Increasing cyst yields in *Artemia* culture ponds in Vietnam: the multi-cycle system

P Baert, N T N Anh, Vu Do Quynh & N V Hoa  
Shrimp and *Artemia* R&D Institute (SARDI), Can Tho University, Can Tho, Vietnam

P Sorgeloos  
Laboratory of Aquaculture & *Artemia* Reference Centre, University of Gent, Belgium

Correspondence: Dr Vu Do Quynh, Shrimp and *Artemia* R & D Institute, Can Tho University, Can Tho, Vietnam

---

**Abstract**

In this study, one-cycle and multi-cycle culture systems for *Artemia* in seasonal salt ponds are compared. In one-cycle systems, *Artemia* is inoculated only once per season, while in multi-cycle systems ponds are drained and re-stocked several times per season. In Vietnam, three-cycle systems gave significantly higher cyst yields than did the one-cycle system. However, after two cycles, systems were not significantly different. Food limitation probably caused the steady decline in cyst yields, as observed in the one-cycle ponds. In these ponds, females have smaller broods (from the second cycle onwards) and during the last cycle the number of adult females is lower than in multi-cycle ponds.

**Introduction**

Although *Artemia* is not endemic in South East Asia (Vanhrecke, Tackaert & Sorgeloos 1987), culturing of brine shrimp has proven to be a profitable business in countries such as Thailand and Vietnam. First inoculation of *Artemia* in Vietnam took place in 1982 (Vu Do Quynh & Nguyen Ngoc Lam 1987). First trials were mainly made in Southern Vietnam (east coast of the Mekong Delta). This region is nowadays an important supplier of high-quality cysts (estimated at 6–8 1 t year⁻¹).

The *Artemia* culture system as developed in Vietnam is referred to as semi-intensive (Tackaert & Sorgeloos 1991) and static (Vu Do Quynh & Nguyen Ngoc Lam 1987). The term 'semi-intensive' is used to denote small seasonal man-managed systems in which brine shrimp are inoculated at high densities (> 20 litre⁻¹). Ponds are managed intensively i.e. inoculation of selected strains, manipulation of primary and secondary production, predator control, etc.). Contrary to the more common flow-through systems (Tackaert & Sorgeloos 1991), ponds in static systems are not interconnected. *Artemia* is inoculated in ponds with the appropriate salinity. Once stocked, the ponds are managed as separate units. Green water is pumped from a common fertilization pond and if needed mixed with brine, to maintain high salinity levels (> 80%o) in the culture ponds (Vu Do Quynh & Nguyen Ngoc Lam 1987: Baert, Bosteels & Sorgeloos 1997). In this paper the term 'continuous' or 'one-cycle' system denotes culture systems in which the *Artemia* population is maintained throughout the culture season. i.e. the complete dry season. Or in other words, animals are introduced only once, at the beginning of the dry season.

A problem often faced when culturing brine shrimp is the steady decline in cyst yields with time. This is especially true in the larger salt works, where *Artemia* is cultured on a year-round basis (Camara & De Meldores Rocha 1987). But even in Vietnam where the culture season is relatively short (December–May), cyst yields quickly decrease (unpublished data of SARDI 1989–1994). In recent years a new system has been developed, the so-called 'multi-cycle' system, in which cyst yields do not decrease with time. As investment and
production costs of this system are similar to costs for the more traditional culture method, profit margins could be increased considerably.

### Material and methods

#### Experimental set-up

The experiments were conducted at the field station in Vinh Chau (south-east coast of the Mekong Delta, Vietnam), during the 1995 and 1996 dry season. Two different culture systems were tested (Table 1).

1. **One-cycle system.** Semi-intensive static continuous system as described above.
2. **Multi-cycle system.** In this system, culture cycles only last for several 5-6 weeks. At the end of each cycle, ponds are drained and the remaining *Artemia* killed. Next ponds are re-filled with green water and new brine shrimp are inoculated. In Southern Vietnam, *Artemia* can be inoculated three times per season.

A randomized block design was adopted, as culture results differed significantly in time (1995 compared to 1996 season) and space (adjacent ponds T1–T2 compared to adjacent ponds T3–T4). Each treatment was repeated three times (three blocks). However, ponds were not allocated randomly to the two treatments, i.e. ponds in which cyst yields were lowest in the first 6 weeks (= first cycle) were allocated to the multi-cycle treatment.

Inoculation procedures and daily management of the ponds were similar for both treatments and were aimed at maximizing cyst yields (Baert et al. 1996). At the beginning of the 1995 culture season, ponds were stocked at 100 nauplii litre⁻¹. For the second and third cycle of 1995, however, and all 1996 cycles, a stocking density of 50 nauplii litre⁻¹ was used. Other research conducted at the site showed that stocking densities of 100 nauplii litre⁻¹ were suboptimal.

#### Data collection

Turbidity levels were measured with a Secchi disc according to Baert et al. (1996) and expressed in cm. Besides the total harvestable amount of cysts (wet weight, WW) collected in each pond, the population abundance and the reproductive outputs of the oviparous females were recorded.

In 1995, six samples were collected per week per pond. Samples were taken using a cotton net (mesh size < 100 μm; surface area 0.22 m²), dragged horizontally over a distance of 7.5 m. In 1996, samples were collected using a plankton net (mesh size 100 μm; surface area 0.25 m²), hauled vertically through the water column. In 1996 the number of samples per week per pond was increased to 10.

Samples were analysed in the lab, where we determined the average number of females, males, juveniles and nauplii in each pond (animals m⁻³). Although sample distributions were seldom normal, we still used the arithmetic sample mean in our graphs as an estimator of the population mean (Elliott 1977). However, when comparing female abundance in the different ponds we opted for non-parametric tests.

In 1996 the average brood size of the oviparous females was also determined. To avoid underestimation of brood size—which is inevitable if females are preserved—the females were immediately dissected after collection when still alive. To assure random collection of the females, (1) several samples collected at different places in the pond were thoroughly mixed together; then (2) small subsamples were scooped out with a Petri dish. The dish was placed under a stereomicroscope and moved from left to right/ top to bottom; the first 30 females encountered carrying cysts were dissected.

#### Statistical analysis

Data were analysed using a 'two-factor ANOVA' (randomized block design) if the assumptions of this test were met (Sokal & Rohlf 1995). If assumptions were not met and transformation of the data (logarithmic) did not solve such problems, the Mann–Whitney U-test was used. In the latter case.
data were pooled per treatment (Sokal & Rohlf 1995).

Results

Table 2 shows an overview of the average cyst yields per treatment. Besides yield per season (= total yield), yields per cycle are also given. The division of the one-cycle system in three cycles is somewhat arbitrary. However, it appeared that in the systems applied, only three generations contributed to the cyst yields in one-cycle systems (unpublished data). Therefore cyst yields of each consecutive generation in the one-cycle ponds were matched with the yields obtained during one cycle in the multi-cycle systems. Usually, the short culture period and the high stocking density allowed only the first generation to reach maturity, in the multi-cycle systems.

Results of the two-factor ANOVA (assumptions met for all data) are also included in Table 2. Clearly multi-cycle ponds give significantly higher total yields (an average of 50%). Also interesting is the fact that differences increase towards the end of the culture season (Fig. 1, Table 2): in fact, if total yields in both systems are compared after two cycles, differences are not yet significant (two-factor ANOVA; p-value = 0.29). Finally the yields obtained in the one-cycle system are similar to the average yields obtained by the farmers (average of 80 kg WW ha⁻¹ per season, unpublished data SARDI 1989–1994). In Fig. 2, abundance data are summarized. Even when animals are stocked at optimal density, the number of animals in the culture ponds increases quickly. In ponds where per capita food levels initially are high (i.e. higher initial mortality), this population increase is even more pronounced (i.e. pond T4 in 1996), as brood size tends to be larger.

Results for the average number of females per m² are given in Fig. 3. In multi-cycle systems, one to two weeks are needed before newly introduced nauplii reach maturity. Obviously, at such times and at moments when ponds are being drained, significantly fewer adult females will be found in the multi-cycle ponds compared with the one-cycle ponds (weeks 7, 8, 14 and 15: Mann–Whitney U-test, n = 26, p < 0.05) However, towards the end of the culture season (weeks 17, 18 and 19), the number of adult females is significantly higher in multi-cycle ponds (Mann–Whitney U-test, n = 26, p < 0.05).

Average brood size data are summarized in Fig. 4. The trends observed are similar to those for female abundance, but are more pronounced. The significantly smaller brood size (two-factor ANOVA, n = 30, p < 0.0001), which explains the lower yields, in multi-cycle ponds at the beginning of the season, reflects the way ponds were allocated to the different treatments (ponds giving lowest yields were allocated to the multi-cycle system). From the second cycle onwards, brood size is significantly larger in the multi-cycle systems (two-factor ANOVA, n = 30, p < 0.0005).

Discussion

It is clear that increasing the number of culture cycles has a significant influence on cyst yields. Although at the start of the season, the ponds with the lowest cyst yields were allocated to the multi-cycle treatment, these ponds still yielded significantly higher total cyst harvests. Yields even increased towards the end of the culture season (Fig. 1).
Figure 2: Animal abundance (relative estimates, animals m⁻¹) in the different culture ponds. White segments, nauplii; shaded segments, juveniles; black segments, adults.

As investment and management costs for both systems are similar (US$400–500, Nguyen Van Hoa, Vu do Quynh, Nguyen Kim Quang & Baert 1994), the increased yields make the multi-cycle system more attractive. Because those ponds which initially gave the lowest yields were allocated to the multi-cycle system, maximal possible yields probably have been underestimated. Still, as the results obtained suggest that yields after two cycles do not differ significantly between the two culture systems, the multi-cycle system should only be recommended if at least three cycles can be completed per season. On the other hand, if problems are encountered with the cultures (poor growth, development of
filamentous algae, etc.), switching from a one-cycle system to a multi-cycle system is always good practice.

The higher number of females and the significantly larger brood size of cyst-bearing females in the multi-cycle ponds towards the end of the season, explain the higher yields in the multi-cycle ponds. The smaller brood size and lower number of adult females in the one-cycle ponds indicate that culture conditions in these ponds are suboptimal. Most probably, food levels are not sufficient to allow proper development of the second and third generation.

As shown in Fig. 2, the number of animals in the pond increases quickly. Furthermore, salinity limits pumping rates while excessive use of organic manure inevitably leads to oxygen stress. Therefore, food level cannot be increased indefinitely (i.e. in the Vinh Chau area, pumping rate and use of organic manure are probably maximal). Of course, we can choose a stocking density so as to assure optimal feeding levels for the first generation. Yet, owing to the quick increase in numbers, the second and third generations will receive increasingly less food. Not only is less food per animal available, but animals belonging to later generations will have to compete with larger animals having a better-developed feeding apparatus. The decrease in brood size and number of adult females (increased maturation time and/or mortality), as shown by our data, seems logical.

In multi-cycle systems, only the first generation is allowed to develop and release cysts. Once yields decline, which often coincides with the disappearance of the first cohort, ponds are emptied and a new cycle is started. Once again, ponds are stocked at a density assuring quick development of the newly introduced animals. These better culture conditions are translated into a higher reproductive output, as compared with the one-cycle systems, and better cyst yields. Figure 5 shows the turbidity as measured in the different ponds. Although turbidity is not a very accurate measure for primary productivity in Vietnam (i.e. water has a very high level of total dissolved solids comprising not only algae), this graph indicates that turbidity levels in the multi-cycle ponds tend to be higher towards the end of the season. Still, the stocking densities we used are high. Work of other researchers (Vu Do Quy nh & Nguyen Ngoc Lam 1987) and some of our data (i.e. see changes with time in pond T4, 1996) suggest that the second generation could contribute considerably to overall cyst yields. If animals are
Acknowledgments

This study has been supported by the European Union, the Flemish Inter University Council (VLIR), the Flemish Association for Education and Technical Support Abroad (VVOB) and the Belgian Administration for Development Cooperation (ABOS). PS acknowledges the International Foundation for Science and the European Union DG XII for sponsoring his participation in the workshop ‘Aquaculture Research and Sustainable Development in Inland and Coastal Regions in South-East Asia’ (University of Can Tho, Vietnam, March 18–22, 1996).

References


