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東港沿岸海域之草蝦分佈與攝餌生態

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Distribution and Feeding Ecology of *Penaeus monodon* Along the Coast of Tungkang, Taiwan[1]

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Abstract

The distribution, size composition and feeding ecology of *Penaeus monodon* in the coastal waters of Tungkang, Taiwan, were studied from July 1982 to August 1985.

Gravid female shrimp are found inshore and offshore at depths between 10 and 40 m from June to December. Spawning peaks occur in August and November. Juveniles and subadults are found in the Kaoping, the Tungkang and the Linpien estuaries from March to May. Emigration of subadults from Dapong Bay occurs mainly from June to October. Subadults and adults are caught in appreciable numbers in coastal waters between Dapong Bay and Nanshufu at depths less than 40 m from June to January with the peak from July to October. The stomach contents of the shrimp are mainly composed of crustacea, mollusca, fish, detritus and sand granules. Seasonal and geographical variations in stomach content compositions are significant.

Introduction

To establish an effective system of shrimp ranching fisheries in Taiwan, the Tungkang Marine Laboratory has selected the shrimp fishing grounds along the coast of Tungkang as the experimental area and engaged in a series of studies on the biology, ecology and population dynamics of the economically-important shrimp in this area.

In this paper, the distribution, size composition and feeding ecology of *P. monodon* in the coastal area of Tungkang are presented.

Materials and Methods

The study area includes the Tungkang coast and its adjacent estuaries and bays (Fig. 1).

The catch and effort data were collected from a commercial beam trawler (5.5 t, 22 hp) operated in the coastal area from July 1982 to July 1985. The methods of data collection and processing are the same as those described by Su and Liao (1984). The data of three years were summed up by month and by sampling site and catch per unit effort (CPUE) was calculated.

To assess shrimp in estuaries, a motor raft was employed. A 4 m wide beam trawl fitted with 20-mm mesh net was towed in daytime at a speed about 20 m/min. over the bottom. Each month, five 20-min. trawls were made at the Kaoping, Tungkang and Linpien estuaries from September 1984 to August 1985.

To estimate the emigration of shrimp from the bay into the sea, a sample was taken from a set net at the mouth of Dapong Bay four times every month from September 1984 to August 1985.

In addition to the catch and effort data, monthly samples were collected from the various sampling sites from September 1984 to August 1985. The carapace length (CL) of each specimen was measured to the nearest 0.1 mm, and the body weight (BW) to the nearest 0.01 g. Individual sex was determined and in the case of females a visual estimate of ovarian development was recorded. Stomach contents were preserved in 5% formalin. The fullness of each stomach was determined visually and an index of 0-4 was given corresponding to the quantitative range of empty to full. For stomach content analysis, the entire contents of each stomach were rinsed into a petri dish and examined under a binocular microscope. The frequency of occurrence method (Hyslop 1980) was then employed to elucidate on the spectrum of food ingested.

Results

The monthly distribution of gravid females (spawners) in the coastal waters is shown in Fig. 2. The spawners were absent from the sampling area from January to May. They were caught in the waters between the estuary of Linpien River and Nanshufu at depths of 10-40 m from June to December with the peaks in August and November. CPUEs of 7-8 spawners per ten hours occurred in the peak season.

Fig. 3 shows the monthly distribution of shrimp (excluding spawners) in the coastal waters. No shrimp were caught between Chungjou and Fangliao at depths more than 20 m from February to May. The shrimp

occurred between Chungjou and Nanshufu at depths less than 40 m from June to January. Shrimp were more abundant from February to May in the Kaoping, Tungkang and Linpien estuaries and in August in the Tungkang estuary (Fig. 4). The catch data collected at the mouth of Dapong Bay revealed that the shrimp emigrate from the bay to the sea from June to October (Fig. 4).

The size composition of carapace length (CL) by area is shown in Fig. 5. These results show the broad size ranges of shrimp residing in the sampled estuaries and of shrimp emigrating from the Dapong Bay to the sea. The largest shrimp were in general found in the deeper offshore waters.

The intensity of feeding is assumed to be high when the fullness index of stomach is 3 or 4 (50-75% and 75-100% full, respectively). As shown in Table 1, the shrimp in the Dapong Bay forage more intensively in winter and spring. However, in coastal waters intensive feeding occurs in spring and summer.

The stomach contents were classified into eight categories. The relative importance of stomach content by season and by locality is shown in Table 2. In Dapong Bay, Crustacea, Mollusca, fish, detritus and sand granules are the main food. Crustacea occur more often in summer, Mollusca and detritus in spring and sand granules in winter, respectively. Seasonal variation of foraging on fish is not apparent. In coastal waters, Crustacea, Mollusca, detritus and sand granules constitute the main diets. The shrimp forage more often on Crustacea in summer and autumn, Mollusca and detritus in spring and summer and sand grand granules in spring, summer and winter.

Discussion

Judging from the temporal and spatial distribution of CPUEs of spawners (Fig. 2), it is apparent that the main spawning grounds are located at depths from 10 to 40 m to the southwest of the coast between the estuary of Linpien River and Nanshufu. The spawning season is from June to December with peaks in August and November. Motoh (1981) found that the spawners of *P. monodon* could be caught at the mouth of Batan Bay and in the waters off Tigbauan in the Philippines all year-round, but that spawning peaks occur in February, July and November at Batan Bay and in March and October at Tigbauan. Therefore, it is reasonable to conclude that *P. monodon* spawns inshore or offshore depending on favorable salinity and temperature. The spawning season of *P. monodon* in Taiwan is different from the season in the Philippines. Peak spawning takes place in February and March in the Philippines, but not in Taiwan where spawners can rarely be caught from January to May. This difference may be ascribed to geographical variation or overfishing. Local fishermen remember that several years ago spawners of *P. monodon* could be caught in greater numbers from January to May. Urgent action is required to stop the overfishing of *P. monodon* in Taiwan.

Although no shrimp were caught at more than 20 m from February to May (Fig. 3), shrimp were present in estuaries from February to May (Fig. 4). Adolescent and subadult shrimp may be found in nearshore waters at less than 10 m from February to May, although no sampling of these waters was done during this study.

The life cycle of *P. monodon* in the coastal waters of Tungkang is summarized in Fig. 6. Spawning occurs in inshore or offshore waters at depths from 10 to 40 m from June to December. The developing larvae gradually move toward the nearshore waters, estuaries and bays where they grow into adolescents or subadults. After 4-6 months in the natural nurseries, the shrimp swim to deeper water and grow into adults, the mature shrimp at first residing in inshore waters, then moving offshore gradually.

Marte (1980) studied the food and feeding habit of *P. monodon* from Makato River, Philippines, and reported that they feed mainly on Crustacea and Mollusca. Organic detritus, silt and sand were ingested in relatively small amounts. However, this study found that Crustacea, Mollusca, detritus and sand granules are all ingested intensively. The seasonal variations in feeding intensity (Table 1) and stomach contents (Table 2) suggest that the food environment changes with the seasons. Fish fragments are found in the stomach contents of the shrimp from the bay, but not in those from the sea (Table 2). This suggests that their feeding habit is modified by food environment.

The results of this study suggest that *P. monodon* is a suitable species for sea ranching in the coastal waters of Tungkang. The juvenile, adolescent and subadult shrimp reside in the estuaries, the bay and the nearshore waters. The subadults and adults are largely distributed in inshore waters. Shrimp foods are abundant in coastal waters. Released shrimp can have sufficient food for growing and can be harvested from specific areas. In fact, several trial releases of tagged *P. monodon* (50 g BW in average) have been done, with average recovery rates of 15% and maximum growth of about 30 g/month (Su and Liao, unpublished data). It must be noted, however, that unless controls on fry fishing in bays and estuaries are implemented, these waters cannot be used as nurseries. These preliminary results suggest that the future of *P. monodon* ranching in this area is quite promising.

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Table 1. Fullness of stomachs of *P. monodon* by season and locality (%).

Fullness index*	Winter (Jan-Mar) A	Winter (Jan-Mar) B	Spring (Apr-Jun) A	Spring (Apr-Jun) B	Summer (Jul-Sep) A	Summer (Jul-Sep) B	Autumn (Oct-Dec) A	Autumn (Oct-Dec) B
0	17	7	43	0	40	1	43	3
1	33	69	20	52	33	25	27	50
2	16	15	8	14	16	14	11	17
3	17	7	15	5	6	19	9	16
4	17	2	14	29	5	42	11	14
No. of stomachs examined	36	13	49	21	221	144	301	76

*Index 0, 1, 2, 3, 4 indicate: empty, 1-25%, 25-50%, 50-75%, 75-100% fullness, respectively.
A: Dapong Bay; B: Coastal waters.

Table 2. Occurrence of stomach contents of *P. monodon* by season and locality (%).

Stomach contents	Winter (Jan-Mar) A	Winter (Jan-Mar) B	Spring (Apr-Jun) A	Spring (Apr-Jun) B	Summer (Jul-Sep) A	Summer (Jul-Sep) B	Autumn (Oct-Dec) A	Autumn (Oct-Dec) B
Crustacea	63.6	8.3	57.1	24.8	75.2	58.6	53.8	48.2
Mollusca	40.9	33.3	57.1	61.9	40.9	56.9	42.4	28.3
Fish	27.3	0	35.7	0	30.5	4.8	28.0	5.6
Detritus	68.2	75.0	82.1	100	67.6	91.8	82.9	83.0
Sand granules	77.3	75.0	71.4	95.2	65.7	98.3	46.9	92.4
Plant material	0	0	0	0	0	6.5	0	0
Radiolarians	0	0	3	14.2	0	19.5	0	1.8
Sponges	0	0	0	0	0	6.5	0	0
No. of stomachs* examined	22	12	28	21	105	123	132	53

*With fullness index 3 or 4.
A: Dapong Bay; B: Coastal waters.

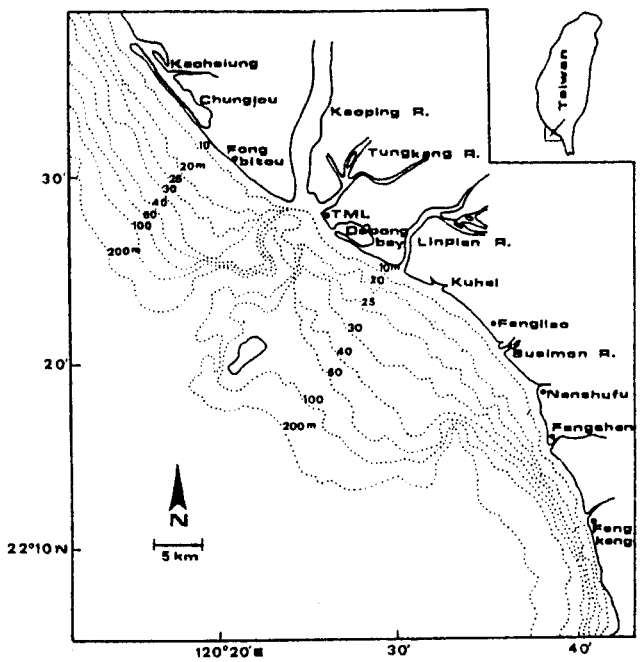

Fig. 1. Map showing the study area.

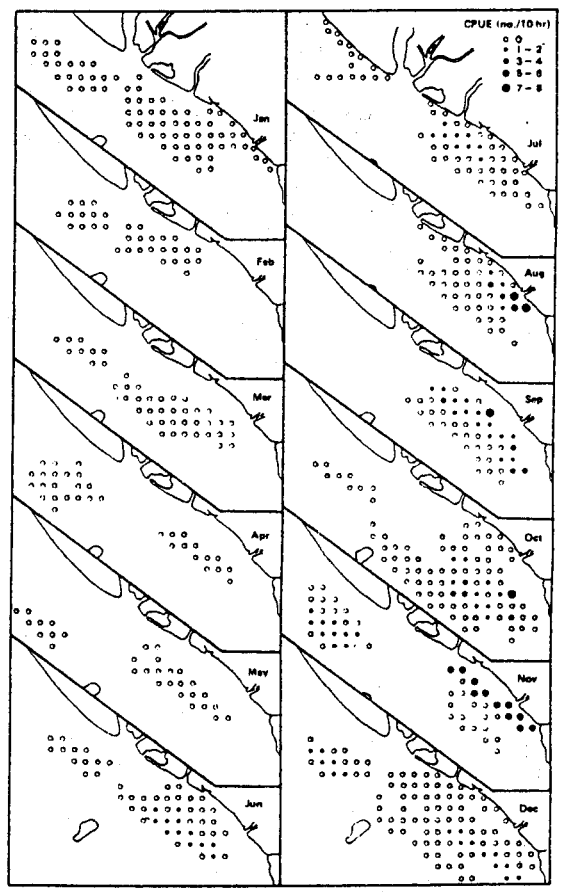

Fig. 2. Monthly distribution of CPUE (in number per 10 hours) of spawners of *P. monodon*.

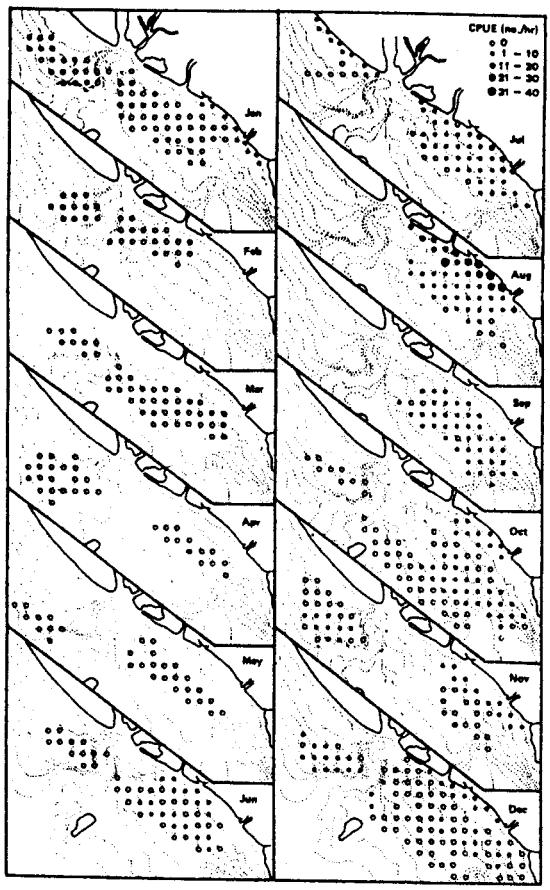

Fig. 3. Monthly distribution of CPUE (in number per hour) of *P. monodon*.

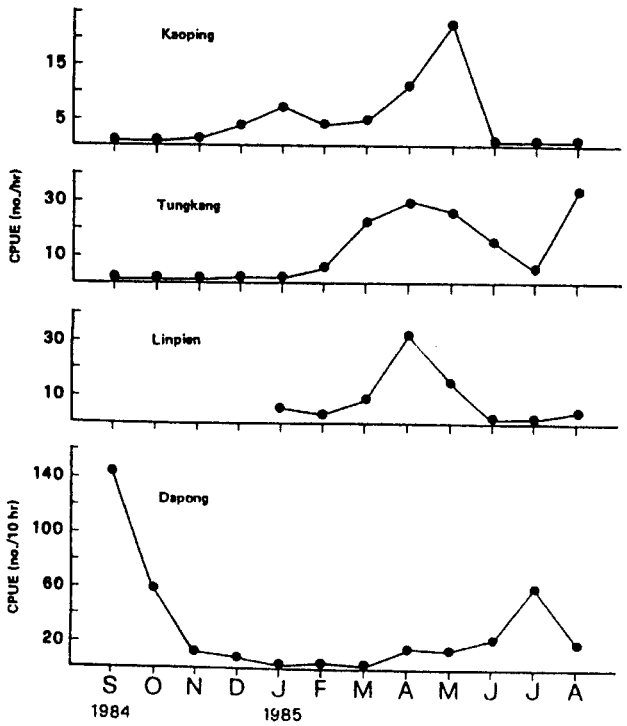

Fig. 4. Monthly occurrence of *P. monodon* at various sampling sites.

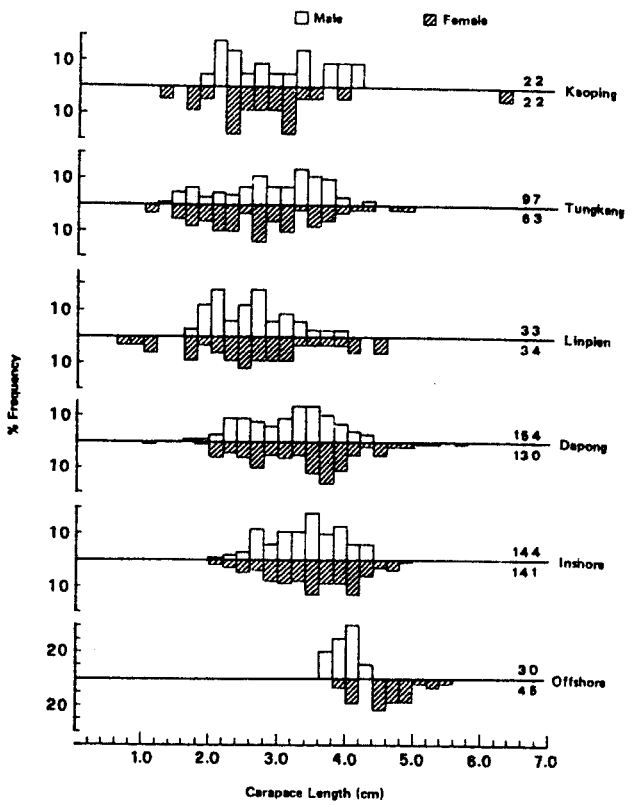

Fig. 5. Carapace length frequency distribution of *P. monodon* by area and sex. The number in the figure indicates sample size.

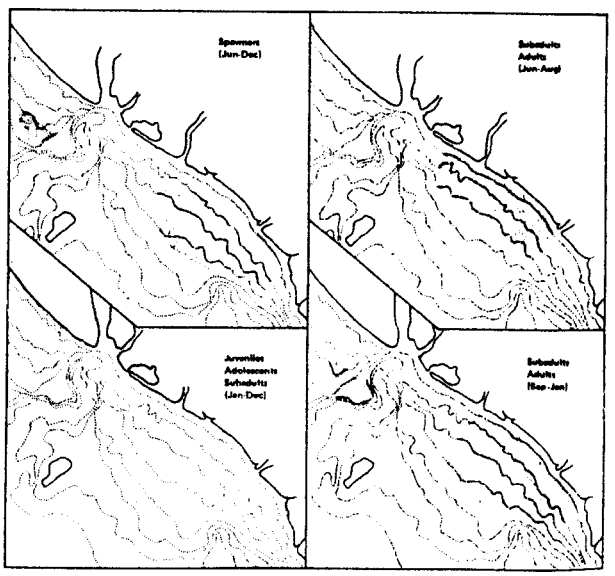

Fig. 6. Schematic figure of life cycle for *P. monodon* in the coastal waters of Tungkang. The shaded area indicates the range of distribution.