

## Use of ongrown *Artemia* in nursery culturing of the tiger shrimp

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Juvenile and adult *Artemia* produced in a semi flow-through culture system were used as food for postlarval shrimp. The growth performance of shrimp reared on such ongrown *Artemia* live prey is identical to the growth obtained when feeding newly hatched *Artemia*. However, a significantly better stress resistance is obtained when the postlarvae are exposed to a low salinity in a stress test. Besides nutritional and energetic advantages, the use of *Artemia* biomass for feeding postlarval shrimp also results in improved economics as expenses for cysts and weaning diets can be reduced.

KEYWORDS: *Artemia*, *Penaeus monodon*, Intensive culture, Biomass, Stress

### INTRODUCTION

An indoor super-intensive *Artemia* culture system was first described by Bossuyt and Sorgeloos (1980) who introduced a batch production system using rice bran as food. The batch concept was later replaced by a flow-through system in which higher biomass productions could be obtained (Brisset *et al.*, 1982). Every 2 weeks, biomass yields of up to 15 kg m<sup>-3</sup> were obtained by Lavens and Sorgeloos (1991) after optimizing culture and feeding techniques. Despite the evolution in *Artemia* production systems from a simple low-density *Artemia* rearing technique to a sophisticated semi-industrial biomass production technique, the integration of tank-production of *Artemia* juveniles in commercial shrimp hatcheries never took place. Reasons for this were on one hand the lack of information about the application possibilities and advantages of indoor-produced *Artemia*, and on the other hand, the fear of extra costs of investment in *Artemia* rearing facilities and the supplementary burden on technicians to culture brine shrimp. Often-voiced criticisms of existing *Artemia* production systems are the complexity of the production method and the lack of production reliability which could place hatcheries in very vulnerable positions.

Recently, Dhert *et al.* (1992b) developed a simplified, semi flow-through *Artemia* biomass production method. The system is very reliable, requires minimal technical expertise and is very cheap in construction and maintenance. By manipulating the food concentration and the density of the *Artemia*, this system offers the possibility of producing homogeneous populations with well-defined prey sizes. These important

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findings have stimulated a new interest in the possible use of ongrown *Artemia* for the nursery feeding of tropical species such as the tiger shrimp, *Penaeus monodon*, and several bass and grouper species. Ongrown *Artemia* are also being considered in Norway and Scotland for the rearing of halibut, *Hippoglossus hippoglossus*, larvae.

## MATERIALS AND METHODS

### *Artemia*

Great Salt Lake (Utah, USA) *Artemia* were reared on rice bran under semi flow-through culture conditions following the procedure described by Dhert *et al.* (1992a). The 1000 l rearing tank was stocked at a density of 10 000 nauplii l<sup>-1</sup>. Every day, part of the produced *Artemia* biomass was harvested to feed the postlarval shrimp. As a result of these harvests the food distribution with rice bran had to be adjusted according to the actual *Artemia* density in order to prevent overfeeding. The amounts of food and the growth performance of the *Artemia* in the rearing tank are given in Fig. 1.

### *Penaeus monodon*

*Penaeus monodon* postlarvae (PL4) were obtained from a commercial hatchery in Tigbauan (Philippines). A first experiment studied the effect of prey size on food uptake. In order to facilitate the observations and counting of the ingested prey, one postlarva

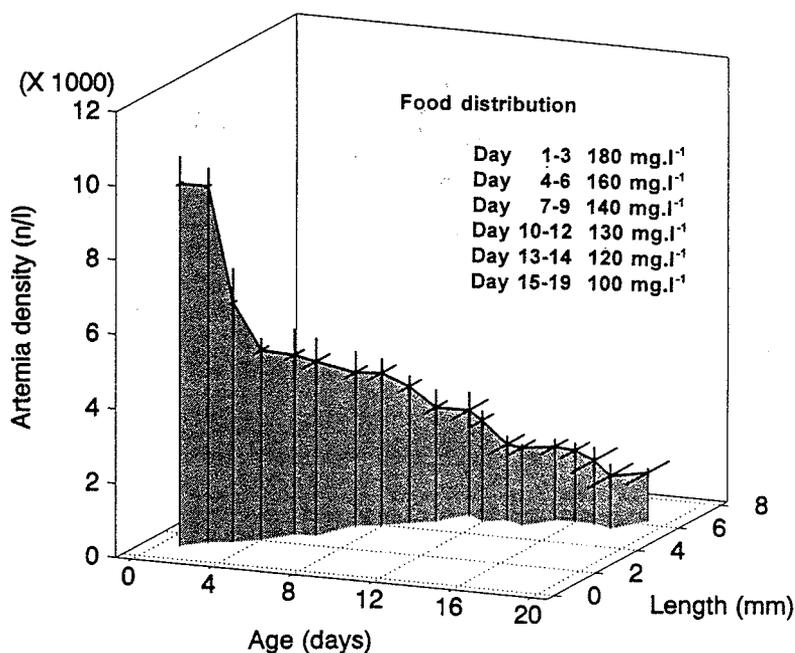


FIG. 1. *Artemia* culture characteristics and growth performance of *Artemia* used as food in the shrimp experiments.

was placed in each petri dish and fed *ad libitum* with *Artemia* of different sizes. Every morning, the number of ingested prey was calculated based on the number of free-swimming (i.e. untouched) and partly eaten *Artemia*, after which water was renewed. The results were obtained from four replicates in the period PL5-PL20. The different treatments are given in Table 1.

The second experiment with *Penaeus monodon* postlarvae consisted of a rearing experiment in which postlarvae were grown on a pilot scale from PL5 to PL25. The postlarvae were stocked at a density of  $10\text{ l}^{-1}$  in a 100 l cylindro-conical tank. Two-thirds of the water in the rearing tank was renewed daily. Sediments and faecal material were siphoned from the bottom of the tanks at PL10, PL15 and PL20.

Five different feeding regimes were tested in four replicates as illustrated in Table 2. As a function of the age of the postlarvae, progressively bigger prey sizes were used, except for treatment A where newly-hatched *Artemia* nauplii were fed during the complete experiment. Salinity stress tests were conducted according to the methodology of Dhert et al. (1992b). The salinity of the test medium was adjusted as a function of the age of the postlarvae and was kept at 14 ‰ for PL10 and 4 ‰ for PL15. From PL20 onwards the stress test was performed with freshwater. The stress sensitivity index was always calculated after 110 min.

## RESULTS

Observations on the feeding behaviour of individual postlarvae in the petri dish experiment are represented in Fig. 2. It is obvious that when large prey (7 days old *Artemia*, 4.0 mm) were fed instead of small prey (4 days old *Artemia*, 2.0 mm), the number of ingested prey decreased by approximately 20%. However, it is interesting to note that in both cases the number of torn prey remained constant at 37%. When *Artemia* of progressively bigger sizes were fed, starting with newly hatched *Artemia* (0.6 mm) at PL5 and ending with preadult brine shrimp (6.0 mm) at PL25, the number of ingested prey was higher than when only large prey were fed. In this treatment, however, the number of torn prey was reduced to approximately 22%.

The pilot-run experiment did not reveal any significant differences in survival rate ( $59 \pm 6\%$ ). When the growth of the postlarvae was analysed, no significant differences ( $p < 0.05$ ) could be detected either (Fig. 3). The different prey sizes of the *Artemia* and/or

**TABLE 1.** Age and size of *Artemia* fed in the different treatments to individual postlarvae reared from PL5 to PL20

Treatment	Age of <i>Artemia</i> (days)	Size of <i>Artemia</i> (mm)
1	4	2.0 (0.2)
2	5	2.5 (0.4)
3	6	3.1 (0.4)
4	7	4.0 (0.5)
5	0 → 14	0.5 → 6.0

**TABLE 2.** Density (number of *Artemia* ml<sup>-1</sup>) and size of *Artemia* fed twice a day in treatments A to E for different postlarval stages of *Penaeus monodon*

PL age (days)	A <i>Artemia</i> nauplii	B Ongrown <i>Artemia</i>	C Ongrown <i>Artemia</i>	D Ongrown <i>Artemia</i>	E Ongrown <i>Artemia</i>	Size of ongrown <i>Artemia</i> (mm)
6	1.0	0.25	0.50	0.75	1.0	1.0 (0.1)
7					0.8	1.4 (0.1)
8					0.4	1.7 (0.1)
9					0.3	2.2 (0.3)
10	1.5	0.13	0.25	0.36	0.2	2.8 (0.5)
11					0.2	3.1 (0.6)
12					0.15	3.5 (0.6)
13					0.15	4.1 (0.6)
14					0.09	4.3 (0.7)
15	1.75	0.07	0.12	0.18	0.09	4.6 (0.7)
16					0.09	5.1 (0.8)
17					0.09	5.1 (0.8)
18					0.09	5.4 (0.7)
19					0.09	4.8 (0.6)
20	1.75	0.04	0.06	0.09	0.09	5.4 (0.7)
21					0.09	5.8 (0.8)
22					0.09	5.5 (0.9)
23					0.09	5.6 (1.2)
24					0.09	6.3 (1.3)

feeding regimes did not affect the resistance to stress before PL20 (Table 3). After PL20, the resistance of the postlarvae improved significantly except for treatments A and B. The fact that all postlarvae receiving ongrown *Artemia* at PL25 performed better, except B; may indicate that in this latter treatment the food provision was too low.

By applying different feeding regimes and prey sizes when feeding the postlarval shrimp, important savings could be obtained on the amount of *Artemia* cysts required to produce the postlarval food (Table 4). The total amount of cysts used in the feeding experiment to obtain PL25 in treatments B, C and D was only 8.3, 16.7 and 25% of the cyst material needed to grow postlarvae on *Artemia* nauplii only (treatment A).

## DISCUSSION

The petri dish experiment revealed that the number of ingested prey decreased when larger prey were given, which means that the postlarvae were eating to satiation.

When the size of the available prey was 4 mm instead of 2 mm approximately half the number of *Artemia* were ingested (Table 5). Converted to dry weight, ongrown *Artemia* of 4 mm weigh approximately 8 times as much as *Artemia* of 2 mm. Satiation is thus obtained by the volume of *Artemia* in the stomach rather than the weight of the prey.

In order to verify if the prey density could have an effect on the feeding behaviour of the postlarvae, a similar experiment was run in 300 ml vessels with only one postlarva per vessel. Since this experiment revealed the same results, it can be concluded that the

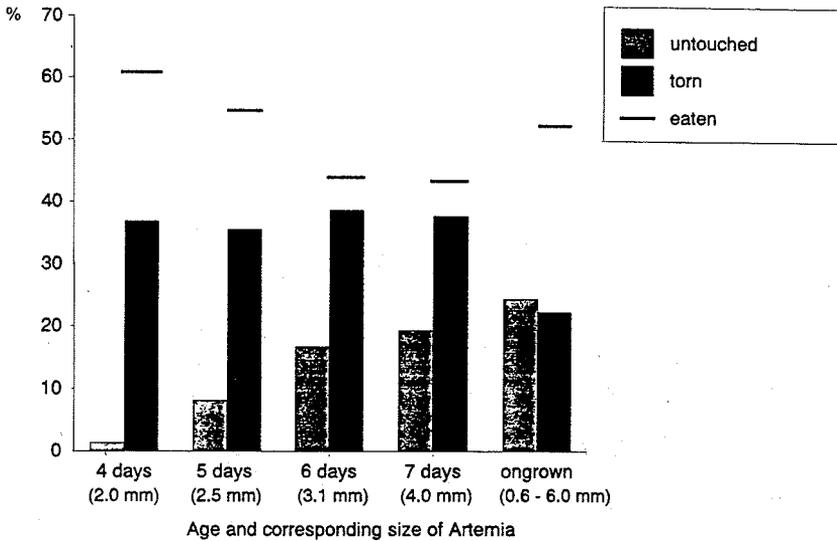


FIG. 2. Percentage of *Artemia* of constant size (2.0, 2.5, 3.1 and 4.0 mm) or of gradually increasing size (0.6 to 6.0 mm) eaten or torn by shrimp postlarvae from PL5 to PL20.

feeding behaviour of the postlarvae is not density dependent. Also in this experiment the number of killed *Artemia* in the treatment using progressively larger *Artemia* was lowest.

In the pilot run, the daily food administration in terms of dry weight was identical for treatments A and E. In terms of dry weight, feeding scheme E is comparable to feeding scheme D during the period PL 6–9 and PL 20–24. In the other PL stages (PL 10–19) the food supply was higher than in feeding scheme B but lower than in C. The lower feeding scheme during the period PL 10–19 in treatment E was tested because previous observations showed that around PL10 the postlarvae were very aggressive and killed a lot of prey without eating them; after PL20 this behaviour stopped and almost no further prey were killed. This behaviour was not observed in the petri dish experiment where the larvae were stocked individually.

During the period PL 10–19 dead *Artemia* were found on the bottom of the tanks, especially in treatment D. Also in this treatment free-swimming *Artemia* were observed from PL16 onwards, which may indicate that the feeding regime was not appropriate because the postlarvae were overfed. On the other hand the high stress sensitivity index obtained in treatment B indicates that this feeding regime was also not appropriate as the shrimp were underfed.

## CONCLUSIONS

Feeding regimes C and E gave the best results but can still be improved.

The good growth performance and the better stress resistance of shrimp postlarvae reared on ongrown *Artemia* should stimulate the use of *Artemia* biomass produced in semi flow-through intensive systems.

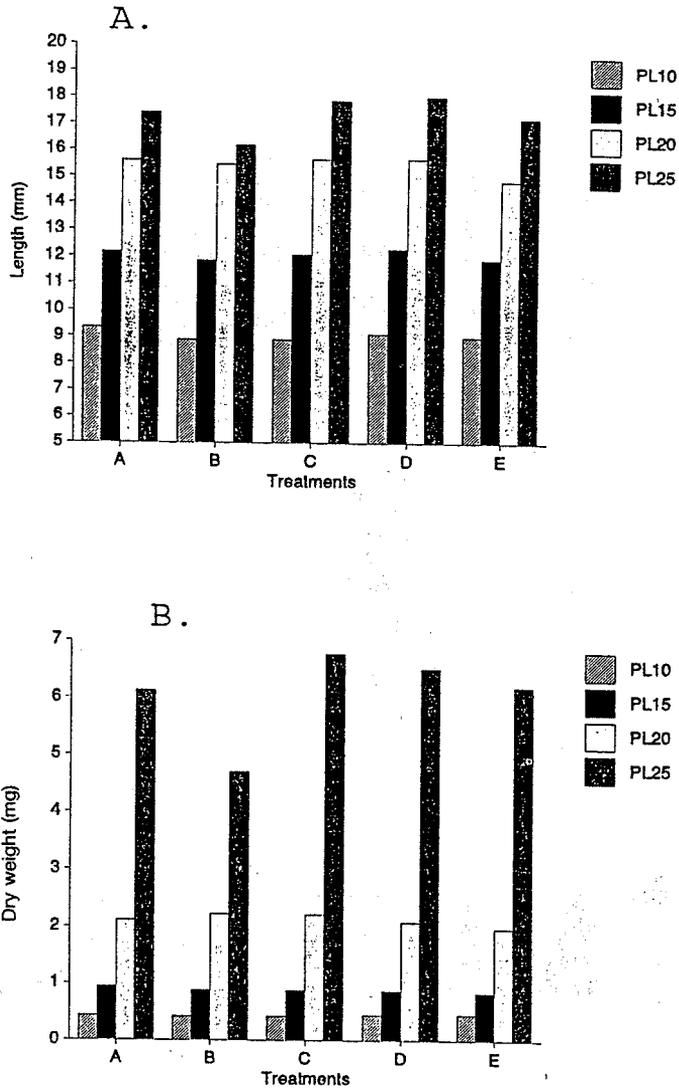


FIG. 3. Length (A) and dry weight (B) of *P. monodon* at different postlarval stages as a function of the *Artemia* diet (for legend to treatments see Table 2).

**TABLE 3.** Stress sensitivity (expressed by the mean sensitivity index and standard deviation) of *P. monodon* at different postlarval stages as a function of the diet

Postlarval stage	Treatment				
	A	B	C	D	E
PL10	76 (24)	96 (32)	101 (14)	87 (14)	82 (20)
PL15	115 (14)	137 (17)	132 (20)	143 (42)	137 (5)
PL20	157 (11)	115 (34)	154 (17)	137 (19)	145 (14)
PL25	138 (23)	126 (11)	36* (20)	36* (20)	27* (22)

\*Denotes treatments which are significantly different at  $p < 0.01$  level.

**TABLE 4.** *Artemia* cyst consumption for *P. monodon* postlarvae fed on different feeding regimes in the period PL5–PL25. The FCR is expressed as the ratio food (= *Artemia* cysts) over shrimp biomass at PL25

	Treatment				
	A	B	C	D	E
Consumption of <i>Artemia</i> cysts (g)	30.0	2.50	5.00	7.50	4.20
Shrimp biomass at PL25 (g dry weight)	4.20	2.62	3.66	3.66	3.80
<i>Artemia</i> cyst conversion rate (FCR)	7.10	0.95	1.33	2.00	1.10

**TABLE 5.** Length and dry weight characteristics of *Artemia* used in the petri dish experiment

Prey age (days)	Length (mm)	Dry weight <sup>a</sup> (µg)	Number of ingested pray
4	2.0	9	719 (121)
5	2.5	18	655 (128)
6	3.1	36	510 (108)
7	4.0	72	342 (104)

<sup>a</sup>The dry weight of the ongrowing *Artemia* was calculated based on the length–dry weight correlation of Reeve (1963).

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