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SHORT PAPER

Growth, Survival and Pathogen Effects on Long-term Rearing of Mangrove Red Snapper (*Lutjanus argentimaculatus*) Broodstocks in Earthen Ponds

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Abstract

This study evaluated long-term growth, survival, and health challenges during earthen-pond rearing of mangrove red snapper (*Lutjanus argentimaculatus*) from juveniles to broodstock potential over 24 months. Juvenile fish were stocked at 200 per ponds and cultured for 24 months. Growth (ADG, SGR), survival, and health assessments were recorded, and sick individuals were laboratory-tested for pathogens. Results showed that average total length reached 47.3 cm and weight 1,959.4 g. ADG was 2.50 g/day and SGR was 0.35%/day. Final survival ranged from 75.5% to 92.0% (mean 83.8%). Water quality remained within acceptable ranges. Meanwhile, infections (viral nervous necrosis) and *Caligus* sp. parasites emerged around 20–22 months, reduced feeding and survival, and prevented attainment of broodstock size (3–7 kg). While baseline growth and survival data were established, broodstock-size targets were not met. Future directions included nutritional optimization, enhanced health management, and strengthened biosecurity to improve broodstock yield.

Introduction

The mangrove red snapper *Lutjanus argentimaculatus* (Forsskål 1775) is an important commercial marine fish species and a good candidate species for mariculture. It is distributed throughout the coastal waters of the tropical regions from the eastern Indian Ocean to the Pacific Ocean (Spiji et al., 2019). In 2020, trends in fisheries indicated that snapper catches either remained at their peak levels or declined only marginally from the recorded peak. At that time, demand for seafood had been rising notably, while natural marine resources were diminishing due to overexploitation and habitat destruction, with *L. argentimaculatus* identified as a species under threat in many areas (FAO, 2022). In addition, their mariculture production is very limited (Amorim et al., 2019). Promising solutions to cope with this problem include restocking existing fisheries and developing the mariculture of *L. argentimaculatus*. Nevertheless, the supply of fish resources from *L. argentimaculatus* mariculture to farms depends almost entirely on juveniles collected from the wild, which is necessary to maintain sustainable mariculture activities (Coniza et al., 2012; Mosequera et al., 2023).

In Thailand and elsewhere, broodstock programs for *L. argentimaculatus* relied heavily on natural juveniles, and there was a paucity of baseline data documenting long-term rearing of this species from juvenile to adult stages in earthen ponds. This knowledge gap hampered the development of standardized management practices and the scalability of broodstock production (Melianawati et al., 2019; Sookdara et al., 2022). Generally, long-term rearing in marine fish broodstocks presented specific challenges, including water quality management, disease emergence, and growth trajectories required to achieve broodstock size (De Silva & Davy, 2010; Boyd et al., 2020). Therefore, this study aimed to evaluate growth performance, survival, and health status of *L. argentimaculatus* reared from juvenile to adult stages over 24 months in earthen ponds. It monitored water quality parameters and assessed their relationships with growth, survival, and disease prevalence. It identified viral, bacterial, and parasitic pathogens associated with morbidity and mortality during the rearing period, and provided practical guidelines for the management of long-term rearing of this species to support reliable broodstock production.

The knowledge gained from the study could be used to provide key information for the cultivation management of *L. argentimaculatus* that will ultimately make a positive contribution toward a better understanding of the long-term rearing of this fish in earthen ponds to its utilization as a broodstock source in the future.

Materials and Methods

Study Site and Source of Fish

The study was conducted at the Klongwan Fisheries Research Station (KFRS), Prachuap Khiri Khan province, Thailand during May 2021 to April 2023. The wild juveniles of the mangrove red snapper, *Lutjanus argentimaculatus* (Figure 1), with a total length of 11.8-22.7 cm and a body weight of 31.3-168.4 g were caught by local fishers using fish traps in the coastal area of Suk Samran district, Ranong province, Thailand. The fish were transferred to the KFRS hatchery, and were kept in 1.2×6.0×1.0 m concrete stocking ponds at a density of 30 fish/m^2 for 7 days. Then, fish (average initial size: 22.0 cm in length and 160.7 g in body weight) were transferred to earthen ponds with a surface area of 1,600 m^2 at an initial density of 200 fish per ponds.

Fish Rearing

The fish were fed daily at 09:00 am with trash fish (mixed marine species) at approximately 3–5% of body weight, and rearing lasted 24 months. The total length (in cm) and the body weight (in g) of a subset of 5% of the total fish randomly from each pond were examined at the start of rearing and subsequently once each month. Every 6 months and the end of the rearing period, the number of surviving fish was counted and each fish was measured to assess final body weight. The average daily growth (ADG), specific growth rate (SGR), and survival rate were calculated.

To maintain good water quality, about half of the water was exchanged weekly. Water quality parameters were monitored twice weekly. Dissolved oxygen concentration (DO) and water temperature were recorded with an oxygen probe (YSI 550A), while salinity was measured with a refractometer (Prima Tech) and the water pH was assessed using a portable pH meter (Cyber Scan pH 11); total ammonia, nitrite, and alkalinity were determined using the indophenol blue method, the colorimetric method, and the titration method, respectively.

In addition, sick *L. argentimaculatus* were identified during rearing based on showing signs of prominent infection or changes in their appearance, and behavior, such as eating less food, not eating, not swimming, or swimming irregularly. These fish were checked for viral and bacterial infection based on samples of 10 sick fish that were transferred to the laboratory of the Department of Biochemistry, Faculty of Science, Kasetsart University, Thailand, where the viruses and bacteria were isolated.

Data Analysis

The primary data on growth, survival, and other rearing conditions of *Lutjanus argentimaculatus* were analyzed using a statistical software package. Mean and percentage values were the main descriptive statistics used to estimate baseline data and parameters for fish cultivation. The secondary data were obtained indirectly

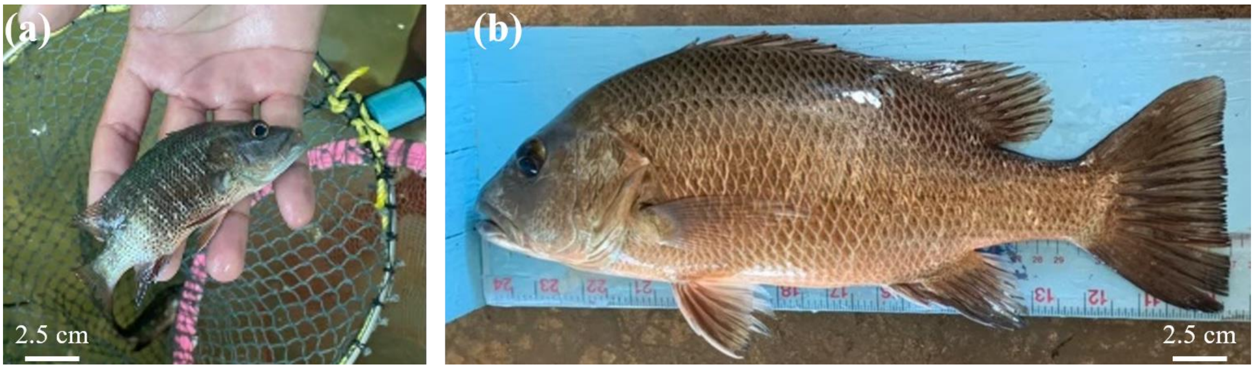

Figure 1. Mangrove red snapper *Lutjanus argentimaculatus* (Forsskål 1775): (a) juvenile fish from nature; (b) adult fish reared in earthen pond at 24 months.

from articles in journals and books related to cultivation of this fish species and other factors.

Results

Growth and Survival

The descriptive statistics for *L. argentimaculatus* cultivation for 24 months with the main goal being for future fish broodstock production are summarized in Table 1.

The rearing period of 24 months produced a mean size of fish with total length of 47.3 cm and body weight of 1,959.4 g. The ADG, SGR, and survival rate of *L. argentimaculatus* were determined every 6 months up to 24 months. The fish reared in earthen ponds had average ADG values of 2.50 g/day, and SGR values of 0.35%/day. The final survival rate values of the fish reared in both earthen ponds being in the range 75.5-92.0%, with an average value of 83.8%.

Rearing Conditions

Water quality parameters measured during the long-term rearing of the *L. argentimaculatus* the earthen ponds from May 2021 to April 2023 indicated that salinity was in the range 25.0-36.1 ppt (mean±SD, 31.8±3.4 ppt), DO was in the range 3.4-8.4 mg/l (4.8±1.2 mg/l), water temperature was in the range 26.4-32.4°C (29.7±1.5°C), pH was in the range 6.6-9.1 (8.1±0.7), total ammonia was in the range 0.00-0.56 mg-N/l (0.14±0.12 mg-N/l), nitrite was in the range 0.00-0.23 mg-N/l (0.03±0.04 mg-N/l), and total alkalinity was in the range 99.1-216.3 mg/l $CaCO_3$ (144.4±24.9 mg/l $CaCO_3$).

In addition, during the rearing period, some factors could potentially cause mortality, as to detected viral and bacterial infections, especially at about 20-22 months (during December 2022 to February 2023 for the current study). We identified the signs of prominent infection in the *L. argentimaculatus* reared (Figure 2) consisting of viral nervous necrosis (VNN), *Staphylococcus kloosii*, and *Vibrio* spp. In the phylogenetic tree study, the identified pathogens were 73% *V. harveyi*, 18% *V. vulnifcus*, and 9% *V. parahaemolyticus* (Figures 3 and 4). Copepod parasites, namely *Caligus* sp. (Figure 5), infected *L. argentimaculatus* being reared and also resulted in decreased feed consumption by the fish.

Discussion

Based on the growth results of mangrove red snapper *Lutjanus argentimaculatus* in this study, these data did not define breeding suitability because the fish were not mature and large enough, as other research reported that the broodstock of *L. argentimaculatus* ready to spawn needed to be 3-7 kg and at this weight, the brooders would be 4-5 years old (Yamada, 2010). However, there is not clear information on the required period to rear *L. argentimaculatus* in an earthen pond

Table 1. Baseline data of mangrove red snapper *Lutjanus argentimaculatus* reared in earthen ponds for 24 months

Detail	Fish cultivation		
	Pond No.1	Pond No.2	Average
Pond size (m^2)	1,600	1,600	1,600
Initial density ($fish \cdot pond^{-1}$)	200	200	200
Initial total length (cm)	19.4-26.4	19.4-23.5	22.0
Initial body weight (g)	106.8-238.9	117.7-197.2	160.7
Final total length (cm)	46.3-49.7	44.3-51.1	47.3
Final body weight (g)	1,787.5-2,407.5	1,632.4-2,453.8	1,959.4
Number of fish survival (fish)	151	184	168
Survival rate (%)	75.5	92.0	83.8
Average daily growth (g/day)	2.67	2.33	2.50
Specific growth rate (%/day)	0.35	0.34	0.35
Total feeding (kg)	2,558.6	2,253.7	2,406.2

Figure 2. Appearance of mangrove red snapper *Lutjanus argentimaculatus* with viral and bacterial infections (white arrows) at about 20-22 months during rearing in earthen ponds.

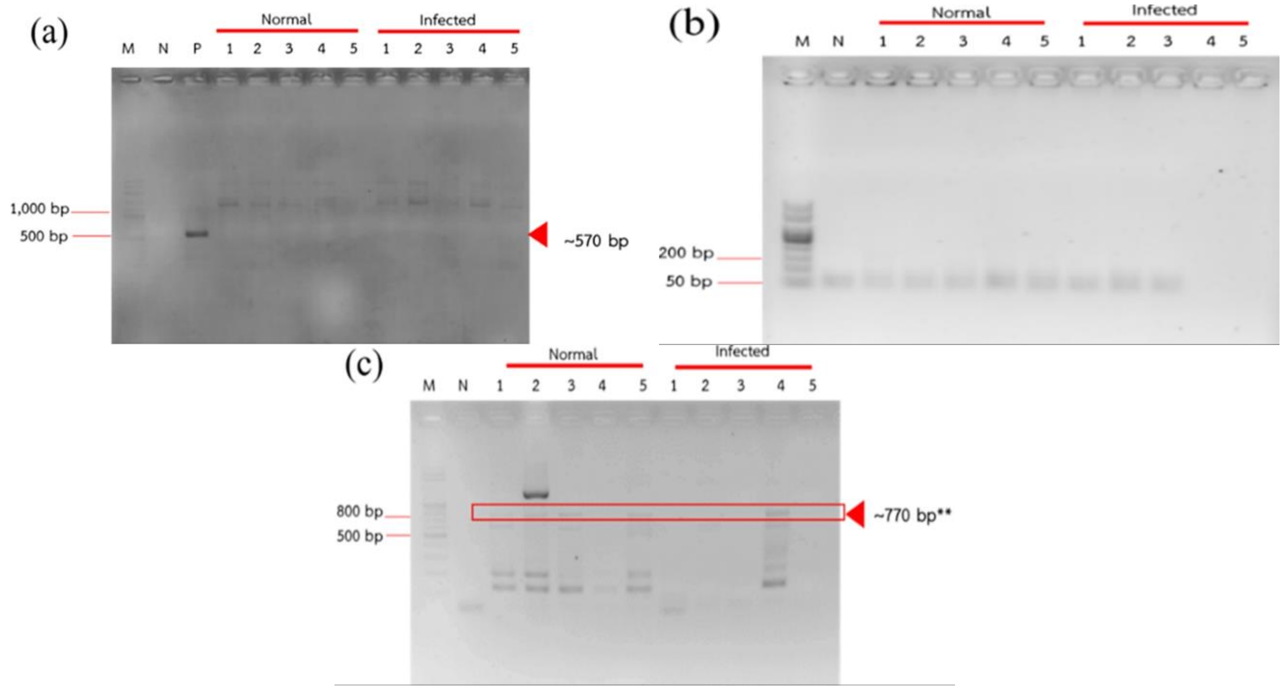

Figure 3. Gel electrophoresis of virus checked in mangrove red snapper *Lutjanus argentimaculatus* reared in earthen ponds and showing signs of infection: (a) infectious spleen and kidney necrosis virus (ISKNV); (b) scale drop disease virus (SDDV); and (c) viral nervous necrosis (VNN). M = marker 50 bp (in SDDV) and 100 bp (in ISKNV and VNN), N = negative control, P = positive control.

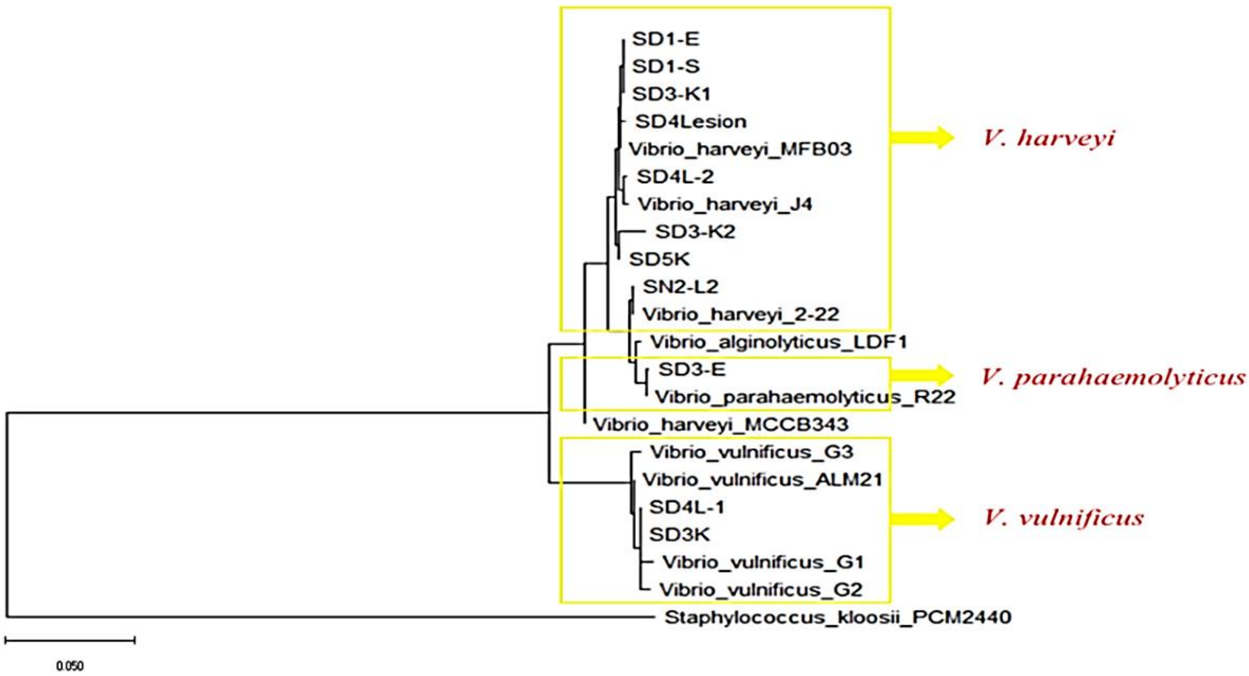

Figure 4. Phylogenetic tree of mangrove red snapper *Lutjanus argentimaculatus* reared in earthen ponds and infected with *Vibrio* spp.

cultivation system to achieve brooder-sized fish because in the past, the reports were for wild-caught broodstock (approximately 3-5 kg in size) that were subsequently fattened for breeding purposes only (Le & Hoa, 2017; Philipose et al., 2017; Melianawati et al., 2019). There have been similar reports for other snapper species reared for broodstock, such as John's snapper *L. johnii* (Murugan et al., 2016), red snapper *L. campechanus* (Bardon-Albaret & Saillant, 2017), and Pacific red snapper *L. peru* (Santamaría-Miranda et al., 2021). In addition, our observations and those reported in other papers suggested that the water conditions in the reared ponds were standard and had not affected the growth and survival of *L. argentimaculatus*. It was reported that the suitable water quality for rearing this species comprised an average temperature not below

27°C, salinity of 25–35 ppt, DO not less than 4 mg/L, pH of 7.5–8.5, ammonia not exceeding 0.4 mg/L, and nitrite not exceeding 0.1 mg/L (Chi & True, 2018; Muyot et al., 2021; Asiandu & Malayudha, 2022; Mosequera et al., 2023). The fish reared in this study had an average ADG of 2.50 g/day and SGR of 0.35%/day, with an average survival of 83.8%. These results were similarly reported for rearing in other culture systems, such as floating cage and polyculture, which showed approximately 1.0–1.4 g/day, 0.9–2.5%/day SGR, and 78–94% survival (Muyot et al., 2021; Asiandu & Malayudha, 2022; Sookdara et al., 2022).

In the current study, pathogen infected *L. argentimaculatus* being reared and also resulted in decreased feed consumption by the fish. For pathogen in marine fish, VNN is a worldwide disease with serious impact that can be classified as one of the most important diseases in marine fish, as it occurs often in fry and juvenile fish with large economic losses. Sometimes, it occurs in adult fish, with fish death caused by bacterial infections and not by VNN (Zorriehzahra et al. 2019). Some bacterial infections are serious diseases in the economic marine fish cultivation of other species, causing heavy mortality rates, such as in groupers *Epinephelus* spp., Asian seabass *Lates calcarifer*, and snappers *Lutjanus* spp. (Kasornchandra, 2002; Nagasawa & Cruz-Lacierda, 2004). Furthermore, one significant factor contributing to failures in marine fish farming is the presence of parasites that affect cultured fish stocks (Truong et al., 2022). Caligid copepods have been reported to infect various marine fish species across Indonesia, Malaysia, Philippines, Vietnam, and Thailand (Truong et al., 2022). This study also identified this copepod attacking *L. argentimaculatus* reared in earthen ponds.

The cause of mortality in *L. argentimaculatus* during the 24-month pond culture was not clear. Mortality events occurred at irregular intervals and were not attributable to infectious disease or adverse water quality parameters that could cause sudden death in aquatic animals, such as low DO (Boyd et al., 2020). Generally, the success of marine fish culture depended on the carrying capacity of the aquatic environment, defined as its ability to sustain life processes over the long term. It was closely related to the availability of natural resources and environmental factors that influenced growth rates. The environmental carrying capacity of waters was crucial for aquaculture success in that setting (De Silva and Davy 2010). Based on the results from the current study, it is very difficult to identify exactly which factors are the main causes of *L. argentimaculatus* mortality during their long-term rearing in earthen ponds. Diseases are a natural part of the life of all animals and usually result from the presence of disease-causing agents (pathogens) or an unsuitable environment. Some main causes of fish infection by viruses, bacteria and parasites are poor water quality, environmental stress, and physical damage to the fish, with other factors including low genetic immunity and an incorrect diet (Kasornchandra, 2002; Nagasawa & Cruz-Lacierda, 2004; Purivirojkul & Areechon, 2008). When issues arise, conduct on-site clinical assessments to differentiate infectious from non-infectious causes, and use lab tests as needed. Containment measures include isolating affected groups; supportive care focuses on correcting water quality and nutrition and reducing stress, with targeted therapies guided (antibiotics based on sensitivity, antiparasitics), a formal health management plan with action thresholds, staff training, and thorough documentation for regulatory compliance. Collectively, these actions are intended to enhance the long-term sustainability of marine fish broodstock farming.

While a full cost–benefit analysis is beyond this study, we offer a preliminary schematic framework to guide future assessments: cost inputs, time to reach broodstock criteria, expected seed yield, potential revenue from seeds, and risk adjustments due to disease and environmental variability. This framework can be populated once longitudinal cost data become available.

Conclusion

The current study determined the growth rate of the mangrove red snapper *L. argentimaculatus* reared in the earthen ponds for 24 months with the ADG being 2.50 g/day and SGR being 0.35%. After about 20-22 months of rearing, viral, bacterial, and copepod parasites infected the fish, with their final survival being 83.8%. Although *L. argentimaculatus* rearing for broodstock production was not possible after 24 months of culture due to size limitations, the development of baseline data on fish cultivation in earthen ponds is

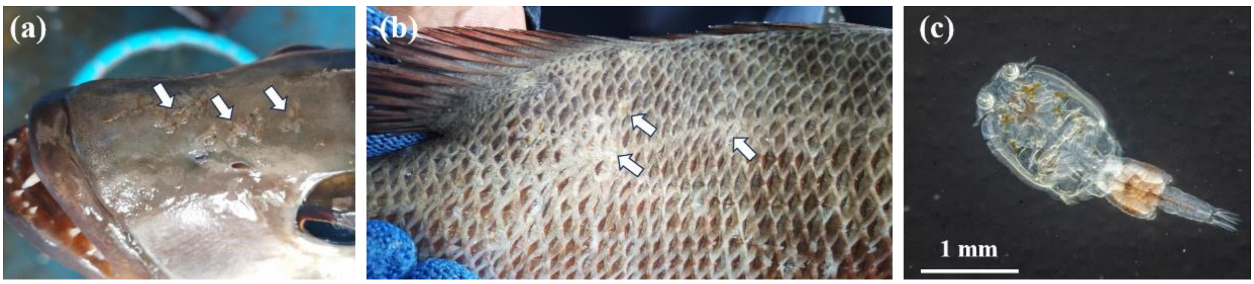

Figure 5. Copepod parasites on body surface (white arrows) of reared mangrove red snapper *Lutjanus argentimaculatus* (a, b) and characteristic caligid copepod, *Caligus* sp. (c).

necessary and should be continued to contribute to their successful economic cultivation in the longer term and for their further utilization as a brooder resource.

Ethical Statement

Animal care and all experimental procedures were approved by the National Research Council of Thailand (Animal Use License no. U1-02074-2558).

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Author Contribution

WA: Investigation, Data curation, Writing-original draft; RK: Resources, Data curation; VO: Project administration, Conceptualization, Writing-review and editing; CL: Review.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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