Jurnal Teknologi Perikanan dan Kelautan
Vol. 17 No. 1, February 2026: 49-55
ISSN: 2087-4871
EISSN: 2549-3841
DOI: https://doi.org/10.24319/jtpk.17.49-55

THE EFFECT OF ARTEMIA BIOENCAPSULATION WITH SPIRULINA POWDER ON THE GROWTH PERFORMANCE OF DEPIK FRY (*Rasbora tawarensis*)

PENGARUH ARTEMIA BIOENKAPSULASI DENGAN BUBUK SPIRULINA TERHADAP KINERJA PERTUMBUHAN BENIH IKAN DEPIK (*Rasbora tawarensis*)

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(Received August 20, 2024; Revised November 3, 2025; Accepted January 23, 2026)

ABSTRACT

The depik (*Rasbora tawarensis*) is one of the leading fishery commodities in Central Aceh Regency and is endemic to Laut Tawar Lake. Due to overfishing and environmental degradation, the depik is now endangered, necessitating domestication. The success of the domestication stage is influenced by providing feed that meets the fish's needs, such as Artemia encapsulated with spirulina to enhance the nutritional quality of the Artemia. This study aims to evaluate the effect. of spirulina dosage as an Artemia enrichment material on the growth performance of depik. The applied research design was a completely randomized design with four treatments replicated four times. The treatments included Artemia without bioencapsulation (Treatment 1/P1), Artemia bioencapsulation with 0.5 g of spirulina powder per liter of water (Treatment 2/P2), Artemia bioencapsulation with 1 g of spirulina powder per liter of water (Treatment 3/P3), and Artemia bioencapsulation with 2 g of spirulina powder per liter of water (Treatment 4/P4). The parameters observed were absolute length growth (ALG), absolute weight growth (AWG), specific growth rate (SGR), and survival rate. Based on the ANOVA test, different doses of spirulina had a significant effect ($P < 0.05$) on the growth and survival of depik fry. The higher the dose given, the higher the growth and survival performance produced. Based on the Duncan test, the best treatment was shown in Treatment 4, namely the provision of bioencapsulated Artemia with 2 g of spirulina powder as feed for the depik fry.

Keywords: Artemia, bioencapsulation, *Rasbora tawarensis*, spirulina

ABSTRAK

Ikan depik (*Rasbora tawarensis*) merupakan salah satu komoditas perikanan unggulan di Kabupaten Aceh Tengah dan sebagai ikan endemik Danau Laut Tawar. Akibat penangkapan yang berlebih dan degradasi lingkungan, kini status ikan depik sudah terancam punah, sehingga perlu dilakukan domestikasi. Keberhasilan tahap domestikasi salah satunya dipengaruhi oleh pemberian pakan yang sesuai dengan kebutuhan ikan depik, contohnya adalah Artemia yang dienkapsulasi dengan spirulina untuk meningkatkan kualitas gizi Artemia. Penelitian ini bertujuan untuk mengevaluasi pengaruh dosis spirulina sebagai bahan pengkaya Artemia terhadap kinerja pertumbuhan ikan depik. Rancangan penelitian yang diaplikasikan adalah rancangan acak lengkap dengan empat perlakuan yang diulang sebanyak empat kali. Adapun perlakuannya meliputi Artemia tanpa bioenkapsulasi (Perlakuan 1/P1), bioenkapsulasi Artemia dengan 0,5 g bubuk spirulina per liter air (Perlakuan 2/P2), bioenkapsulasi Artemia dengan 1 g bubuk spirulina per liter air (Perlakuan 3/P3), dan bioenkapsulasi Artemia dengan 2 g bubuk spirulina per liter air (Perlakuan 4/P4). Parameter yang diamati adalah pertumbuhan panjang mutlak (PPM), pertumbuhan bobot mutlak (PBM), laju pertumbuhan harian (LPH), dan sintasan. Berdasarkan uji ANOVA, dosis spirulina yang berbeda memberikan pengaruh yang nyata ($P < 0,05$) terhadap pertumbuhan dan sintasan benih ikan depik. Semakin tinggi dosis yang diberikan, semakin tinggi pula kinerja pertumbuhan dan sintasan yang dihasilkan. Berdasarkan uji Duncan, perlakuan terbaik ditunjukkan pada Perlakuan 4, yaitu pemberian Artemia bioenkapsulasi dengan 2 g bubuk spirulina sebagai pakan benih ikan depik.

Kata kunci: Artemia, bioenkapsulasi, *Rasbora tawarensis*, spirulina

INTRODUCTION

The depik (*Rasbora tawarensis*) is a leading fishery commodity in Central Aceh Regency and is endemic to Laut Tawar Lake. This fish is a typical dish for the Gayo people (an ethnic group native to the Central Aceh and Bener Meriah Regencies). Compared to other freshwater fish, depik is relatively expensive, ranging from IDR 60,000 to IDR 80,000 per kg during the fishing season (based on interviews with depik sellers at the market). Although only marketed locally in Central Aceh and Bener Meriah, depik supplies are very limited, especially outside the fishing season.

The need for depik fish is currently met only from wild catches, which have resulted in declining catches from fishermen year after year (Central Aceh Fisheries Office 2019–2024), threatening the sustainability of depik in Laut Tawar Lake. In addition to overfishing, habitat pollution and environmental degradation are also contributing to the decline in depik production in Laut Tawar Lake (Muchlisin *et al.* 2018). Since 1990, the depik has been listed as vulnerable (IUCN 1996), and in 2019, it was further classified as critically endangered (Lumbantobing 2019). Therefore, researchers in the Aceh region, in collaboration with the Lukup Badak Fish Hatchery Center (BBI) in Central Aceh, are conducting intensive research on the domestication of the depik. The hope is that this fish can be cultivated so that market demand is no longer dependent on wild catches, and the sustainability of the fish in Laut Tawar Lake is also maintained.

In domestication, feed is the second most important factor to consider, after environmental factors. Feed quality that meets fish needs not only supports survival but can also improve growth performance. Based on previous research, the best natural food for depik fry is rotifers (Komariyah and Afrizal 2019). However, the availability of rotifers at the Lukup Badak Fish Cultivation Center remains a challenge, particularly in terms of culture installation and the availability of natural Chlorella feed. Therefore, an alternative natural food that is practical to provide yet provides the nutrients needed by depik fry is needed. This natural food is Artemia. Artemia is chosen as a substitute for rotifers because it is adapted to the mouth opening of depik and the feeding habits of the fish in the wild. Based on the results of Hasri's (2010) research, the main food of the depik in the wild is insects. In other words, the source of protein that the fish requires is animal protein, so Artemia was chosen as the test food used in this study. Furthermore, Artemia has been widely used as a natural feed for cultivated fish and shrimp (Palin *et al.* 2022), including whiteleg shrimp (Perdana *et al.* 2021), eel (Yusup *et al.* 2015), milkfish (Baiduri *et al.* 2018), and many other commodities.

In aquaculture, bioencapsulation is the process of enriching nutrients, supplements, or other active ingredients into the body of a living organism, either orally or through phagocytosis, pinocytosis, or endocytosis (Fernández 2001). According to Sedjati *et al.* (2022), bioencapsulation of Artemia aims to improve quality through an enrichment process with additional ingredients. Enrichment is carried out to increase the nutritional value of Artemia, thus meeting the nutritional needs of depik. Spirulina powder is one such ingredient that can be used as an enrichment due to its high protein content. Previous studies have also conducted similar studies on post-larvae of white shrimp (Kurniasih 2008) and tilapia (Suyanto *et al.* 2019). Therefore, this study aims to evaluate the effect of spirulina dosage as an enrichment for the Artemia on the growth performance of the depik.

METHODS

The research was conducted for 40 days in August–September 2023. The research location was the Lukup Badak Fish Hatchery Center (BBI), Central Aceh. The materials used included depik fry as test fish, Artemia cysts as test feed, and commercial spirulina powder as enrichment. The method used in this study was experimental.

Research design

The design in this study was a non-factorial completely randomized design (CRD) with four treatments and four replications. The treatments applied in this study were different doses of spirulina as an enrichment ingredient in Artemia natural feed, including Artemia without bioencapsulation (Treatment 1, P1), Artemia bioencapsulation with 0.5 g of spirulina powder per liter of water (Treatment 2, P2), Artemia bioencapsulation with 1 g of spirulina powder per liter of water (Treatment 3, P3), and Artemia bioencapsulation with 2 g of spirulina powder per liter of water (Treatment 4, P4).

Preparation of test animals

The depik fry were obtained from hatching eggs taken from Laut Tawar Lake and hatched

at the Lukup Badak Fish Hatchery Center (BBI). The fry used were 10 days old with an initial weight ranging from 0.8 to 1 mg. The depik eggs were collected from traps called didisen (a traditional fish trap used in Laut Tawar Lake, Aceh, Indonesia). These traps were placed at the lake inlet by fishermen to catch depik. Depik parents caught in the traps spawn naturally, using the trap walls as a place to attach their eggs.

The eggs attached to the "didisen" (trap) walls were collected and placed in plastic bags filled with water and oxygen in a 1:1 ratio. The eggs were then hatched in a hatchery to produce the fry used in this study. Depik larvae were fed Artemia before being used as test animals.

Preparation of test feed

Artemia cysts at 2 g/L were hatched using artificial seawater from the sea with a salinity of 25 ppt. During hatching, additional strong aeration was provided for 24 hours (Rudtanatip *et al.* 2019). Furthermore, referring to Sedjati *et al.* (2022), second-instar Artemia (24 hours after hatching) were placed into a container containing a spirulina solution according to the treatment dose, with a density of 100 Artemia individuals/mL. The Artemia were soaked for 5 hours (Suyanto *et al.* 2019). After soaking, the Artemia were rinsed using freshwater and then fed to the depik fry.

Maintenance of test fish

The test fish were reared in 16 aquariums (30×15×15 cm^3), each filled with 8 L of freshwater. An aerator was installed to meet the dissolved oxygen requirements of the test fish. Once the DO (dissolved oxygen) levels met the requirements of the depik, 20 fish were stocked per tank. During maintenance, feed was provided according to the treatment four times a day (at 8:00, 12:00, 16:00, and 20:00 West Indonesia Time) ad libitum. Fish weight and length sampling were conducted at the beginning and end of the study. An analytical balance with internal calibration (OHAUS PA224C) was used for weight sampling, while millimeter block paper was used for length sampling. In addition, observations of dead fish were conducted daily.

Water quality data were measured, including temperature, pH, and DO (Rahayu *et al.* 2021). Temperature was measured using a thermometer, pH using a pH meter, and DO using a DO meter.

Statistical analysis

ANOVA and Duncan's test were used to analyze the observational data during the study. Statistical analysis was performed at α=0.05 using SPSS software (Steel and Torrie 1994).

Observation parameters

Absolute weight growth (AWG)

The equation used to calculate absolute weight growth (AWG) is as follows (Dehaghani *et al.* 2015):

$$AWG\ (g) = Average\ final\ weight\ (g) - Average\ initial\ weight\ (g)$$

Absolute length growth (ALG)

The calculation of absolute length growth (ALG) uses the equation (Dehaghani *et al.* 2015):

$$ALG\ (g) = Average\ final\ length\ (mm) - Average\ initial\ length\ (mm)$$

Specific growth rate (SGR)

The calculation of the specific growth rate of fish using the Effendie (2002) equation:

$$SGR\ (\%/day) = \frac{(\ln final\ weight - \ln initial\ weight)}{Rearing\ period} \times 100$$

Survival Rate

Survival rate use the following equation (Dehaghani *et al.* 2015):

$$Survival\ Rate\ (\%) = \frac{Number\ of\ fish\ at\ the\ end\ of\ the\ experiment\ (individuals)}{Number\ of\ fish\ at\ the\ end\ of\ the\ experiment\ (individuals)} \times 100$$

RESULTS AND DISCUSSION

The average data of growth performance observation (AWG, ALG, and SGR) can be seen in Table 1. Based on the results of the ANOVA test, the provision of Artemia feed enriched with spirulina powder at different doses had a significant effect ($P < 0.05$) on the growth performance of depik fry. Meanwhile, based on Duncan's further test, the AWG of depik fry at P1 was significantly different from P3 and P4 but not significantly different from P2; P2 was

only significantly different from P4, and P4 was significantly different from other treatments. The ALG and SGR of depik fry at P4 were significantly different from other treatments, while P1, P2, and P3 were not significantly different. The best AWG was found in P4, which was the provision of natural Artemia feed enriched with spirulina powder at a dose of 2 g/L.

Observations showed that the growth performance of depik fry increased with increasing doses of spirulina powder as an enrichment for Artemia. This indicates that spirulina powder can increase the nutritional content of Artemia, such as protein content, resulting in higher growth performance. Consistent with these results, Saputra *et al.* (2025) stated that bioencapsulation of Artemia salina using a different enrichment material, namely single-cell protein (SCP), can increase protein levels in Artemia. The higher the SPC dose, the higher the protein retention in Artemia.

These results align with previous research on tilapia fry conducted by Youssef *et al.* (2023), which showed that the growth performance of tilapia fry (length, weight, and specific growth rate) fed spirulina-containing feed was significantly increased. This increase in growth is consistent with the increase in spirulina levels in the feed. According to Khalila *et al.* (2018), spirulina has a positive effect on fish growth due to its high content of protein, amino acids, vitamins, and minerals. Furthermore, according to Abdel-Tawabe *et al.* (2008), spirulina can increase fish appetite, thereby increasing feed consumption and impacting fish growth. Additionally, Al-Deriny *et al.* (2020) suggested that adding spirulina to fish feed can increase the length and width of intestinal villi, thereby improving nutrient absorption. Thus, spirulina, even at low doses, can meet fish nutritional needs without negatively impacting growth and feed efficiency (Zhang *et al.* 2020).

The survival rate of depik fry fed Artemia natural feed enriched with spirulina powder at different doses is presented in Table 2. Based on the ANOVA test, the provision of Artemia natural feed enriched with spirulina powder had a significant effect ($P < 0.05$) on the survival rate of depik fry. Meanwhile, based on Duncan's further test, P1 and P2 were not significantly different but were significantly different from other treatments, and P3 and P4 were not significantly different. The best survival was found in P3 and P4.

The high survival rate in P3 and P4 (treatments fed with higher doses of spirulina) is thought to be due to the feed containing sufficient nutrients and compounds that support the health of depik fry, resulting in good fish health. This is because the spirulina contained in the Artemia body acts as an immunostimulant (Abdellatief *et al.* 2018; Suyanto *et al.* 2019). According to Sedjati *et al.* (2022), studies have been conducted to maintain the health of aquaculture commodities using immunostimulants. This is evidenced by the results of research conducted by Abdellatief *et al.* (2018), which show that there was an increase in fish immunity after being fed spirulina. In addition, spirulina also contains phycocyanin, which can make fish immune to pathogen infections (Satyantini *et al.* 2016; Muchtar *et al.* 2019). The same research results were also mentioned by Sedjati *et al.* (2022), who found that Artemia encapsulated with spirulina (enriched with spirulina) resulted in higher survival rates compared to non-bioencapsulated Artemia. Suyanto *et al.* (2019) also stated that bioencapsulated *Artemia salina* with *Spirulina platensis* affected the survival rate of tilapia fry. Tilapia fed the highest dose of spirulina also showed high survival rates.

Table 1. Absolute weight growth (AWG), absolute length growth (ALG), and specific growth rate (SGR) of depik (*Rasbora tawarensis*) fry fed with natural Artemia feed enriched with spirulina powder.

Treatment	AWG (g)	ALG (mm)	SGR (%/day)
P1	0.04 ± 0.01^{a}	5.00 ± 0.00^{a}	2.92 ± 0.20^{a}
P2	0.05 ± 0.02^{ab}	6.00 ± 1.73^{a}	3.49 ± 1.11^{a}
P3	0.06 ± 0.00^{b}	6.33 ± 2.08^{a}	3.29 ± 0.57^{a}
P4	0.09 ± 0.00^{c}	10.33 ± 0.58^{b}	4.84 ± 0.39^{b}

Note: The same letters in the same column indicate treatments that are not significantly different ($P > 0.05$). The values listed are the mean and standard deviation.

Table 2. Survival rate of depik (Rasbora tawarensis) fry fed natural Artemia feed enriched with spirulina powder.

Treatment	Survival (%)
P1	65.00 ± 8.66[a]
P2	71.67 ± 7.64[a]
P3	83.33 ± 2.87[b]
P4	86.67 ± 2.88[b]

Note: The same letters in the same column indicate treatments that are not significantly different (P > 0.05). The values listed are the mean and standard deviation.

Table 3. Water quality data for the cultivation media for depik (Rasbora tawarensis) fry fed with natural Artemia feed enriched with spirulina powder.

Treatment	Temperature (°C)	pH	DO (mg/L)
P1	21.9	7.8	8.5
P2	21.8	8.2	8.5
P3	21.8	8.1	8.7
P4	21.6	8.1	8.7

Observations of the water quality of the depik fry maintenance media can be seen in Table 3. Based on the measurement results, the range of water quality, including temperature, pH, and DO in all treatments, was 21.6–21.9 °C, 7.8–8.2, and 8.5–8.7 mg/L, respectively. This water quality range is still within normal limits for depik maintenance. Based on the Government Regulation of the Republic of Indonesia Number 82 of 2001 (Class II), good water quality for freshwater fish cultivation is a pH of 6–9 and a DO level of more than 4 mg/L.

CONCLUSION

The growth and survival of depik fry can be improved by administering encapsulated spirulina powder to Artemia. The 2 g/L dose of spirulina powder resulted in the best growth performance compared to other treatments.

ACKNOWLEDGMENT

Thank you to Samudra University, UPTD BBI (Regional Technical Implementation Unit, Fish Hatchery Center), Lukup Badak, Gajah Putih University, and all the research teams involved in assisting in terms of funding or other assistance so that the research could be carried out well.

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