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Nursery production of hatchery-reared milkfish, *Chanos chanos* in earthen ponds

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Abstract. To ensure stable supply of milkfish, *Chanos chanos* fingerlings for stocking in ponds or cages where they will be reared until harvestable size, nursery production of hatchery-reared milkfish fry in earthen ponds and fed solely on natural food (periphyton) was developed. Trials were conducted using 500 m^2 earthen ponds during the dry and wet months. The ponds were prepared and added with fertilizers in order to enhance the production of natural food. Hatchery-reared milkfish fry were stocked at densities ranging 20 – 39 fry/m^2. At least a month (< 40 days) after stocking, the fry reached the fingerling stage (2.59 – 4.63 g) with survival rates of 68.6% - 81.0%. There was better production during the dry months due to abundant supply of natural food, although it was also possible to obtain good production during the wet months when pond conditions are favorable. This strategy of rearing milkfish fry in nursery ponds using natural food could be a viable and inexpensive technique in maintaining sustainable milkfish aquaculture.

Key Words: milkfish, *Chanos chanos*, hatchery, nursery production.

Introduction. There has been a tremendous increase in the global production of aquaculture; hence, it is considered as the fastest growing food sector (FAO 2009). In most Southeast Asian countries, aquaculture contributes significantly to food production and government revenues, but as the population growth rate in this region continues to soar, there is a need to intensify production of low trophic level fish species such as tilapia, *Oreochromis* spp. and milkfish, *Chanos chanos* to meet the growing food demands (Marte 2003).

Milkfish is an important food fish in Southeast Asian countries including Indonesia, Taiwan and the Philippines. It is abundant in near-shore waters and supports a valuable fishery for the pond culture industry (Bagarinao 1991). Based on industry estimates, more than a billion milkfish fry are needed to supply the seedstock requirements of ponds in Indonesia and the Philippines (Patadjai 2001; Bagarinao 1998), however, the supply of fry from the wild cannot meet these demands (Marte 2003). This massive shortfall in the supply of wild-caught fry led to the establishment of milkfish hatcheries in the Southeast Asian countries. Milkfish hatcheries in Indonesia have been set up in Bali, East Java and South Sulawesi to supply the demand for milkfish fry as well as fingerlings that are used as tuna bait (Patadjai 2001). In the Philippines, there are few commercial scale milkfish hatcheries that supply at least 10% of the total fry requirements in ponds (Marte 2003). And with the introduction and expansion of milkfish cages in the country, the demand for milkfish fry has increased further (Marte et al 2000).

Mass production of milkfish fry over the years has mainly been obtained from naturally spawned eggs of broodstock in floating net cages (Marte & Lacanilao 1986), concrete tanks (Emata & Marte 1993) and ponds (Chang et al 1993). The fertilized eggs are routinely collected, packed and brought to hatcheries for larval rearing in tanks or in ponds (Garcia & Toledo 1988; Chang et al 1993). At 21-23 days after hatching, the milkfish fry are harvested and transferred to nursery ponds where they are again cultured for 30-45 days prior to the grow-out phase. On some occasions, the milkfish fry are kept in the hatchery until metamorphosis is almost complete, which normally lasts 30-45 days (Hilomen-Garcia 1997).

The use of nursery ponds prior to the grow-out culture phase is widely practiced in the farming of shrimps. It is part of a two-phase grow-out system because it involves the initial rearing of the stock in nursery ponds then transferred to the rearing ponds until harvest (Lawrence & Huner 1987). The advantages of using nursery ponds include: improved control of counts when stocking in the grow-out ponds, more size uniformity at final harvest, better utilization of pond infrastructure, improved risk management particularly for biosecurity, higher survival and decreased feed waste (Garza De Yta et al 2004). The use of nurseries is more common in semi- and intensive farming systems (Samocha & Lawrence 1992). It is more critical in temperate climates, low salinity environments and areas facing potential disease problems (Garza De Yta et al 2004). In the case of milkfish culture, the use of nurseries is one approach to utilize excess production of milkfish fry in hatcheries by stocking them in these ponds rather than throwing them as well as to ensure higher survival rates of the fish during stocking in the grow-out ponds. In addition, the use of nursery ponds ensures that there is year-round supply of milkfish fingerlings that can be stocked in the grow-out ponds even if there is no ongoing hatchery operation.

This practice of stocking milkfish fry in nursery ponds prior to their culture in grow-out ponds is common among milkfish farmers in the Philippines. However, standardized procedures for this practice have not been properly documented and were mostly based on current practices employed in a particular locality. In the present study, we described a protocol for the nursery production of milkfish in ponds using an extensive system. This particular approach utilizes the natural food production in the ponds as feed for the milkfish fry, and they fed solely on the natural food throughout the nursery production phase. Trials have been conducted during the dry (December – April) and wet (June – September) months in Central Philippines and the status on the production of milkfish fingerlings was described.

Materials and Methods

Preparation of nursery ponds. Earthen ponds with an area of 500 m^2 were repaired of leaks and levelled prior to their use as nursery ponds. In between these ponds, there was a supply canal capable of temporarily storing water during the neap tide in order to maintain the desired water depth inside the nursery ponds. Fine-meshed screens were installed at both the inlet and outlet gates to prevent the entry of unwanted species during flooding and possible escape of the milkfish stock during the period of nursery production. After pond repairs and levelling, the bottom was crack-dried by sundrying for 10 days. During the wet months, when crack drying was difficult to undertake, the ponds were added with water to a depth of 5 cm. This was followed by the application of teased powder at a rate of 20 ppm/ha (Jaspe et al 2011) to kill unwanted fish larvae and juveniles that will prey on the milkfish larvae. After a few days, the water is flushed out of the ponds to remove residues.

After crack-drying or teased application, hydrated lime was broadcasted on the pond bottom at a rate of 2 tons/ha and allowed to stand for a week. Flushing was again done to remove residues and unwanted dead fish. The ponds were subsequently prepared for the growth of natural food. The natural food in the nursery ponds plays a vital role in providing the nutritional requirements of the milkfish fry as they develop to the fingerling (juvenile) stage. It has been observed that there is fast growth of milkfish from the fry to fingerling stage when benthic algae (periphyton) are fed to the fish.

The growth of periphyton in the nursery ponds is carried out in the following steps: dried chicken manure is evenly spread in the nursery ponds at a rate of 4 tons/ha and sundried for two weeks. Water is then admitted to the nursery ponds during spring tide just enough to moisten the pond bottom and left for a couple of days. During this time, patches of benthic algae could be seen and scattered all over the pond bottom. When the growth became denser, a gradual increase of water was undertaken, at 3-5 cm, depending on the density of the algal mat on the pond bottom. This was to ensure minimal disturbance on the growth of the benthic algae that attached on the bottom of the ponds.

Luxuriant growth of the periphyton is maintained until stocking of the milkfish fry through the regular addition of inorganic fertlizers, 16-20-0 and urea. An initial application was applied at a rate of 50 kg/ha when the water level in the pond was 3 cm. Subsequent applications were done when the water level in the pond reached 5, 10, 15 and 20 cm. The water level was maintained at 30-40 cm prior to stocking of the milkfish larvae.

Stocking of milkfish larvae. Twenty three day-old apparently healthy milkfish fry were procured from local hatcheries, transported and stocked in the nursery ponds. Milkfish fry must be of the same batch to ensure uniform growth during rearing in the nursery ponds. They were also checked for the presence of deformities and their swimming behavior before being released to the ponds.

Stocking of the milkfish fry was usually done early in the morning when the air temperature is quite low. Prior to stocking, the water parameters such as salinity, temperature and dissolved oxygen were checked. To ensure proper acclimation of the milkfish fry and to prevent mortalities, the salinity and temperature at the source (hatchery) and during transport were adjusted with the salinity and water temperature of the nursery ponds. It was also observed that during stocking of the milkfish fry, it was better if there should be gradual addition of tidal water into the nursery ponds.

Management of nursery ponds. During the nursery production in ponds, the milkfish fry relied entirely on natural food composed mainly of benthic algae (periphyton) that grew on the pond from the day of stocking until the fingerling stage. In order to maintain a stable and abundant growth of natural food in the nursery pond, inorganic fertilizers were added every two weeks, preferably after the last day of water exchange. Inorganic fertilizers were added at a rate of 50 kg/ha. Filamentous algae were also grown in the nursery ponds, usually towards the latter part of the nursery productiion phase when the fish has already reached the fingerling stage.

In certain cases during pond preparation when filamentous algae grew predominantly instead of the benthic algal mat, it was practiced to wean the fry with supplemental feeds for one week. Thereafter, the fish relied on filamentous algae until they reach the fingerling size. The abundant growth of filamentous algae in the nursery ponds usually took place during the wet months when the salinity levels are low.

Supplemental feeding in the form of commercial feeds was given only in cases when the natural food production in the ponds is low or almost depleted. There could also be sudden die-offs of the natural food especially after heavy rainfall that would cause fluctuations in salinity levels. When this situation occurred, supplemental feeding was given until the natural food production in the ponds would resume to its normal level.

During the course of the nursery production in ponds, water exchange was done during the spring tide. This was done by draining 50% of the pond water and replenished with the incoming tidal water to the desired water depth. Water exchange was done gradually to prevent the benthic algal mat to be dislodged from the pond botom. When there was heavy rainfall, the surface water (mainly freshwater) of the pond was immediately drained off to prevent fluctuation in salinity and to maintain the growth of benthic algae. Water depth was maintained at 30 cm throughout the nursery production phase.

Water sampling and physico-chemical analyses. Dissolved oxygen, temperature and salinity were measured on the field weekly. Salinity was measured using Atago refractometer, while temperature and dissolved oxygen were determined using the YSI model DO meter.

Harvesting and packing of milkfish fingerlings for transport. Harvest of milkfish fingerlings was done using a fine meshed seine net. During seining, the fingerlings are transferred to concrete tanks in the hatchery. These tanks were provided with aeration to condition the fingerlings prior to transport the following day. This procedure was practiced when a single buyer requires about 30,000-50,000 fingerlings and the fingerlings will be transported early in the morning or will have longer transport times.

However, when the fingerlings will be transported over short distances or lesser number of fish required, the fingerlings are directly packed on site in plastic bags, provided with aeration and placed with crushed/cube ice outside the bags to maintain the desired water temperature and oxygen levels during transport.

Results and Discussion. There were three milkfish nursery production runs conducted in 2007-2008 involving 4-6 500 m^2 earthen ponds. Table 1 shows the data on each production run that was done. Trials 1 and 2 were done during the dry months, while Trial 3 was undertaken during the wet months. The stocking density of the milkfish fry was at least 20 milkfish fry/m^2, with the highest stocking density recorded during the third production trial at 39 milkfish fry/m^2. The milkfish fry that were initially stocked had an average initial body weight of 10 mg.

Table 1

Trials on nursery production of milkfish in earthen ponds conducted during 2007-2008

Trial	Number of Ponds	Season	Total Stock (pcs)	Stocking density (pcs/m^2)
1	6	Dry	60,000	20
2	5	Dry	66,000	26
3	4	Wet	78,000	39

After at least a month (34-38 days) in the nursery ponds, the milkfish in their fingerling stage were harvested and ready to be tranported to the different grow-out ponds where they will be stocked and reared until they attain harvestable sizes. Table 2 shows the production data of the different trials done on nursery production of milkfish in ponds. The average body of the fingerlings upon harvest ranged 2.59 – 4.63 g with a survival rate ranging 68.6% - 81.0%. The growth rate of the milkfish in the nursery ponds ranged 0.07 – 0.13 g/day.

Table 2

Production of milkfish fingerlings in earthen nursery ponds during 2007-2008

Trial	Average weight (g)	Survival Rate (%)	Days of Culture (DOC)	Growth rate (g/day)
1	2.84	68.6	38	0.07
2	4.63	80.2	35	0.13
3	2.59	81.0	34	0.08

Table 3 shows the levels of the different physico-chemical parameters of the water during each trial. There were no wide fluctuations in the readings for dissolved oxygen, salinity and water temperature during the trial period as well as among the three production runs. Except for occasional low levels of dissolved oxygen in the nursery ponds, the levels of the water quality were within the optimum values required for fish culture.

Table 3

Range of the physico-chemical parameters of the water in nursery ponds during the production runs

	Trial 1	Trial 2	Trial 3
Salinity (ppt)	29 – 37	38 - 45	27 - 30
Temperature (°C)	26.8 – 27.6	28.2 – 29.2	27.5 – 28.7
Dissolved Oxygen (ppm)	3.0 – 4.4	2.9 – 4.1	2.7 – 4.3

In the present study, we reared hatchery-reared milkfish fry to the fingerling stage in earthen ponds and fed mainly with natural food (periphyton). The nursery production of milkfish ensures continuous supply of fingerlings for milkfish aquaculture since this particular species of fish is capable of compensatory growth.

In the pond culture of milkfish, the stock usually relies on the presence of natural food in the pond usually during the first two months of culture followed by supplemental feed application until harvest (Kühlmann et al 2009). In order to promote the growth of natural food, the ponds are applied with lime and fertilizers (both organic and inorganic) during preparation (Otubusin & Lim 1985). The natural food is mainly composed of greenish algal mats associated with unicellular organisms and crustaceans (Kado et al 1989; Fortes & Pinosa 2007). We have followed the same approach during the nursery poduction of milkfish in ponds and also in the modified extensive pond culture of white shrimp, *Litopenaeus vannamei* (Jaspe et al 2011). However, to maintain stable growth of natural food, there was periodic application of inorganic fertilizers during the nursery production phase.

The trials that we conducted seemed to indicate that higher production of milkfish fingerlings was obtained during the dry months in comparison to the wet months, although this was based on preliminary observations. This could be explained by the relative abundance and quality of the natural food in the ponds during the rearing phase (Fortes & Pinosa 2007). They found that there were differences in the composition and density of periphyton in milkfish ponds during the dry and wet months. The diatoms dominated the population of the algal mat during the dry months, and the cyanobacteria-rich flora during the wet months. In addition, they have obtained higher densitites of the algae during the dry months than in the wet months. Kühlmann et al (2009) also showed seasonal differences in the proximate composition of the natural food in milkfish ponds, wherein the crude protein of the periphyton obtained during the dry months was 3.4 times higher than that was obtained during the wet months. It also had higher gross energy content compared with the from the wet months. The presence of higher amounts and nutritionally superior natural food in the nursery ponds during the dry months could augment the food requirements of the milkfish fry, thus favoring faster growth and higher production rates.

During the wet months, good production of milkfish fingerlings can be obtained through proper management. One major setback during the nursery production of milkfish during the wet months is the occurrence of erratic salinity conditions due to intermittent rainfall. Kado et (1989) showed that there was a decline or collapse of natural food in milkfish ponds during heavy precipitation. However, the stocking density of the milkfish fry in the nursery ponds was quite low, thus, a reduction in the density and composition of the natural food may not severely affect the food and nutritional requirements of the growing stock. Depression in the growth of the milkfish fry in ponds during the wet season might be clearly manifested at higher stocking densities, and this could be one area of focus in future studies. Despite a reduction in the population of natural food in the nursery ponds during the wet season, the prevailing low salinity levels are also beneficial for the growth of milkfish. It has been shown previously that with decreasing salinity, the growth of milkfish increased (Alava 1998). This was evident in milkfish when they enter a transition from the fry (18-21 days after hatching) to the fingerling stage, when they prefer estuarine or freshwater environment. At lower salinity levels, milkfish fry are able to attain stability in their ionic and osmotic contents (Almendras 1982). The maintenance of ionic and osmotic equilibrium at lower salinity could have required less energy expenditure, resulting in better growth (Alava 1998). In this study, we stocked 23-day old milkfish fry in the nursery ponds and such physiological phenomenon taking place in mikfish at this particular stage of development during low salinity could have contributed to a better growth. Moreover, Ferraris et al (1986) demonstrated that the rate of movement of the food in the intestines was lower and the protein digestibility of some food components in millkfish juveniles was higher in fish reared in either fresh- or brackishwater. These conditions could effectively enhance the efficiency of food conversion in milkfish reared in low saline conditions, and will compensate for whatever reduction in the availability of food supply. The aforementioned reasons provide strong indications that under extensive conditions, nursery production of milkfish in ponds during the wet months could not severely affect the growth of the stock and subsequent production, and perhaps could be at par with the level of production during the dry months.

The different physico-chemical parameters of the water in the ponds that were monitored during the nursery production cycle were within the optimum levels required for milkfish aquaculture. Guanzon et al (2004) showed that changes in the levels of dissolved oxygen had an inverse relationship with growth and production of milkfish in ponds but do not necessarily mean that these are detrimental to the fish. The lowest value of the dissolved oxygen reading that we obtained was at 2.7 ppm. However, this level was temporary and could immediately increase later in the day when the rate of photosynthesis increases. Bagarinao (1999) states that milkfish cease to feed when the level of dissolved oxygen in the water falls below 3 ppm, but they can survive even at a concentration of 1 ppm (Schroeder 1996).

Regardless of the season, we observed minimal fluctuations in the water temperature of the nursery ponds. Guanzon et al (2004) also obtained similar results on their polyculture studies on milkfish with seaweeds. The optimum temperature for milkfish culture is 20-43^{o}C (Villaluz & Unggui 1983), and our readings were within this range.

Salinity changes contribute to a positive effect on the growth of milkfish in a polyculture system with seaweeds (Guanzon et al 2004). Kühlmann et al (2009) stressed that milkfish are more efficient in digesting food components at lower salinities, leading to better growth. Milkfish are able to tolerate hypersaline conditions, *i.e.*, a salinity reading of more than 100 ppt (Crear 1980). Their tolerance limits are at salinities ranging from 0 to 158 ppt (Crear 1980). The salinity readings that we obtained in the nursery ponds in the three production runs were within the tolerance limits.

When the milkfish in the nursery reached the fingerling stage, they were harvested, packed for transport and stocked in the grow-out ponds or cages. A common problem encountered in hatchery-reared milkfish is the presence of morphological deformities particularly on the operculum and branhciostegal rays (Hilomen-Garcia 1997), which is a predetermined conditioned during the fry stage. We have few milkfish fingerlings that had these deformities, but they were segregated from the normal fish during prior to packing or they died at seining during harvest. As such, stocking grow-out ponds or cages with milkfish fingerlings reared prior in nursery ponds ensures that the stock is free from these abnormalities. Therefore it results in higher survival and better growth rates when compared with ponds or cages that are directly stocked with milkfish fry.

Conclusions. In summary, we have described a protocol for the nursery production of hatchery-reared milkfish in earthen ponds. At a stocking density of 20-39/m^2, the milkfish fry relied solely on the natural food (periphyton) present in the ponds during the entire nursery rearing phase and reached the fingerling stage at least one month after stocking. Based on three trials, the production of fingerlings was higher during the dry months, when natural food present in the ponds was stable and abundant. However, production was also not affected during the wet months, when salinity levels were lower that could favor better pond conditions. Hence, the nursery production of hatchery-reared milkfish is a favorable strategy to maintain stable year-round supply of fingerlings to be stocked in ponds or cages where they will be reared to marketable size.

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