

Analysis of Growth and Survival of Kelabau Fish Larvae (*Osteochilus melanopleurus*) Fed Natural Feeds With Different Feed-Transition Periods

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Abstract.

Kelabau fish is a local freshwater fish with high economic value, however, successful seed production is still constrained by high mortality and slow growth during the larval stage. This study aimed to analyze the growth and survival of kelabau fish larvae fed natural feeds with different feed-transition periods. The study was conducted at the Mandiangin Freshwater Aquaculture Center using a completely randomized design (CRD) with four treatments and three replications. The tested treatments consisted of different transition times among natural feeds, namely infusoria, Artemia nauplii, and Moina, for larvae aged two days after hatching during a 15-day rearing period. The observed parameters included absolute length growth, absolute weight growth, and larval survival. The data were analyzed using analysis of variance (ANOVA) at a 95% confidence level, followed by Duncan's test when significant differences were found. The results showed that different natural-feed transition periods had a significant effect ($P < 0.05$) on larval length growth, but had no significant effect ($P > 0.05$) on weight growth or survival. The highest length growth was obtained in treatment A at 8.55 ± 0.34 mm, followed by treatment B at 8.42 ± 0.28 mm, while the lowest value was recorded in treatment D at 7.08 ± 0.13 mm. Weight growth ranged from 0.0161 ± 0.0016 to 0.0179 ± 0.0033 g, and survival ranged from $83.33 \pm 3.85\%$ to $95.56 \pm 5.09\%$. Treatment A, consisting of infusoria feeding until day 2 and a combination of infusoria and Artemia nauplii starting on day 3, was the best treatment for improving larval length growth. Therefore, an earlier transition to Artemia nauplii, beginning on day 3 of rearing, is the optimal period to support the growth of kelabau fish larvae without reducing their survival rate.

Keywords: Kelabau fish, natural feed, growth and survival rate.

I. INTRODUCTION

Kelabau fish (*Osteochilus melanopleurus*) is one of the local freshwater fish species with high economic value and is widely found in inland waters of Southeast Asia, including Indonesia, particularly in Kalimantan and Sumatra. This species is a fishery commodity favored by the community because of its good taste and relatively high market value. Domestication efforts for kelabau fish have been carried out by the Mandiangin Freshwater Aquaculture Center (BPBAT Mandiangin), and the species was successfully released in 2016. Nevertheless, aquaculture and hatchery technologies still need to be continuously developed to increase production and maintain the sustainability of kelabau fish resources in nature.

The abundance of kelabau fish in public waters is currently suspected to be declining as a result of various environmental pressures and human activities. According to Bishop (1973) in Aizam et al. (1983), declining fish populations in public waters can be caused by ecological changes, such as forest clearing that leads to erosion and water-body sedimentation, increased fishing activity due to rising community consumption needs, and non-selective fishing practices that threaten the survival of juvenile fish. Similar conditions were reported by Hasanah et al. (2022) in Dewantoro et al. (2019), who stated that pressure on local fish resources may reduce stocks in their natural habitats. Therefore, the development of aquaculture technology is an important step in supporting the conservation of kelabau fish.

One of the main constraints in kelabau fish hatchery activities is the high mortality rate during the larval stage. Larval rearing after yolk-sac depletion is often a critical point in the success of seed production. Yusuf et al. (2014), Mulyani et al. (2015), and Soedibya in Pramono et al. (2022) stated that the larval stage is the most vulnerable phase in the hatchery process because mass mortality frequently occurs. In addition, larval growth also tends to be slow, as reported by Dewi (2006), Pramono and Marnani (2009), and Andani

et al. (2020) in Pramono et al. (2022). High mortality and low larval growth are limiting factors in increasing kelabau fish seed production.

High mortality during the larval stage is generally associated with the suboptimal utilization of yolk reserves and the transition process toward the use of external feed. Soedibya and Pramono (2018), as well as Vebiola et al. (2021), explained that suboptimal yolk utilization can impair growth and increase the risk of larval mortality. Effendie (1997) stated that the critical phase occurs when yolk reserves begin to run out and larvae must adapt to obtain nutrients from external feed. Furthermore, Effendie (2002) emphasized that most larval mortality occurs during the early developmental phase because larvae are unable to adapt to changes in feed sources.

Preliminary tests showed that, on day 9, kelabau fish larvae were able to consume natural feed in the form of zooplankton. This was indicated by visual observations showing that the larval mouth opening was already compatible with the size of zooplankton, as well as by the presence of zooplankton shell remains in the larval digestive tract. On day 15, larval morphology showed more complete development, including skin thickening and improved digestive-organ development. These findings indicate that larval digestive organs develop gradually, so the required type and size of feed also change according to larval age and developmental stage.

Information on the feeding habits of kelabau fish also shows changes in feed type as the fish grow. A study by Nasution and Nuraini (2004) in Nasution et al. (2006) on the stomach contents of kelabau fish showed that this species consumes moss, diatoms, phytoplankton, and insect larvae in the Kampar River. In the adult stage, kelabau fish make greater use of moss, detritus, and fruits derived from vegetation along river basins. These changes in feeding patterns indicate that the nutritional requirements and feed types of kelabau fish are dynamic and depend on their life stage.

Natural feed is a major nutrient source that is highly important for fish larvae because it has a suitable size for the larval mouth opening, is easy to digest, and contains nutrients required to support growth and survival. Several studies have examined the use of various natural feeds during the larval stage. Diansyah et al. (2017) tested feeds such as chicken egg yolk, frozen Tubifex, Moina, and Daphnia for nilam fish larvae. Meanwhile, Asiah et al. (2024) studied the use of Tubifex sp., Artemia nauplii, and Daphnia for kelabau fish larvae. Another study by Yusuf et al. (2014) used nilam fish larvae with treatments involving Spirulina sp. and powdered pellet feed. Although various natural feeds have been studied, information on the timing of natural-feed transition that matches the development of the digestive organs of kelabau fish larvae remains very limited.

Feed replacement or transition during the larval stage must be carried out appropriately so that it matches body size, mouth-opening ability, digestive-system development, and larval nutritional needs. Mahardika et al. (2017) in Nurfatiha et al. (2022) stated that proper timing of feed replacement plays an important role in improving fish larval growth and survival. Feed transition that is either too early or too late may reduce nutrient utilization, result in suboptimal growth, and even increase mortality. Therefore, this study aimed to analyze the growth and survival of kelabau fish larvae fed natural feeds with different feed-transition periods.

II. METHODS

This study was conducted at the Mandiangin Freshwater Aquaculture Center, Jl. Tahura Sultan Adam No. 14, Mandiangin Barat Village, Karang Intan District, Banjar Regency, South Kalimantan. The study used a one-factor completely randomized design (CRD) with four treatments and three replications. The tested factor was the difference in the transition period for natural-feed administration to kelabau fish larvae aged two days after hatching, with a rearing period of 15 days. The treatments were as follows:

- Treatment A: two-day-old larvae were given infusoria as the initial feed until day 2; on days 3-5 they were given a combination of infusoria and Artemia nauplii; on days 6-7 they were given Artemia; on days 8-10 they were given a combination of Moina and Artemia nauplii; and on days 11-15 they were given Moina.
- Treatment B: two-day-old larvae were given infusoria as the initial feed until day 3; on days 4-6 they

were given a combination of infusoria and *Artemia nauplii*; on days 7-8 they were given *Artemia*; on days 9-11 they were given a combination of *Moina* and *Artemia nauplii*; and on days 12-15 they were given *Moina*.

- Treatment C: two-day-old larvae were given infusoria as the initial feed until day 4; on days 5-7 they were given a combination of infusoria and *Artemia nauplii*; on days 8-9 they were given *Artemia*; on days 10-12 they were given a combination of *Moina* and *Artemia nauplii*; and on days 13-15 they were given *Moina*.

- Treatment D: two-day-old larvae were given infusoria as the initial feed until day 5; on days 6-8 they were given a combination of infusoria and *Artemia nauplii*; on days 9-10 they were given *Artemia*; on days 11-13 they were given a combination of *Moina* and *Artemia nauplii*; and on days 14-15 they were given *Moina*.

The parameters observed in this study included the following:

Absolute Length Growth

Absolute length growth was calculated using the formula proposed by Effendie (1997) as follows:

$$L_m = L_t - L_0$$

Description:

- L_m = absolute length growth (cm)
- L_t = fish length at the end of the period (cm)
- L_0 = fish length at the beginning of the period (cm)

Absolute Weight Growth

Growth was measured by determining the absolute weight-growth rate of the fish using the formula proposed by Effendie (1997) as follows:

$$W = W_t - W_0$$

Description:

- W = fish weight gain (g)
- W_t = final fish weight at time t (g)
- W_0 = initial fish weight (g)
- t = duration of the study (days)

Survival Rate

Survival was expressed as a percentage according to the formula of Effendie (1997):

$$SR = (N_t / N_0) \times 100\%$$

Description:

- SR = survival rate (%)
- N_t = number of fish at the end of the period (individuals)
- N_0 = number of fish at the beginning of the period (individuals)

Data on absolute length growth, absolute weight growth, and larval survival were analyzed using analysis of variance (ANOVA) at a 95% confidence level ($\alpha = 0.05$) to determine the effect of different natural-feed transition periods. When ANOVA indicated a significant difference, Duncan's Multiple Range Test (DMRT) was performed to identify the best treatment.

III. RESULTS AND DISCUSSION

Absolute Length Growth

Based on the results of the analysis of absolute length and weight growth of kelabau larvae tested through observations of natural-feed administration with different transition periods, the results are presented in the following table:

Table 1. Length growth data of kelabau fish larvae

Treatment	Length growth (mm)
A	8.55 ± 0.34 ^a
B	8.42 ± 0.28 ^a
C	7.55 ± 0.44 ^b
D	7.08 ± 0.13 ^b

The ANOVA results showed that differences in the transition period of natural-feed administration had a significant effect on the length growth of kelabau fish larvae. The average larval length obtained ranged from 7.08 ± 0.13 mm to 8.55 ± 0.34 mm. Treatment A produced the highest length growth, namely 8.55 ± 0.34 mm, followed by treatment B at 8.42 ± 0.28 mm, whereas treatments C and D produced 7.55 ± 0.44 mm and 7.08 ± 0.13 mm, respectively. These results indicate that different natural-feed transition times influence the ability of larvae to utilize nutrients for body-length growth.

The higher length growth in treatments A and B was presumably caused by the earlier administration of a combination of infusoria and *Artemia nauplii*, beginning on days 3 and 4 of rearing. During this phase, larvae begin to require higher-quality external nutrient sources to support the development of organs and body tissues. According to Effendie (1997), fish growth occurs when excess energy obtained from feed remains after the needs for body maintenance and basal metabolism have been fulfilled. Therefore, the availability of feed with good nutritional quality during the early larval stage strongly determines growth success.

The development of larval mouth opening during the study showed a relationship with body-length growth. On days 3 and 4, the larval mouth-opening sizes reached 0.202 mm and 0.246 mm, respectively, while the size of *Artemia nauplii* ranged from 0.10 to 0.39 mm. This size compatibility enabled the larvae to consume feed optimally so that nutrient intake could be maximally utilized for growth. According to Peng et al. (2023), *Artemia nauplii* are highly suitable natural feed for fish larvae because they are small, easy to capture, and highly digestible.

The high length growth in treatments A and B was also presumably related to the high protein content of *Artemia*. Earlier *Artemia* administration allowed the larvae to obtain sufficient protein for tissue formation and growth. According to Sjandri (2015), *Artemia* contains 52.2% protein, which plays an important role in supporting fish larval growth and development. In contrast, delayed *Artemia* administration in treatments C and D caused the larvae to depend longer on feed with lower nutritional content, resulting in less optimal length growth.

The lower length growth in treatments C and D indicates that delayed feed transition may reduce the efficiency of nutrient utilization during the critical larval phase. According to Kordi and Tancung (2007), fish growth is influenced by internal and external factors, particularly feed quality, the fish's ability to utilize feed, and rearing-environment conditions. Based on the results of this study, it can be concluded that an earlier transition to *Artemia nauplii*, namely on days 3 to 4 of rearing, is more effective in increasing the length growth of kelabau fish larvae than a transition conducted on days 5 to 6.

Absolute Weight Growth

Based on the results of the analysis of larval absolute weight growth, the data are presented in the following table:

Table 2. Results of absolute weight-growth analysis of kelabau fish larvae

Treatment	Weight growth (g)
A	0.0163 ± 0.0015^a
B	0.0161 ± 0.0016^a
C	0.0175 ± 0.0016^a
D	0.0179 ± 0.0033^a

The observations showed that the average weight of kelabau fish larvae ranged from 0.0161 ± 0.0016 g to 0.0179 ± 0.0033 g. The highest weight value was obtained in treatment D at 0.0179 ± 0.0033 g, followed by treatment C at 0.0175 ± 0.0016 g, treatment A at 0.0163 ± 0.0015 g, and treatment B at 0.0161 ± 0.0016 g. However, the ANOVA results showed that differences in the transition period of natural-feed administration did not have a significant effect on the weight growth of kelabau fish larvae. This indicates that all treatments produced relatively similar weight-growth responses during the rearing period.

The absence of significant differences among treatments was presumably because the larvae were still in the early growth phase, so most of the energy obtained from feed was used for organ development, improvement of the digestive system, and body-length growth. According to Huet (1994), during the larval

stage, weight growth occurs more slowly than length growth because available energy is allocated more to morphological and physiological development. This condition caused the increase in body weight to be statistically insignificant despite differences in feeding treatments.

The previous results showed that treatments A and B produced higher length growth than treatments C and D, but this condition was not followed by a significantly different increase in weight. This indicates that, during the larval stage, growth is more allometric, meaning that an increase in length is more dominant than an increase in body mass. According to Effendie (1997), the growth pattern of fish in the early stages is generally directed more toward increasing body size to support organ development and swimming ability before faster weight gain occurs in the following phase.

The uniformity of weight growth among treatments was also presumably influenced by relatively stable rearing-environment conditions and sufficient availability of natural feed in all treatments. Water-quality parameters such as temperature, pH, dissolved oxygen, and ammonia during the study remained within ranges that supported larval life. According to Lovell (1989), fish weight growth is influenced by the ability of fish to convert feed nutrients into body tissue, which is supported by optimal environmental conditions. Therefore, although the feed-transition times differed, the larvae were still able to utilize the available feed to maintain relatively uniform weight growth.

The results of this study indicate that differences in the timing of natural-feed transition did not have a significant effect on the weight growth of kelabau fish larvae during 15 days of rearing. This shows that all feed-transition patterns applied in this study were still able to meet the nutritional needs of larvae to support weight growth during the early life stage. The treatment effect was more evident in length growth than in weight growth, indicating that larval development during the study period was more focused on increasing body size than on adding body mass.

Survival Rate (SR)

Based on the results of the survival-rate (SR) analysis of kelabau larvae tested through observations of natural-feed administration with different transition periods, the data are presented in the following table:

Table 3. Survival-rate data of fish larvae

Treatment	SR (%)
A	95.56 ± 5.09 ^a
B	92.22 ± 7.78 ^a
C	83.33 ± 3.85 ^a
D	94.44 ± 2.94 ^a

The observations showed that the survival rate (SR) of kelabau fish larvae ranged from 83.33 ± 3.85% to 95.56 ± 5.09%. The highest survival value was obtained in treatment A at 95.56 ± 5.09%, followed by treatment D at 94.44 ± 2.94%, treatment B at 92.22 ± 7.78%, and treatment C at 83.33 ± 3.85%. However, the ANOVA results showed that all treatments were not significantly different from one another. This indicates that differences in the timing of natural-feed transition did not have a significant effect on the survival of kelabau fish larvae during the rearing period.

The absence of significant differences among treatments was presumably because all types of natural feed provided were still able to meet the nutritional needs of larvae at each developmental phase. In addition, the compatibility between feed size and larval mouth-opening development enabled the feed to be consumed properly, so it did not cause problems with survival. According to Effendie (1997), fish survival is influenced by sufficient feed availability and the ability of fish to utilize the feed provided during the rearing period.

The high survival values in all treatments also indicate that environmental conditions during the study remained within ranges that supported larval life. Water quality, including temperature, pH, dissolved oxygen, and ammonia, remained suitable for larval fish rearing during the study. According to Kordi and Tancung (2007), stable environmental factors that correspond to the biological needs of fish are among the main factors determining the success of rearing and the survival rate of larvae.

Although treatment A produced the highest survival value, the difference was not large enough to

produce a statistically significant effect compared with the other treatments. This condition indicates that all feed-transition patterns applied in this study were still able to support larval survival until the end of the experiment. According to Huet (1994), a high survival rate during the larval stage indicates that nutritional requirements and environmental conditions during rearing have been properly fulfilled, thereby reducing mortality.

The results of this study indicate that differences in the transition period of natural-feed administration did not have a significant effect on the survival of kelabau fish larvae. The high survival values in all treatments show that rearing management, environmental quality, and natural-feed availability during the study were able to optimally support larval life. Therefore, the timing of natural-feed transition had a greater effect on larval length growth than on survival rate.

IV. CONCLUSION

The analysis of the growth and survival of kelabau fish larvae fed natural feeds with different feed-transition periods showed that the transition period of natural-feed administration had a significant effect on larval length growth, but had no significant effect on larval weight growth or survival. Treatment A, consisting of infusoria feeding until day 2, a combination of infusoria and *Artemia nauplii* from days 3 to 5, *Artemia* from days 6 to 7, a combination of *Artemia* and *Moina* from days 8 to 10, and *Moina* from days 11 to 15, produced the best length growth at 8.55 ± 0.34 mm with a survival rate of $95.56 \pm 5.09\%$. The results indicate that an earlier transition to *Artemia nauplii*, beginning on day 3 of rearing, is the most optimal period to support the growth of kelabau fish larvae without reducing their survival rate.

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