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Mao-Sun Su and I-Chiu Liao

臺灣西南沿岸海域產對蝦類之群聚構造

蘇茂森・廖一久

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COMMUNITY STRUCTURE OF PENAEID PRAWNS ALONG THE COASTAL WATERS OF SOUTHWEST TAIWAN[1]

MAO-SEN SU[2] and I-CHIU LIAO[3]

ABSTRACT

The community structure of penaeid prawns along the coastal waters of Southwest Taiwan were studied based on surveys conducted from October 1984 to December 1987.

A total of 20 species of penaeid prawns were collected. Of these species, *Metapenaeopsis barbata*, *Metapenaeus ensis*, *Penaeus semisulcatus*, *Penaeus monodon* and *Parapenaeopsis cornuta* accounted for 83.97% of the total catch in weight. Analysis of species diversity of penaeid community revealed significant spatial and temporal variations. In the offshore waters, the community was grouped into assemblages of 10, 20, 30-40, 60 and 100 m zones, according to water depths. *Metapenaeus ensis* and *Penaeus japonicus* were the dominant species in the estuary of Kaoping River; their seasons of occurrence were different. *Metapenaeus ensis* and *Penaeus monodon* were the main species found in the estuary of Tungkang River and their seasons of distribution overlapped. *Metapenaeus ensis* was the only dominant species in the estuary of Linpien River. On the other hand, more species dominated Dapong Bay, and these included *Metapenaeus ensis*, *Penaeus monodon*, *Penaeus penicillatus* and *Penaeus semisulcatus*. The peak seasons of the occurrence of the four species overlapped.

INTRODUCTION

The establishment of stock enhancement techniques to increase the production of coastal fisheries has been drawing much attention in Taiwan. To promote this venture, the Tungkang Marine Laboratory (TML) of the Taiwan Fisheries Research Institute (TFRI) has selected the coastal waters of Southwest Taiwan as an experimental area for prawn releases.

From the point of view of community ecology, stock enhancement can be considered as the manipulation of an ecosystem with a goal to increase production of a selected species in a given area. All species in a community are interrelated and interact with each other (Odum, 1971). To develop a stock enhancement program, the primary concern should be to delineate the community structure in the selected waters. The purpose of the present study was to investigate the species composition and community structure of penaeid prawns along the coastal waters of Southwest Taiwan.

MATERIALS AND METHODS

Collection of Prawn Samples

Thirteen stations in the offshore waters and one station each in the estuaries of Kaoping River, Tungkang River and Linpien River in Southwest Taiwan (Fig.

1. Contribution A No. 92 from the Tungkang Marine Laboratory.
2. Tungkang Marine Laboratory, Taiwan Fisheries Research Institute, Tungkang, Pingtung 92804, Taiwan, Republic of China.
3. Taiwan Fisheries Research Institute, 199 Hou-Ih Road, Keelung 20220, Taiwan, Republic of China.

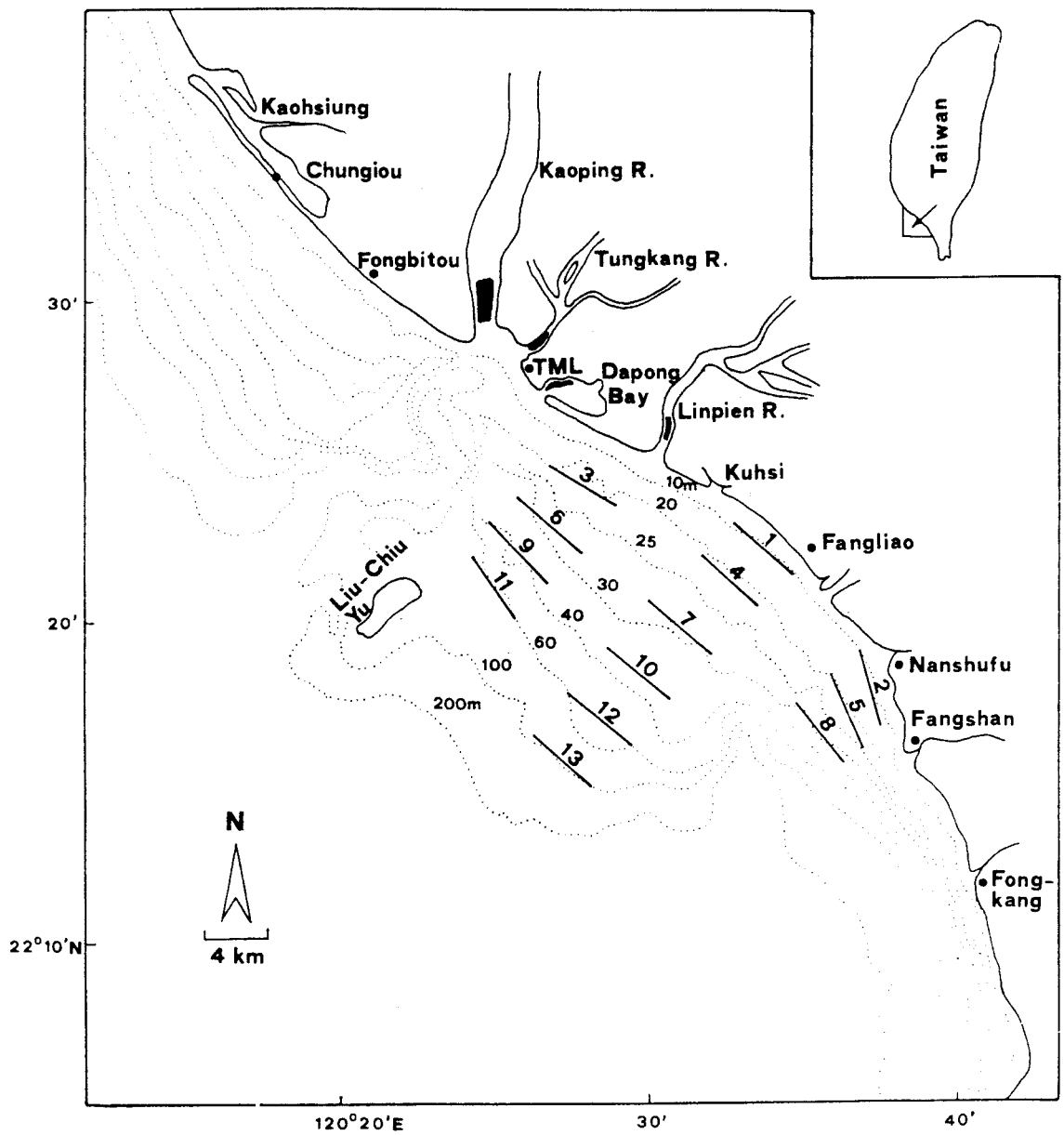

Fig. 1. Location of the 13 sampling stations in offshore waters and three stations in the estuarine waters of the three rivers; TML=Tungkang Marine Laboratory.

1) were established for experimental trawling. At each station, one sample was collected using a chartered beam trawler (5.5 t; 22 HP) in the offshore waters from October 1984 to September 1985 and a motor raft in the estuarine waters from January 1985 to December 1985. In addition, prawn samples were collected monthly from commercial trap nets set in Dapong Bay (Fig. 1) from January 1985 to December 1987.

In the laboratory, prawns from each sample were classified and identified according to the taxonomic keys developed by Lee and Yu (1977) and Yu and Chan (1986).

The total number and weight of each species were then measured for each

sample. The body weight and carapace length were measured for each specimen of *Penaeus monodon*, *Penaeus semisulcatus* and *Metapenaeus ensis*. The length was measured to the nearest 0.1 mm using a vernier caliper and the weight to the nearest 0.01 g using a top loading balance.

Methods of Analysis

Species diversity index was calculated for each sample using the Shannon formula (Shannon and Weaver, 1963; Pielou, 1966; Hill, 1973), thus,

$$H' = -\sum_{i=1}^{s} \frac{N_i}{N} \ln \frac{N_i}{N}$$

Where:

N_i = number of individuals of a species
N = total number of individuals of all species
s = total number of species

The analysis of similarity in species composition between samples was carried out by applying Kimoto's index, $C\pi$ (Kimoto, 1967):

$$\sum\pi_1^2 = \frac{\sum_{i=1}^{s} n_{1i}^2}{N_1^2}, \quad \sum\pi_2^2 = \frac{\sum_{i=1}^{s} n_{2i}^2}{N_2^2}$$

$$C\pi = \frac{2\sum_{i=1}^{s} n_{1i} \cdot n_{2i}}{(\sum\pi_1^2 + \sum\pi_2^2) N_1 \cdot N_2}$$

Where:

n_{1i}, n_{2i} = number of individuals of i species in sample 1 and sample 2, respectively
N_1, N_2 = total number of all species in sample 1 and sample 2, respectively
s = total number of species

Cluster analysis (Mountford, 1962) was then applied to construct the similarity dendrogram to show the affinity of species composition of prawns in the study area.

RESULTS

Species Composition

In the offshore waters, a total of 20 species belonging to seven genera, namely, *Solenocera*, *Penaeus*, *Parapenaeus*, *Parapenaeopsis*, *Metapenaeus*, *Metapenaeopsis*, and *Trachypenaeus* were collected. Of these species, *Metapenaeopsis barbata*, *Metapenaeus ensis*, *Penaeus semisulcatus*, *Penaeus monodon* and *Parapenaeopsis cornuta* were the dominant species (Table 1).

In the estuary of Kaoping River, *Metapenaeus ensis*, *Penaeus monodon* and *Penaeus japonicus* were the dominant species among the nine species of the genera *Penaeus* and *Metapenaeus* collected. In the estuary of Tungkang River, *Metapenaeus ensis* and *Penaeus monodon* were the main species among the 10 species of the genera *Penaeus* and *Metapenaeus* collected. In the estuary of Linpien River, *Metapenaeus ensis* and *Penaeus monodon* were the dominant species among the nine species of the genera *Penaeus* and *Metapenaeus* collected. In Dapong Bay, *Penaeus monodon*, *Metapenaeus ensis*, *Penaeus penicillatus* and *Penaeus semisulcatus* were the

Table 1. Prawn species taken from the combined collections of 13 sampling stations in offshore waters from October 1984 to September 1985, ranked by biomass

Species	Biomass (g)	%	Rank
Metapenaeopsis barbata	35,483	36.63	1
Metapenaeus ensis	16,814	17.36	2
Penaeus semisulcatus	10,498	10.84	3
Penaeus monodon	9,647	9.96	4
Parapenaeopsis cornuta	8,890	9.18	5
Trachypenaeus curvirostris	3,085	3.18	6
Metapenaeus affinis	2,509	2.59	7
Parapenaeus longipes	2,494	2.57	8
Solenocera melantho	1,796	1.85	9
Parapenaeopsis hardwickii	1,678	1.73	10
Penaeus penicillatus	1,434	1.48	11
Penaeus japonicus	870	0.90	12
Parapenaeopsis sculptilis	428	0.44	13
Penaeus sp.	411	0.42	14
Penaeus marginatus	276	0.29	15
Penaeus canaliculatus	208	0.22	16
Metapenaeus joyneri	192	0.20	17
Metapenaeus moyebi	124	0.13	18
Trachypenaeus anchoralis	23	0.02	19
Penaeus longitylus	14	0.01	20

main species among the 12 species of the genera *Penaeus* and *Metapenaeus* collected (Table 2).

Species Diversity

In the offshore waters, the species diversity was higher in waters deeper than 60 m all year round and in waters at depths of less than 20 m during summer and early autumn and lower in waters at depths of less than 60 m during winter and early spring (Fig. 2).

In the estuarine waters, the species diversity was higher in Dapong Bay all year round and in estuaries of Kaoping and Tungkang Rivers during spring and summer and lower in the estuary of Linpien River all year round (Fig. 3).

Spatial Structure of the Community

Based on the combined data of species composition for the whole year, the similarity dendrogram among 13 stations was constructed (Fig. 4). The dendrogram indicates that the stations can be grouped into three major assemblages, namely, stations 1-2, stations 3-4-5-6-7-8-9-10-11-12 and station 13. The second assemblage can be subdivided into three groups, namely, stations 3-4-5, stations 6-7-8-9-10 and stations 11-12. Considering the depth of each station, the divisions are closely related to water depths. In other words, the community can be divided, according to water depths, namely, into 10, 20, 30-40, 60 and 100 m zone assemblages.

The relative abundance of each species at each station is shown in Fig. 5. In the 10 m zone, the dominant species were *Parapenaeopsis cornuta, Trachypenaeus curvirostris, Penaeus monodon, Metapenaeus affinis, Parapenaeopsis hardwickii* and

Table 2. Prawn species collected from different estuarine waters of three rivers in 1985 and Dapong Bay in 1986, ranked by biomass

Estuary	Species	Biomass (g)	%	Rank
Kaoping	*Metapenaeus ensis*	1,782	45.98	1
	Penaeus monodon	1,192	30.75	2
	Penaeus japonicus	634	16.36	3
	Penaeus penicillatus	78	2.01	4
	Penaeus canaliculatus	58	1.50	5
	Metapenaeus affinis	50	1.29	6
	Penaeus semisulcatus	40	1.03	7
	Penaeus longitylus	37	0.95	8
	Metapenaeus joyneri	5	0.13	9
Tungkang	*Metapenaeus ensis*	34,427	60.44	1
	Penaeus monodon	21,541	37.82	2
	Metapenaeus affinis	223	0.39	3
	Penaeus semisulcatus	205	0.36	4
	Penaeus penicillatus	200	0.35	5
	Penaeus canaliculatus	112	0.20	6
	Penaeus japonicus	96	0.17	7
	Metapenaeus moyebi	96	0.17	8
	Penaeus sp.	59	0.10	9
	Penaeus marginatus	4	0.01	10
Linpien	*Metapenaeus ensis*	14,137	78.66	1
	Penaeus monodon	3,076	17.12	2
	Penaeus japonicus	408	2.27	3
	Metapenaeus joyneri	119	0.66	4
	Penaeus sp.	93	0.52	5
	Penaeus semisulcatus	88	0.49	6
	Metapenaeus affinis	22	0.12	
	Metapenaeus moyebi	22	0.12	
	Penaeus penicillatus	7	0.04	9
Dapong	*Penaeus monodon*	48,101	41.37	1
	Metapenaeus ensis	28,361	24.40	
	Penaeus penicillatus	19,514	16.79	
	Penaeus semisulcatus	11,451	9.85	4
	Penaeus sp.	6,172	5.31	5
	Penaeus japonicus	1,480	1.27	6
	Metapenaeus moyebi	814	0.70	7
	Metapenaeus affinis	257	0.22	8
	Penaeus marginatus	50	0.04	9
	Penaeus canaliculatus	30	0.03	10
	Penaeus latisulcatus	22	0.02	11
	Metapenaeus joyneri	5	0.00	12

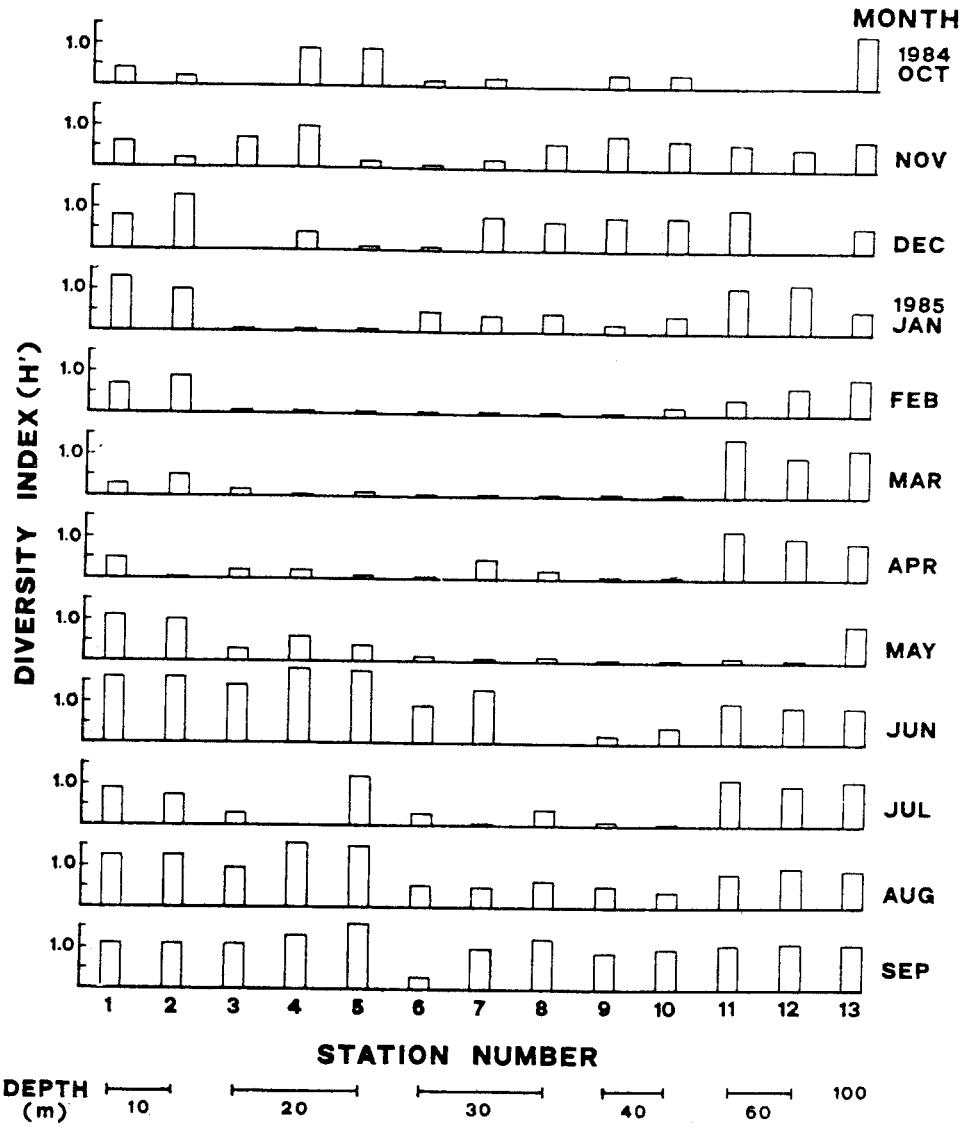

Fig. 2. The species diversity by month and station in offshore waters.

Parapenaeopsis sculptilis. In the 20 m zone, the dominant species included *Metapenaeopsis barbata, Trachypenaeus curvirostris, Metapenaeus ensis, Parapenaeopsis cornuta* and *Penaeus monodon.* In the 30-40 m zone, the dominant species were *Metapenaeopsis barbata, Metapenaeus ensis, Metapenaeus affinis, Parapenaeus longipes* and *Penaeus semisulcatus.* In the 60 m zone, the dominant species were *Parapenaeus longipes, Metapenaeus ensis, Metapenaeopsis barbata,* and *Trachypenaeus curvirostris.* In the 100 m zone, the dominant species were *Parapenaeus longipes, Metapenaeus ensis, Solenocera melantho* and *Metapenaeopsis barbata.*

Temporal Structure of the Community

Based on the monthly combined data of species composition of all stations in the offshore waters, the similarity dendrogram among 12 months was constructed. Three major periods were noted, namely, (1) January-May, (2) June-September

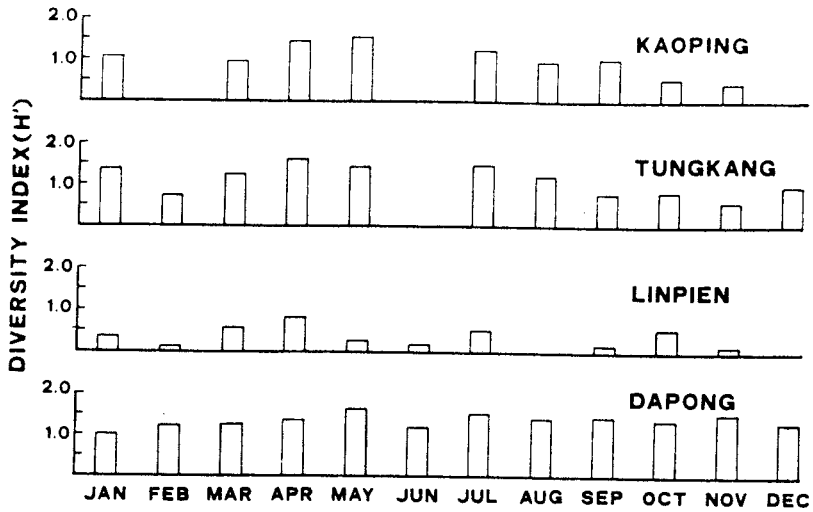

Fig. 3. Monthly change in species diversity of prawns in the various estuarine waters of three rivers in 1985 and Dapong Bay in 1986.

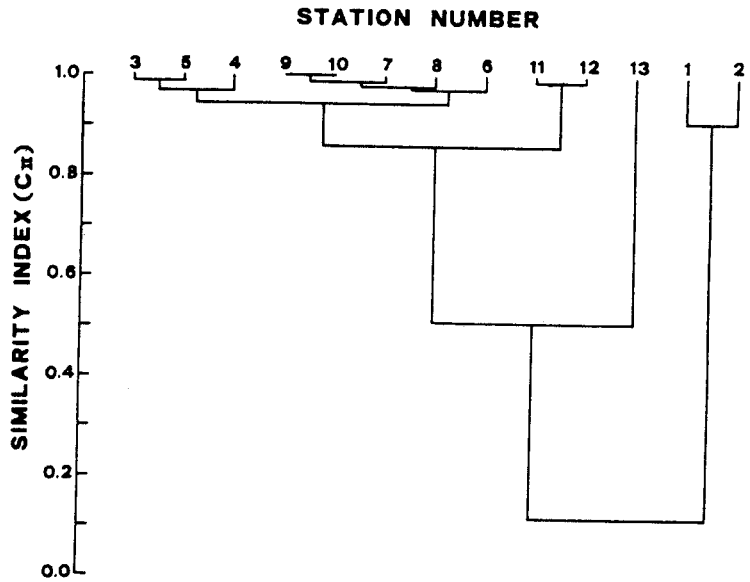

Fig. 4. The similarity dendrogram of species composition among 13 sampling stations.

and November-December and (3) October (Fig. 6). The main species in the first period were *Metapenaeopsis barbata, Parapenaeopsis cornuta, Metapenaeus ensis, Parapenaeus longipes, Trachypenaeus curvirostris, Solenocera melantho* and *Penaeus semisulcatus*; in the second period, *Metapenaeopsis barbata, Parapenaeopsis cornuta, Metapenaeus ensis, Trachypenaeus curvirostris, Parapenaeus longipes, Metapenaeus affinis, Penaeus monodon, Parapenaeopsis hardwickii* and *Parapenaeopsis sculptilis*; and in the third period *Parapenaeopsis cornuta, Metapenaeopsis barbata* and *Metapenaeus ensis* (Fig. 7).

The similarity dendrogram of species composition among 12 months by estuary was also constructed. In the estuary of Kaoping River, three major clusters were observed, namely, October-March, April-May and July (Fig. 8). The dominant species in the first period was *Metapenaeus ensis*; in the second period, *Penaeus*

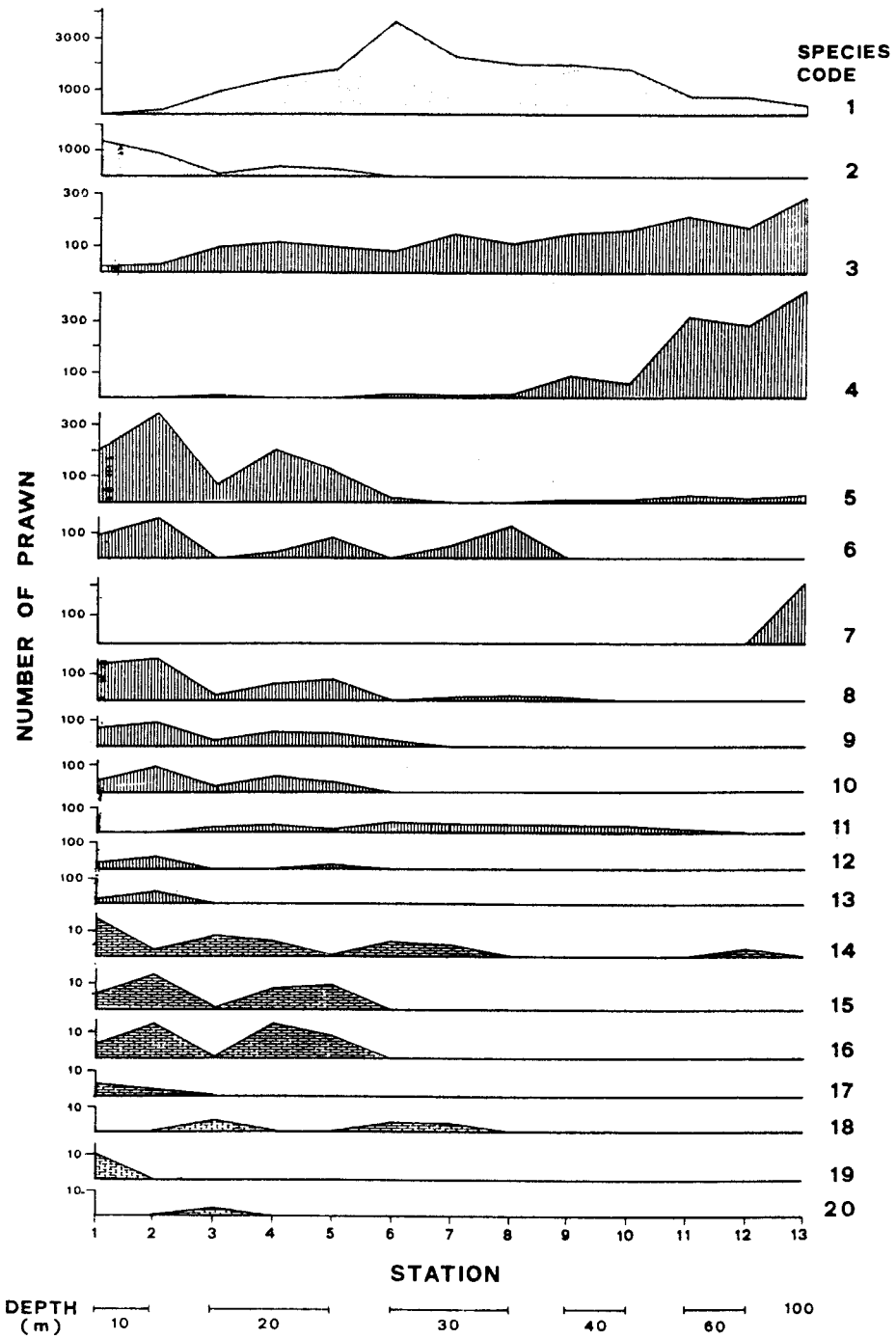

Fig. 5. Spatial variations of relative abundance of prawn species in offshore waters, based on the combined data of CPUE (no./h) for the whole years. 1: *Metapenaeopsis barbata*; 2: *Parapenaeopsis cornuta*; 3: *Metapenaeus ensis*; 4: *Parapenaeus longipes*; 5: *Trachypenaeus curvirostris*; 6: *Metapenaeus affinis*; 7: *Solenocera melantho*; 8: *Penaeus monodon*; 9: *Parapenaeopsis hardwickii*; 10: *Parapenoeopsis sculptilis*; 11: *Penaeus semisulcatus*; 12: *Metapenaeus joyneri*; 13: *Penaeus marginatus*; 14: *Penaeus japonicus*; 15: *Penaeus penicillatus*; 16: *Metapenaeus moyebi*; 17: *Penaeus* sp.; 18: *Penaeus canaliculatus*; 19: *Trachypenaeus anchoralis*; 20: *Penaeus longistylus*.

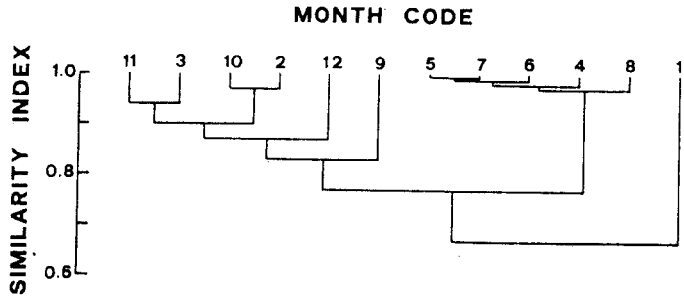

Fig. 6. The similarity dendrogram of species composition of prawns among 12 months. 1: Oct. 1984; 2: Nov.; 3: Dec.; 4: Jan. 1985; 5: Feb.; 6: Mar.; 7: Apr.; 8: May; 9: June; 10: July; 11: Aug.; 12: Sept.

japonicus, *Metapenaeus ensis*, *Penaeus monodon* and *Penaeus canaliculatus*; and in the third period, *Metapenaeus ensis*, *Penaeus monodon*, *Penaeus penicillatus* and *Metapenaeus affinis* (Fig. 9). In the Tungkang River estuary, three major periods were identified. The first period included January-February and September-November; the second period included March, July-August and December; and the third period, April-May (Fig. 8). During the first period, the main species were *Metapenaeus ensis*, *Penaeus monodon*, *Metapenaeus moyebi*, *Penaeus japonicus* and *Penaeus semisulcatus*; second period, *Metapenaeus ensis*, *Penaeus monodon*, *Metapenaeus affinis*, *Penaeus japonicus* and *Penaeus semisulcatus*; third period, *Penaeus monodon*, *Metapenaeus ensis*, *Metapenaeus affinis*, *Penaeus japonicus* and *Penaeus semisulcatus* (Fig. 10). In the Linpien River estuary, three major periods were identified. The first period consisted of three groups, i.e., January-March, May-July, September-November; the second period, April and the third period, August (Fig. 8). The main species in the first period were *Metapenaeus ensis*, *Penaeus monodon* and *Penaeus japonicus*; in the second period, *Penaeus monodon*; and in the third period, *Metapenaeus ensis* (Fig. 11). In Dapong Bay, four major periods were identified. The first period included September-February and May; the second period, March-April; the third period, June and August; and the fourth period, July (Fig. 8). In the first period, the main species were *Metapenaeus ensis*, *Penaeus monodon*, *Penaeus penicillatus*, *Penaeus semisulcatus* and *Penaeus* sp.; the second period, *Metapenaeus ensis*, *Penaeus monodon*, *Penaeus penicillatus*, *Penaeus* sp., *Metapenaeus moyebi*, *Penaeus japonicus*, and *Metapenaeus affinis*; the third period, *Metapenaeus ensis*, *Penaeus monodon*, *Penaeus penicillatus*, *Penaeus semisulcatus*, and *Metapenaeus moyebi*; and the fourth period, *Metapenaeus ensis*, *Penaeus penicillatus*, *Penaeus semisulcatus* and *Penaeus monodon* (Fig. 12).

DISCUSSION

A total of 20 species of penaeid prawns were collected from the offshore waters during this survey. Among them, nine species were known to inhabit the estuary of Kaoping River; 10 species, the Tungkang River; nine species, the Linpien River; and 12 species, the Dapong Bay. All these species which inhabit estuaries belong to the genera *Penaeus* and *Metapenaeus*. Kutkuhn (1966) reported that *Metapenaeopsis barbata* inhabit estuaries. In the present study, however, it was not observed to enter the estuarine waters.

By the similarity of species composition, the community of penaeid prawns in the offshore waters can be divided, according to water depths, into 10, 20, 25, 30,

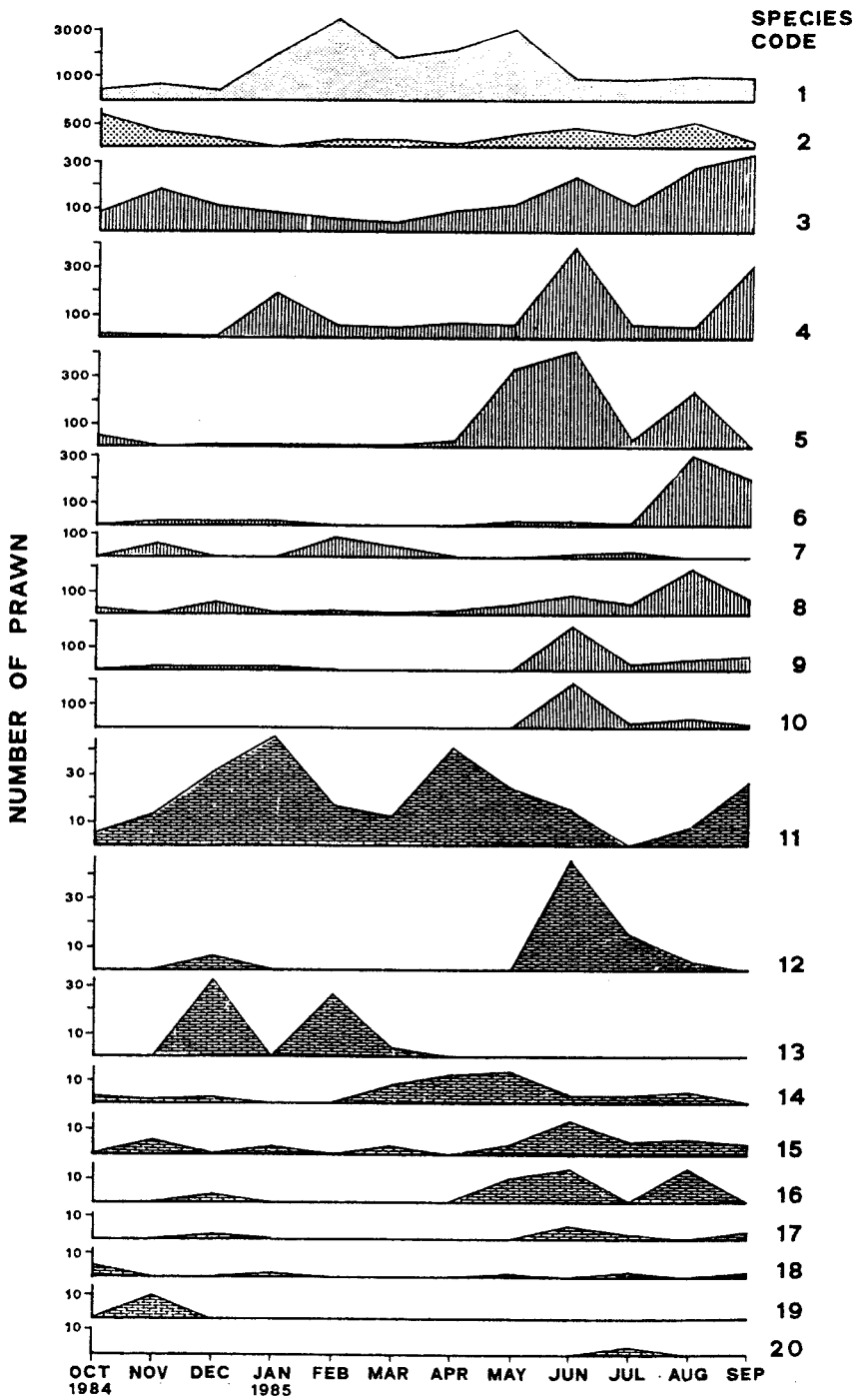

Fig. 7. Seasonal changes in abundance of prawn species in offshore waters, based on the combined data of CPUE (no./h) of the 13 stations. 1: *Metapenaeopsis barbata*; 2: *Parapenaeopsis cornuta*; 3: *Metapenaeus ensis*; 4: *Parapenaeus longipes*; 5: *Trachypenaeus curvirostris*; 6: *Metapenaeus affinis*; 7: *Solenocera melantho*; 8: *Penaeus monodon*; 9: *Parapenaeopsis hardwickii*; 10: *Parapenaeopsis sculptilis*; 11: *Penaeus semisulcatus*; 12: *Metapenaeus joyneri*; 13: *Penaeus marginatus*; 14: *Penaeus japonicus*; 15: *Penaeus penicillatus*; 16: *Metapenaeus moyebi*; 17: *Penaeus* sp.; 18: *Penaeus canaliculatus*; 19: *Trachypenaeus anchoralis*; 20: *Penaeus longistylus*.

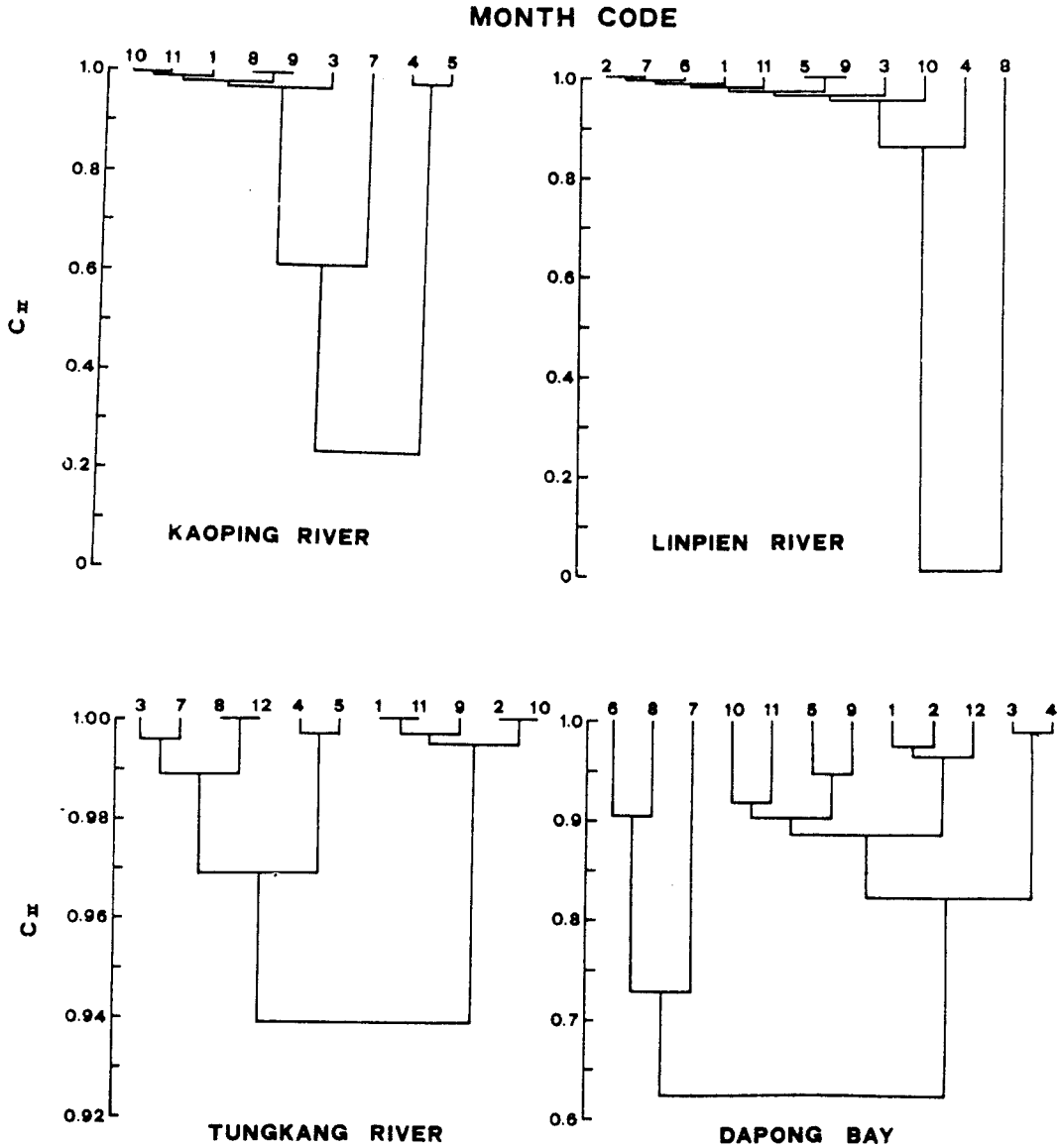

Fig. 8. The similarity dendrogram of species composition of prawns among 12 months by estuary. 1: Jan.; 2: Feb.; 3: Mar.; 4: Apr.; 5: May; 6: June; 7: July; 8: Aug.; 9: Sept.; 10: Oct ; 11: Nov.; 12: Dec.

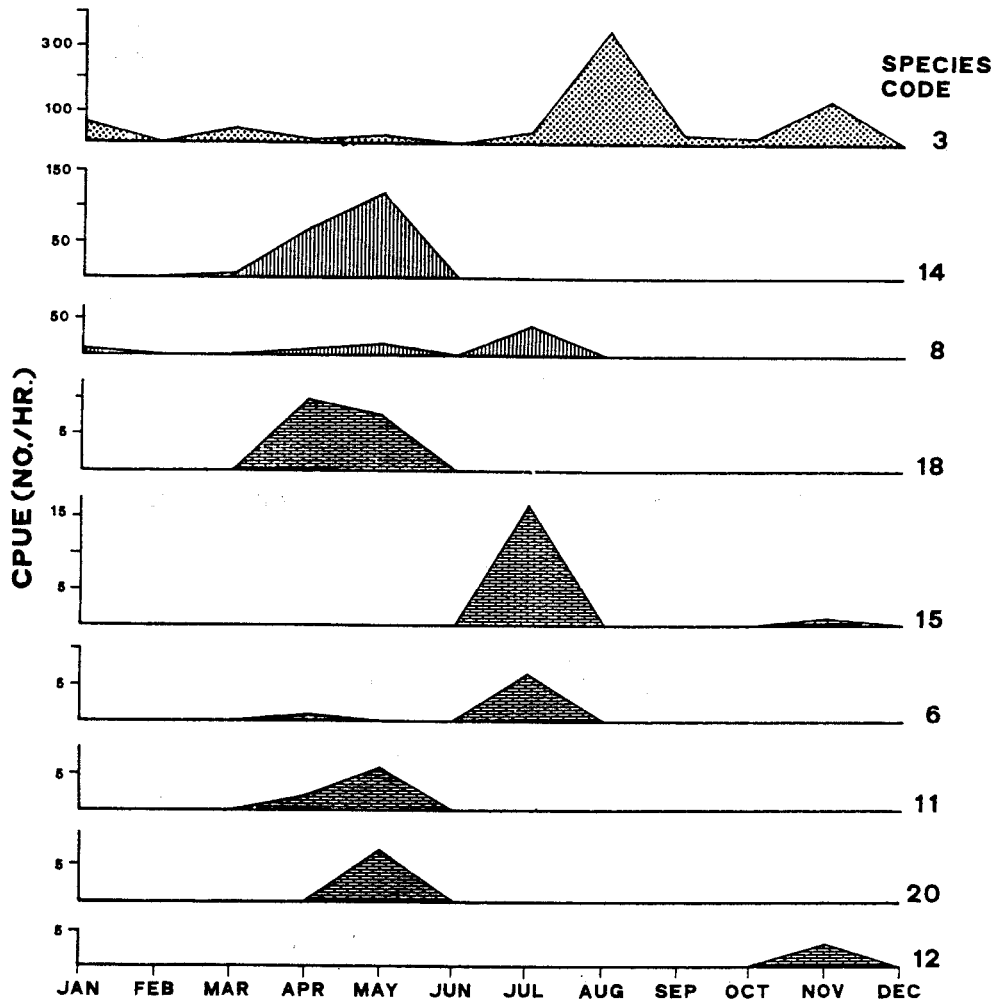

Fig. 9. Seasonal changes in abundance of prawn species in the estuary of the Kaoping River in 1985. 3: *Metapenaeus ensis*; 6: *Metapenaeus affinis*; 8: *Penaeus monodon*; 11: *Penaeus semisulcatus*; 12: *Metapenaeus joyneri*; 14: *Penaeus japonicus*; 15: *Penaeus penicillatus*; 18: *Penaeus canaliculatus*; 20: *Penaeus longistylus*.

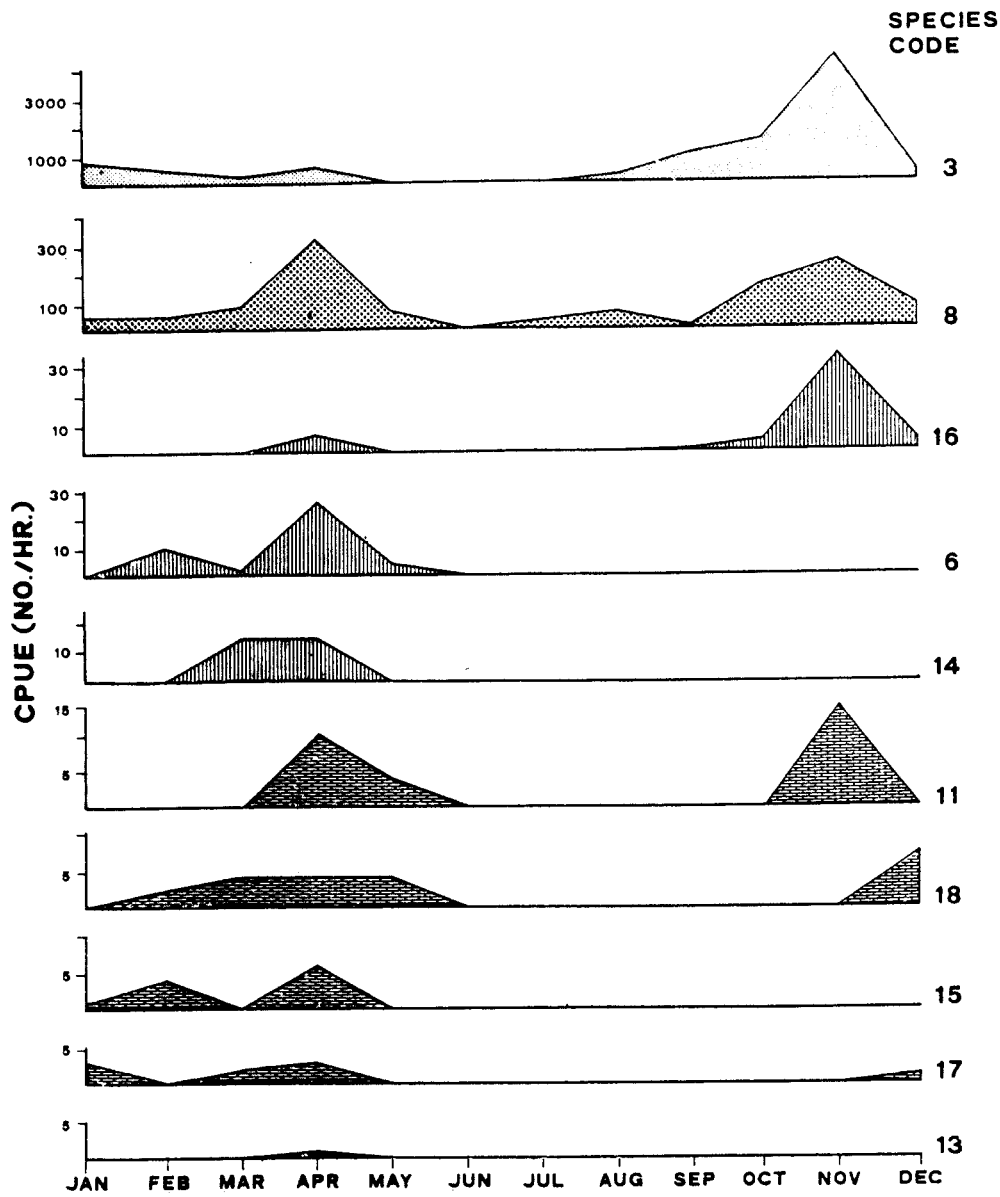

Fig. 10. Seasonal changes in abundance of prawn species in the estuary of the Tungkang River in 1985. 3: *Metapenaeus ensis*; 6: *Metapenaeus affinis*; 8: *Penaeus monodon*; 11: *Penaeus semisulcatus*; 13: *Penaeus marginatus*; 14: *Penaeus japonicus*; 15: *Penaeus penicillatus*; 16: *Metapenaeus moyebi*; 17: *Penaeus* sp.; 18: *Penaeus canaliculatus*.

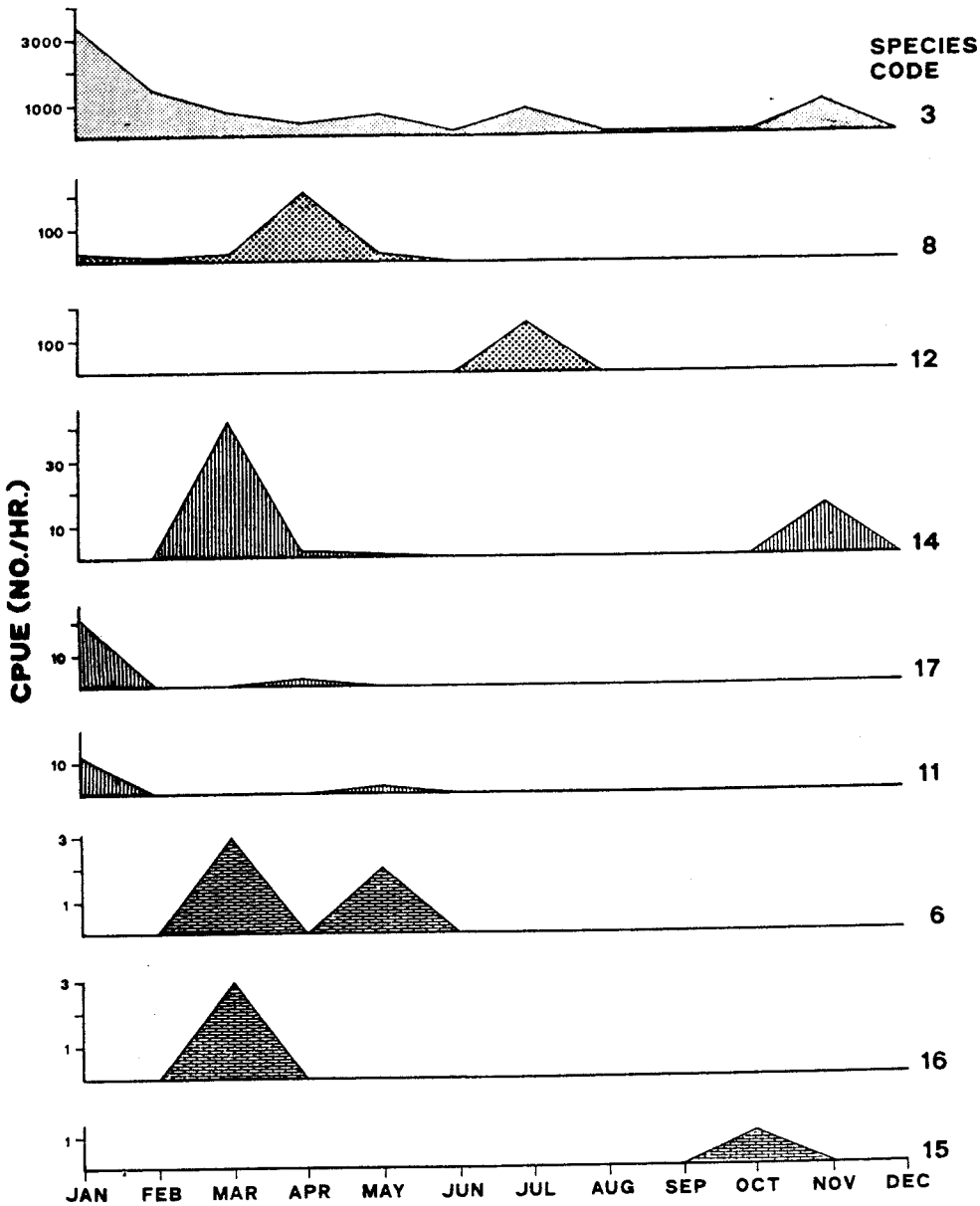

Fig. 11. Seasonal changes in abundance of prawn species in the estuary of the Linpien River in 1985. 3: *Metapenaeus ensis*; 6: *Metapenaeus affinis*; 8: *Penaeus monodon*; 11: *Penaeus semisulcatus*; 12: *Metapenaeus joyneri*; 14: *Penaeus japonicus*; 15: *Penaeus penicillatus*; 16: *Metapenaeus moyebi*; 17: *Penaeus* sp.

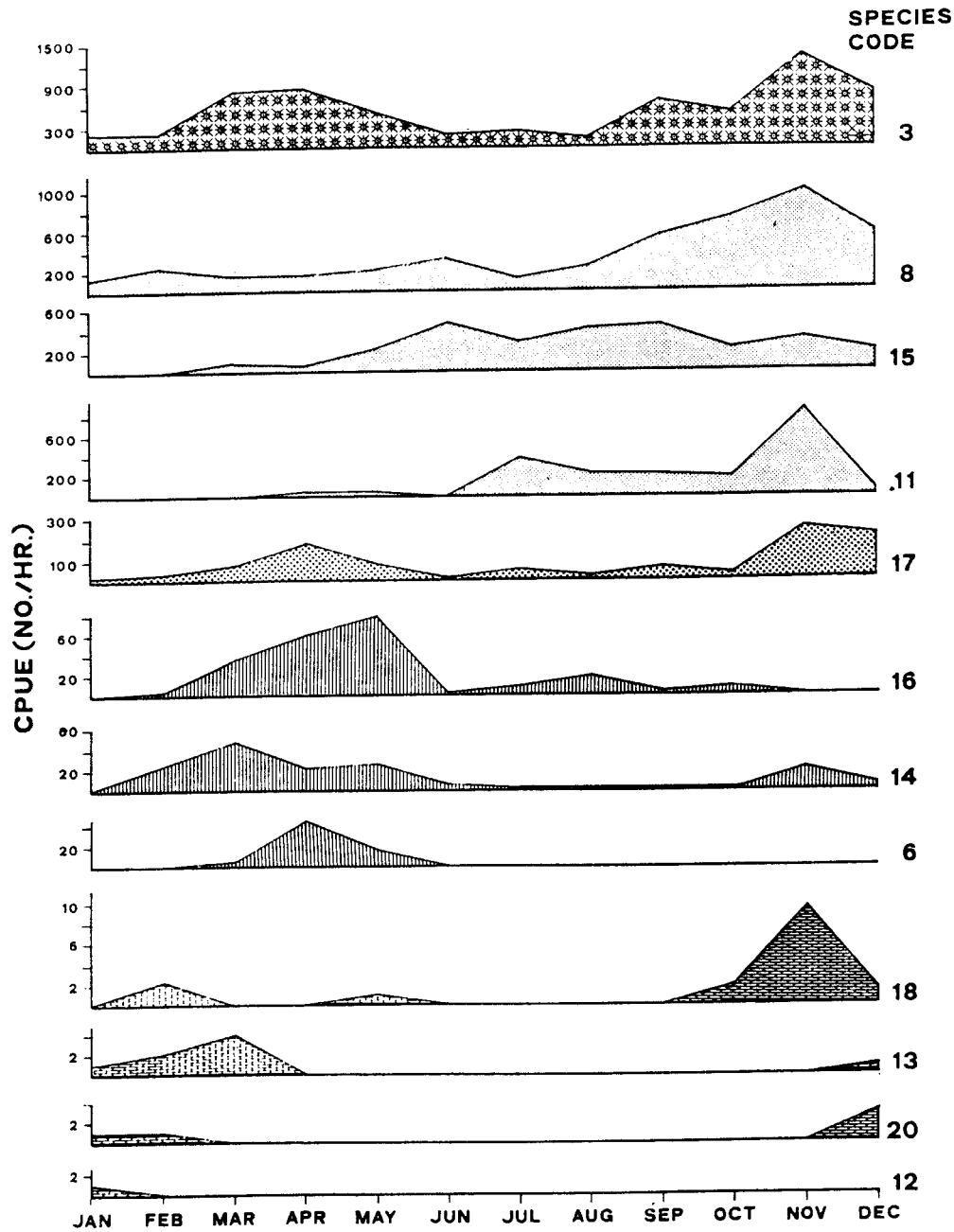

Fig. 12. Seasonal changes in abundance of prawn species in Dapong Bay in 1986. 3: *Metapenaeus ensis*; 6: *Metapenaeus affinis*; 8: *Penaeus monodon*; 11: *Penaeus semisulcatus*; 12: *Metapenaeus joyneri*; 13: *Penaeus marginatus*; 14: *Penaeus japonicus*; 15: *Penaeus penicillatus* 16: *Mntapenaeus moyebi*; 17: *Penaeus* sp.; 18: *Penaeus canaliculatus*; 20: *Penaeus longistylus*.

40, 60 and 100 m zone assemblages. However, more studies are needed to determine the key environmental factors which influence the community structure of penaeid prawns in this area.

It was found that *Metapenaeopsis barbata, Metapenaeus ensis, Penaeus semisulcatus, Penaeus monodon* and *Parapenaeopsis cornuta* were the dominant species in the offshore waters. Among them, *Penaeus monodon, Penaeus semisulcatus* and *Metapenaeus ensis* are the most economically important ones. These three species are, therefore, recommended as target species for stock enhancement.

Penaeus monodon is mainly distributed in 10 and 20 m zones from May to September (Figs. 5 & 7). In these zones, the species which are more abundant than *Penaeus monodon* included *Parapenaeopsis cornuta, Trachypenaeus curvirostris* and *Metapenaeus affinis* (Fig. 5). *Parapenaeopsis cornuta* appeared mainly from May to October, *Trachypenaeus curvirostris*, from May to August and *Metapenaeus affinis*, from July to September (Fig. 7). Therefore, *Penaeus monodon* may encounter competition for substrate or food from *Parapenaeopsis cornuta, Trachypenaeus curvirostris* and *Metapenaeus affinis* from May to September. *Penaeus semisulcatus* was mainly distributed in 30-40 m zones from December to February and from April to May (Figs. 5 & 7). In these zones, the species which were more abundant than *Penaeus semisulcatus* included *Metapenaeopsis barbata, Metapenaeus ensis* and *Metapenaeus affinis* (Fig. 5). *Metapenaeopsis barbata* appeared mainly from January to May and *Metapenaeus ensis* from July to November (Fig. 7). The present study showed that these species are more or less seasonally separated and hence, avoided possible competition between each other. *Metapenaeus ensis* was mainly distributed in 30-40, 60 and 100 m zones from July to November (Figs. 5 & 7). In these zones, the species which were more abundant than *Metapenaeus ensis* included *Metapenaeopsis barbata* and *Parapenaeus longipes* (Fig. 5). *Parapenaeus longipes* appeared mainly in January, July and September (Fig. 7). Therefore, *Metapenaeus ensis* may encounter competition from *Parapenaeus longipes* from July to September. Accordingly, to develop an effective stock enhancement program for *Penaeus monodon* and *Metapenaeus ensis*, the possible competition for space and food from other relative species must be considered.

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臺灣西南沿岸海域產對蝦類之羣聚構造

蘇 茂 森　　廖 一 久

摘　　要

本研究旨在探討臺灣西南沿岸海域產對蝦類之羣聚構造，以提供建立此海域蝦類栽培漁業體系所需之基礎資料。

在調查期間（1984 年 10 月至 1987 年 12 月），總共採得 20 種對蝦類，期中以鬚赤對蝦、劍角新對蝦（俗稱砂蝦）、短溝對蝦（俗稱熊蝦）、草對蝦（俗稱草蝦）與角突仿對蝦爲優勢種。種多樣度在時空間上有明顯的變化。種類組成類似度分析結果顯示，此海域之對蝦類羣聚可依互爲平行之10, 20, 30～40, 60 與 100 m 等深線加以明確區分。

從生態地位與經濟層面加以綜合評估，草對蝦、短溝對蝦與劍角新對蝦爲此海域發展蝦類栽培漁業之有希望種類。本報告進一步依據種類組成之時空變化，分別探討此等種類與其他種類之競爭關係，以供選擇最佳放流策略之參考。