The JSFS 85th Anniversary-Commemorative International Symposium
"Fisheries Science for Future Generations"
Symposium Proceedings, No. 02003

Original article

Bottom feeding and high density stocking improve yield and profitability of milkfish culture in marine cages

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Keywords: Milkfish marine cage culture; High density stocking; Bottom feeding; Net yield; Profitability.

Received: 18 July 2017 / Accepted: 5 September 2017

Introduction

Milkfish culture in marine cages contributes significantly to the total fisheries production in the Philippines and has the potential of replacing traditional brackishwater production systems in mangrove areas. For years however, it has been plagued with problems related to pollution [1,2] and erratic harvests primarily attributed to improper and unregulated culture management practices. The present study introduced bottom feeding in high density culture of milkfish in marine cages as a strategy to improve productivity without compromising environmental integrity.

Aside from the work of the authors, there have been no records of bottom feeding in milkfish farming in the Philippines. The use of high density stocking (100 fish m^{-3}) on the other hand, is not a recommended practice although demonstrated to be feasible [3]. Lack of sufficient scientific evidence on the relationship of increased density with growth and the absence of strategies to improve growth and survival under high density stocking in milkfish cage culture prevents its adoption. The use of underwater hydro-kinetic bottom feeder designed to improve feeding access even in highly crowded milkfish cage culture conditions addresses this issue. With improved feeding access at high density stocking, yield per unit volume is also expected to increase thus diminish the area required in generating equivalent production at lower stock densities.

Poor growth with increasing density have been observed in farmed fish [3,4] although the underlying mechanisms are still poorly understood [4]. In farmed rainbow trout, the commonly reported effects with increasing density are reductions in food conversion efficiency, nutritional conditions, growth and an increase in fin erosion [5]. These contrast with the results on other species which showed positive relationships. For instance, higher growth and elevated scramble feeding were observed in hybrid striped bass held in large memberships [6]. Similarly, lower feed intake, higher growth and higher feed efficiency with increasing group size were reported in juvenile perch [7]. Growth variance in fish is often caused by aggression arising from food distribution and ration size [8,9].

Materials and methods

Feeding trials on milkfish with average weight of 35 g were conducted in triplicates in a marine cove with a depth of 10 m and a water velocity of 8 cm sec^{-1}. Fish were stocked according to treatment assignment in nine (9) 5m x 5m x 5m commercial net cages at densities of 50 fish m^{-3}, 75 fish m^{-3} and 100 fish m^{-3} and were reared for 120 days. The test animals were fed four times daily (0700 hours; 1000 hours; 1300 hours; and 1600 hours) with extruded (floating) commercial pellets at declining rates of 10%, 8%, 6% and 4% of ABW (average body weight). The daily ration which was adjusted monthly was split into two equal portions, one given by hand at the top and the other through the underwater hydro-kinetic bottom feeder. The bottom feeder is filled with extruded pellets then tightly capped and suspended 4 m below the water surface. The feeds are released manually by opening the cap through a string as soon as the bottom feeder is securely fastened at the desired depth. The feeder which operates through water displacement is retrieved every after feeding (15-20 min) and reused. Weight and length measurements of 200 anaesthetized fish (with the use of MS-222) were taken per cage for fortnightly growth monitoring while 10% of the stock per cage were measured at harvest. Video footages on feeding behavior were collected to document physical responses of fish to top and bottom feeding.

Results and discussion

Growth performance with increasing density
Milkfish exhibited consistently higher periodic growth with increasing density (Fig. 1). This can be explained

by the better well being of fish evidenced by high condition index (Fig. 2), and bigger and fatter fish at higher population densities (Table 1.). The observed slightly better feed conversion ratio (FCR) of fish at higher population densities also supports this (Table 1). Earlier studies [7] suggest that high growth and low feed conversion ratio with increasing density may be caused by benefits obtained from shoaling such as reduced levels of stress. In the present study, feeding activity of milkfish showed a calm behavior at all density levels when bottom-fed compared with the almost relentless scramble feeding (frenzy feeding) behavior it displays when feeds were introduced at the top. The apparent calm behavior of bottom-fed milkfish during feeding (which is a form of exercise) may have reduced energy expenditures in resource procurement thus benefitting the fish in terms of improved growth and high survival (Fig. 2; Table 1). Intensive exercise has been observed to result in glucose concentration rise in some species [10] and recovery after 24 hours has been reported for the yellow perch *Perca flavescens.*

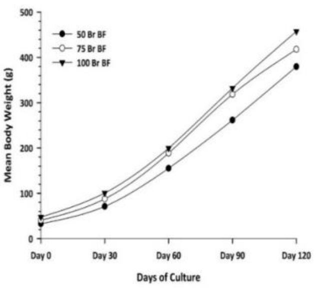

Fig. 1. Monthly growth rates of milkfish reared for 120 days in marine cages at different stocking densities.

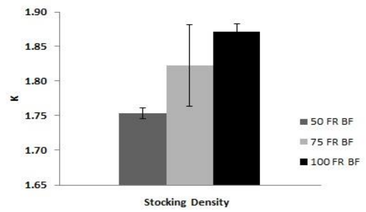

Fig. 2. Condition index (K) of milkfish with increasing density (P<0.05).

Table 1. Biometrics of milkfish grown for 120 days in marine cages at different stocking densities. Values are mean ± SEM

SD	W_1	W_2	FCR	S
50	**35**± 3.5	**380**±6	**2.15**± 0.09	**99.8**±0 .04
75	**24**± 8.4	**418**±72	**2.08**± 0.26	**99.6** ±0.21
100	**48**± 3.9	**458**±19	**2.03**± 0.10	**99.7**± 0.05

Notes:SD=stocking density; $W_1$and W_2 are initial and final weights in grams, respectively; FCR= feed conversion ratio; S =survival in %.

Net yield, biomass production and profitability

Doubling the stocking density from 50 fish m^{-3} to 100 fish m^{-3} increased net yield by 75%. Net yield from the density of 100 m^{-3} (33.91±0.97 kg m^{-3}) was significantly higher (P<0.01) than those at 50 m^{-3} (19.41±0.74 kg m^{-3}) and 75 m^{-3} (22.77±1.96 kg m^{-3}), respectively (Fig. 3). This redounds to increased profitability and sustainability because of the diminution of culture areas required in generating equivalent production at lower stock densities.

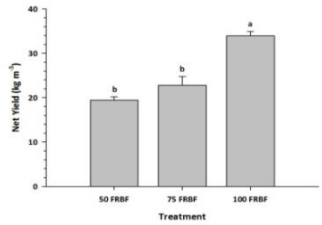

Fig. 3. Average net yield of milkfish (kg m^{-3}) reared for 120 days at different stocking densities (P<0.01).

Conclusions

Bottom feeding can sustain profitable production of milkfish in high density marine cage culture. It is expected to generate additional production without compromising the integrity of the coastal marine environment.

Acknowledgements

This study was funded by the Philippine Department of Science and Technology (DOST). The authors are grateful to our private collaborator, Oversea Feeds Corporation which provided the feeds, seedstocks, and logistical support to the project.

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