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Full Length Article

Zooplankton Community Structure in the Tiger Shrimp (*Penaeus monodon*) Culture Pond at Malacca, Malaysia

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Abstract

In aquaculture pond, zooplankton offer themselves as food to culture organism likes shrimp. Biomass and productivity of zooplankton in different size ranges are important factors modifying the productivity of higher trophic-level organisms as well as production of culture. In this view point, the composition of zooplankton was investigated in shrimp culture ponds for one culture cycle in the tropics. Zooplankton abundance did not differ significantly between old and new culture ponds. The major groups of zooplankton were copepods, rotifers, sergestidae, lucifer, gastropod larvae, bivalve larvae, pelagic polychaetes, nematodes, crustacean nauplii, insects and mysidacea. Among these, copepods (51.69-53.57%) and crustacean nauplii (28.39-41.81%) were the dominant groups in all culture ponds. Zooplankton density increased by >46% at the end of the culture period in all ponds probably due to the recruitment of zooplankton through reproduction in the ponds over time. The findings of this study suggests that zooplankton composition in culture ponds appeared to be an important source of food and nutrition for shrimp post larvae, at least for earlier period (1-4th week) after the ponds are stocked, hence managing of zooplankton density prior to stocking of post larvae in the culture pond is important. © 2014 Friends Science Publishers

Keywords: Zooplankton; Composition; Aquaculture Pond; Malaysia

Introduction

Aquaculture species are smaller in size during the early stage of culture and mostly rely on natural diets even though prepared diets are supplied. Many cultured species become omnivores during the early stages of their life history and consume what are available in the nature or captive condition (Stickney, 1994). As a natural diet, zooplankton serves an important role in the food chains of culture pond ecosystem by transferring energy from phytoplankton to the culture species. The inorganic nutrients from shrimp metabolic wastes, uneaten feed and dead plankton undergoes microbial mineralization and taken by phytoplankton to grow. This phytoplankton provides food for assemblages of pond zooplankton, which is limited by the presence of shrimp population in the culture ponds.

The natural diets of shrimp post larvae are mostly based on zooplankton in control environment (Emmerson, 1984; Yufera *et al*., 1984) and the shrimps consumed more zooplankton when their density is high (Chen and Chen, 1992). Predation of zooplankton by shrimp (Martinez-Cordova *et al*., 1998) may transfer a significant proportion of nutrients from natural biota to the cultured shrimps as observed by stable isotopes method (Anderson *et al*., 1987) and gut content analysis (Maguire *et al*., 1984; Allan *et al*., 1995). Penaeid shrimps can also catch prey organisms such as caridean shrimp (Moriarty, 1977) and copepod (Gleason and Zimmerman, 1984) in open water habitat. Furthermore, Bombeo-Tuburan *et al*. (1993) observed that copepod was a significant food source compared to diatom in the ponds resulting higher growth of shrimps.

Rubright *et al.* (1981) reported that zooplanktons are a valuable food to penaeid shrimp while they enter into the detrital food web in the culture pond. In addition, zooplankton contains high (50-75%) moisture free or dry weight protein (NRC, 1977) than other live food like phytoplankton (30%). Previous studies on zooplankton in shrimp ponds have observed that there are complex assemblages with rapid temporal changes in zooplankton structure (Preston *et al*., 2003). However, the understanding of zooplankton composition and dynamics, and their influence on shrimp growth is limited. Thus, we assumed that zooplankton density and communities in culture pond may influence the production. The objective of the present study is to quantify the variation in the abundance and composition of zooplanktons in the commercial Tiger Shrimp aquaculture ponds throughout the culture period.

Materials and Methods

Culture Pond and Study Area

The study ponds were situated at Kampung Tedong (2º 08´ 50" N and 102º 24´ 00" E) in Merlimau, District Malacca. The ponds were managed by Farmers' Organization

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Authority Malaysia (Lembaga Pertubuhan Peladang). Four culture ponds were randomly taken for this study, of which two were more than ≥3 years old and considered as old culture ponds (4,225 m^2 each). Another two ponds were newly constructed on a former mangrove land and considered as new culture ponds (4,355 m^2 and 3,969 m^2). The soil type of the culture ponds was silty clay (Abu Hena *et al*., 2012).

Collection of Zooplankton

Zooplankton samples were collected at every three weeks interval using a Patalas trap covering a volume about 12061 cm^3. Four samples from each sampling pond were collected. Samples were preserved with 10% formalin mixed with rose bengal. All samples were kept in the laboratory for further analysis. A major taxonomic group of zooplankton was identified as described by referring to Mori (1964), Chihara and Murano (1997) and Ismail (2001).

Shannon Diversity Index

The Shannon diversity index (H') and evenness (E) were used to summarize the information about the relative abundances of zooplankton species found within the culture ponds. H' is commonly used to describe the diversity of the particular community and as an indicator for the assessment of an ecosystem with regards to abundance and diversity (Bahls *et al*., 1992). H' and evenness (E) were calculated for each of the sample bases on the following formula (Magurran, 1988):

$$H' = -\sum \mathrm{p}i \ln \mathrm{p}i$$

Where pi is the proportional abundance of the ith species = $\left(\frac{\mathrm{n}i}{\mathrm{N}}\right)$

ni = number of individual species counted

N = total number of species

$$E = \frac{H'}{\ln S}$$

Where ln S is the natural log of the total number species

Statistical Analysis

Multiple regression analysis was used to evaluate the best predicting physico-chemical factors on the abundance of zooplankton throughout the culture period in culture ponds.

Results

The abundance of zooplankton did not differ markedly between old and new culture ponds in the present study (Figs. 1 and 2). The major groups of zooplankton encountered were copepods, rotifers, sergestidae, lucifer, gastropod larvae, bivalve larvae, pelagic polychaetes, nematodes, crustacean nauplii, insects and Mysidacea in the investigated ponds (Table 1 and Fig. 3).

Copepods and crustacean nauplii were the dominant groups in all culture ponds. Ten species of copepod were recorded from these commercial tiger shrimp culture ponds. The abundance of copepod was higher at the end of the culture period in all ponds. Among the pelagic copepods, calanoid copepod was larger in size and present higher

Table 1: Species composition of zooplankton from old and new culture ponds during the culture period

Groups	Species
Copepoda	*Eucalanus crassus ; Calanopia* sp.
	Euterpina acutifrons (Hapact)
	Scolecithricella bradyi
	Paracalanus sp. ; *Centropages* sp.
	Microsetella sp. *; Othiona plumifera*
	O. rigida ; O. nana
Rotifea	*Brachionus* sp.
Sergestidae	*Sagitta* sp.
Lucifer	*Lucifera* sp.
Gastropoda	Gastropod larvae (2 types)
Bivalvia	Bivalvia larvae
Polychaeta	Polychaeta larvae
Nematoda	*Nematoda* sp.
Nauplii	Crustacean nuplii
Insecta	Midge larvae
Mysid	*Mysid* sp.

Table 2: Shannon diversity index and evenness of zooplanktons throughout the culture period of the studied ponds

Ponds		Week					
		1	4	7	10	13	16
Old ponds	*H*'	0.62	0.81	0.66	0.81	0.54	ND
	E	0.39	0.49	0.75	0.59	0.56	ND
New ponds	*H*'	1.04	1.09	0.80	0.66	0.84	0.77
	E	0.61	0.68	0.65	0.77	0.76	0.70

H´= Shannon diversity index, E= Evenness

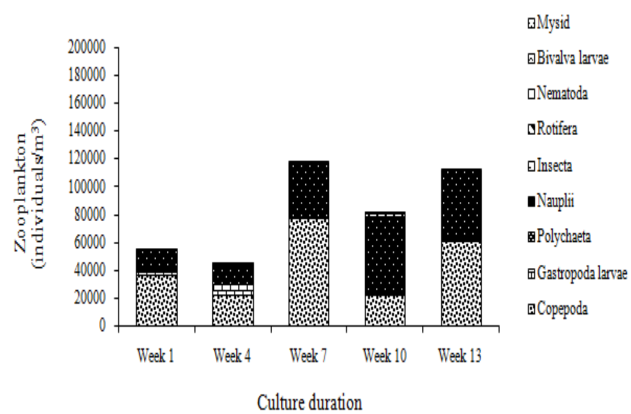

Fig. 1: Population of zooplankton in old culture ponds during the culture period

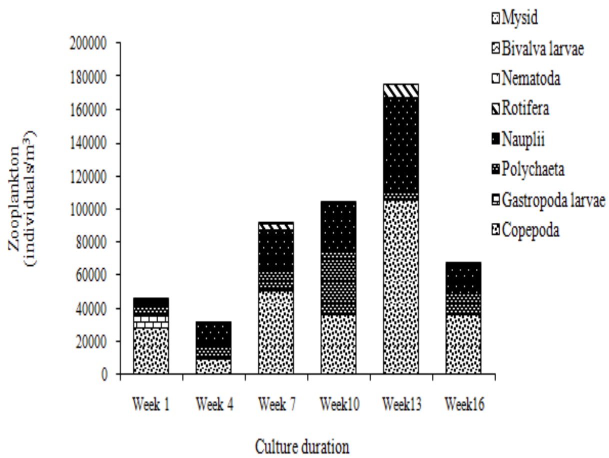

Fig. 2: Population of zooplankton in new culture ponds during the culture period

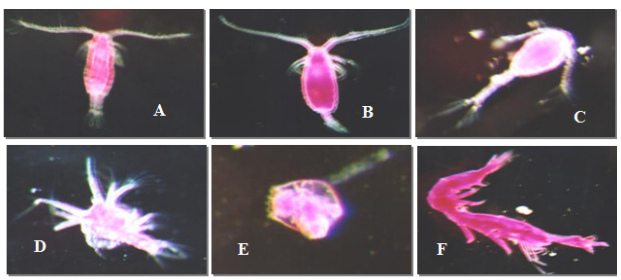

Fig. 3: Some of the zooplankton found in the shrimp culture ponds [A] *Acartia* sp. (x12) [B] *Labidocera* sp. (x12) [C] *Oithona* sp. (x25) [D] Crustacean larvae (x20) [E] *Brachionus* sp. (x40) [F] *Lucifera* sp. (x8).

amount in all zooplankton samples especially *Eucalanus* sp. in all culture ponds followed by *Oithona* spp. as a second dominant group. Percent composition of copepods in the total zooplankton was 51.69-53.57% while nauplii consist of 28.39-41.81% in all culture ponds. Rotifers were present in new culture ponds throughout the culture period as the third dominant species. Two species of gastropod larvae were present at the beginning of the culture in all ponds. The decrease of gastropod was noticed with the progress of culture and diminished from the old culture ponds on week 7. Gastropod larvae were present in the new culture ponds at the beginning of culture but they were unable to increase their population toward the progress of culture. No major trend was found for pelagic polychaetes in the old and new culture ponds. The population of pelagic polychaetes was not observed on week 7 from the new culture ponds while they started to grow on week 10 in old culture ponds.

Percentage compositions of zooplankton in different culture ponds throughout the culture period are given in Figs. 4 and 5. The diversity indices of zooplankton of the study ponds are given in Table 2. The diversity index of

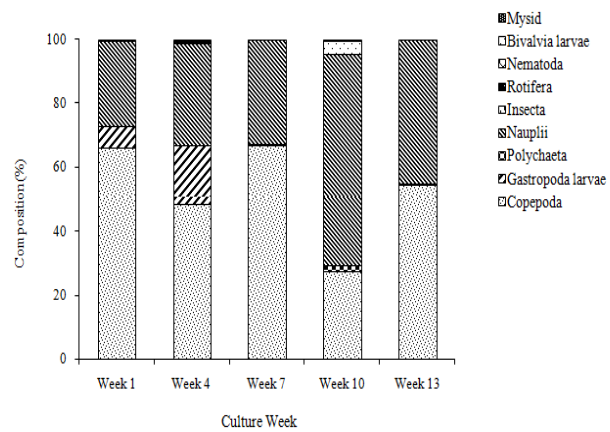

Fig. 4: Percent composition of zooplankton in old culture ponds during the culture period.

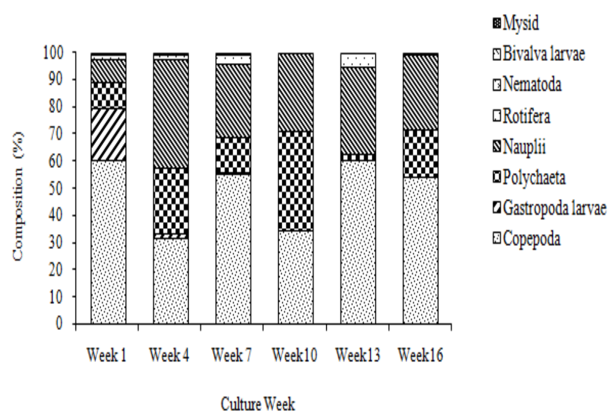

Fig. 5: Percent composition of zooplankton in new culture ponds during the culture period

zooplankton fluctuated in the ponds during culture period. The diversity and evenness of zooplankton species were higher in the new culture ponds compared to old culture ponds. Besides, the diversity of zooplankton decreased at the end of culture period in the studied ponds.

Discussion

The culture ponds exists a high number of zooplankton at the earlier days of culture period or one day after stocked post larvae. A rapid decline of zooplankton numbers was observed on week 4 than week 7 in the culture ponds. Coman *et al*. (2003) have also reported that post larvae prey zooplankton in the ponds as post larvae begin to eat by tearing. About 18-30% of total zooplankton decreased within one month after stocking of post larvae in the ponds probably due to occasional predation by small post larvae. The number of zooplankton density (63 µm) increased by >46% at the end of the culture period in all ponds.

This phenomenon could be due to the recruitment of zooplankton through reproduction in the ponds over time. Another possible reason could be that zooplankton were no longer consumed by larger benthic shrimps as zooplankton are pelagic. Shrimps may also avoid using zooplankton as a direct food source because shrimps were too large to capture the small zooplanktonic organisms.

During earlier period of the culture or before stocking of post larvae no supplemental diets was added in the ponds and all ponds were left for one week for phytoplankton to grow. This phytoplankton was probably the main source of food for zooplankton. As reported by Abu Hena (2005), abiotic factor e.g. pH, salinity, dissolve oxygen, temperature, total suspended solid (TSS) and water nutrients with zooplankton density revealed that none of these, either alone or in combination significantly influenced zooplankton abundance**.** Chlorophyll *a* was positively correlated with zooplankton density in the old culture ponds ($r=0.61$, $p<0.05$) and new ($r=0.74$, $p<0.05$) culture ponds. Likewise, Martinez-Cordova *et al*. (1998) and Preston *et al*. (2003) observed that zooplankton abundance is partially related to the concentration of chlorophyll *a*, detritus, uneaten feeds and phytoplankton density in the culture ponds. Variations in zooplankton abundance and composition in the ponds at the end of culture may be affected by variations in pond water quality such as high TSS or low transparency, high sulphide, high phosphate and water management systems (Coman *et al*., 2003).

Variation in total zooplankton density (415408.50-517932.80 individuals/m^3) over the culture period was higher than the estimates (140000 individuals/m^3) of Burford (1997). The data of the present study indicated the reduction of gastropod larvae (3800-8816 individuals/m^3 in week 1 to 0-469 individuals/m^3 in week 7 in both the old and new ponds) and copepod (36978 individuals/m^3 in week 1 to 22226 individuals/m^3 in week 4 in old pond and 27857 individuals/m^3 in week 1 to 10142 individuals/m^3 in week 4 in new pond) during the early stages of culture probably due to occasional grazing effects by post larvae. The zooplankton abundance found relatively higher for the rest of the culture period suggesting that shrimps had adapted with new food source like supplied feed and benthos as more preferred diet (Chen and Chen, 1992; Martinez-Cordova *et al*., 1998; Preston *et al*., 2003).

Little is known about changes in pond zooplankton densities due to predation by shrimp post larvae. Chen and Chen (1992) observed that juvenile *P. monodon* held in small containers (1-L and 500-mL beakers) are capable of capturing and ingesting zooplankton such as *Oithona* sp. and *Acartia* sp. The results of the present study also suggested that zooplankton composition in culture ponds appeared to be an important source of food and nutrition for shrimp post larvae, at least for earlier period (1-4^{th} week) after the ponds were stocked (55840 individuals/m^3 in week 1 to 45856 individuals/m^3 in week 4 in old pond and 46084 individuals/m^3 in week 1 to 32210 individuals/m^3 in week 4 in new pond). Therefore, it is very important to know the density of zooplankton prior to stocking of post larvae in the culture pond to grow. Nevertheless, the optimum range of zooplankton density in the culture ponds is not well established and needed more research. It has been established that live rotifers were indeed eaten by adult shrimps. Large zooplankton such as the sergestidae may pose a predatory threat to adult shrimps (Abu Hena and Hishamuddin, 2012). However, in a eutrophic environment like semi intensive culture ponds, the abundance of dense zooplankton population is a food source for shrimps, regardless of any stages. The pelagic zooplankton may become available as food for the benthic dweller adult shrimps when they swim close. This helps to build up a trophic relationship in the culture pond food web and influences the dynamics of pond ecosystem. Boyd (1982) reported that certain types of zooplankton abundance i.e. crustaceans and rotifers are related to primary productivity in the fish culture pond. However, primary productivity is affective up to 0.4-0.6 m of the water surface in fish pond where favorable light conditions exist (Boyd and Tucker, 1998).

In conclusion, it could be said that zooplankton abundance and composition in culture ponds appeared to be an important source of food and nutrition for shrimp post larvae, at least for earlier period when the ponds are stocked, therefore managing of zooplankton abundance prior to stocking of larvae in the aquaculture pond is important and may reduce the feed cost if well maintain.

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