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Polyculture of white shrimp, *Litopenaeus vannamei* and milkfish, *Chanos chanos* as a strategy for efficient utilization of natural food production in ponds

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Abstract. Both shrimps and milkfish are important aquaculture species in the Philippines. In the present study, we described a modified extensive polyculture method for white shrimp, *Litopenaeus vannamei* and miklkfish, *Chanos chanos* in ponds during the wet months. This particular culture system uses two or more species in a particular production area with the purpose of maximizing the utilization of the available natural food present in the system. Two 1-hectare earthen ponds were prepared and added with organic and/or inorganic fertilizers to enhance natural food production. The ponds were stocked with white shrimp postlarvae (PL) at a density of 1 PL m^{-2} and milkfish at 750 juveniles ha^{-1}. There was no water exchange during the first two months of culture followed by a bi-weekly water exchange until harvest. No artificial feeding was provided during the culture period, instead, the ponds were supplemented with inorganic fertilizers every month to ensure stable production of natural food. Both shrimps and milkfish appeared healthy and no disease outbreaks were observed during the production cycle. The physico-chemical parameters of the water in the ponds were within the optimum levels that are required for both shrimp and milkfish farming. The phytoplankton population was stable and predominantly composed of *Chlorella* sp., a green microalga (Chlorophyta). The cultured stock were harvested after 100 days of culture at sizes of 13-15 for white shrimp and > 250 g for milkfish. There was high survival rate of milkfish but low for white shrimps, and this could be affected by the prevailing climatic condtions during culture and the age and size of the species during stocking.
Key Words: polyculture, shrimp, milkfish, *Litopenaeus vannamei*, *Chanos chanos*, natural food

Introduction. Aquaculture is a global activity and its production has grown tremendously over the past years. There are a number of aquatic species that are being developed for aquaculture, and among these, crustaceans contribute a significant portion in terms of production and value (FAO 2007, 2009). Penaeid shrimps are among the preferred crustaceans in aquaculture and proof of this is the vast expanse of land area devoted to shrimp farming (Martínez-Porchas et al 2010). Due to intensive shrimp aquaculture in most parts of the world, this activity has resulted in several problems including higher incidence of disease outbreaks (Martínez-Porchas et al 2010), environmental pollution of the waterways (Sansanayuth et al 1996), over-dependence on the use of fish meal in commercial feeds (Porchas-Cornejo et al 2011) and low prices due to oversupply in the market (FAO 2007). To curb these problems several techniques such as the use of probiotics, low or zero water exchange, recirculating systems, bioremediation of effluents, natural feeding and polyculture/crop rotation techiques have been utilized to minimize the deleterious effects of intensive shrimp farming (Martinez-Cordova et al 1998; Sangamaheswaran et al 2001; Otoshi et al 2003; Muangkeow et al 2007; Vieira et al 2007; Krummenauer et al 2010; Porchas-Cornejo et al 2011).

Polyculture is also known as multi-trophic aquaculture, co-culture or integrated aquaculture (Bunting 2008). The use of this approach in shrimp farming has several benefits such as lessening the risk of ecological impacts, improving the yield of both the primary and secondary stock and maintaining optimum water quality in a particular aquaculture system (Muangkeow et al 2007; Troell et al 2009). It also effectively utilizes the different natural food present in the production area, thus improving efficiency of converting available resources to the end product.

There have been several studies that demonstrated the beneficial effects of culturing shrimps with other aquatic species. Shrimps have been polycultured with other fish such as tilapia, several species of macroalgae and shellfish (Akiyama & Anggawati 1999; Bunting 2006; Da Silva-Copertino et al 2009). The use of these secondary species in shrimp ponds provided benefits such as reducing the amounts of dissolved nutrients, filtering suspended solids, feeding on excess organic matter, improving water quality and enhancing disease resistance against pathogens (Martínez-Porchas et al 2010).

Several shrimp species are being cultured in ponds, and one particular species that is gaining popularity in tropical countries is the white shrimp, *Litopenaeus vannamei*. This penaeid shrimp has fast growth rate, thus, its culture period is significantly reduced. Altough not endemic in the Philippines, white shrimp is now fast catching up with tiger shrimp, *Penaeus monodon* as the preferred species for culture, especially because the Philippine government has already lifted the ban on importation of this species in the country (Cuvin-Aralar et al 2009). There have been culture initiatives for white shrimps in various parts of the country, and in a previous study we described a modified extensive culture of white shrimps in ponds as a sustainable form of aquaculture (Jaspe et al 2011).

The use of polyculture system of aquaculture has been studied in white shrimps together with oysters and clams (Martinez-Cordova & Martinez-Porchas 2006), seaweeds (Lombardi et al 2006) and red tilapia (Yuan et al 2010). In all these studies, co-culturing white shrimps with these aquatic species resulted in positive effects on both the primary and secondary species. However, no such studies were done in the Philippines to demonstate whether polyculture of white shrimps with other aquatic species is a viable strategy in sustainable aquaculture. Previously, we have shown that a modified extensive pond culture of white shrimps is an environment-friendly aquaculture technique. In the present study, we determined whether this particular method could be applied in the polyculture of white shrimps with milkfish, *Chanos chanos*, a traditional fish species in Philippine aquaculture. More specifically, this study aimed to determine the grow-out performance of both white shrimps and milkfish during a particular season by subsisting entirely on natural food organisms in the ponds. Moreover, the different water quality parameters were measured to find out the optimum levels of each parameter that are required for the pond culture of both species.

Materials and Methods

Pond preparation. Two 1-ha earthen ponds were used for the polyculture of white shrimp and milkfish. Pond preparation activities were done during the wet months following the protocol described by Jaspe et al (2011) for the modified extensive system in pond culture. Briefly, the ponds were added with brackishwater at a depth of 10 cm then applied with teaseed powder at a dose of 20 ppm to kill unwanted fish juveniles and larvae. The ponds were left untouched for a few days then added with inorganic fertilizer (ammonium phosphate and urea) at a rate of 50 kg per hectare. The inorganic fertilizers facilitated the growth of natural food consisting mostly of filamentous algae, which are dominant during the rainy months. Two weeks after the addition of inorganic fertilizers the water level was increased to 30 cm followed by a second application of fertilizers at the same dosage. After a few days, the water level was increased to 70 cm and kept at this depth until stocking.

Stocking of shrimp and milkfish. Pond-reared milkfish juveniles (average body weight of 2.02 g) were purchased from a local milkfish nursery pond operator and transported to the pond site. Shrimp postlarvae (PL 12) were obtained from a commercial shrimp hatchery in Central Philippines. The milkfish were stocked at 750 juveniles per hectare, while the shrimps were stocked at 10,000 PLs per hectare (1 shrimp PL m^{-2}). Milkfish juveniles were stocked in the ponds one week ahead of the shrimp postlarvae. The protocols for stocking both milkfish and shrimp were the same. Stocking was done early in the morning when the air temperature was relatively cool. Prior to transport of the milkfish juveniles and the shrimp postlarvae to the pond site, they were acclimated to the salinity of the pond in order to prevent salinity stress. At the pond site, the transport bags were opened and allowed to float on the pond water. Once the temperature of the transport bags was stable, the contents of transport bag were gradually mixed with the water from the pond and the milkfish juveniles or the shrimp larvae were slowly released to the pond. Initial readings for salinity, water temperature and dissolved oxygen were recorded during stocking.

Pond management and natural food production. The culture stock were fed solely with the natural food in the ponds during the culture period. To ensure stable production of natural food, inorganic fertilizers (ammonium phosphate and urea) were added at a dose of 20 kg per hectare every month. There was zero-water exchange during the first two months of culture, however, the ponds were only filled with water during the high tide to maintain the desired water level. From the third month until harvest, water exchange was carried out very spring tide by gravity flow.

Analyses of water samples. Water samples were collected weekly for the analyses of the different chemical parameters including ammonia, alkalinity and water pH. Dissolved oxygen, temperature, salinity and water depth were taken on the field twice a week. Water samples for phytoplankton counts were taken bi-weekly.

Temperature and dissolved oxygen were determined using the YSI model DO meter, whereas salinity was measured using Atago refractometer. Water pH was determined with a digital pH pen. Ammonia and total alkalinity were determined following standard procedures (APHA 1989).

Water samples for the quantitative determination of phytoplankton population in the ponds were obtained following Jaspe et al (2011). The phytoplankton organisms were identified at the genus level and enumerated following the keys and illustrations of Prescott (1962).

Results and Discussion. The growth curves of the shrimps and milkfish in the two ponds are shown in Figure 1a and 1b, respectively. The stock was harvested after 100 days of culture (DOC). Upon harvest, the shrimps had average body weight of 13.85 g and 15.6 g in Pond 1 and 2, respectively. On the other hand, the milkfish attained an average weight of 285 g and 365 g in the two ponds. The production parameters are shown in Table 1. The growth rates of the shrimps in the two ponds were 0.97 and 1.09 g $week^{-1}$, whereas for milkfish the growth rates were 2.83 and 3.63 g day^{-1}. There was low survival of the shrimps in both ponds (25.3% and 22.0%), whereas the milkfish had high survival rates (> 90%). Previous studies have shown that shrimps in monoculture system grew better when cultured during the dry months (Guerrero-Galván et al 1999; Jaspe et al 2011). In the present study, the culture was done during the rainy months when it was difficult to grow periphyton algae and other benthic assemblages, which are the preferred food of shrimps (Rubrigth et al 1981). However, the growth rates of the shrimp in polyculture with milkfish during this time were comparabe to the growth rates in a monoculture sytem using the same level of management (Jaspe et al 2011). This likely indicates that in a modified extensive system, the prevailing climatic conditions and the type of culture that is being used do not necessarily influence the growth of shrimps. In the case of milkfish, they reached marketable size (at least 250 g) in less than four months of culture.

The survival rates of shrimps in the present study were comparable to the values obtained in a monoculture system of our previous study (Jaspe et al 2011). There were many factors that could have been involved including wide fluctuations in salinity levels due to occasional heavy rains, the presence of predatory birds and the overgrowth of filamentous green algae that could restrict movement and entangle the shrimps. For comparison, given the same level of pond management, Ogle et al (1992) and Yan et al (2007) obtained lower survival of the shrimps in the wet months, which are characterized by low salinity levels. This was in contrast to the results of the study done by Guerrero-

Galván et al (1999) in which they observed higher survival of the shrimp during the wet months.

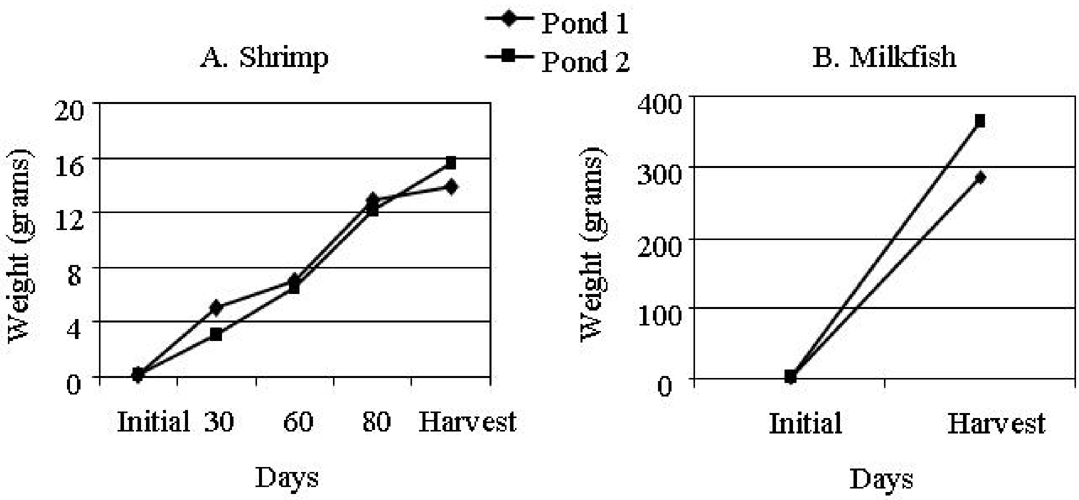

Figure 1. Growth of white shrimps and milkfish in modified extensive polyculture ponds during a production cycle.

Table 1

Production of white shrimps and milkfish in modified extensive polyculture ponds

	Days of Culture	Weight at harvest (g)	Growth rate	Survival Rate (%)
A. Shrimp				
Pond 1	100	13.85	0.97 g wk^{-1}	25.3
Pond 2	100	15.60	1.09 g wk^{-1}	22.0
B. Milkfish				
Pond 1	100	285.0	2.83 g day^{-1}	98.0
Pond 2	100	365.0	3.63 g day^{-1}	93.0

In the case of milkfish, the survival rates were high and apparently not affected by the climatic conditions. The size and age of the fish during stocking could be the major factors that contributed to the high survival rate of milkfish in this culture system. Milkfish were stocked in the ponds at the early juvenile stage, hence, they were better equipped biologically to cope with stress and changes in the pond environment during the first few days after stocking. Additional studies have to be done to accurately determine the effects of the prevailing climatic conditions on the growth and survival of both shrimp and milkfish in a modified extensive polyculture system.

Table 2 shows the water quality parameters monitored in both ponds during the culture period. The shrimps and milkfish were cultured in the ponds during the rainy months, hence it was expected that there was wide fluctuation in the salinity levels (20-30 ppt in Pond 1 and 16-30 ppt in Pond 2). These levels were similar to our previous study on monoculture of white shrimps during this particular time of the year (Jaspe et al 2011). The levels of the other water quality parameters were within the optimum levels required for either shrimp and milkfish culture and were comparable to previous studies done on monoculture of shrimp (Martinez-Cordova et al 1998; Guerrero-Galván et al 1999; Casillas-Hernández et al 2007; Jaspe et al 2011; Porchas-Cornejo et al 2011) and in milkfish (Sumagaysay-Chavoso & San Diego-McGlone 2003; Guanzon et al 2004). We have not observed erratic changes in the other water quality parameters at the latter part of the culture period as observed by Casillas-Hernández et al (2007) because of the type of pond management that we used. A modified extensive method of polyculture was used in the study, as such there was no feed input throughout the duration of the culture period. By having no feed input during the culture of white shrimps and milkfish, the risk of organic matter build-up in the pond was minimized, thus reducing the load of nitrogen metabolites and suspended solids, which could severely affect water quality in the ponds.

Table 2

Physico-chemical parameters of the water in ponds
during the culture period

	Pond 1	Pond 2
Salinity (ppt)	20 – 30	16 - 30
Temperature (°C)	19.0 – 30.1	19.0 – 30.2
Dissolved Oxygen (ppm)	1.2 – 6.7	1.3 – 5.7
pH	7.7 – 8.7	7.5 – 8.9
Ammonia-N (ppm)	0.013- 0.14	0.01 – 0.49
Alkalinity (ppm)	76.2 – 140.3	55.9 – 122.5

The natural food population in the ponds in terms of quantity is shown in Figure 2. In both ponds, the highest phytoplankton density was observed during stocking and decreased thereafter. During the culture period, the growth of the phytoplankton was more or less stable. This was in contrast with our earlier study on the modified extensive shrimp monoculture system wherein a decreasing trend in the phytoplankton population was observed (Jaspe et al 2011). The feeding activities of the two species having different food preferences might have an influence on establishing a stable population of the natural food in the ponds by exploiting the different food organisms equally, unlike in a monoculture system where a specific organism is being eaten more than the other natural food present in the pond.

The natural food in the ponds was dominated by *Chlorella* sp., a green alga (Chlorophyta) (Figure 3). This was observed throughout the duration of the culture period. The other phytoplankton populations present in the ponds include the Cyanophyta (blue-green algae) and the Chrysophyta (golden algae and diatoms). This kind of species composition of the phytoplankton population that was observed in the polyculture ponds was similar to the shrimp monoculture ponds in our previous study (Jaspe et al 2011). However, there were differences in the trend of the abundance of the blue-green algae in the two culture systems.

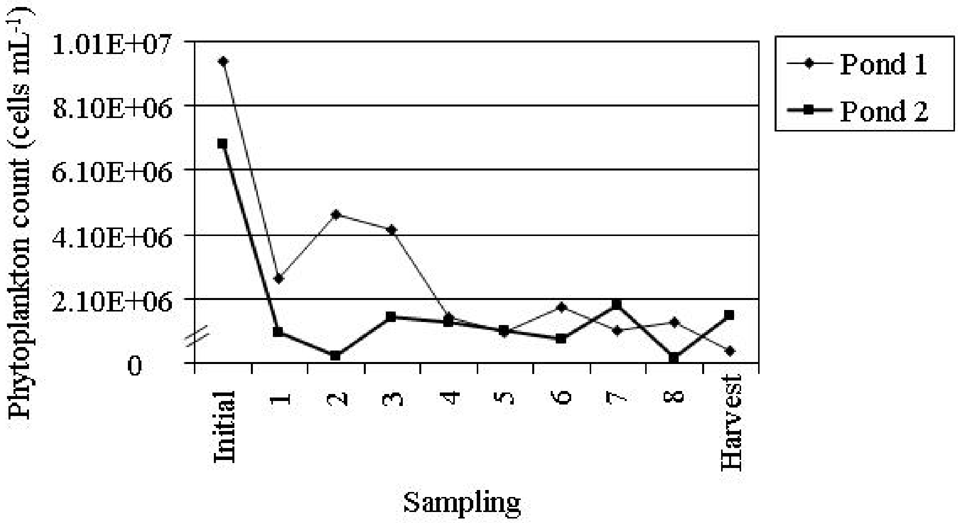

Figure 2. Phytoplankton population in modified extensive white shrimp-milkfish polyculture ponds.

In the polyculture system, there was no clear pattern in the abundance of blue-green microalgae in the ponds, although the percentage composition of this group of microalgae was low to moderate. In the shrimp monoculture system, a clear increase in the population of blue-green algae was observed towards the latter part of the culture period (Jaspe et al 2011).

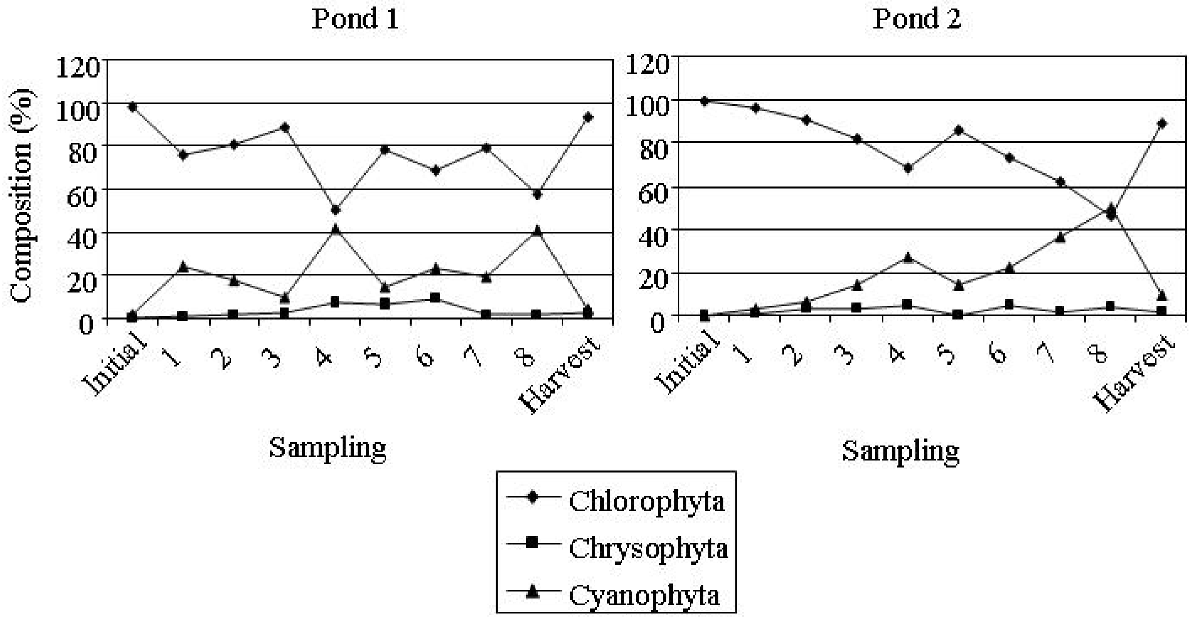

Figure 3. Composition of phytoplankton population in modified extensive white shrimp-milkfish polyculture ponds.

We have noticed that there were occasional spikes in the composition of blue-green algae (composed mostly of *Oscillatoria* sp., and to a lesser extent *Chroococcus* sp.) in the polyculture ponds, and these peaks could be related to the erratic weather conditions that are prevalent during the wet months. Bombeo-Tuburan et al (1989) and Kado et al (1989) observed massive decline of natural food in milkfish ponds during a heavy rainfall and this could result in the release of nitrogenous compounds in the process of organic matter decomposition. The presence of high amounts of nitrogenous substances in the pond coupled with low salinity levels during the wet months could trigger the increased production of blue-green algae (Daniels & Boyd 1993). This could possibly explain why there were occasional increases in the composition of blue-green algae in the polyculture ponds. However, the composition of blue-green algae in the polyculture ponds did not exceed the population of the green microalgae, hence, the deleterious effects of the blue-green algae on the either shrimp or milkfish are not manifested. The presence of high populations of *Chlorella* sp in the pond could be a contributing factor why there were no incidence of diseases during the culture period, although this needs further studies.

Conclusions. In summary, a protocol for the modified extensive system of culturing both white shrimps and milkfish during the wet/rainy months has been described. This method relied entirely on the presence of natural food organisms in the ponds and supplemented by fertilization with inorganic fertilizers. This particular aquaculture practice is sustainable because of its low inputs, low risk of disease episodes and environmental degradation. Natural feeding is able to support both shrimp and milkfish biomass of at least 200 kg per hectare of production area. Both shrimps and milkfish attained harvestable size (13-15 g for white shrimps and > 250 g for milkfish) in 100 days of culture. The different water quality parameters did not fluctuate during the culture period. The phytoplankton population was largely dominated by *Chlorella* sp., a green microalga, which could have inhibitory effects against the overgrowth of blue-green algae and other pathogenic organisms.

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References

Akiyama D. M., Anggawati A. M., 1999 Polyculture of shrimp and tilapia in East Java. American Sybean Association (ASA), Technical Bulletin AQ 47.

APHA (American Public Health Association), 1989 Standard methods for the examination of water and wastewater, 17th ed. Port City Press, Baltimore, pp. 10-203.

Bombeo-Tuburan I., Agbayani R. F., Subosa P. F., 1989 Evaluation of organic and inorganic fertilizers in brackish-water milkfish ponds. Aquaculture **76**:227-235.

Bunting S. W., 2006 Low impact aquaculture. Centre for Environment and Society Occasional Paper 2006-3, Universty of Essex, UK.

Bunting S. W., 2008 Horizontally integrated aquaculture development: exploring consensus on constraints and opportunities with a stakeholder Delphi. Aquacult Int **16**:153-169.

Casillas-Hernández R., Nolasco-Soria H., Garcia-Galano T., Carrillo-Farnes O., Paez-Osuna F., 2007 Water quality, chemical fluxes and production in semi-intensive Pacific white shrimp (*Litopenaeus vannamei*) culture ponds utilizing two different feeding strategies. Aquac Eng **36**:105-114.

Cuvin-Aralar M.L.A., Lazartigue A.G., Aralar E.V., 2009 Cage culture of the Pacific white shrimp *Litopenaeus vannamei* (Boone, 1931) at different stocking densities in a shallow eutrophic lake. Aquac Res **40**:181-187.

Daniels H. V., Boyd C. E., 1993 Nitrogen, phosphorus and silica fertilization of brackish-water ponds. J Aquacul Trop **8**:103-110.

Da Silva-Copertino M., Tormena T., Seeliger U., 2009 Biofiltering efficiency, uptake and assimilation rates of *Ulva clathrata* (Roth) J. Agardh (Chlorophyceae) cultivated in shrimp aquaculture waste water. J Appl Phycol **21**:31-45.

FAO, 2009 The State of World Fisheries and Aquaculture 2008. Food and Agriculture Organization of the United Nations. Rome, Italy.

FAO, 2007 The State of World Fisheries and Aquaculture (SOFIA). Rome, Italy.

Guanzon N. G. Jr., de Castro T. R., Lorque F. M., 2004 Polyculture of milkfish *Chanos chanos* (Forsskal) and the red seaweed *Gracilariopsis bailinae* (Zhang et Xia) in brackish water earthen ponds. Aquacult Res **35**:423-431.

Guerrero-Galván S. R., Páez-Osuna F., Ruiz-Fernández A. C., Espinoza-Angulo R., 1999 Seasonal variation in the water quality and chlorophyll *a* of semi-intensive shrimp ponds in a subtropical environment. Hydrobiologia **391**:33-45.

Jaspe C. J., Caipang C. M. A., Elle B. J. G., 2011 Modified extensive pond culture of *Litopenaeus vannamei* for sustainable shrimp culture in the Philippines. AES Bioflux **3**:44-52.

Kado R., Rodriguez E., Banno J., 1989 Changes of the gut contents of milkfish fry and juveniles in relation to "lab-lab" and plankton in aquaculture pond. Japan International Cooperation Agency **1**:192-198.

Krummenauer D., Cavalli R.O., Ballester E.L.C., Wasielesky W. Jr., 2010 Feasibility of Pacific white shrimp *Litopenaeus vannamei* culture in southern Brazil: effects of stocking density and a single or a double CROP management strategy in earthen ponds. Aquacult Res **41**: 240-248.

Lombardi J. V., Marques H. L. A., Pereira R. T. L., Barreto O. J. S., de Paula E. J., 2006 Cage polyculture of the Pacific white shrimp *Litopenaeus vannamei* and the Philippines seaweed *Kappaphycus alvarezii*. Aquaculture **258**:412-415.

Marinez-Cordova L. R., Martinez-Porchas M., 2006 Polyculture of Pacific white shrimp, *Litopenaeus vannamei*, giant oyster, *Crassostrea gigas* and black clam, *Chione fluctifraga* in ponds in Sonora, Mexico. Aquaculture **258**:321-326.

Martinez-Cordova L. R., Villareal-Colmenares H., Porchas-Cornejo M. A., 1998 Response of biota to aeration rate in low water exchange ponds farming white shrimp, *Penaeus vannamei* Boone. Aquacult Res **29**:587-593.

Martínez-Porchas M., Martínez-Córdova L. R., Porchas-Cornejo M. A., López-Elías J. A., 2010 Shrimp polyculture: a potentially profitable, sustainable, but uncommon aquacultural practice. Rev Aquacult **2**:73-85.

Muangkeow B., 3-902.Ikejima K., Powtongsook S., Yi Y., 2007 Effects of white shrimp, *Litopenaeus vannamei* (Boone), and Nile tilapia, *Oreochromis niloticus* L., stocking density on growth, nutrient conversion rate and economic return in integrated closed recirculation system. Aquaculture **269**:363-376.

Ogle J. T., Beaugez K., Lotz J. M., 1992 Effects of salinity on the growth and survival of *Penaeus vannamei*. Gulf Res Rep **8**:415-421.

Otoshi C. A., Arce S. M., Moss S. M., 2003 Growth and reproductive performance of broodstock shrimp reared in a biosecure recirculating aquaculture system versus a flow-through pond. Aquacult Eng **29**:93-107.

Porchas-Cornejo M. A., Martinez-Cordova L. R., Ramos-Trujillo L., Hernandez-Lopez J., Martinez-Porchas M., Mendoza-Cano F., 2011 Effect of promoted natural feed on the production, nutritional, and immunological parameters of *Litopenaeus vannamei* (Boone, 1931) semi-intensively farmed. Aquac Nutr **17**:e622-e628.

Prescott G. W., 1962 Algae of the Western Great Lakes with an Illustrated Key to the Genera of Desmids and Freshwater Diatoms. Brown, Dubuque, LA.

Rubrigth J. S., Harrel J. S., Holcomb H. W., Parker J. C., 1981 Response of planktonic and benthic communities to fertilizer and feed applications in shrimp mariculture ponds. J World Mariculture Soc **12**:281-299.

Sangamaheswaran A. P., Kumar R. S., Jeyaseelan M. J. P., Sundararaj V., 2001 Bioremediation technology for the treatment of shrimp farm effluent: an ecofriendly approach. Perspectives in Mariculture, pp. 413-420.

Sansanayuth P., Phadungchep A., Ngammontha S., Ngdngam S., Sukasem P., Hoshino H., et al., 1996 Shrimp pond effluent: pollution problems and treatment by constructed wetlands. Water Sci Tech **34**:93-98.

Sumagaysay-Chavoso N. S., San Diego-McGlone M. L., 2003 Water quality and holding capacity of intensive and semi-intensive milkfish (*Chanos chanos*) ponds. Aquaculture **219**:413-429.

Troell M., Joyce A. Chopin T., Neori A., Buschmann A. H., Fang J. G., 2009 Ecological engineering in aquacuture – potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems. Aquaculture **297**:1-9.
Vieira F., Santiago-Pedrotti F., Buglione-Neto C., Pedreira-Mouriño J. L., Beltrame E., Laterca-Martins M., et al., 2007 Lactic-acid bacteria increase the survival of marine shrimp, *Litopenaeus vannamei*, after infection with *Vibrio harveyi*. Brazilian J Oceanog **55**:251-255.
Yan B., Wang X., Cao M., 2007 Effects of salinity and temperature on survival, growth and energy budget of juvenile *Litopenaeus vannamei*. J Shellfish Res **26**:141-146.
Yuan D., Yi Y., Yakupitiyage A., Fitzimmons K., Diana J. S., 2010 Effects of addition of red tilapia (*Oreochromis* spp.) at different densities and sizes on production, water quality and nutrient recovery of intensive culture of white shrimp (*Litopenaeus vannamei*) in cement tanks. Aquaculture **298**:226-238.

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