Development of Intensive Shrimp Farming, *Litopenaeus vannamei* In Land-Based Ponds: Production and Management

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Abstract. The aim of this study is to evaluate the development of intensive shrimp farming in land-based ponds and its production and management. This study was carried out in traditional growth ponds of the farmers in Pankep regency, South Sulawesi. There were seven ponds used for shrimp growth with intensive system such as used of high quality feed, seed, probiotic bacteria, intensive aeration, minerals and vitamins. Shrimp growth ponds used intensively culture system with profile condition as follows: (1) water depth of ponds, 120 - 150 cm, feeding rate four times a day, water quality parameters were measured every day for, water temperature, pH, salinity, turbidity, dissolved oxygen (DO). Average daily gain (ADG), Survival rate (SR), Feed conversion ratio (FCR) and MBW were measured every week. Stocking density every ponds was different, 49 - 56 individuals/m². Feeding process was conducted four times a day: 08.00 am, 10.00 am, 14.00 p.m. 16.00 p.m. Culture periods were different per ponds between 105 - 112 days. All ponds used zero water exchange system and addition water from well for change loss water by evaporation. The results of this study showed that shrimp production, 1,778 - 3,664 kg; FCR: 1.28 - 1.4; ADG : 0.22 - 0.31; MBW 21 - 23, water temperature, 29 - 34 °C; pH 7.6 - 8.6; dissolved oxygen, 2.6 - 6.1 mg/L. Salinity 13 - 22 ppt. Water depth with range, 100- 130 cm, survival rate (SR) 88 - 91 % and shrimp size in the final culture period average 43 individuals/m². In summary, Water quality parameters such DO, temperature, salinity, pH and others were in range suitable for shrimp growth and its productivity was 8,800 kg/ha. This study has benefit for shrimp growth performance, feed efficiency utilization and productivity significantly improve.

1. Introduction
Aquaculture is one of the fastest-growing food production sectors in the world which play significant role in eliminating hunger, promoting health and reducing poverty [1]. To increase the contribution of aquaculture sector to human nutrition for growing world population, aquaculture production should increase five-fold during the next five decades [2]. Based on limiting factors such as land and water as well diseases outbreak. Intensification system in aquaculture sector is one of the best possibilities to increase aquaculture production [2,3].

Some studies have reported that fish and shrimp production can be increased by intensive management system such as application of high stocking density, high quality and quantity of commercial feed, intensive aeration and others input [2,4]. The other side, these systems faced some problems because they produced a lot of waste, depended on artificial feed and disease outbreak [3,5]. Aquatic organisms such as shrimp and fish need a high protein content as energy sources in their feed.
Application of high commercial feed had effect both water quality deterioration and high cost production [2]. Based on three main problems for intensive aquaculture systems, some new strategy approaches in these systems are application of biofloc technology (BFT) and minimal or zero water exchange.

Microbial communities in intensive shrimp culture play important role not only for water quality improvement but also for natural feed in aquatic cultured. Flocculated material composed of microbial communities (biofloc) have advantages such as maintenance of good water quality, natural feed source and high efficiency of feed utilization [6,7]. Protein usage by fish or shrimp in intensive biofloc systems is almost twice as high as the protein usage in conventionally feed intensive aquaculture systems [2]. Water quality management system with limited or zero water exchange in intensive shrimp culture support development of phytoplankton and microbial communities in recycling of aquaculture waste in the ponds [6,8,9,10].

This study was conducted to evaluate the development of intensive white shrimp farming *Litopenaeus vannamei* on land-based ponds especially the growth, survival, FCR, water quality, Phytoplankton stability and production.

2. Materials and Methods

The study was conducted at nine of shrimp growout ponds in Pangkep Reagency, South Sulawesi. Brackish water (16 ppt) was pumped from the river into the ponds. Incoming water was filtered through 200 µm filter bag and then chlorinated with Kaporite 60 % with concentration 5 – 10 ppm and aeration with paddlewheel 24 hours. Before stocking of shrimp, phytoplankton was grown using sintetic fertilizer such as urea, Trisuper phosphate (TSP) and traditional fermented substance. All earthen ponds were stocked with PL 10 specific pathogen free (SPF) white shrimp, *Litopenaeus vannamei* which were purchased (PT. Central Proteina Prima Tbk. Indonesia). Each ponds was stocked with different stocking density with range 42 – 59 individuals/m². The shrimp were fed with commercial feed with 30 % crude protein (CP) (Irawan, PT. Central Proteina Prima Tbk. Water depth of ponds is different with range 115 – 140 cm.

During the rearing shrimp, all ponds were fed four times per day (08:00; 10:00; 14:00 and 18:00) with commercial feed. Feed was provided manually. Daily rations for the first week were based on a fixed percentage of the estimated total shrimp biomass in each pond. Rations from the second week were adjusted based on feed consumption, shrimp mean weight and the estimated survival and FCR. The amount of feed per feeding time was determined based on shrimp feeding response. Feed trays were used to determine the amount of feed in each pond being consumed. This information was used to help adjust feed ration for next feeding.

All ponds were operated with zero water exchange. However, water was added as needed to replace water loss due to evaporation and solid waste (sludge) removal, approximately 5 % with water from artesian well. Each pond was aerated with 3-4 paddlewheels creating a circular current. Sludge that accumulated in the pond centre as waste product of feeding and detritus was removed weekly using siphon system. Sampling for shrimp growth and biomass monitoring was performed once a week. The end of this culture period, total shrimp number and biomass were counted and calculated to determine survival rate (SR), growth, total yield and feed conversion ratio (FCR). Culture period was different each pond with range 105 – 112 days.

Temperature, °C, (YSI digital DO meter, pH (pH meter), salinity (ppt) (refractometer) and secchi depth (secchi disc) were monitor *in situ* at twice daily (morning and afternoon). The density of phytoplankton was observed on the first, seventh and the last week of culture period under a light microscope using a Sedgewick Rafter subsequent to fixation with 1 % formaldehyde.

Harvesting process was conducted using partial harvesting method with three times, first harvesting at 70-80 days of culture, second partial 90 days of culture and the last harvesting 112 days cultured. This method was carried out to reduce shrimp population so that shrimp growth remain will increase growth gain (g/week) and stability of water quality.
3. Results and Discussion
The results of this study showed that water quality parameter such as dissolved oxygen (DO), salinity, pH, water transparency and temperature were within acceptable ranges during culture period. The results summarized in Tabel 1 showed there were a significant improvement in survival rate, feed conversion ratio and production.

Table 1. Profile of water quality, shrimp of *L*ianaemei* cultured in land-based ponds with zero water exchange management system

| No. | Parameter                        | Pond 1 | Pond 2 | Pond 3 | Pond 4 | Pond 5 | Pond 6 | Pond 7 |
|-----|----------------------------------|--------|--------|--------|--------|--------|--------|--------|
| 1   | Pond size (m²)                  | 2000   | 2300   | 2800   | 2500   | 2200   | 4000   | 2300   |
| 2   | Stocking density (inds/m²³)     | 52     | 49     | 56     | 55     | 56     | 50     | 49     |
| 3   | Culture period (days)           | 108    | 112    | 112    | 105    | 105    | 105    | 105    |
| 4   | Water depth (cm)                | 115-130| 100-120| 105-120| 100-115| 100-120| 100-120| 100-120|
| 5   | Water transparency (cm)         | 10     | 15     | 20     | 12     | 15     | 10     | 17     |
| 6   | DO (mg/L)                       | 3.7-4.9| 3.1-5.4| 2.6-5.1| 3.5-6.1| 4.8-6.1| 3.5-5.1| 3.2-5.7|
| 7   | pH                              | 7.6-8.5| 7.7-8.6| 7.5-8.5| 7.7-8.5| 7.3-8.4| 7.5-8.6| 7.6-8.6|
| 8   | Salinity (ppt)                  | 15-22  | 13-17  | 14-17  | 13-17  | 13-22  | 15-22  | 14-22  |
| 9   | Temperature (°C)                | 28-34  | 29-34  | 29-34  | 30-33  | 29-33  | 29-33  | 30-33  |

Table 1 summarizes water quality parameters measured during culture period with different range from 105 – 112 days. Water quality level were within safe levels for normal shrimp health, growth, and survival. Water transparency was a little level because of high content of particle suspension and high microbial content in water column such as phytoplankton and bacteria.

Growth parameters such as ADG, MBW, FCR, survival and production were in progressive improvement. Feed efficiency was good enough. Table 2 summarizes growth parameter and shrimp production.

Table 2. Growth parameters shrimp *L. vannamei* cultured in land-based ponds with zero water exchange management system

| No. | Parameter            | Pond 1 | Pond 2 | Pond 3 | Pond 4 | Pond 5 | Pond 6 | Pond 7 |
|-----|----------------------|--------|--------|--------|--------|--------|--------|--------|
| 1   | ADG (g/d)            | 0.23   | 0.33   | 0.22   | 0.24   | 0.24   | 0.25   | 0.31   |
| 2   | Final MBW            | 21     | 22.7   | 23     | 23     | 21.5   | 23     | 23     |
| 3   | Survival rate (%)    | 91     | 90     | 90     | 89     | 90     | 88     | 90     |
| 4   | Total Feed (kg)      | 2356   | 2657   | 3958   | 3224   | 2700   | 4696   | 2923   |
| 5   | FCR                  | 1.33   | 1.4    | 1.35   | 1.28   | 1.34   | 1.28   | 1.3    |
| 6   | Shrimp size (ind/kg) | 48     | 44     | 42     | 43     | 43     | 43     | 44     |
| 7   | Yield (kg)           | 1,778  | 1,881  | 2,910  | 2,507  | 2,010  | 3,664  | 2,231  |

Based on Tabel 1, The results showed that average productivity of seven earthen ponds cultured with white shrimp with stocking density average 50s individuals/m² were able to increase productivity 8.800s kg/ha per culture period (105 – 112 days). Survival rate with the range between 88 – 91 %.
4. Discussion
Development of the Pacific white shrimp (L. vannamei) in seven land-based ponds under zero water exchange showed the feasibility of producing shrimp product with good growth, survival, FCR and yield. Water quality parameters during days of culture were within acceptable for growth and survival of normal shrimp. Although pond conditions used in this study were slightly different such as pond size, stocking density, water depth and cultured period, water quality parameters were similar each other such as D0, pH, salinity and temperature. Water transparency during cultured periods were range 10 – 20 cm. This condition caused by application of zero water exchange and intensive feeding rate so population of phytoplankton and bacteria in the water column increase and water color was green brown. Dissolved oxygen profiles all day cultures were good enough because it has been used intensively aeration 24 hours all culture periods by using paddle wheels. Photosynthesis, nitrification and heterotrophic processes that likely to occur in control system possibly resulted in pH fluctuation because of alteration of CO₂ concentration and pH changed in water [6].

Although water quality indicators such as total ammonia nitrogen (TAN), nitrite, nitrate, and alkalinity were not monitored during this experiment, the other water quality such as water transparency, dissolved oxygen, pH, salinity and temperature were in suitable for normal shrimp growth. Intensive aquaculture systems produced a large number of waste because of highly commercial feed utilization in this system so that it was rapidly accumulated organic and inorganic nitrogen materials which reduce water quality most this system [11]. Application of probiotic bacteria was carried out every week to control water quality which added in commercial feed and water treatment. The use of bio-augmentation agent was highly beneficial in maintain water quality shrimp growth due to high bacterial population in this system will degrade the waste products without depleting the nutrients needed for phytoplankton growth [7]. Under aerobic condition, microbial breakdown of organic matter leads to the production of new bacterial cells from 40 – 60 % of metabolized organic matter [1].

Growth parameters of white shrimp, L. vannamei showed that average daily growth (ADG), final MBW, survival rate (SR) and feed conversion ratio (FCR) were a good performance of shrimp growth with zero water exchange strategy. Survival rates were average 90 % and FCR with range 1.28 -1.4, respectively. Total final biomass of shrimp varied depend on pond size and stocking density. Shrimp size at the final experiment was size range of 42 – 48 inds/kg. Numerous studies showed that white shrimp, L. vannamei can be raised in limited water exchange strategy with excellent health condition, good growth, low feed conversion rates, high survival rate and high yield [3]. During this experiment, water quality profile was good enough which characterized with high microbial population based on water color and low transparency. Intensive feed utilization in this system provided nutrient for microbial population in water such as bacterial and phytoplankton communities. Microbial communities play important role in water quality and natural feed as protein resource for shrimp culture. There are three ways to remove ammonia nitrogen in aquaculture systems namely photoautotrophic removal by microalgae, autotrophic bacteria by nitrification process, and heterotrophic bacterial conversion of ammonia nitrogen directly to microbial biomass [6].

Salinity levels were slightly different with different ponds with range from 13 – 22 ppt. Location of all the earthen-ponds was far enough from the coastal area and water resources was supplied from river and artesian well. This study was carried out at the end of rain season and there was much rains at the time so it made salinity level below fifteen ppt. White shrimp, L. vannamei has a good adaptation with low salinity level. Decreasing of salinity drastically made phytoplankton communities died so water quality changed and make shrimp stress then shrimp was easy to be attacked by opportunistic bacteria such as white feces diseases (WFD). This study was conducted with zero water exchange during culture period then water lose by evaporation and seepage was change by water from artesian wells. Closed system like this made build up inorganic nitrogen such as ammonia. Characteristic encouraging microbial dominance in zero or limited exchange intensive ponds is the accumulation of organic substrates. The organic residues serve as growth substrates for bacteria [11]. The presence of active microbial consortia make to
control water quality and to optimize feed utilization [1]. Manipulation of the microbial biomass enables to control water quality by conversion of inorganic nitrogen to microbial protein in turn the microbial protein may be utilized to feed for shrimp [11].

5. Conclusion
Water quality parameters such as: dissolved oxygen, temperature, salinity, pH phytoplankton stability and others were in the suitable range for shrimp growth. Shrimp growth, survival rate (SR) and feeding efficiency were good enough during culture period. Average productivity was 8,800kg/ha. Development of intensive white shrimp culture system in traditional land-based ponds has a high promising to be developed to increase shrimp product in South Sulawesi.

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