



Effect of *Moina* sp. Enrichment with Fishmeal on the Growth of Nile Tilapia (*Oreochromis niloticus*) Juveniles

Pengaruh Pengayaan *Moina* sp. Dengan Tepung Ikan Terhadap Pertumbuhan Benih Ikan Nila (*Oreochromis niloticus*)

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Abstract

This study evaluated the effectiveness of enriching *Moina* sp. with fishmeal as a natural feed to enhance the growth performance of Nile tilapia (*Oreochromis niloticus*) juvenile. A completely randomized design was applied with five treatments and four replicates, consisting of unenriched *Moina* sp., and enrichment levels of 6 g/L, 8 g/L, 10 g/L and 12 g/L fishmeal. Observed parameters included absolute length growth, absolute weight gain, specific growth rate (SGR) and survival rate. The results indicated that the treatments produced different growth responses, with the 8 g/L enrichment yielding the highest performance, producing an absolute length of 1.37 ± 0.457 cm, absolute weight of 1.32 ± 0.155 g and SGR of 4.93 ± 0.219 % per day. ANOVA demonstrated significant effects on absolute length, absolute weight and SGR ($p < 0.05$), while survival rate, ranging from 90.00–97.50 %, showed no significant differences among treatments ($p > 0.05$). Water quality parameters remained within suitable ranges throughout the culture period. Overall, enrichment of *Moina* sp. with fishmeal at 8–10 g/L exhibits strong potential as a strategy to improve the nutritional value of natural feed. This approach also aligns with sustainable aquatic resource management within the framework of SDGs 14.

Keywords: *Moina* sp., fish meal, Nile tilapia, growth, live feed enrichment

1. Introduction

Nile tilapia (*Oreochromis niloticus*) has long been one of the dominant aquaculture species, primarily due to its high economic value and steadily increasing demand in various major production regions (Susilowati *et al.*, 2016; Sopiandi *et al.*, 2022). This species is known for its good adaptability and tolerance to

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Abstrak

Penelitian ini mengevaluasi efektivitas pengayaan *Moina* sp. menggunakan tepung ikan sebagai pakan alami untuk meningkatkan performa pertumbuhan benih ikan nila (*Oreochromis niloticus*). Penelitian menggunakan rancangan acak lengkap dengan lima perlakuan dan empat ulangan, yaitu tanpa pengayaan, 6 g/L, 8 g/L, 10 g/L dan 12 g/L. Parameter yang diamati meliputi pertambahan panjang, pertambahan berat, laju pertumbuhan spesifik, dan tingkat kelangsungan hidup. Hasil analisis menunjukkan bahwa perlakuan memberikan respons pertumbuhan yang berbeda, dengan perlakuan 8 g/L menghasilkan panjang $1,37 \pm 0,457$ cm, berat $1,32 \pm 0,155$ g dan SGR $4,93 \pm 0,219$ % per hari. Uji ANOVA menunjukkan pengaruh signifikan pada panjang mutlak, berat mutlak dan SGR ($p < 0,05$), sedangkan tingkat kelangsungan hidup berada pada kisaran 90,00–97,50 % tanpa perbedaan nyata antarperlakuan ($p > 0,05$). Selama pemeliharaan, parameter kualitas air tetap berada pada kisaran yang sesuai untuk benih ikan nila. Secara keseluruhan, pengayaan *Moina* sp. dengan tepung ikan pada kisaran 8–10 g/L menunjukkan potensi sebagai strategi peningkatan nutrisi pakan alami. Pendekatan ini juga sejalan dengan tujuan pengelolaan sumber daya perairan yang berkelanjutan dalam kerangka SDGs 14.

Kata Kunci : *Moina* sp., tepung ikan, ikan nila, pertumbuhan, pengayaan pakan alami

changes in environmental conditions, making it a popular choice for both intensive and semi-intensive aquaculture (Job *et al.*, 2015). Its nutritional content, comprising high-quality protein, various essential minerals such as calcium, zinc, iron, magnesium, and sodium, as well as other important nutritional components, makes this fish an accessible source of animal-based food for the public (Pervin *et al.*, 2020; Uddin *et al.*, 2018). Nevertheless, during the juvenile stage, tilapia still exhibit a relatively high susceptibility to infections and other biological disturbances that can hinder their early growth performance (Azhar and Wirasisya, 2019; Akbar *et al.*, 2025b). Information

regarding the nutritional composition of tilapia from various freshwater ecosystems also indicates protein content ranging from 17–19%, which is generally dominated by essential amino acids such as lysine, as well as other important minerals, including selenium and calcium (Susilowati *et al.*, 2016). The combination of biological characteristics, economic value, and development potential makes tilapia an important subject of study, particularly regarding the nutritional aspects of the juvenile stage, which are critical to the success of subsequent rearing phases.

The potential for aquaculture development in Indonesia is estimated to reach 15.59 million hectares. Of this total, approximately 2.23 million hectares are utilized for freshwater aquaculture, 1.22 million hectares for brackish water aquaculture, and 12.14 million hectares for marine aquaculture. Nile tilapia is one of the most widely farmed species in Southeast Asia due to its simple rearing techniques and high adaptability. According to 2018 data, tilapia production reached 1,249,060.05 tons and increased to 1,337,831.69 tons in 2019. However, in 2020, production plummeted to 367,747.10 tons. Overall, these figures indicate an increase of approximately 88,771.64 tons from 2018 to 2019, before experiencing a drastic decline in 2020, with a total difference of 970,084.59 tons (Amalia *et al.*, 2018).

The potential for developing freshwater fish farming in Indonesia is reflected in the vast availability of land and water resources spread across various regions, as well as the high level of community involvement in utilizing economically valuable commodities such as tilapia (*Oreochromis niloticus*). National production data reported by the Ministry of Marine Affairs and Fisheries indicate that tilapia is one of the commodities experiencing increased distribution and development across various regions (Salsabila and Suprpto, 2018). These data illustrate the role of tilapia as a pillar of freshwater fisheries productivity and simultaneously as a provider of affordable animal protein for the community (Pramono *et al.*, 2018). Given the vast potential of available aquaculture areas, public interest in developing tilapia continues to grow because this commodity is easy to manage, has stable market prospects, and contributes to increased household income for those in the fisheries sector. The combination of market demand, the fish's adaptability, and the potential for utilizing aquatic resources makes tilapia aquaculture a strategic sector to be further developed in support of local economic activities across various regions (Salsabila and Suprpto, 2018; Pramono *et al.*, 2018).

Natural feed plays a very important role in supporting the growth and maintaining the survival of cultured organisms, particularly during the early stages of hatchery rearing. One type of natural feed commonly used is *Moina sp.*, a small zooplankton that fits within the mouth opening of fish juvenile. This organism contains nutrients that are easily absorbed by the juvenile's digestive system, thereby supporting optimal physical development. Its small and proportionate body shape makes *Moina sp.* suitable for consumption by fish larvae or juvenile, while its active movement stimulates feeding responses in young fish (Febriyanto *et al.*, 2017). In terms of nutritional content, *Moina sp.* has a composition of approximately 37.38% protein, 13.29% fat, 0.00% crude fiber, 11.00% ash, and a moisture content of 99.60%. Although its nutrient content is not as high as that of *Artemia sp.*, the quality of this organism can still be improved through enrichment processes to meet the nutritional needs of fish juvenile.

The use of fish meal in aquaculture has garnered widespread attention because this ingredient provides essential nutrients required by aquatic organisms. Its high protein content and the presence of omega-3 fatty acids make it an effective source of animal-based nutrition to support tissue development

and metabolism in fish larvae (Aryanti *et al.*, 2022). In addition to being used as a primary feed component, fish meal can also be utilized for zooplankton organisms such as *Moina sp.*, which then serve as high-quality live feed for fish juvenile. Previous studies have shown that fish meal possesses a balanced nutritional composition, including protein, fat, carbohydrates, fiber, and ash in appropriate proportions to enhance the nutritional value of natural feed (Christian and Madyaningrana, 2023). This material also provides various essential minerals, including zinc, iodine, magnesium, and selenium, which play a role in maintaining physiological functions and supporting the growth of aquatic organisms. With these characteristics, fish meal is a potential candidate for enrichment to improve the nutritional quality of *Moina sp.* before it is fed to fish during the early rearing phase.

Previous studies on the use of *Moina sp.* as natural feed for fish juvenile have been conducted by *et al.* (2023), on tilapia; Prastiwi *et al.* (2016), on catfish; and Dewi *et al.* (2019) on baung. However, to date, no studies have been conducted on the enrichment of *Moina sp.* with fish meal and its effects on tilapia (*Oreochromis niloticus*) juvenile.

2. Materials and Methods

2.1. Time and Location

This study was conducted at the Fish Histology and Nutrition Laboratory, Faculty of Marine Sciences and Fisheries, Syiah Kuala University. Nile tilapia juvenile were obtained from the Ujung Batee Brackish Water Aquaculture Center.

2.2. Equipment and Materials

The equipment used in this study included 20 jars, a pH meter, a thermometer, a DO meter, a refractometer, an aerator, aeration stones, a sieve, a scale, a ruler, a scoop, a camera, writing utensils, and a siphon tube. The materials used consisted of 200 tilapia fingerlings, fish meal, *Moina sp.*, and culture water prepared according to the research requirements.

2.3. Research Design

The research design was formulated using a Completely Randomized Design with five treatments and four replicates, modified based on the protocol by Mellisa *et al.* (2023). The fish meal concentrations used in the *Moina sp.* enrichment process were set as follows.

- Treatment A: No fish meal added (control).
- Treatment B: 6 g/L fish meal.
- Treatment C: 8 g/L fish meal.
- Treatment D: 10 g/L fish meal.
- Treatment E: 12 g/L fish meal.

2.4. Research Procedure

During the preparation phase, all research containers were first cleaned and arranged according to the experimental design. The containers used were 25-liter jars, which served as the seed rearing medium. After the cleaning process was complete, each jar was filled with 15 liters of clean water and equipped with an aeration system to ensure oxygen availability during the rearing period. All rearing units were then arranged according to the predetermined treatments so they were ready for use in the next stage.

2.4.1. *Moina sp.*

Moina sp. typically inhabits water bodies contaminated with organic matter, such as ponds and swamps. These waters often contain decaying wood and animal waste. Bacteria and phytoplankton serve as optimal food sources for the growth of *Moina sp.* Additionally, this species can be easily cultured using organic media or fertilizers, as organic fertilizers function as food

for *Moina* sp. (Danakusumah and Rahmatia, 2020). The preparation of the container used to culture *Moina* sp. involves a fiberglass tank, which is washed thoroughly and dried. Afterward, 2 kg of chicken manure is added and left for 3–5 days. Then, water is added to a depth of 30 cm and left to stand for another 2–4 days to cultivate microorganisms as food for *Moina* sp. Once the water turns a brownish-green color, additional water is added to a depth of 50–60 cm. *Moina* sp. larvae are introduced at a stocking density of 30 larvae per liter. Before release, *Moina* sp. is first washed thoroughly by placing the *Moina* sp. on a mesh cloth and rinsing with clean water; once clean, the *Moina* sp. is placed into the culture container. The growth density of *Moina* sp. typically peaks after 7 to 11 days.

2.4.2. Enrichment of *Moina* sp.

The fish meal was first weighed according to the predetermined concentration required for the enrichment process. *Moina* sp. was then placed into the enrichment containers according to the prepared treatments. Afterward, the fish meal at the concentration specified for each treatment was added to the containers. The mixture of *Moina* sp. and fish meal was left to stand for approximately five hours before being used as juvenile feed. This time is necessary to ensure optimal nutrient absorption in *Moina* sp., which generally takes about five to six hours, as reported by Prastiwi *et al.* (2016). After the enrichment process is complete, *Moina* sp. is harvested using a sieve, rinsed with clean water to remove residual enrichment materials, and then fed directly to the fish juvenile.

2.4.3 Fish Rearing and Feeding

Tilapia juvenile were reared for 30 days. The juvenile were placed in jars containing 15 liters of water at a density of 1 juvenile per liter (Linayati *et al.*, 2024). The enriched *Moina* sp. was provided as natural feed when the juvenile reached 25 days of age. Subsequently, *Moina* sp. is fed three times daily, at 08:00, 12:00, and 17:00 WIB. Feeding continues until the fingerlings are satiated.

2.5. Research Parameters

This study used the parameters of absolute length, absolute weight, specific growth rate, and survival rate to assess the growth response of tilapia juvenile (Akbar *et al.*, 2025d).

$$SGR = \frac{L_m - L_o}{\ln W_t - \ln W_o} \times 100$$

$$SR = \frac{N_t}{N_o} \times 100$$

The symbols used are explained as follows. L_m absolute length, L_t final length, L_o initial length, W_m absolute weight, W_t final weight, W_o initial weight, SGR specific growth rate, t rearing duration in days, SR survival rate, N_t number of live fish at the end of rearing, and N_o number of fish at the start of rearing.

2.6. Water Quality Parameters

During the study, water quality was monitored using four main parameters: pH, temperature, dissolved oxygen, and salinity. These parameters were measured at three observation stages: at the beginning, middle, and end of the rearing period (Akbar *et al.*, 2025c).

2.7. Data Analysis

Growth data, including absolute length, absolute weight, specific growth rate, and survival rate, were first organized into tables and then analyzed using SPSS 26. An ANOVA test at a significance level of $p < 0.05$ was used to assess differences among treatments, and Duncan's multiple range test was applied as a post-hoc test to identify treatments with significant differences. Water quality data recorded during the rearing period were presented descriptively, as they served only as supporting parameters for the rearing medium conditions.

3. Results and Discussion

3.1. Results

Statistical analysis showed that enriching *Moina* sp. with fish meal resulted in significant changes in the absolute length, absolute weight, and specific growth rate of tilapia juvenile, whereas survival rates did not differ significantly at the $p < 0.05$ level. During the study, absolute length values ranged from 1.37 ± 0.034 cm to 1.83 ± 0.105 cm, and treatment D emerged as the group with the most pronounced increase compared to the control. Absolute weight ranged from 0.84 ± 0.141 grams to 1.32 ± 0.155 grams, with treatment C yielding the highest value. Specific growth rate ranged from 3.26 ± 0.434 percent per day to 4.93 ± 0.219 percent per day, and treatment C again demonstrated the best performance, which was significantly different from the control. Regarding survival rates, all treatments fell within the range of 97.00 ± 8.870 percent to 97.50 ± 5.000 percent, with no significant differences between groups. Overall, the data pattern indicates that treatments C and D tended to yield better average growth values compared to other treatments, particularly for the parameters of absolute length, absolute weight, and specific growth rate, while all treatments maintained high and relatively similar survival rates.

Table 1. Data Analysis of Growth Parameters of Nile Tilapia (*Oreochromis niloticus*) Juvenile

Treatment	Absolute Length (cm)	Absolute Weight (grams)	Specific Growth Rate (%/Day)	Survival Rate (%)
A (Control)	1.37 ± 0.034^a	1.10 ± 0.130^{abc}	3.32 ± 0.489^a	92.50 ± 9.574^a
B (6 g/L)	1.71 ± 0.120^b	0.93 ± 0.066^{ab}	3.26 ± 0.434^a	95.00 ± 10.00^a
C (8 g/L)	1.37 ± 0.457^a	1.32 ± 0.155^c	4.93 ± 0.219^b	97.50 ± 5.000^a
D (10 g/L)	1.83 ± 0.105^b	0.84 ± 0.141^a	3.27 ± 0.527^a	97.50 ± 5.000^a
E (12 g/L)	1.74 ± 0.181^b	1.16 ± 0.270^{bc}	3.76 ± 0.834^a	90.00 ± 8.870^a

Note: Different superscripts in the same column indicate a significant difference ($p < 0.05$), while the same superscript in the column indicates that the values are not significantly different ($p > 0.05$)

Observations of water quality during tilapia juvenile rearing showed that the temperature ranged from 26.8 to 28 °C. The pH value was recorded between 7.5 and 7.8 during the rearing period. Dissolved oxygen measurements showed a value of 6.3 mg/L, while salinity was at 3 ppt. The quality standards used as a reference were a temperature of 25 to 30 °C, a pH of 6.5 to 8.5, dissolved oxygen greater than 5 mg/L, and salinity of 0 to 5 ppt. The water quality measurement data in the table show that all recorded parameters fell within the range of 26.8–28 °C for temperature, 7.5–7.8 for pH, 6.3 mg/L for dissolved oxygen, and 3 ppt for salinity. All these values were recorded periodically during the maintenance period and are presented as ranges and single values according to the measured parameters.

Table 2.

Analysis Data of Water Quality Test Parameters for Nile Tilapia (*Oreochromis niloticus*) Juvenile

Test Parameter	Temperature (°C)	pH	DO (mg/L)	Salinity
Water Quality	26.8–28°C	7.5–7.8	6.3	3
Quality Standards	25–30°C (SNI 6141:2009)	6.5–8.5 (SNI 6141:2009)	>5 (SNI 6141:2009)	0–5 (SNI 7550:2009)

3.2. Discussion

The enrichment of *Moina sp.* with fish meal was shown to significantly enhance the growth of Nile tilapia (*Oreochromis niloticus*) juvenile, particularly in terms of increased total length and body weight, with a p-value of <0.05. This performance improvement is associated with the increased content of protein and essential amino acids absorbed by *Moina sp.* during the enrichment process, as these components are essential for tissue formation and fish growth during the early stages. These findings align with the report by Lestari and Rahmatia (2021), which demonstrated that enriching *Artemia sp.* with vitamin A can stimulate the absolute length growth of catfish (*Pangasius*) juvenile. Additionally, the use of fish meal as an enrichment ingredient has been reported to effectively enhance the length and weight growth of white snapper larvae, attributed to its high nutritional content: carbohydrates 10.8%, ash 10.3%, fiber 2.6%, fat 6.3%, and protein 64.3%. Fish meal also contains essential minerals such as the essential fatty acids EPA and DHA, selenium, zinc, and magnesium, as well as iodine, which play a significant role in supporting metabolic processes and accelerating fish growth (Christian and Madyaningrana, 2023).

The contribution of fish meal to the enrichment process of *Moina sp.* is evident in the increase in the absolute weight of tilapia juvenile, as indicated by statistical test results with $p < 0.05$. This effectiveness is likely related to the higher protein and essential fatty acid content in *Moina sp.* following enrichment, enabling the juvenile to build body biomass more efficiently. A similar phenomenon was also reported in the enrichment of *Daphnia sp.* using soybean meal, which was shown to increase the absolute weight of carp juvenile through improvements in nutritional quality and digestibility (Prastiwi et al., 2016). Christian and Madyaningrana (2023) added that combining natural feeds such as *Nannochloropsis sp.* with fish meal can result in an increase in *Rotifera sp.* populations, which is more effective than using a single type of feed alone. In other commodities, the administration of *Chaetoceros-enriched Artemia sp.* was shown to optimize the growth rate and specific growth rate (SGR) of vanamei shrimp (*Litopenaeus vannamei*) larvae, although it did not affect their survival rate (Perdana et al., 2021). This aligns with the statement by Santoso and Hudaidah (2015) that enriched natural feed has higher nutritional value compared to unenriched feed, thereby significantly increasing feed utilization efficiency and protein deposition in the larvae's bodies.

The specific growth rate of tilapia juvenile showed significant differences among treatments ($P < 0.05$) when the *Moina sp.* fed to the juvenile was enriched with fish meal. The SGR serves as a measure of daily weight gain expressed as a percentage, thereby indicating how efficiently the juvenile utilize feed nutrients during rearing. These findings align with those of Fangka et al. (2023), who demonstrated that feeding *Daphnia sp.* supplemented with vitamin C significantly increased SGR. Research on moma catfish (*C. Meladarma*) larvae also noted an increase in SGR ($P < 0.05$) due to higher availability of metabolic energy and essential fatty acids, which are essential for supporting daily growth (Jayanthi and Arico,

2022). Tocher (2015) emphasized that the early life stages of fish require a large supply of essential fatty acids because larval metabolism is at a high level for the formation of new tissues. Thus, various previous reports reinforce the findings of this study that improving the nutritional quality of feed, whether through the enrichment of fish meal or the addition of specific nutrients, is directly related to increased SGR values in juvenile.

In contrast to growth parameters, the survival rate of tilapia juvenile did not show significant differences among the *Moina sp.* enrichment treatments with fish meal ($p > 0.05$). The high survival rates across all treatments, ranging from 90.00% to 97.50%, indicate that *Moina sp.*, whether enriched or not, remains suitable for use as natural feed during the early life stages of tilapia. This finding is consistent with the report by Prastiwi et al. (2016), which stated that although feed enrichment can enhance larval growth, its presence does not always have a significant impact on survival because environmental factors and rearing management play a greater role. A similar view was expressed by Izwan et al. (2021), who found that the survival of milkfish juvenile also did not differ between the enriched and control treatments, although growth showed significant variation. Sa'adah et al. (2023) emphasized that temperature and dissolved oxygen have a greater influence on larval survival compared to variations in nutrient quality, which remain within acceptable ranges. Additionally, Todolo et al. (2022) explained that the appropriate size and digestibility of *Moina sp.* can reduce stress and improve larval survival rates, while Casiraghi et al. (2025) added that fish survival in aquaculture is highly influenced by environmental conditions and feed efficiency. Thus, stable water quality during the study was the primary factor supporting the high survival rates across all treatments.

During the rearing period, measurement results showed that all water quality parameters fell within the ranges specified by SNI 6141:2009. The recorded temperature range, namely 26.8 to 28°C, is still within the range that supports the metabolic activity of tilapia juvenile. Arifin (2017) and Siegers et al. (2019) explain that the ideal temperature for tilapia growth is within the range of 28 to 32°C (). When temperatures drop below 25°C, fish activity typically begins to decrease, while at higher temperatures, appetite tends to decline, causing metabolism to slow down as well. A pH range of 7.5 to 7.8 indicates neutral to slightly alkaline water conditions, and this range is considered suitable for the physiological needs of tilapia juvenile. Dadiono et al. (2017) noted that freshwater fish generally tolerate pH conditions between 7 and 8.5, a range that supports optimal fish growth. Similar findings were reported by Pradhana et al. (2021), indicating that tilapia thrive in water with a stable pH range of 6.5 to 8.5. The dissolved oxygen concentration recorded during the study was 6.3 mg/L. According to Abdel-Tawwab et al. (2015), the minimum DO required to support tilapia growth is 5 mg/L, and values above 6 mg/L can efficiently support aerobic metabolic processes. The recorded salinity parameter, 3 ppt, is also within a safe range for tilapia fingerlings. Akbar et al. (2023) state that tilapia can grow at salinities ranging from 0 to 15 ppt, with optimal performance generally occurring between 0 and 5 ppt. Overall, stable water quality during rearing plays a crucial role in supporting juvenile growth and maintaining high survival rates, ranging from 90.00 to 97.50 percent across all treatments. Lamangkaraka et al. (2024) emphasize that water quality management is one of the key factors determining the success of tilapia aquaculture operations.

In general, this study indicates that the use of *Moina sp.* enriched with fish meal at a dosage range of 8 to 10 g/L significantly improves the growth performance of tilapia

juvenile. These improvements are reflected in the parameters of total length, total weight, and specific growth rate, while survival rates did not show any statistically significant differences. These findings suggest that the addition of fish meal enriches the nutritional components of *Moina sp.*, thereby enhancing the nutritional value of the feed consumed by the fingerlings. From a practical standpoint, the use of enriched *Moina sp.* can serve as an approach to improve the quality of natural feed in hatchery operations and enhance production efficiency. Nutrient contents such as protein, essential amino acids, and omega-3 fatty acids, which tend to increase after enrichment, are suspected to directly contribute to better growth responses during the early life stages of the juvenile. To validate these findings, further research involving a longer rearing period, proximate analysis of *Moina sp.* before and after enrichment, and measurement of fatty acid content such as EPA and DHA is essential to confirm the biochemical effectiveness of enrichment and determine the optimal dosage formulation for commercial-scale applications.

4. Conclusion

Research results on the enrichment of *Moina sp.* using fish meal in Nile tilapia (*Oreochromis niloticus*) juvenile indicate that variations in fish meal dosage ranging from 6 to 12 g/L did not result in statistically significant differences in growth parameters or juvenile survival rates ($p > 0.05$). Nevertheless, biological trends indicate that treatments with concentrations of 8 to 10 g/L yielded better growth responses compared to other treatments. These findings indicate that fish meal can enhance the nutritional value of *Moina sp.*, thereby making the feed provided to the fingerlings more nutritionally rich. Thus, the use of *Moina sp.* enriched with fish meal has the potential to serve as a natural feed alternative that can help address the nutritional limitations of conventional feed and support the growth performance of tilapia fingerlings during the early rearing phase.

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