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***Editor's note:** ICLARM Conf. Proc. 26 (Trophic Models of Aquatic Ecosystems), edited by Villy Christensen and Daniel Pauly (1993) is a useful compendium of applications of ECOPATH II across large- and small-scale ecosystems. It contains 50 papers on ecosystems ranging from ricefields to oceans. This book is available from ICLARM at US$15 (surface mail) and $32 (airmail).*

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Experimental Culture of *Acartia plumosa*:

A Copepod for Use in Marine Fish Hatcheries

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Introduction

Marine copepods (*Acartia* spp.) are being promoted as a food organism in some marine hatcheries. They used to be collected from the wild, as plankton, and fed to marine fish postlarvae, as alternatives or supplements to *Artemia nauplii*. Substitution of an *Artemia* diet with wild copepods has often improved the growth and survival of grouper (*Epinephelus fuscoguttatus*) larvae (Slamet and Diani 1993). However, collecting plankton takes a long time, and the availability of the required species and quantities are never sure. Continuous culture of such copepods might provide a stable supply.

Acartia spp. are rich in highly unsaturated fatty acids, especially eicosapentaenoic acid and docosahexaenoic acid (Watanabe et al. 1983). Moreover, they provide a wide size range of food organisms for hatchery use (six naupliar stages and six copepodid stages). Unlike some other copepods that carry egg sacs (e.g., *Pseudocalanus, Pseudodiaptomus* and *Oitona* spp.), the eggs of *Acartia* spp. sink to the bottom of culture tanks and are easily separated from adult populations by siphoning.

The taxonomy of *Acartia* spp. has been well studied (e.g., Mori 1940; Ito 1956; Abraham 1970; Greenwood 1972; Ueda and Hiromi 1987) and mass culture of *Acartia* spp. has been described (e.g., Stottrup et al. 1986; Ohno and Okamura 1988; Ohno et al. 1990). Sunyoto (1991) identified two species in West Java: *Acartia pasifica* and *A. plumosa*. The former was dominant in the open sea and the latter in a seawater pond. The Bojonegara Research Station for Coastal Aquaculture, West Java, used to collect these species for rearing marine fish larvae of seabass (*Lates calcarifer*), grouper (*E. fuscoguttatus*), but there are no reports from Indonesia of attempts to culture copepods for this purpose. We assumed that *A. plumosa* would be the more suitable species for use in hatcheries because it tolerates a wide range of salinities: from brackishwaters up to about 55 ppt.

Experimental Culture

Comparative Feeding Trials

A. plumosa adults were collected from a seawater pond (salinity, 50 ppt), transferred to 100-l seawater tanks (salinity, 34 ppt) with gentle aeration, and were fed with *Chlorella* and *Tetraselmis*. All work was done at 26-29°C. For a preliminary trial one day later, batches of adults were stocked in nine 3-l glass flasks at 9,000 per flask. There were three replicated feeding treatments: 1) *Chlorella/ Nannochloropsis* (2-6 µm); 2) *Tetraselmis* (8-14 µm); 3) baker's yeast (3-6 µm). The daily amounts fed per flask were 200-400 x 10^7 for *Chlorella*, 200-400 x 10^5 for *Tetraselmis* and 0.03 g for baker's yeast. The bottom water in the flasks was siphoned out every day. The experiment was terminated after nine days and surviving *Acartia* counted. The survival was 17 to 23% (mean 18%) for treatment 2 (*Tetraselmis*) and zero to 0.1% for the other feeds.

In a second experiment, the bottom water was siphoned from an *Acartia* culturing tank that contained eggs and the eggs were washed in clean seawater and stocked in nine 1-l glass flasks at 2,000 per flask. They hatched into nauplii after one day. Three naupliar feeding treatments were set up as 1-3 above, but the experiment was terminated after only four days. Again, only nauplii fed with *Tetraselmis* survived (7-10%; mean 8%). Nauplii that received the other feeds failed to survive beyond day 2. Table 1 summarizes the measurements made on surviving nauplii.

In a third experiment, several hundred thousand eggs, spawned by females in culture tanks, were stocked in a tank containing 100 l of filtered seawater. After hatching, cultured *Tetraselmis* were supplied as food. Daily sampling was conducted to measure the growth (total length) and survival of nauplii and copepodids. The experiment was terminated after 10 days when a new generation of nauplii appeared.

Table 1. The mean body length (µm) ± SD of *Acartia plumosa* nauplii, fed *Tetraselmis* for four days.

Replicate	Days of rearing			
	1	2	3	4
1	122 ± 11	176 ± 23	191 ± 26	211 ± 21
2	116 ± 8	155 ± 22	188 ± 20	191 ± 22
3	112 ± 12	169 ± 20	183 ± 20	223 ± 19

Naupliar stages developed over four to six days, with development to copepodid stages starting after day 4. The numbers of copepodids increased up to day 6, with complete metamorphosis into copepodids by day 7. The body lengths of the various developmental stages were: egg (diameter) 71 µm; nauplius (just hatched), 85 µm; last nauplius stage, 246 µm; and early copepodid, 338 µm. After 10 days, the copepodids became adults and new generation nauplii were found. The maximum sizes of adult males and females were 713 and 833 µm, respectively. The daily growth (mean size) of *A. plumosa* from eggs to adult reared in a 100-l tank is presented in Table 2.

Table 2.The mean body length (µm) ± SD of *Acartia plumosa* reared in a 100-l tank.

Days of rearing	Naupliar stages	Copepodid stages
0	84 (just hatched)	-
1	128 ± 8	-
2	161 ± 20	-
3	201 ± 22	-
4	202 ± 29	388 ± 52
5	202 ± 26	417 ± 74
6	206 ± 26	451 ± 60
7	-	464 ± 47
8	-	472 ± 39
9	-	486 ± 37
10	new nauplii found	536 ± 171

Implications for Hatchery Work

Here, *A. plumosa* survived and grew only on the relatively large and actively moving alga *Tetraselmis*. Iwasaki et al. (1977) grew *A. clausi* on *Isochrysis galbana* (5-6 µm) and *Monochrysis lutheri* (8-10 µm); and Stottrup et al. (1986) grew *A. tonsa* on *Rhodomonas baltica* (5-8 µm) and *I. galbana* (4 µm). The times for development of *Acartia* spp. from egg to adult depend upon species and temperature: e.g., for *A. clausi*, 14-16 days at 20.3°C and 27 days at 13.1°C; for *A. steuri*, 31.1 days and 16.2 days at 16.8°C and 23°C, respectively (Uye 1980).

What is the real potential of *Acartia* spp. as live foods in fish hatcheries? It appears that there is a critical period in the metamorphosis of nauplii to copepodids. Landry (1978) reported cannibalism in *A. clausi*: all copepodid stages consumed some nauplii and the more advanced copepodid stages consumed more. Clearly more work is needed on these and other potential 'live food' crustaceans species; both to assess their nutritional value for various target fish species and to devise mass culture systems that maximize growth and survival.

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