Growth Pattern The Second Generation of Marine Fish Larvae Mangrove Red Snapper *Lutjanus argentimaculatus* (Forsskål, 1775)

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Abstract. Mangrove red snapper *Lutjanus argentimaculatus* is a high economically value of snapper. Growth is important biological parameters during larvae stage. The growth of the second generation (F-2) of cultivated *L. argentimaculatus* is important to be evaluated as part of cultivation success. This study was conducted to determine the growth pattern of *L. argentimaculatus* F-2 during larval to juveniles stage. Larval rearing was done in hatchery. Larvae were fed zooplankton rotifers *Brachionus rotundiformis* and *Artemia*, also micro pelet as the artificial feed. Microscopic measurement on larval samples were performed periodically every 5 days from 5 to 40 days old larvae, by using 10 larval samples each time. The biological parameters of larvae were total length, standard length, dorsal spine length, ventral spine length, anal spine length and body weight. The results of this study indicated that the growth of mangrove red snapper larvae took place for 35-40 days to metamorphosis become juveniles. The growth pattern on all parameters was exponential. The larval total length has a positive correlation to its body weight with correlation value of 0.99. Larvae had certain characteristic growth during metamorphosis stage. Mangrove red snapper *L. argentimaculatus* F-2 had a similar growth pattern with those of larvae F-1.

Key words: growth pattern, mangrove red snapper *L. argentimaculatus*, larvae, metamorphosis, F-2

1. Introduction

*Lutjanus argentimaculatus* is an important market fish in Indo-Pacific regions [1] and it is considered over exploited in some area [2]. Exploitation which is carried out continuously is feared to lead to a decline in the population in nature and will have an impact on its scarcity. Therefore, *L. argentimaculatus* is a good candidate for mariculture cultivation and has been established [3]. The cultivation of those species in Institute for Mariculture Research and Fisheries Extension (IMRAFE) has already done [4]. The first generation (F-1) of those species have already become broodstock, spawned to produce eggs and then generated the second generation (F-2) of mangrove red snapper [5]. The condition of those F-2 larvae should be observed to ensure the quality of larvae remains as good as the larvae of F-1.

Biological aspect, mainly which related to fish growth, plays an important role as a tool to monitor the quality of larvae. Larvae stage starts from the fish eggs hatch to a certain time when the larvae will
undergo metamorphosis that characterized by structural changes of body shape to become juveniles whose body similar to adult [6]. Larvae is a critical period in the life of fish [7].

Growth is an increase body size of fish, both length and weight, in a certain period of time [8] and it was influenced by several factors such as genetic, environmental and the age of larval itself [9]. At the larval stage, the growth parameters which were commonly observed are length and weight of body. For snapper larvae, length of spines are others morphometric parameters that commonly observed [10]. The analysis of length and weight of larvae mathematically is expected could express the growth pattern and biological conditions of the larvae.

This study was conducted to evaluate the growth pattern of L. argentimaculatus F-2 during larvae to juveniles stage compared to those of the first generation (F-1). This study more detail to observe the period time from larvae to achieve metamorphosis stage to be juveniles (1), to analyse the growth, which consist of body length, length of spine and body weight during larval to juveniles stage (2), to describe the relationship between length and weight of the body (3) and to determine the growth characteristic during larvae to juveniles stage (4). The results of this study are expected to be a reference and biological indicators to evaluate the growth patterns of mangrove red snapper in general and particularly for F-2.

2. Methods

2.1. Source of eggs
The mangrove red snapper eggs were obtained from natural spawning of the first generation (F-1) broodstock who are produced from the wild broodstock (F-0) that have been already domesticated in Institute for Mariculture Research and Fisheries Extension (IMRAFE). The eggs which already were collected in egg collector then transferred carefully to 200 L incubator tank made from transparent fiberglass. Furthermore, the eggs are selected between fertilized and infertile eggs. Only the selected fertile eggs are then used in this study.

2.2. Larvae rearing
Larvae rearing was undertaken in hatchery. Larvae kept in concrete tank volume 4,000 L that equipped with aeration system to supply the saturated oxygen. Larvae rearing was done until larvae were metamorphosed to become juveniles.

Phytoplankton and zooplankton were added during larval rearing period. Phytoplankton Nannochloropsis oculata were added to rearing tanks started from 2 Days After Hatching (DAH). Zooplankton rotifers Brachionus rotundiformis were used as the initial live feed to larvae. Rotifers were given started from 2 DAH evening with initial density was 5-10 individuals/mL. The density of rotifers increased with increasing age of larvae. Another kinds of zooplankton that also used as live feed was Artemia which were given started from 20 DAH. The density of Artemia also increased with increasing age of larvae, as well as on rotifers. Artificial feeds, besides live feeds, were also given to larvae started from 8 DAH. Larvae were fed twice a day, at 08.00-09.00 am and 02.00-03.00 pm.

2.3. Samples collection
Growth of larvae was observed every 5 days started at 5 until 40 DAH. The growth were measured by using 5 larvae which taken as sample. Larval samples were placed on single concave object glass and measured by micrometer in stereoscopic microscope type Olympus, while larvae weighing was done using digital weigh type Ohaus with accuracy 0.0001 grams.

2.4. Parameters
The parameters measured were total length, standard length, length of 1st dorsal spine, length of 2nd dorsal spine, length of ventral spine and anal spine, also measuring the body weight. Technical term and measurement of length was done according to protocol of snapper morphology [10]. However, not all of the parameters in those protocols were measured because it was adjusted with the available biological parameters of fish in larvae stage.
2.5. Data analysis

All data presented graphically and analyzed qualitatively. Trendline equations in graphics are made with Microsoft Excel Statistical software.

3. Results and Discussions

The results on measuring total length of mangrove red snapper *L. argentimaculatus* F-2 showed that total length of 5 DAH larvae was of 2.18 ± 2.12 mm and then increased until reached 19.24 ± 1.25 mm at 40 DAH (Figure 1a). That figure also showed, there was a huge increase in total length from 8.11 ± 1.27 mm at 25 DAH to 15.22 ± 1.42 mm at 30 DAH larvae. The growth pattern in total length from 5 up to 40 DAH larvae was exponential, which means that in those period the total length of larvae has increased exponentially with the equation $y = 1.65e^{0.33x}$. There was a close correlation between total length and age of larvae ($r = 0.99$).

![Figure 1a](image1.png)

(a) Exponential trendline equation: $y = 1.651e^{0.327x}$, $r = 0.99$

![Figure 1b](image2.png)

(b) Exponential trendline equation: $y = 1.650e^{0.297x}$, $r = 0.988$

The 5 DAH larvae have 2.09 ± 2.12 mm of standard length (Figure 1b). Standard length of larvae increased up to 15.54 ± 1.05 mm at 40 DAH. Those data showed the tendency of larval standard length to increase with increasing larval age, as well as the total length of larvae. The pattern of standard length larval growth from the age of 5 to 40 days is exponential with the equation $y = 1.65e^{0.30x}$. There was a close correlation between standard length and age of larvae ($r = 0.99$).

The results in Figure 1a and 1b showed the difference between total length and standard length of larvae. The difference in value appeared to increase with increasing age of larvae (Figure 2a). There was low increase from 0.10 to 0.19 mm in period 5 up to 15 DAH. On the other hand, there was high increase ± 1.42 mm at 25-30 DAH larvae. This showed that during period larvae 25-30 DAH there has been an increase in growth, both total length and standard length, which is the largest compared to the age period before and after. The ratio of standard lengths-total lengths showed decreasing values with increasing age of larvae (Figure 2b). The ratio of 5 DAH larvae was 95.64 ± 0.56%, while 40 DAH 40 decreased to 80.77 ± 0.47%. Decreasing those value ratio is equivalent to the increasing the difference distance between total length and standard length, which can be assumed to increase the width space for caudal fin. This results indicate that the greater age of larvae have larger width space for caudal fin which will be formed.
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Figure 2. Difference in total length-standard length (a) and ratio of standard length-total length (b) of mangrove red snapper larvae F-2

The 1st dorsal spine larvae began to be detected at 15 DAH larvae and the length was 0.54 ± 0.12 mm (Figure 3a). The length of those spines then continued to grow with increasing the age of larvae. The biggest increase of 1st dorsal spine occurred at 25 DAH larvae from 1.55 ± 0.36 mm to be 2.92 ± 0.28 mm at 30 DAH or ± 1.37 mm. The length of those spine looked stagnant after larvae reached 30 DAH. The growth pattern of 1st dorsal spines during 5 up to 40 DAH was exponential with the equation $y = 0.193e^{0.389x}$ and showed very close correlation with the increasing age of larvae ($r = 0.98$).

Figure 3. Length of the 1st dorsal spines (a) and the 2nd dorsal spines (b) of mangrove red snapper larvae F-2

Mangrove red snapper larvae also have the 2nd dorsal spines. In this study, those spines also began to be detected at 15 DAH larvae, as well as the 1st dorsal spines, but it was shorter, i.e. 0.26 ± 0.04 mm (Figure 3b). Generally, length of the 2nd dorsal spines were shorter than those of the first. Length of those spines was increased by the increasing of larval age and also closely correlated with age ($r = 0.98$). There was an increase of length of the 2nd dorsal spines from 0.98 ± 0.23 mm to 2.13 ± 0.31 mm in period of 25-30 DAH larvae or increased ± 1.16 mm. The growth pattern of those 2nd dorsal spines was exponential with the equation $y = 0.077e^{0.483x}$ and showed very close correlation with the increasing age of larvae ($r = 0.98$).
spines at 5 up to 40 DAH larvae were increase exponentially with the equation $y = 0.07793e^{0.483x}$. Those length of spines are seen still showing increase at 30 and 40 DAH larvae. This tendency looks different from the 1st dorsal spines which did not show an increase in size after 30 DAH.

Larvae also have ventral spines which were beginning to be detected at 15 DAH larvae and the length was $0.71 \pm 0.18$ mm (Figure 4a). Those length of spines were increase exponentially with increasing age of larvae with the equation $y = 0.254e^{0.371x}$. Those spines also had close correlation with the age of larvae ($r = 0.99$). In the period of 25-30 DAH larvae, there was a large increase of those spines length, i.e $\pm 1.36$ mm, from $1.75 \pm 0.54$ mm at 25 DAH larvae to $3.11 \pm 0.26$ mm at 30 DAH.

![Graph of ventral spines length vs. age of larvae](image)

**Figure 4.** Length of ventral spines (a) and length of anal spines (b) of mangrove red snapper larvae F-2

The anal spines also were detected at 15 DAH larvae and the length was $0.27 \pm 0.05$ mm (Figure 4b). Like other spines, anal spines also had a close correlation with the increase in larval age ($r = 0.98$) and the size increased exponentially with the equation $y = 0.079e^{0.484x}$. Figure 4b also mentioned there was a significant increase in length, which is $\pm 1.13$ mm, from $1.07 \pm 0.28$ mm at 25 DAH to $2.20 \pm 0.23$ mm at 30 DAH larvae.

The body weight of 5 DAH *L. argentimaculatus* larvae were $0.64 \pm 0.08$ mg (Figure 5a). The body weight of larvae had positive and very closely correlation with the age of larva ($r = 0.99$) with the equation was $y = 0.475e^{0.342x}$. Figure 5a also reffered that there were an increase in body weight of larvae which was quite large, i.e. $\pm 2.32$ mg, from $2.52 \pm 0.42$ mg at 25 DAH to $4.84 \pm 0.41$ mg at 30 DAH larvae.

This study indicated that the growth pattern of total length, standard length, length of 1st and 2nd dorsal spines, ventral spines, anal spines and body weight of mangrove red snapper larvae *L. argentimaculatus* F-2, all were increased exponentially and had a positive and close correlation ($r = 0.98 - 0.99$) with increasing age of larvae. Those growth pattern were the same as the growth pattern of those of larvae *L. argentimaculatus* F-1 [4]. The result of this study declared that *L. argentimaculatus* F-2 larvae had a similar growth pattern with those of larvae F-1.

In all of the parameters above, there is also a tendency for a relatively higher increase in period 25-30 DAH larvae. The increasing of size is due to during this period larvae started of the metamorphosis stage, which is occurred the changes in body shape of the larvae to juveniles or young fish that resemble their adult. In this study, the metamorphosis process ended at 40 DAH larvae when larvae reached $19.24 \pm 1.25$ mm in total length and $15.54 \pm 1.05$ mm in standard length.
Total length of larvae had linear correlation \( y = 0.325x - 0.101 \), positive and very close \( r = 0.99 \) with the body weight of larvae (Figure 5b). Larvae in size 2.00-10.00 mm total length had body weight 0.5-3.0 mg, while bigger size of larvae, 14.00-22.00 mm in total length had body weight ranged between 4.50 to 7.00 mg. Figure 5b also shows a significant increase in the total length, from 10 cm to 15 cm. The increasing of those size is related to metamorphosis period. It appears that the initial metamorphosis occurred at larvae with ± 10 mm total length and the end of metamorphosis occurred at ± 14 mm total length. As well as total length, the body weight of larvae also had a surge increase from 3 to 4 mg and it was assumed related to the period of larval metamorphosis. Larvae reached at the initial step of metamorphosis at ± 3 mg and then achieved ± 4 mg when metamorphosed.

Performance of *L. argentimaculatus* F-2 shows the clear changes in body shape from larvae to juveniles stage, as well as F-1 larvae (Figure 6). The previous studies above were conducted by using *L. argentimaculatus* F-1 larvae. The results of this study indicated that *L. argentimaculatus* F-2 larvae had slower metamorphosis stage than F-1 larvae. However, those difference achievement time of metamorphosis stage still needs to be studied further by linking it to some factors such as broodstock feed, environmental conditions for larvae, mainly water temperature and feeding of larvae during the rearing period.
Figure 6. Performance of mangrove red snapper F-2 during larvae-juvenile stage

4. Conclusions
The study conclude that mangrove red snapper *L. argentimaculatus* F-2 larvae took place 25-30 days to achieve metamorphosis stage and completely to be juveniles at 35-40 days after hatching. The growth pattern of total length, standard length, length of 1st and 2nd dorsal spines, ventral spines, anal spines and body weight of mangrove red snapper larvae *L. argentimaculatus* F-2, all were increased exponentially and had a positive and close correlation with increasing age of larvae. Total length of larvae had linear correlation, possitive and very close correlation with the body weight of larvae. Larvae had certain characteric growth during metamorphosis stage. Therefore, mangrove red snapper *L. argentimaculatus* F-2 had a similar growth pattern with those of larvae F-1. The biological parameters which used in this study were suitable as biological indicators to evaluate the growth of marine fish mangrove red snapper.

5. References
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