.2				+	+		+	+
<i>Amblyeleotris</i> sp.1				+			+	
<i>A. fontanesii</i>					+			+
<i>A. gymnocephala</i>				+			+	+
Alpheid Shrimps								
<i>Alpheus</i> sp.1				+	+		+	+
<i>A. rapacida</i> ?		+		+		+	+	
<i>A. distinguendus</i>	+		+	+		+	+	
<i>Alpheus</i> sp.A	+			+		+	+	
<i>A. djiboutensis</i>	+	+		+		+	+	
<i>A. bellulus</i>				+			+	
Uncollected alpheid shrimp					+			+

*Remark

1. Sandy bottom of intertidal zone.
2. Sandy bottom covered with rubble of intertidal zone.
3. Semi-microatoll along the reef flat.
4. Inner part of the area surrounding coral zone with sandy bottom.
5. Outer part of the area surrounding coral zone with muddy bottom.

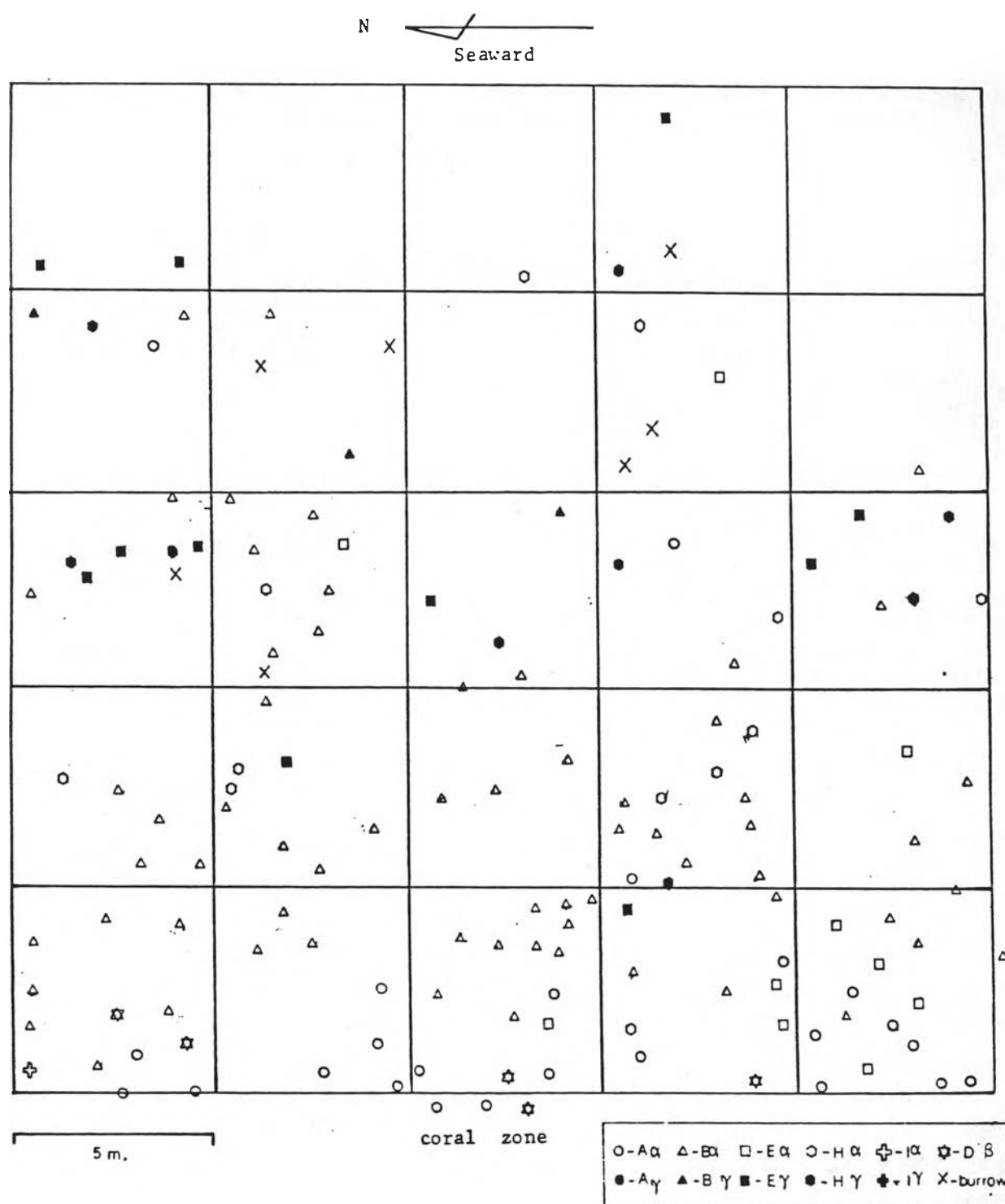


Fig. 17 Distribution of the associations between gobiid fishes and alpheid shrimps in a 25m x 25m quadrat at station B on Khang Khao Island ; March 19, 1986.

A-*C. cinctus* ; B-*Cryptocentrus* sp.1 ; D-*C. singaporensis* ;
E-*Cryptocentrus* sp.2 ; H-*A. gymnocephala* ; I - *Amblyelectris* sp.1 ;
α-*A. bellulus* ; β-*A. djiboutensis* ; γ-*Alpheus* sp.1

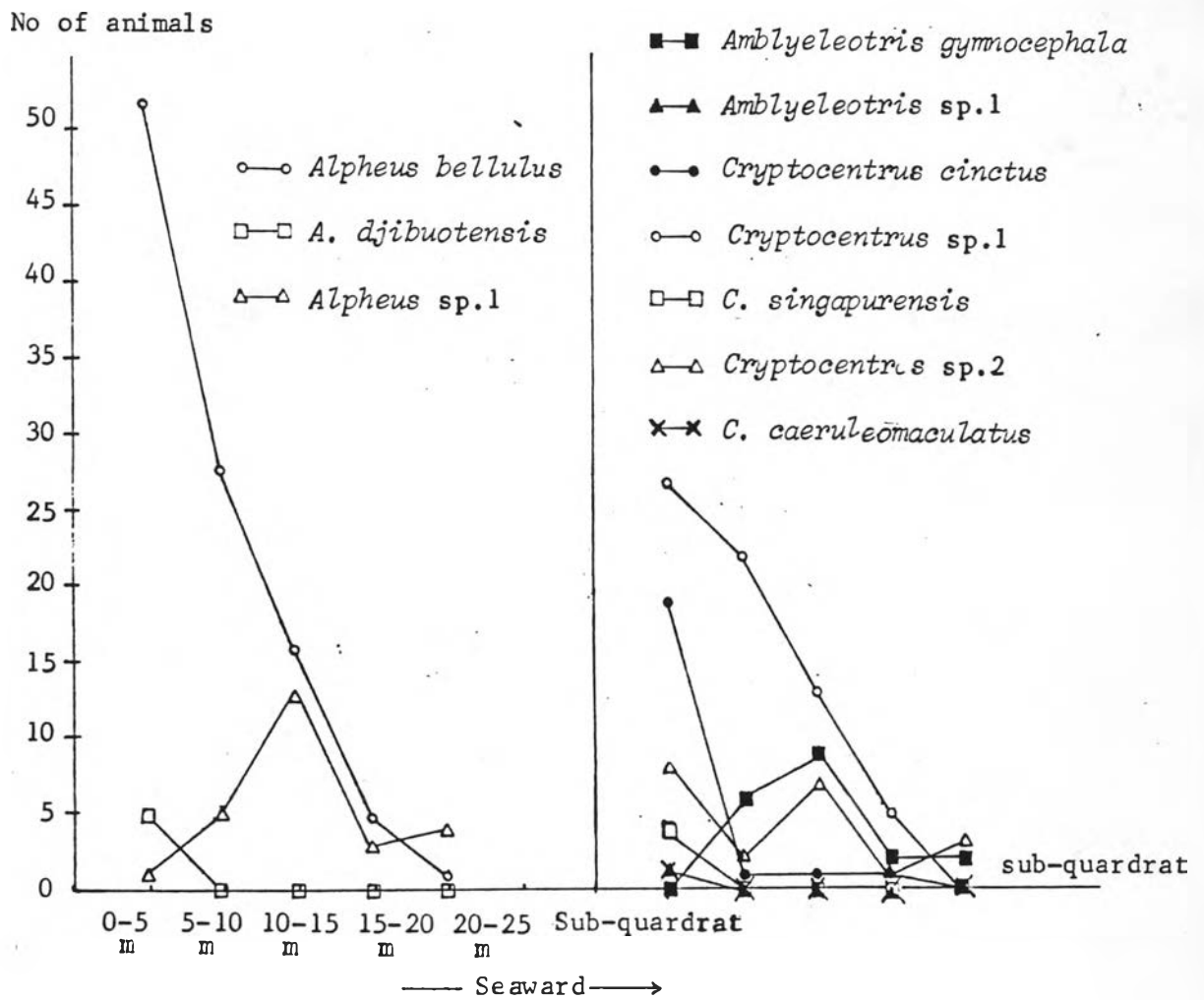


Fig. 18 Numbers of alpheid shrimps (left) and gobiid fishes (right) in five sub-quadrats (5m x 25m) at station B on Khang Khao Island ; March 19, 1986.

Table 6 Occurrence of the combinations between gobiid fishes and
 alpheid shrimps in a 25m x 25m quadrat at station B on
 Khang Khao Island ; March 19, 1986

Alpheid shrimps Gobiid fishes		<i>A. bellulus</i>		<i>A. djiboutensis</i>		<i>Alpheus</i> sp.1		Total	Total of each species
		a	aa	B	BB	Y	YY		
<i>C. cinctus</i>	A	15	0	0	0	1	0	16	24
	AA	0	8	0	0	0	0	8	
<i>Cryptocentrus</i> sp.1	B	38	20	0	0	3	2	63	68
	BB	0	5	0	0	0	0	5	
<i>C. singaporensis</i>	D	0	0	5	0	0	0	5	5
	DD	0	0	0	0	0	0	0	
<i>Cryptocentrus</i> sp.2	E	6	3	0	0	11	0	20	20
	EE	0	0	0	0	0	0	0	
<i>A. gymnocephala</i>	H	6	6	0	0	9	0	21	21
	HH	0	0	0	0	0	0	0	
<i>Ambleyeleotris</i> sp.1	I	0	1	0	0	0	0	1	1
	II	0	0	0	0	0	0	0	
Total		65	42	5	0	25	2		
Total of each species		107		5		27		139*	

* Total burrows observed were 146 but 7 burrows had no occupant.

** Single alphabet means single individuals,
 double alphabet means two individuals.

Fig.19. These associations were relatively few in the south western quarter of the quadrat where the substrate composed of rubble while the rest of the quadrat was fine sand and the associations were abundant. The maximum density of burrows was 1 burrow/m² in the northern half of the quadrat while the other areas were less. The associations between *Cryptocentrus singaporensis* and *Alpheus djiboutensis* were found to be 56% and the most numerous of all. The combinations of species in this quadrat are summarized in Table 7.

3.2 Effects of tidal current on the direction of burrow entrance

At station B, tidal current flows from south to north parallel to the shore line during high tide and in reverse during low tide. Direction of burrow entrances of alpheid shrimps in a 25m x 25m quadrat are presented in Fig.20. Most of the directions of burrow entrances, 84.3% were at some angles to the current direction. A small number of the burrow entrances, 8.2%, were rectangular at right angle to the current direction. Only a small number of the burrow entrances, 7.5%, were that parallel with current direction. The directions of burrow entrance did not change with the changes in the direction of tidal flow between high and low tide, excepted for those burrows which opened against the tidal current. These burrows always collapsed and the shrimps had to build new entrance which would direct in other directions to the tidal current. This effect of burrow collapsing might cause burrow shifting as well.

3.3 Daily activities of gobiid fishes and alpheid shrimps.

Daily activities of gobiid fishes and alpheid shrimps were observed mainly at station SMaRT. Their activities outside the

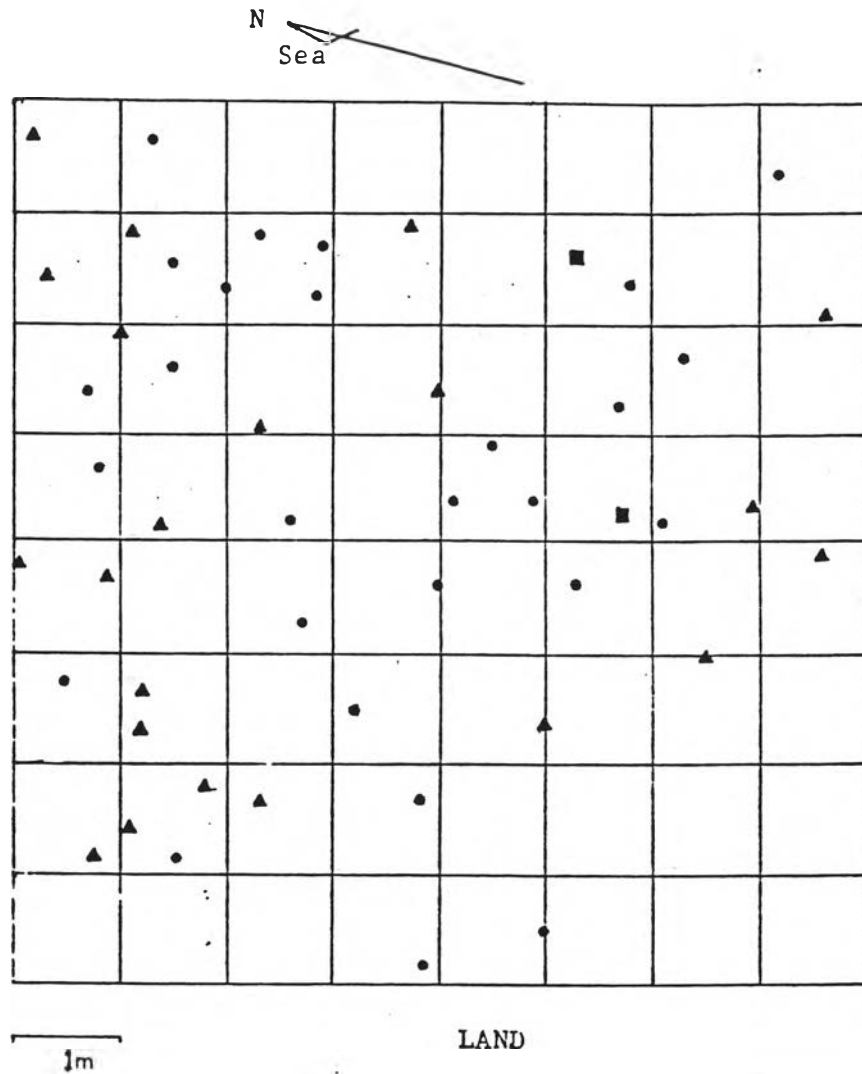


Fig. 19 Distribution of the associations between gobiid fishes and alpheid shrimps in a 8m x 8m quadrat at Station SMaRT on Sichang Island; April 30, 1986.

- : *Cryptocentrus singaporensis*-*Alpheus djiboutensis* ;
- ▲ : *Cryptocentrus caeruleomaculatus*-*Alpheus djiboutensis* ;
- : *Cryptocentrus singaporensis*-*Alpheus* sp.A .

Table 7 Occurrence of the combinations between gobiid fishes and alpheid shrimps in a 8m x 8m quadrat at station SMaRT on Sichang Island ; April 30, 1986.

Gobiid fishes	Alpheid shrimps		Total
	<i>A. djiboutensis</i> (B)	<i>Alpheus</i> sp.A (E)	
<i>C. singaporensis</i> (D)	30	3	33
<i>C. caeruleomaculatus</i> (G)	21	0	21
Total	51	3	54

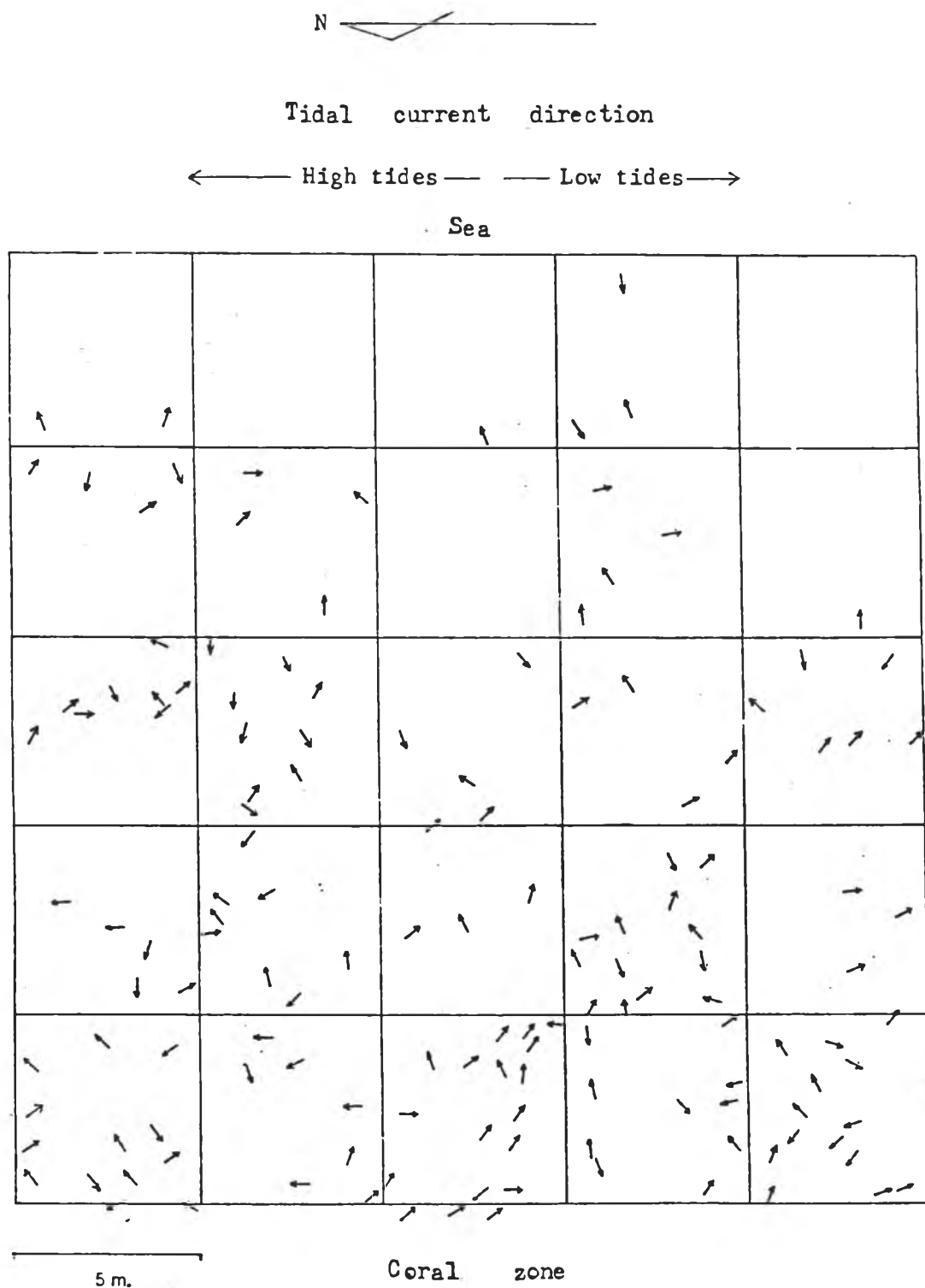


Fig. 20 Direction of the burrow entrances of the associations between gobiid fishes and alpheid shrimps in a 25m x 25m quadrat at station B on Khang Khao Island; March 19, 1986 . Arrow(↑) indicated direction of the burrow entrance .

burrow were restricted to the daytime. During the night observations, neither gobies nor alpheid shrimps were ever observed on the bottom surface. The entrances of the shrimps' burrow were semi-closed with sediment carried up from inside of the burrow by the shrimp. This result was confirmed by laboratory observation which will be described later. Some burrow entrances were tightly closed with sediment or shell fragments resulting from wave and current action. After sunrise, the goby appeared first from each burrow. The shrimp emerged later and cleared or re-constructed the entrance. Appearance time in the morning varied within the range from 6:30 to 10:00 am. The number of opened burrows in the daytime fluctuated day by day and burrows shifting were observed. These results were recorded in Fig.21.

Behaviours of both goby and alpheid shrimp were constantly active from morning to evening. Towards late evening their activities decreased. The goby usually found guarded the burrow entrance without any movement while the shrimp stood still on pebble or shell at the burrow entrance with behaviour as feeding.

Their general activities were the same as described by many authors (Harada, 1969; Preston, 1976 ; Yanagisawa, 1984).

Since the study area was in the intertidal zone, the activities of both animals were affected by tidal stage. During low tide, this area was exposed. Both goby and alpheid shrimp started to withdraw into the burrow when the sea level was as low as about 5cm above bottom surface. During high tide, they both started to be active when sea level reached about 30 cm above bottom surface.

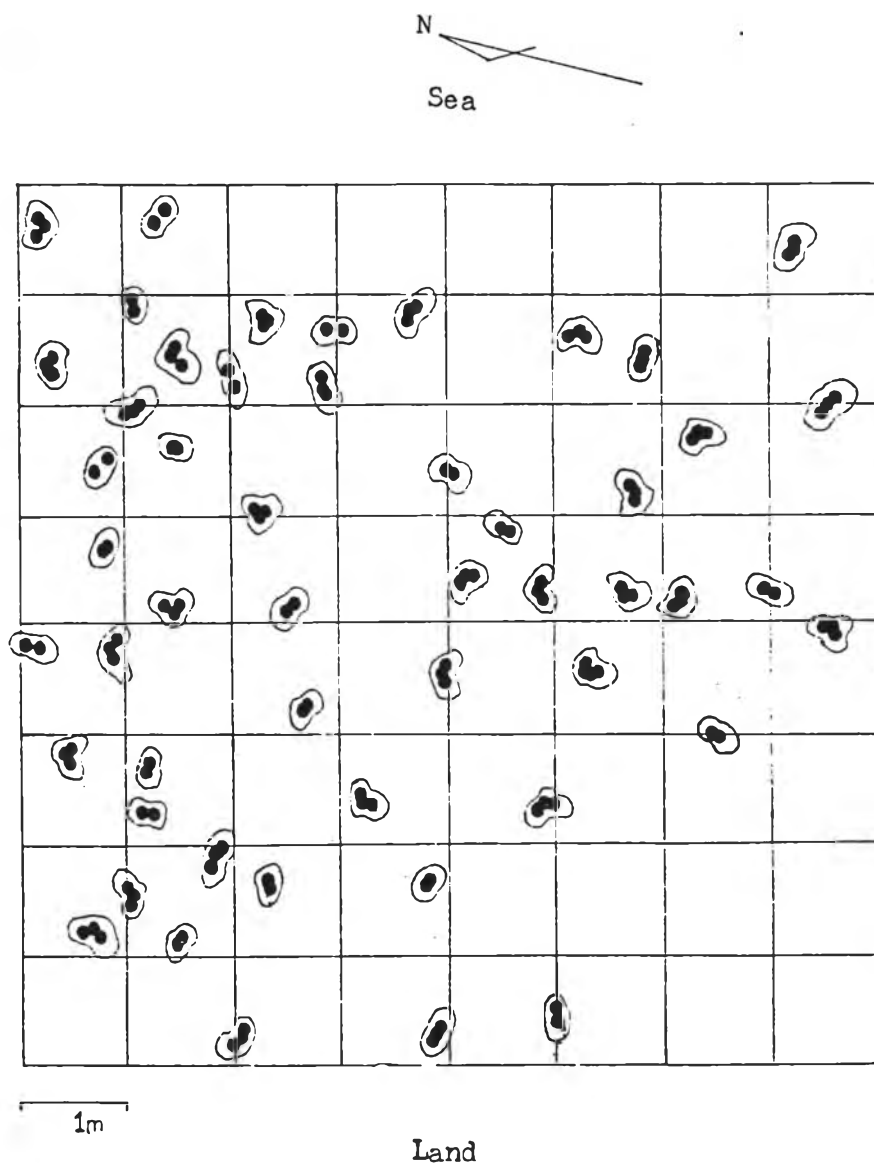
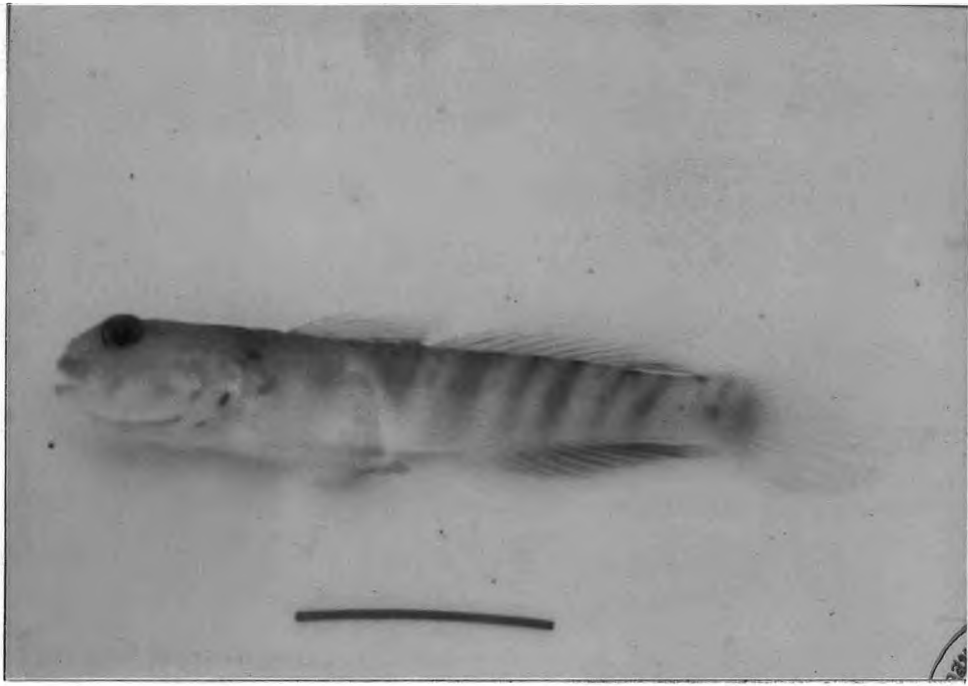
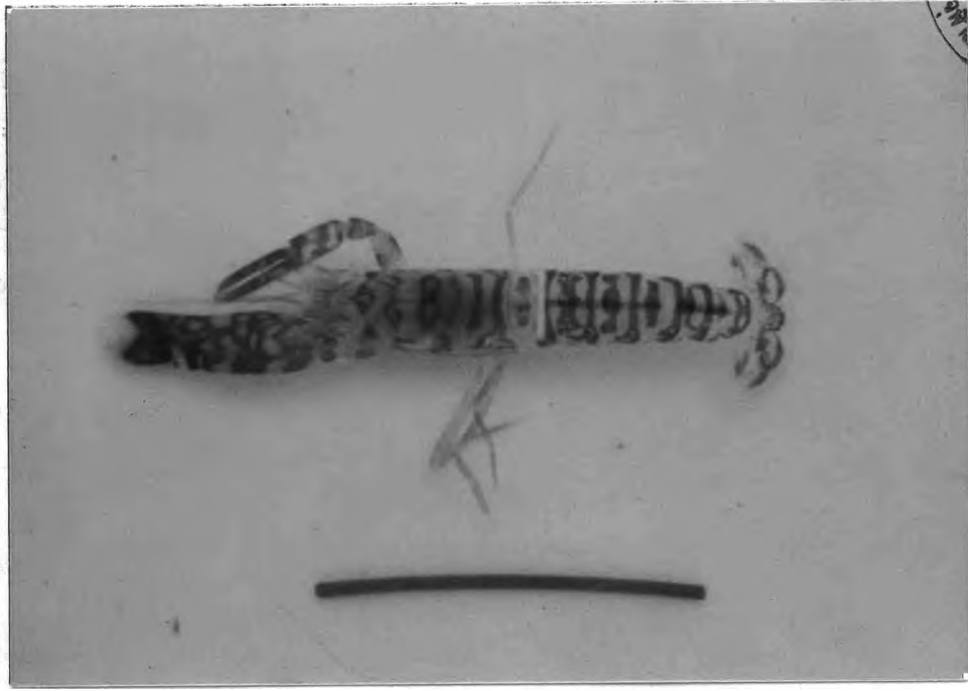


Fig. 21 Map of cumulative positions of the burrow entrances in 5 surveys at Station SMaRT on Sichang Island, during the period from April 30 to May 4, 1986. A patch of entrances enclosed with a solid line is referred to as one burrow.



A



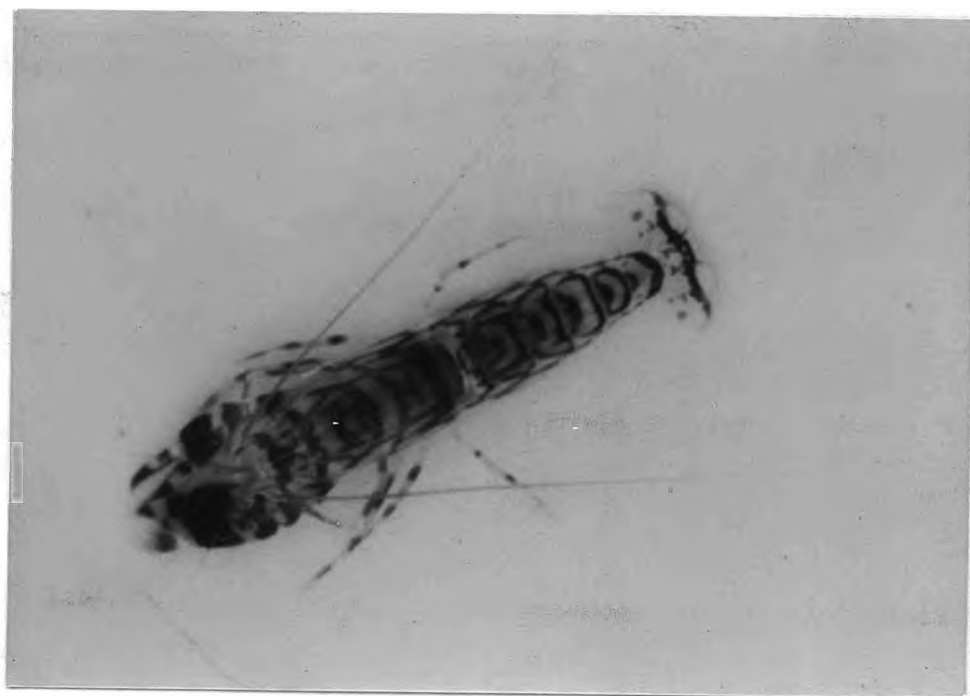
B



Fig. 22 The association pair of *Cryptocentrus singaporensis* and *Alpheus ajiboutensis*



A



B

Fig. 23 The association pair of *Cryptocentrus* sp.1 and *Alpheus bellulus*

Table 8 The two-FAP sequences of *Cryptocentrus singapurensis* and *Alpheus djiboutensis* which have percentage frequency of more than 0.5 %

<i>Cryptocentrus singapurensis</i>		<i>Alpheus djiboutensis</i>	
two-FAP sequences	Percentage frequency	two-FAP sequences	Percentage frequency
S-N	11.34	D-E	32.27
N-S	9.73	E-P	26.15
W-G	9.24	P-I	17.85
M-S	7.97	E-M	5.34
G-M	7.50	M-I	4.70
N-W	5.78	S-I	4.52
S-M	5.56	E-I	3.75
N-G	4.20	D-I	2.76
G-N	4.04	E-S	2.58
G-Ma	3.92	P-S	2.05
Ma-S	3.89	E-D	1.31
M-N	3.65	P-D	0.49
S-W	2.80	M-D	0.49
I-E	1.64		
S-Ma	1.61		
M-G	1.55		
Ma-N	1.43		
E-G	1.21		
N-M	0.97		
Ld-S	0.88		
G-E	0.76		
S-Ld	0.69		
S-A	0.55		
G-Ld†	0.50		

Table 9 The two-FAP sequences of *Cryptocentrus* sp.1 and *Alpheus bellulus* which have percentage frequency of more than 0.5%

<i>Cryptocentrus</i> sp.1		<i>Alpheus bellulus</i>	
two-FAP sequences	Percentage frequency	two-FAP sequences	Percentage frequency
N-G	14.43	I-E	18.03
G-N	14.32	P-W	15.49
S-N	7.36	E-P	11.93
W-G	6.76	W-P	9.21
G-M	6.68	P-I	7.41
N-Ga	6.18	W-S	3.21
Ga-N	5.91	E-I	2.91
N-S	5.42	S-P	2.47
S-M	4.64	M-I	2.40
N-W	4.56	W-I	2.38
M-S	3.52	E-M	2.17
M-N	2.86	D-I	2.08
E-G	2.01	P-S	1.94
M-Ga	1.98	S-I	1.73
G-E	1.43	M-P	1.64
Ma-S	1.37	E-D	1.64
S-W	1.37	D-P	1.59
Ga-M	1.07	S-M	1.59
Ga-W	0.99	S-D	1.54
G-Ma	0.99	P-M	1.27
I-E	0.77	M-S	1.18
M-G	0.74	M-D	0.99
		D-S	0.78
		P-M	0.76
		E-S	0.55

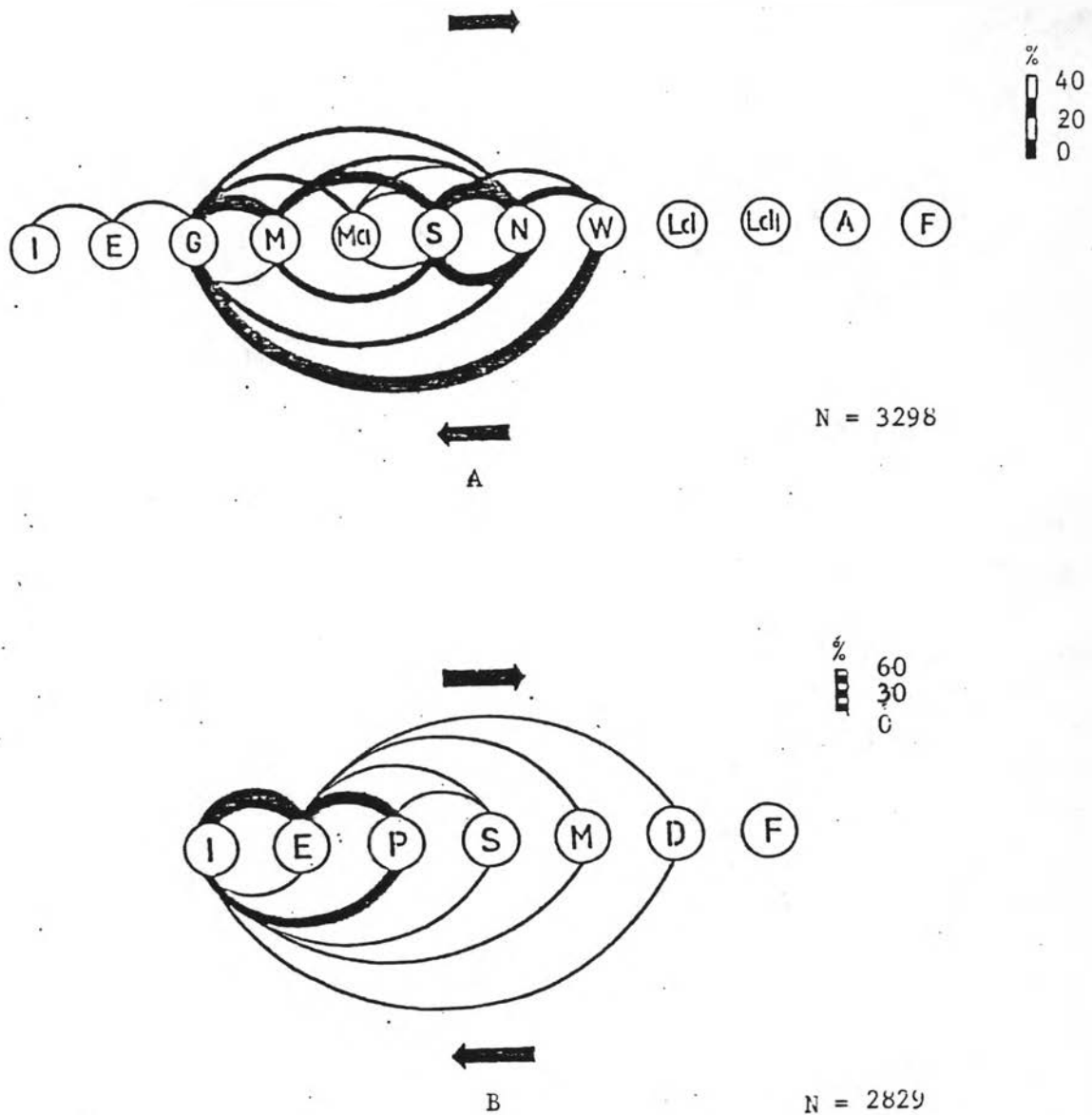


Fig. 24 Ethograms of *Cryptocentrus singapurensis* (A) and *Alpheus djiboutensis* (B) which living in association, during 20 minutes. The circles represent FAP of the goby and the alpheid shrimp. Each FAP is represented by letters which were described in text. The thickness of the lines mean the strength of the connection. The arrows show direction of behaviours.

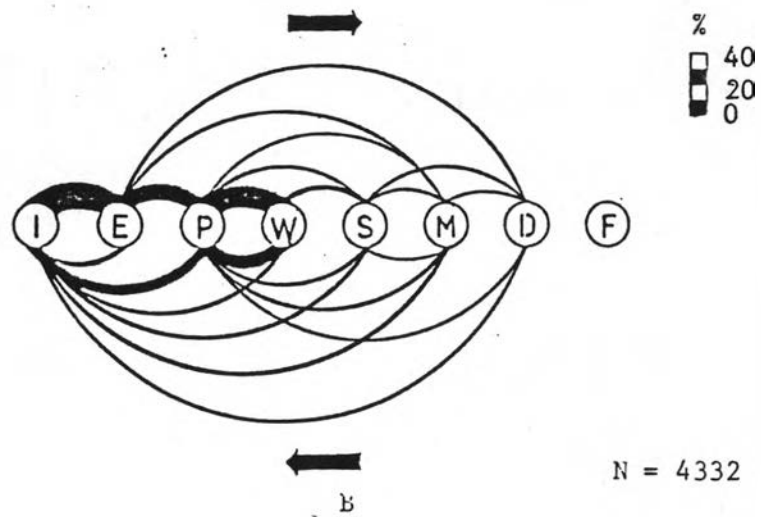
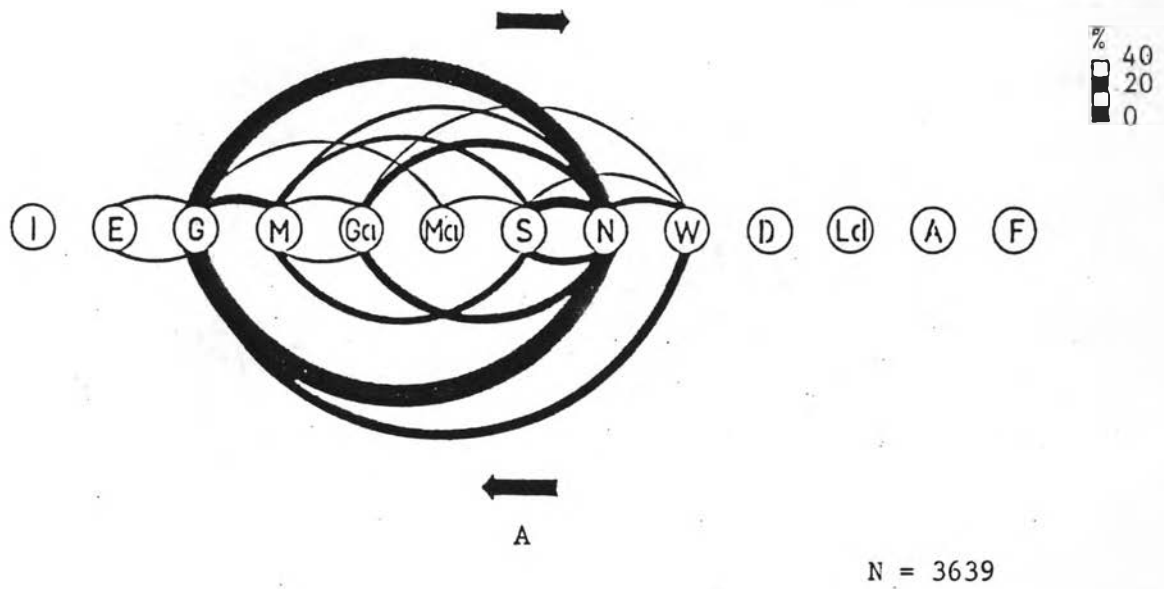


Fig. 25 Ethograms of *Cryptocentrus sp.1* (A) and *Alpheus bellulus* (B) which living in association, during 20 minutes. Details of the ethograms same as Fig. 23.

The burrow entrance always collapsed because of the sediment motion caused by wave action. In such cases, the goby appeared first by protruding its head and body through the collapsed entrance and the shrimp followed later. Their activities remained the same as new day started. Therefore, their activities outside the burrow were limited not only at night but also during low tides.

4. Behavioural study

4.1 Field observation

Associative behaviour between *Cryptocentrus singapurensis* and *Alpheus djiboutensis*

The Fixed Action Patterns (FAP_s) of *C. singaperensis* and *A. djiboutensis* were analyzed from data collected from field observation. The goby in this association pair displayed 12 behavioural characters. "Attack", "Emerge", "Flee", "Guard", "In burrow", "Lateral display", "Move", "Move away", "Nip Sand", "Sit", "Soaring Lateral display" and "Withdraw", while the alpheid shrimps had behavioral characters; "Decorate", "Emerge", "Flee", "In burrow", "Manipulate objects", "Plough", and "Stand"

The gobies showed 71 two-FAP sequences in which 18 sequences had a percentage frequency of more than 1% and 6 sequences had a frequency of more than 0.5%. As for the alpheid shrimps, they showed 27 two-FAP sequences in which 11 sequences had more than 1% frequency and 2 sequences with a frequency of nearly 0.5%. The full results of two-FAP sequences frequency of *C. singapurensis* and *A. djiboutensis* are presented in Appendix A & B and summarized in Table 8. The frequencies of which the various FAPs of the goby and

the alpheid shrimp occurred are demonstrated in two ethograms (Fig.24).

From the ethogram, *C. singaporensis* usually maintain guarded at the burrow entrance, then moved (7.5%) and sat (7.79%) near the burrow entrance, then nip sand (11.34%) and may sat (9.73%) at any position and nip sand again before withdrawing (5.78%) to guarded (9.24%), at the burrow entrance. The goby may nip sand (4.04%) while guarding. Sometimes it moved away (3.92%) from the burrow entrance (not more than 3m) and sat (3.89%) for a moment. After that it nip sand (1.43%) and withdrew to guard again.

For *A. djiboutensis*, activities of the shrimp outside the burrow were limited by the goby's activities. The main FAP when it emerged from the burrow was ploughing (20.15%) after which it moved immediately into the burrow (17.85%) but sometimes it stand (2,05%) at the burrow entrance for a movement before moving into the burrow (4.52), for the other activities, after emerging, it may manipulated objects (5.34%), stand (2.58%) or decorated the burrow entrance (1.31%) after which it moved immediately into the burrow (4.70%, 4.52% and 2.76%)

Associative behaviour between *Cryptocentrus* sp.1 and *Alpheus bellulus*

The goby had 13 behavioral characters "Attack", "Emerge", "Flee", "Guard", "Guard away", "In burrow", "Lateral display", "Move", "Move away", "Nip Sand", "Sit", "Dash" and "Withdraw", whereas the alpheid shrimp had 8 behavioural characters : "Decorate", "Emerge", "Flee", "In burrow", "Manipulated objects", "Plough", "Stand" and "Walk".

The goby showed 60 two-FAP sequences in which 20 sequences had a percentage frequency of more than 1%. As for the alpheid shrimp, it showed 47 two-FAP sequences in which 22 sequences had more than 1% frequency. The full results of two-FAP sequence frequency of *Cryptocentrus* sp.1 and *Alpheus bellulus* are presented in Appendix C & D and summarized in Table 9. The frequencies of which the various FAPs of the goby and the alpheid shrimp occurred are demonstrated in two ethograms (Fig.25).

From the ethogram *Cryptocentrus* sp.1 usually maintain guarding at the burrow entrance and nipping sand (14.32%). The goby always moved (6.68%) and sat (3.52%) near the burrow entrance, then nip sand (7.36%) and may sat (5.42%) at any position and nip sand again before withdrawing (4.56) to guard at the burrow entrance. Many times, it moved along the depression, built by the alpheid shrimp, and guard (1.98%) on the scooped sediment at a distance away from the burrow entrance. Nipping sand (5.91%) always seen here. At guarding position, sometimes the goby moved away (1%) from the burrow and sat (1.37) at any position for a moment, then may nip sand and withdraw to guard. The other activities occurred in lesser frequencies.

The activities of *Alpheus bellulus* outside the burrow were concerned with burrow entrance and depression excavation. Burrow maintenance was represented by FAPs which occurred after "Emerge". These FAPs were "Plough" (11.93%), "Manipulated objects" (2.17%) and "Decorate" (1.64%). After the alpheid shrimp emerged from the burrow and performed its activities, it did not move back into the burrow but always stayed outside the burrow and continued to construct a

depression from the burrow entrance. These behaviours were represented by FAPs which occurred continuously after it stayed outside the burrow. The major FAP which occurred for depression excavation was "Plough", which 16.91% of total frequencies were concerned directly with "Plough" outside the burrow. The other FAPs that the shrimp displayed for building the depression occurred in lesser frequencies: "Manipulated objects" (2.86%) and "Decorate" (2.54%).

4.2 Laboratory Observation

Behaviours of *Cryptocentrus singaporensis* and *Alpheus djiboutensis* in artificial burrow

When the alpheid shrimp was placed in an aquarium, it moved to hide in the corner of the aquarium or base of stones. Until finally on locating of the artificial burrow, it moved into the burrow immediately without any hesitation. After setting in the burrow, burrowing behaviour was then observed.

The goby was placed in the aquarium one hour after the shrimp. The goby moved around until it found the artificial burrow entrance. The goby paused at the entrance for a moment before moving gently into the burrow. As soon as the goby met the alpheid shrimp in the burrow, both appeared apprehensive and stopped their activities for a few minutes. After that, the shrimp sometimes tried to push the goby out of the burrow and snapped its pincer audibly. The re-communication between the partners was completed within 24 hours. Antennal contact always seen both outside and inside of the burrow. During the day, the goby always guarded the burrow entrance and other activities, such as nipping sand, had never been observed in the

aquarium, while the alpheid shrimp always stayed within the burrow, and other activities outside the burrow, such as plough sand, did not occur. The alpheid shrimp emerged from the burrow mainly at feeding time to catch the brine shrimp or drag piece of bivalve fresh into the burrow. It always maintained antennal contact with the goby. The activities outside the burrow of both partners under aquarium condition were lower than in nature. At night, both animals were observed to stay in the burrow together. The goby did not show any activity and appeared to be sleeping while the alpheid shrimp's , burrowing behaviour was always seen but less frequently than in the daytime.

The shrimp's activity inside the burrow was mainly burrowing behaviour. It decorated the inside of the burrow soon after entering and burrowing behaviour was generally similar to that of *A. djiboutensis* as described by Karplus *et. al* (1972), or *A. bellulus* as described Harada (1969). The tunnel thus decorated is generally large in relation to the shrimp's size. The shrimp made a space near the inner end of the artificial burrow twice as large as the tunnel and it always used this space for turning around, resting and feeding etc. Hence, this space may mean the resting site of the shrimp in the burrow. The shrimp always built the burrow longer than what was provided and also created branch tunnels. Thus a new burrow entrance may open at any part in aquarium. During the night, after the goby withdrew into the burrow, it was observed that the shrimp moved forward to occupy a position near the burrow entrance beyond the goby and ploughed sand at that position to decrease the size of the burrow entrance. In the early morning the shrimp ploughed sand to expand the burrow entrance before allowing the goby to move out of the burrow.

After that it decorated the newly-widened burrow entrance. This evidences supported field observations which showed that the burrow entrances of alpheid shrimps at station SMaRT were always semi-closed at night with the sediment carried up from the inside of the burrows by the shrimps.

Feeding behaviour of the shrimps occurred inside the burrow. After trapping brine shrimps or reaching bivalve flesh introduced at feeding times, the shrimp withdrew into the burrow with the food and remained at the resting space. Feeding occurred while it was in this space. After it ate all of food materials brought in, it moved out to get more food and kept doing this again and again. It was also observed that the shrimp always stored food by keeping them under the gravel along the tunnel.

Behaviours of *Cryptocentrus* sp.1 and *Alpheus bellulus* in artificial burrow

Behaviours of both animals after being placed in the aquarium were the same as observed from the former pair. The goby appeared to be easily frightened by the movements around the aquarium more than the former pair. The re-communication between them was also completed within 24 hours.

During the day, the goby always guarded the burrow entrance and sometimes moved along the depression to guard its partner shrimp which came out and built this depression. The depression was always directed from the burrow entrance to the other side of the aquarium at a distance of about 40 cm. The other activities, such as nipping sand and lateral display, had never been observed in the aquarium. For the

alpheid shrimp, it always emerged from the burrow and maintained its activities outside the burrow which was mainly depression construction. It never ploughed sand or manipulated objects from inside to outside of the burrow but sometimes decorated the burrow entrance by using large chelae and 2nd periopods to pile up small stones or shell fragments on top of the roof of the entrance. Inside burrow activities of the shrimp was mainly that of burrow maintenance. It always moved along the main and branch tunnel to maintain the condition of the burrow. Sometimes it manipulated shell fragment from one place to another place within the tunnel.

During the feeding time, if only live brine shrimp was used for feeding, the goby always dashed for the brine shrimps which were swimming near the burrow entrance. The alpheid shrimp also came out to catch the brine shrimps with 2nd periopods, always catching two or three at a time and ate outside the burrow. Sometimes it withdrew to eat inside the burrow. If bivalve flesh was given, with 3-4 pieces of bivalve fresh placed at the burrow entrance. Doing so both partners fled into the burrow. The goby emerged 15-20 seconds later to nip at the bivalve flesh. The alpheid shrimp came out later and usually dragged a piece of bivalve flesh very quickly into the resting space inside the burrow to feed on. Food storage occurred same as *A. djiboutensis*.

During the night, the goby withdrew and stayed still inside the burrow all the time. The alpheid shrimp, however, always came out and walked or swam freely over the whole aquarium. This evidence had also been reported by Karplus *et al.* (1972) for *A. djiboutensis*.