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Experimental Culture of Three New Candidates for Shrimp Farming in Taiwan -- *Penaeus semisulcatus*, *P. brasiliensis* and *P. penicillatus**

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Abstract

Some aquaculturists believe that, as in horticulture, a variety of culture species benefits both the consumers and the producers. With this in mind, researchers at Tungkang Marine Laboratory have been searching for new culture candidates for years. The results to date are:

- Juveniles of *Penaeus semisulcatus* at an average body weight of 0.16 g averaged 33.69 g after being cultured at a density of 20/m^2 for 315 days. The survival rate was 83.0%.
- Juveniles of *P. brasiliensis* at an average of 0.64 g grew to an average of 24.02 g in a culture period of 315 days at a stocking density of 15/m^2. The survival rate was 44.5%.
- Juveniles of *P. penicillatus* averaging 0.49 g at a stocking density of 20/m^2 reached their marketable size of 21.34 g in only 120 days. The survival rate was 80.5%.

The results of the preliminary grow-out experiments are compared and the traits of these three penaeid species are discussed with emphasis on the selection of new culture candidates for shrimp farming in Taiwan.

Introduction

After the development of propagation technology for *Penaeus monodon* in 1968 (Liao et al. 1969), efforts for further improvement have continued in Taiwan. In 1985 and 1986, Taiwan produced

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30,000 t and 60,000 t of *P. monodon,* respectively. The possibility of breaking the 100,000 t barrier by 1990 is quite evident.

In order to satisfy consumer taste and to rotate the crops in the pond, culture of three new target species, *P. semisulcatus, P. brasiliensis* and *P. penicillatus* was attempted to find other suitable shrimp culture candidates.

Few studies comparing the growth of these penaeid species in captivity have been reported before. Browdy and Samocha (1985) succeeded in completing the life cycle of *P. semisulcatus* in captivity. By applying unilateral eyestalk ablation, they were also able to obtain at least four successive spawnings. Although the number of eggs per spawning declined, the quality of the spawn was not adversely affected. This is in contrast to the studies on *P. monodon* which show a decline in egg quality in successive spawnings of ablated females (Liao 1984; Lin and Ting 1986). Therefore, although ablation is contrary to the physiology of the prawn, this particular characteristic of the *P. semisulcatus* would seem to make it a good culture candidate. Ovarian maturation in captivity have also been successfully achieved in *P. penicillatus* without eyestalk ablation (Liao 1973). The results of spontaneous spawnings of *P. brasiliensis* were also encouraging for continuing research and development (Liao, unpublished data). However, comparative growth studies of these three species are relatively limited.

A comparative growth study of the three species was feasible here because *P. semisulcatus* and *P. penicillatus* are locally available and *P. brasiliensis* was successfully propagated after being introduced to Taiwan from Brazil in 1981.

Materials and Methods

The postlarvae of the three experimental shrimp species were obtained from the hatchery at Tungkang Marine Laboratory (TML). The experimental earthen ponds with vertical concrete dykes, were 200 m^2 and 600 m^2 each. These ponds were filled with seawater filtered through beach sand. Temperature of the pond waters fluctuated naturally. Weights of the experimental shrimp were measured every 15 days throughout the experiment.

Four thousand postlarvae of *P. semisulcatus* were stocked in a 200 m^2 pond (20 m^2) on 1 May 1985. The mean initial body weight was 0.16 g. They were fed three times per day with formulated pellets. Tilapia fillet was supplemented once every ten days. The

pond water was aerated by an airblower system. After 315 days the experiment was concluded (12 March 1986). The pellets given totaled 291.6 kg and tilapia fillet 26 kg (water content of tilapia fillet = 80%). Water temperature ranged from 18.0 to 33.6°C; salinity from 21 to 34 ppt; and pH from 7.2 to 9.0.

Three thousand postlarvae of *P. brasiliensis* were raised in a 200 m^2 aerated pond (15 m^2) for 315 days from 1 October 1983 to 11 August 1984. Their mean initial body weight was 0.64 g. They were fed pellets twice a day. An airblower aerated the pond.

Twelve thousand postlarvae of *P. penicillatus* were grown in a 600 m^2 pond (20 m^2) from 28 July 1984 to 25 November 1984, a total of 120 days. The pond water was aerated with a 1-horsepower paddle wheel. The shrimp were fed artificial pellets four times a day. Water temperature, salinity and pH ranged from 24.8 to 32.1°C, 25.5 to 32 ppt, and 8.0 to 8.9, respectively.

Results and Discussion

The frequency distribution of shrimp weights is shown in Fig. 1 and growth curves by sex and mean weights in Fig. 2. *P. semisulcatus* grew from 0.16 g to 33.6 g on average, in 315 days. Females grew faster than males, starting to show a significant difference at 20.73 g (t-test, $p < 0.01$). Female shrimp weighed 36.97 g and males 29.52 g, on average, at the end of the experiment. There was a tendency for the gap in body weight between the two sexes to gradually increase as the culture period progressed. Based on the quantity of feed used, the food conversion rate was calculated to be 2.67.

Mohamed et al. (1981) reported that *P. semisulcatus* with carapace length of 18 mm, equal to a body weight of 5.84 g (Su and Liao, unpublished data), commenced to show significant differences in growth between sexes (Fig. 3). This differs greatly from the findings of this study where significant difference in growth rates started at 20.73 g (Figs. 2, 3). Fig. 3 also reveals that before reaching 26.0 g in body weight, cultured *P. semisulcatus* showed better growth than wild ones. However, the difference diminished as growth progressed. Eventually, the growth of cultured *P. semisulcatus* slowed down considerably and was less than that of wild shrimp. Probably the feed and environmental conditions during the early growth were favorable for the cultured shrimp, but the situation was reversed at a later stage. In the present study, growth increased most rapidly between 100 days and 140 days after the start of the experiment.

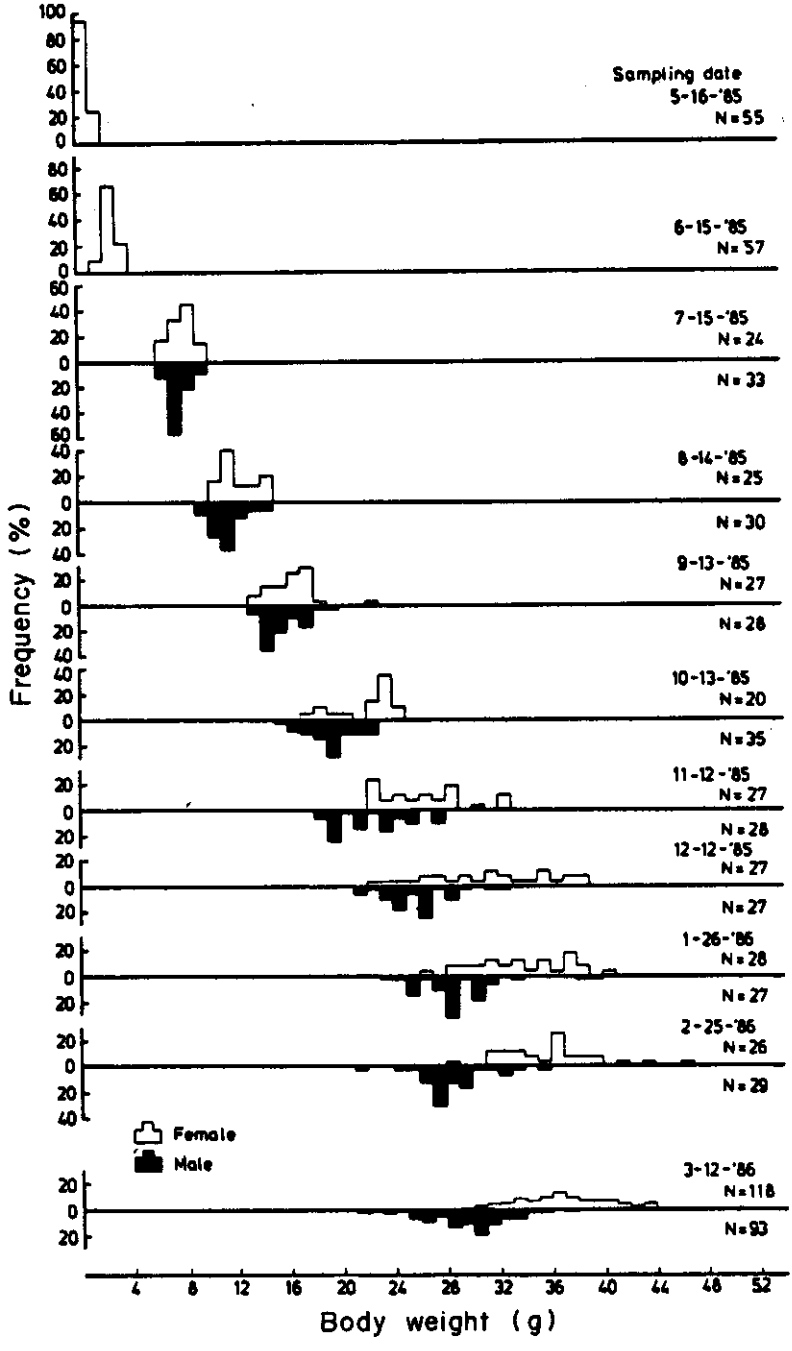

Fig. 1. The frequency distribution of body weight of males and females of *P. semisulcatus*.

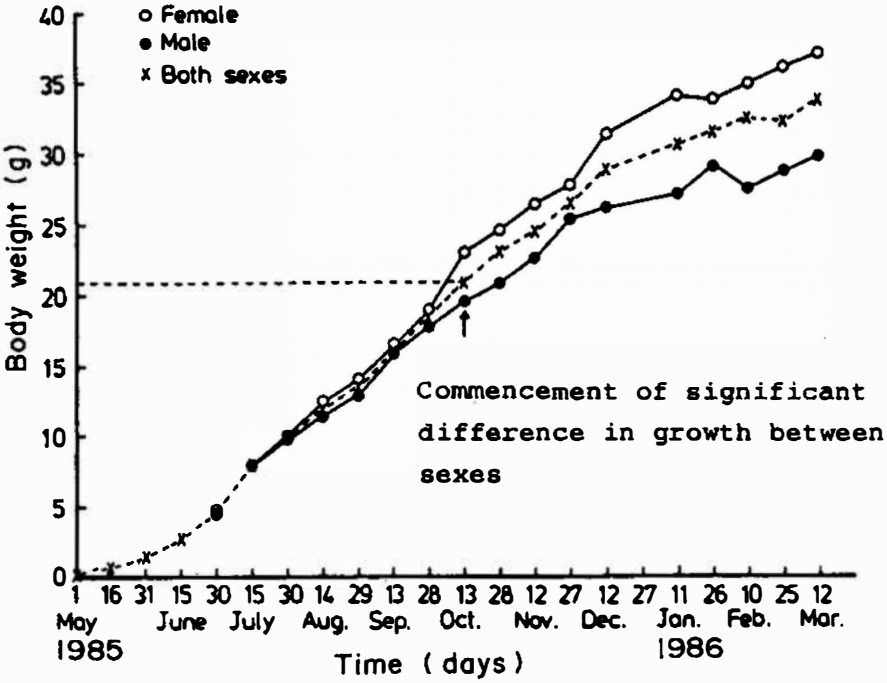

Fig. 2. The growth curves of male and female *P. semisulcatus*.

This would correspond roughly to the months of August and September. After this period, rate of growth slowed markedly. Tseng and Cheng (1981) reported that somatic development of *P. semisulcatus* accelerated during the summer months from May to August. They believed that this was in direct response to the increase in water temperature. Growth of the shrimp in their study also decreased during the winter months. This could be a possible explanation for the slowing down of growth of the shrimp in this study. Deterioration of pond bottom conditions is another possible explanation. This is in accordance with the observations of Tseng and Cheng (1981). Pond bottom conditions should be examined closely. Nutritional requirements are also not well understood. However, relatively good growth rate of *P. semisulcatus* was attained with a mixed feed (Lee and Liao 1970). Further studies are needed to determine if there are other factors which strongly influence growth over time.

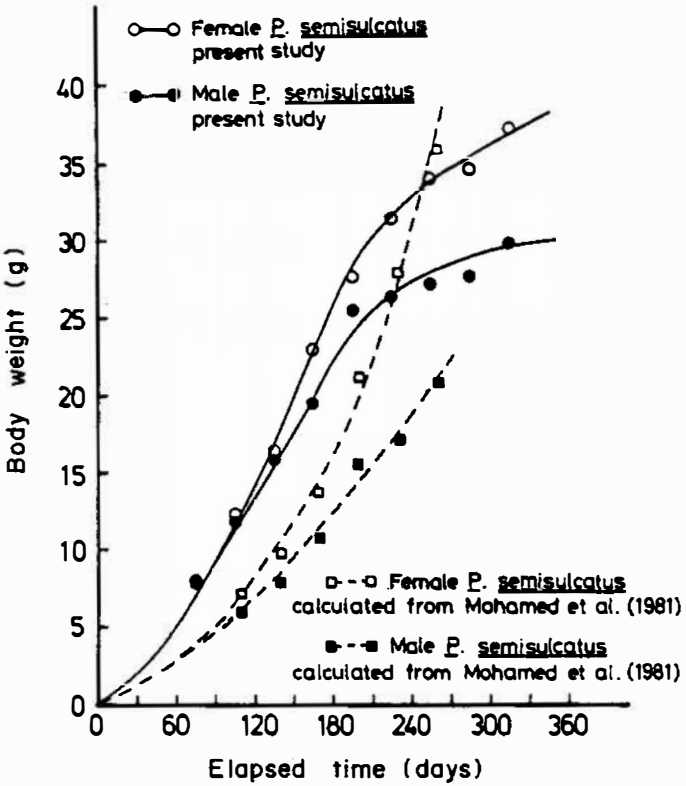

Fig. 3. Comparison of growth curves between wild *P. semisulcatus* in Kuwait waters (calculated from Mohamed et al. 1981) and those of the present study.

The weight-frequency distribution and the growth curve of body weights of *P. basiliensis* are presented in Figs. 4 and 5, respectively. *P. brasiliensis* stocked at 0.64 g reached an average weight of 24.05 g in 315 days.

Similar to *P. semisulcatus*, female *P. brasiliensis* grew faster than males, starting to show a significant difference at 11.28 g (t-test, $p < 0.01$). This difference increased over time. By the end of the experiment, the average weights of female and male were 30.06 g and 20.37 g, respectively.

Fig. 6 shows the weight-frequency distribution of male and female *P. penicillatus* every 15 days. Fig. 7 is the weight growth curve of both sexes. Postlarvae of 0.49 g on average grew to the marketable size of 21.35 g in 120 days.

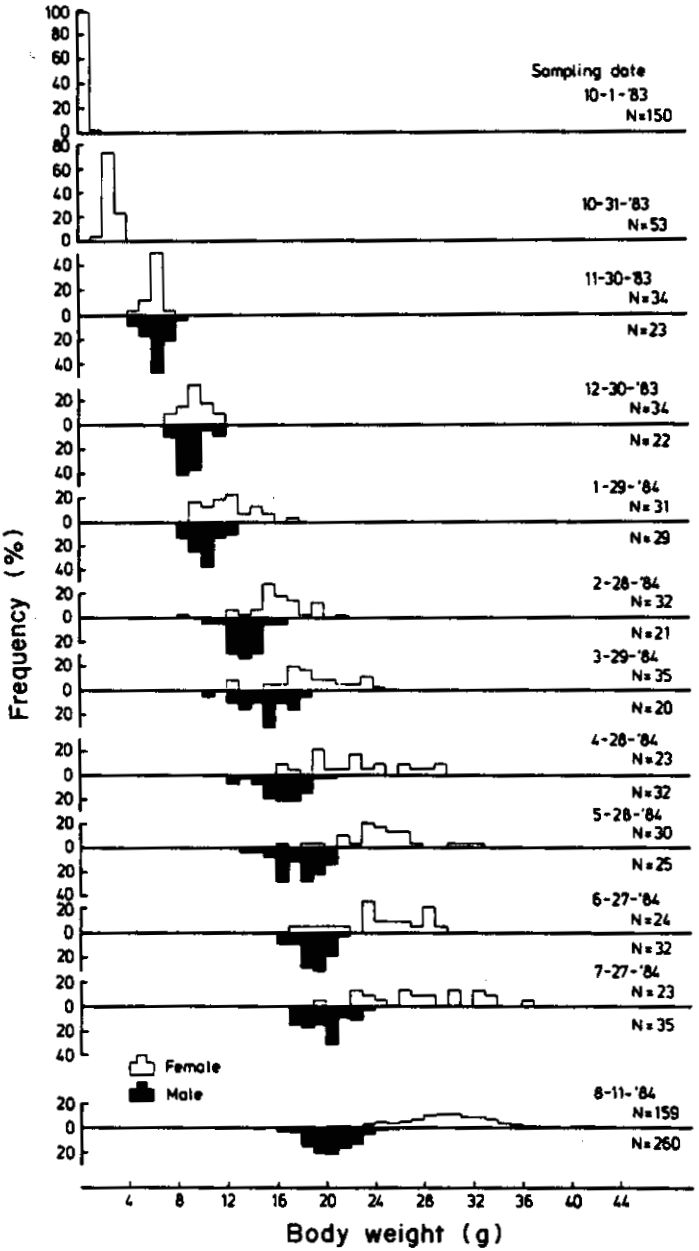

Fig. 4. The frequency distribution of body weight of males and females of *P. brasiliensis*.

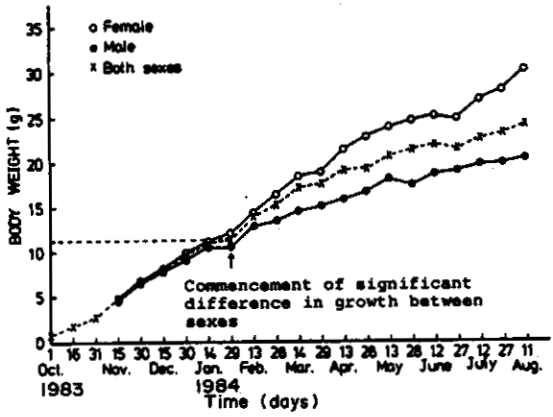

Fig. 5. The growth curves of male and female *P. brasiliensis*.

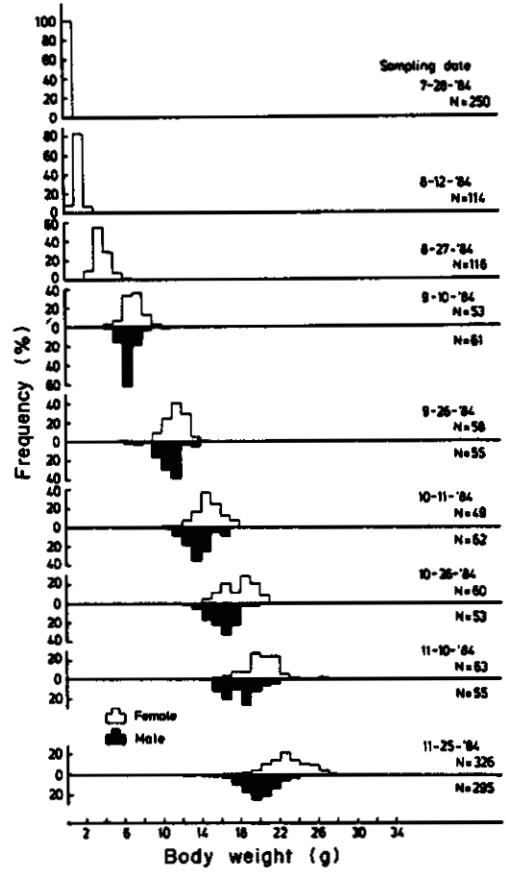

Fig. 6. The frequency distribution of body weight of males and females of *P. penicillatus*.

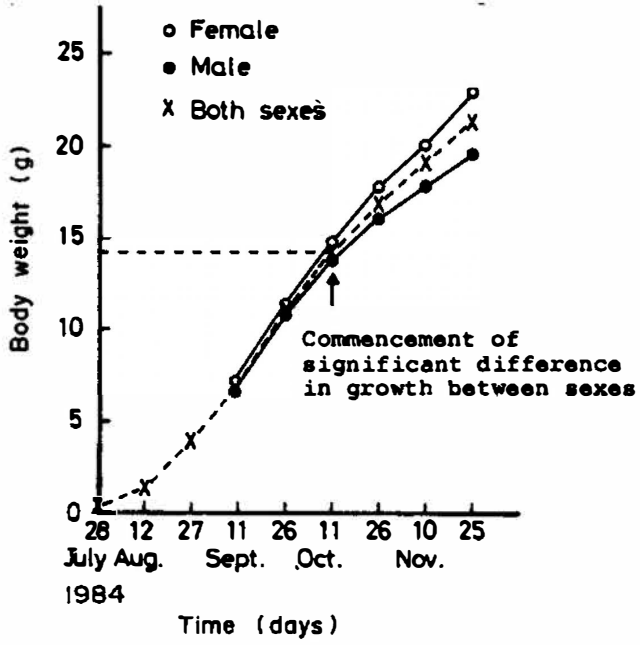

Fig. 7. The growth curves of male and female *P. penicillatus*.

As in the two preceeding cases, females grew faster. At the mean body weight of 14.20 g, differences in growth became visible (t-test, $p < 0.01$). At the end of the culture period the mean body weight was 22.85 g for the females and 19.69 g for the males.

A mean body weight of 12.69 g was the point that significant growth differences commenced between male and female *P. penicillatus* when fed with trash fish and planktonic shrimp, and when they were polycultured with *P. monodon* (Liao 1977).

The total quantity of artificial pellets given to *P. penicillatus* was 483.9 kg and the food conversion rate was 2.42.

Few data on this species are available. In a polyculture experiment of *P. penicillatus* with *P. monodon* at a stocking density of 15 shrimp/m^2, *P. penicillatus* of 0.26 g grew to 16.98 g in 120 days from 10 November 1975 to 10 March 1976 (Liao 1977). In the present experiment, conducted during the warmer months for the same number of days, average size attained for *P. penicillatus* was 21.35 g. Although *P. penicillatus* is cold resistant, warm water seems to affect growth favorably.

The overall comparison of growth curves of the three experimental species in the present study and that of *P. monodon*

reported by Liao (1977) is shown in Fig. 8. It is apparent that under the experimental conditions, *P. penicillatus* grows much faster than *P. semisulcatus* and *P. brasiliensis* but slower than *P. monodon*. Moreover, *P. semisulcatus* seems superior to *P. brasiliensis* in growth. It is not clear, however, if the above results are true reflections of the biological differences among these species.

In these experiments, *P. semisulcatus* was fed both pellets and tilapia fillet while *P. brasiliensis* was given only a pellet diet.

The experiment with *P. semisulcatus* began in May and a large size had already been reached by the colder month of October. On the other hand, in the case of *P. brasiliensis*, the culture experiment began during the cold month of October and at the end of January, they reached a size of only about 10 g.

Identical conditions in all aspects of the experiment would be ideal. However, this is not always possible. As in the present study, it was not possible to have all experimental larvae at the same time.

Body weights of the biggest shrimp in each routine sampling were recorded to compare the maximum growth of the three species (Fig. 9). Such data likely reflect the maximum growth potential of

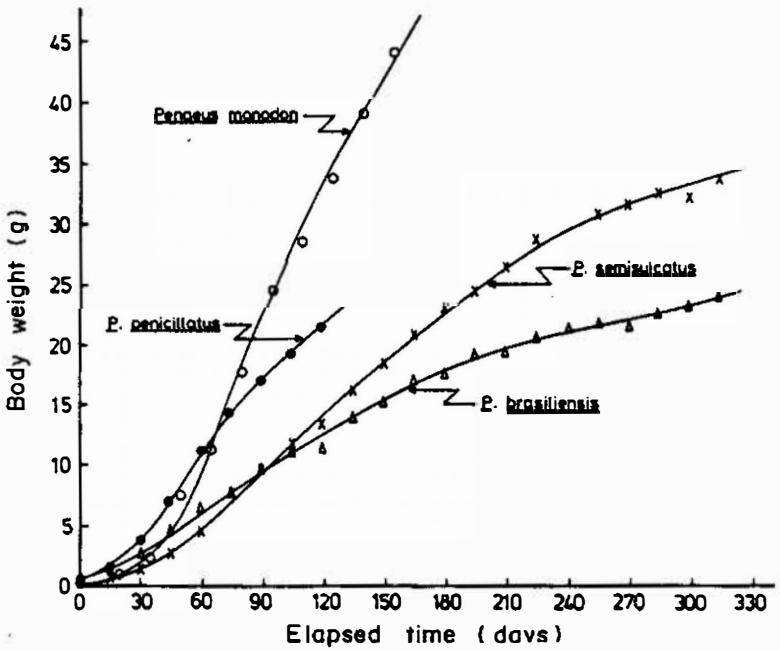

Fig. 8. Comparison of growth curves of *P. semisulcatus*, *P. brasiliensis* and *P. penicillatus* of present study with that of *P. monodon* of a previous study (Liao 1977).

these species. The growth curve plotted (Fig. 9) may serve as reference for the future culture of these species. It may be possible to obtain larger shrimp of the given species once the reasons for such fast growth of the large individuals are understood.

Fig. 9 also shows that of the three species, *P. penicillatus* grows faster than *P. semisulcatus* and *P. brasiliensis* during the first 120 days. In the wild, *P. semisulcatus* usually grows much larger than the other two species with the wild *P. penicillatus* the smallest of the three. It should be of great interest to study the correspondence of the order of their maximum size in nature with the order of their respective growth rates in culture conditions.

P. semisulcatus is widely distributed in nature; it is tolerant of high salinity and is relatively tolerant of low temperature. It has a protein requirement level lower than *P. japonicus* and only slightly higher than *P. monodon* (Liao and Chao 1983). It has been informally evaluated to be the most tasty "gourmet" penaeid shrimp. Yet, its culture was hardly satisfactory. Nevertheless the present result is a

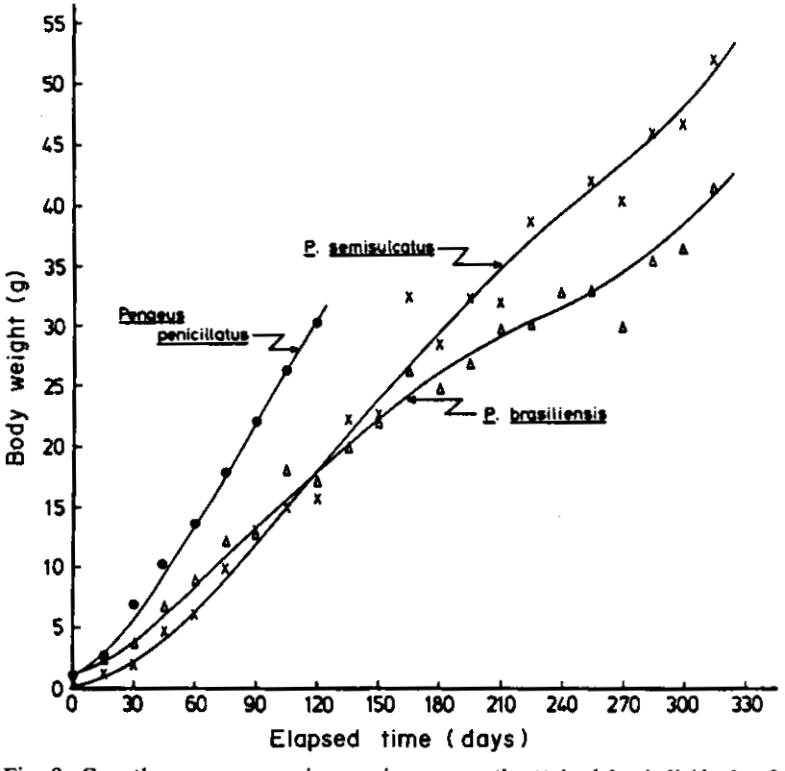

Fig. 9. Growth curves comparing maximum growth attained by individuals of *P. semisulcatus*, *P. brasiliensis* and *P. penicillatus*.

real breakthrough in the pond-rearing of *P. semisulcatus,* showing that it can grow as large as 33.6 g. The feed given in the present study was formulated feed for *P. monodon* and small quantities of tilapia fillet. It is necessary to study the nutritional requirements of *P. semisulcatus* to develop specific formulated feeds. Research on its ecology and physiology is also urgently needed.

P. brasiliensis is an exotic species to Taiwan. In the present study, the larvae used were second generation, raised at TML. A previous experiment on this species showed that it could obtain a size of 40 g after a one year grow-out (Liao and Chao 1983). The results of the current study are not as good. However, there are limited studies on the culture of this species. Studies have been made on its nutritional requirements (Liao et al. 1986). It is hoped that with intensive research *P. brasiliensis* will be mass cultured in the future.

P. penicillatus is one of the white shrimps which are preferred by consumers in the USA and Europe. The advantage of cultivating this species is the availability of the market. In the present study, it was found that within a period as short as 120 days, *P. penicillatus* reached a satisfactory mean body weight of 21.36 g for domestic consumption needs. *P. penicillatus* may also grow at a low temperature of 20°C (Liao and Chao 1983) and it has a low protein level requirement - 22% (Liao et al. unpublished data). It may also be stocked at a density of 100 to 120 shrimp/m^2 (Liao, unpublished data). *P. penicillatus* also demonstrates rapid growth during the early stages of its life (Figs. 8, 9). Culture of this species was booming in Taiwan even before the completion of research on this species. In 1986, it reached an annual production of almost 8,000 t. There is a very optimistic future for exports of this shrimp.

Reviewing the development of *P. monodon* culture in Taiwan, it is impossible to ignore the contribution of related studies. Research into the optimal ecological factors, nutritional requirements and disease prevention, for example, all provided crucial assistance to the expansion of culture of *P. monodon.* With these three new candidate species, there is still much research needed before farming is really successful.

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