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THE EFFECT OF UTILIZING ASIAN CLAM (*Anodonta woodiana*) AS A SUSPENSION FEEDER ON THE WATER QUALITY OF NILE TILAPIA (*Oreochromis niloticus*) IN A YUMINA BUMINA SYSTEM WITH MINIMAL LAND USE.

Pengaruh Pemanfaatan Kerang Kijing (*Anodonta woodiana*) Sebagai Suspension Feeder Terhadap Kualitas Air Ikan Nila Dalam Sistem Yumina Bumina, Lahan Minimalis

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ABSTRACT

Integrated Multi-Trophic Aquaculture (IMTA) has limitations in its application due to the requirement for large cultivation areas. To address this issue, the IMTA system has been modified into the yumina bumina system, utilizing freshwater mussels (*Anodonta woodiana*) as suspension feeders and water spinach (Ipomoea reptans) as nitrogen absorbers. This study employed a completely randomized design with three treatments: (A) Nile tilapia without freshwater mussels, (B) Nile tilapia with 25 freshwater mussels per 15L, and (C) Nile tilapia with 50 freshwater mussels per 15L, over a 30-day period. The results indicated that the addition of freshwater mussels increased nitrite and nitrate levels in treatments B and C, yet supported specific growth rates of Nile tilapia in terms of length and weight, with the highest values observed in treatment C (1.05%/day) and B (3.75%/day), respectively. The system also achieved a survival rate of Nile tilapia above 80% with acceptable water quality parameters, including neutral pH (7.86–8.16) and high dissolved oxygen levels (17.77–18.02 mg/L). This integration demonstrates significant potential for optimizing Nile tilapia production efficiently while ensuring environmental sustainability.

Keywords: aquaponic, freshwater mussel, suspension feeder, urban farming, yumina bumina

ABSTRAK

Integrated Multi Trophic Aquaculture (IMTA) memiliki kekurangan dalam sistem budidaya karena membutuhkan lahan yang luas. Mengatasi hal tersebut maka teknologi IMTA diubah menjadi sistem yumina bumina dengan memanfaatkan kerang kijing (*Anodonta woodiana*) sebagai *suspension feeder* dan tanaman kangkung (*Ipomoea reptans*) sebagai penyerap nitrogen. Studi ini menggunakan rancangan acak lengkap dengan tiga perlakuan, yaitu (A) ikan nila tanpa kerang kijing, (B) ikan nila dengan 25 ekor kerang kijing/15L, dan (C) ikan nila dengan 50 ekor kerang kijing/15L, selama 30 hari. Hasil menunjukkan bahwa penambahan kerang kijing meningkatkan kadar nitrit dan nitrat pada perlakuan B dan C, namun tetap mendukung laju pertumbuhan panjang dan berat spesifik ikan nila, masing-masing tertinggi pada perlakuan C (1,05%/hari) dan B (3,75%/hari). Sistem ini juga menghasilkan tingkat kelangsungan hidup ikan nila di atas 80% dengan kualitas air yang layak, termasuk pH netral (7,86–8,16) dan oksigen terlarut tinggi (17,77–18,02 mg/L). Integrasi ini menawarkan potensi besar untuk mengoptimalkan produksi ikan nila secara efisien sekaligus menjaga keberlanjutan lingkungan.

Kata kunci: kerang kijing; suspension feeder; akuaponik; urban farming; yumina bumina

INTRODUCTION

Fisheries cultivation is one of the important efforts to increase the production of aquatic species that can be carried out in marine and freshwater waters. However, along with the increase in human population, land for cultivation activities is increasingly limited, especially in urban areas. One of the solutions that can be applied is urban farming, which is an urban agricultural system that not only covers agriculture, but also livestock, aquaculture, agroforestry, and horticulture (Wijaya et al., 2020). In the context of aquaculture, urban farming allows the use of narrow land to support food production, although often the quality of aquaculture media, especially water, has not been managed optimally.

Water quality is a major factor that affects the success of fish farming. Parameters such as dissolved oxygen (DO), pH, and nitrogen concentrations (ammonia, nitrite, and nitrate) need to be kept from decreasing during the cultivation process. Increased nitrogen concentrations are often caused by uneaten feed residues, fish excretion, and other metabolic outcomes. One approach to overcome this problem is to use kijing mussels (Anodonta woodiana) which act as suspension feeders. These organisms are able to filter suspended particles in water, including nitrogen compounds, thus helping to maintain water quality (Sari, 2021). The use of kijing mussels can also be integrated in Integrated Multi-Trophic Aquaculture (IMTA) systems, an environmentally friendly cultivation technique that utilizes waste from one organism as an energy source for other organisms (Munaeni et al., 2023).

To adapt IMTA to the needs of narrow land, the Yumina Bumina system is a relevant alternative. Yumina is an abbreviation for Nabati Mina which means Vegetables and Fish, while Bumina is an abbreviation for Buah Mina which means Fruit and Fish (Sarah & Pramulya, 2021). This system integrates fish farming with plants such as kale (Supendi et al., 2016), which are known as people's favorite crops and are easy to grow in hydroponic systems. Kale functions to absorb ammonia, nitrites, and nitrates from the cultivation medium, thereby supporting the growth of tilapia and maintaining water quality. Therefore, research that combines the Yumina Bumina system with kijing mussels and kale plants is expected to be a solution to improve the efficiency of tilapia cultivation on limited land, while preventing environmental pollution.

RESEARCH METHODS

Place and Time

This research was conducted for 30 days in September 2024 in Kubu Village, Kumai District, West Kotawaringin Regency, Central Kalimantan Province. Analysis of ammonia, nitrite and nitrate in water was carried out at the Regional Health Laboratory, West Kotawaringin Regency.

Research Design

The research method used in this study is the RAL (Complete Random Design) method. This study consists of 3 treatments and 3 replicates for each treatment, so that in this study there are 9 experimental units, namely the addition of kijing mussels to the yumina bumina system as follows:

A : 20 Tilapia
B : 20 tilapia + 25 kijing clams/15L
C : 20 tilapia + 50 kijing mussels/15L

Procedure

1. Research preparation
   a) Yumina bumina system
   The yumina system used is the Nutrient Film Technique (NFT) system. Treatment A is carried out by draining water from the tilapia cultivation medium to the paralon pipe and back to the tilapia container. Treatment B and C is carried out by draining water from tilapia cultivation media first to the kijing clam container, then flowing to the paralon pipe and back to the tilapia container.
   b) The number of kijing mussels used in treatment B and C was different, where in treatment B there were 167 fish/container and 333 shellfish/container for treatment C.
   c) Feeding is carried out 3 times a day at 08:00, 12:00 and 16:00 with the provision of 10% of the weight of tilapia biomass.
2. Research Parameters
   a) Survival Rate
   The survival rate (TKH) of fish is calculated based on the following equation:

$$TKH = \frac{Nt}{No} \times 100$$

   Information:
   TKH = Survival rate (%)
   N_t = Number of fish at the end of the study (tail)
   N_0 = Number of fish at the beginning of the study (tail)

   b) The growth rate of the specific weight of tilapia is calculated using the formula below:

$$LPBS\ (\%/hari) = (Ln\ W_t - Ln\ W_o)/t \times 100$$

   Information :
   LPBS = Specific weight growth rate (%/day)
   W_t = Average weight at the end of maintenance (g)
   W_o = Average weight at the beginning of maintenance (g)
   t = Study period (days)

   c) The specific length growth rate of tilapia is calculated using the formula below:

$$LPPS\ (\%/day) = (Ln\ W_t - Ln\ W_o)/t \times 100$$

   Information :
   LPPS = Specific length growth rate (%/day)
   W_t = Average weight at the end of maintenance (g)
   W_o = Average weight at the beginning of maintenance (g)
   t = Study period (days)

RESULT

Water Quality Parameters

Ammonia

Ammonia content levels were measured at the beginning and end of maintenance, showing different results at each treatment. The measurement results can be seen in the Figure 1.

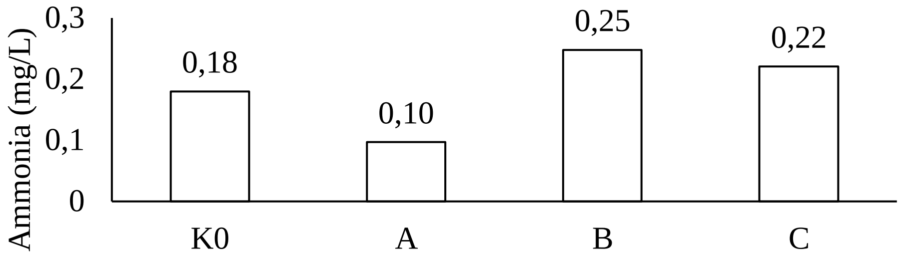

Figure 1. Ammonia content

Ammonia measurements were only taken on raw water and at the end of the study. Figure 1 shows the difference in ammonia levels affected by kijing and kale mussels. The graph shows that the ammonia content at K0 has a value of 0.18 mg/L. In treatment A, the ammonia content at the end of the study was reduced to 0.10 mg/L, while in treatments B and C, the ammonia content increased to 0.25 mg/L and 0.22 mg/L.

Nitrite

The nitrite levels in the cultivation medium measured at the beginning and end of maintenance, showed different results in each treatment. The measurement results can be seen in Figure 2.

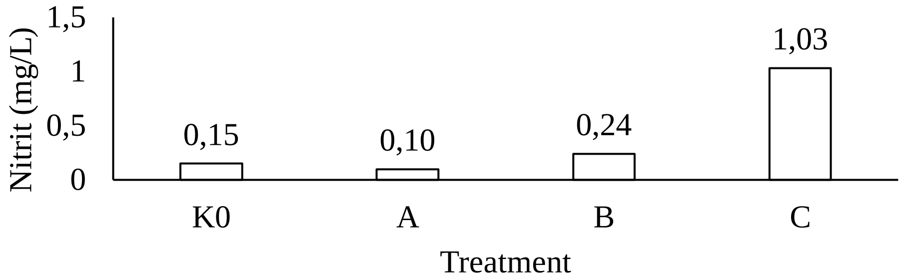

Figure 2. Nitrite Content

Nitrite measurements were only performed on raw water and at the end of the study. Figure 2 shows the difference in nitrite levels affected by kijing and kale mussels. The nitrite content at K0 had a value of 0.15 mg/L. In treatment A, the nitrite content at the end of the study was reduced to 0.10 mg/L, while in treatment B it increased to 0.24 mg/L. The nitrite content increased in treatment C, which was 1.03 mg/L.

Nitrate

The nitrate content of tilapia cultivation media was measured at the beginning and end of maintenance, showing different results in each treatment. The measurement results can be seen in Figure 3.

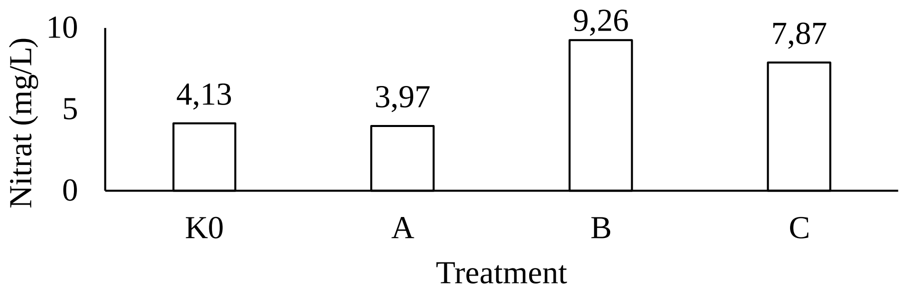

Figure 3. Nitrate Content

Nitrate measurements were only carried out on raw water and at the end of the study. The figure above shows that there are differences in nitrate levels influenced by kijing and kale mussels. Figure 3 shows that the nitrate content at K0 has a value of 4.13 mg/L. In treatment A, the nitrate content at the end of the study was reduced to 3.97 mg/L, while in treatment B and C it increased to 9.26 mg/L and 7.87 mg/L.

Temperature

The temperature levels in the cultivation medium measured at the beginning and end of maintenance, showed different results in each treatment. The measurement results can be seen in Figure 4.

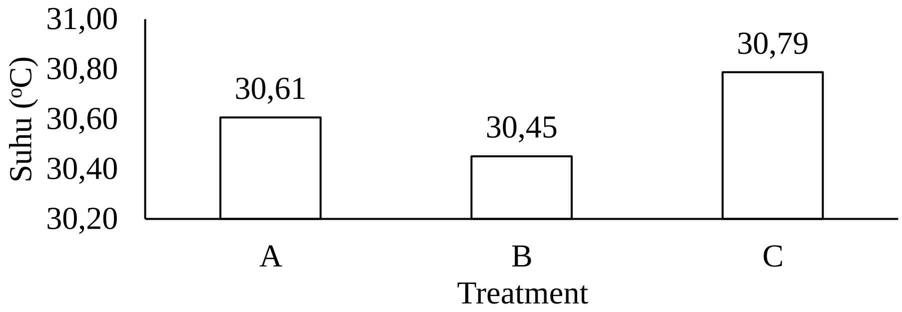

Fig 4. Average water temperature

Temperature measurements are carried out for 30 days, temperature measurements are carried out in the morning, afternoon and evening. on raw water and at the end of the study. The graph above shows the difference in temperature affected by the weather, where the research model is placed in an open area. Figure 4 shows that the lowest water temperature is in treatment B (30.45oC) and the highest is in treatment C (30,79ºC).

Degree of Acidity (pH)

The pH level in the cultivation medium measured at the beginning and end of the maintenance showed different results in each treatment. The measurement results can be seen in the Figure 5.

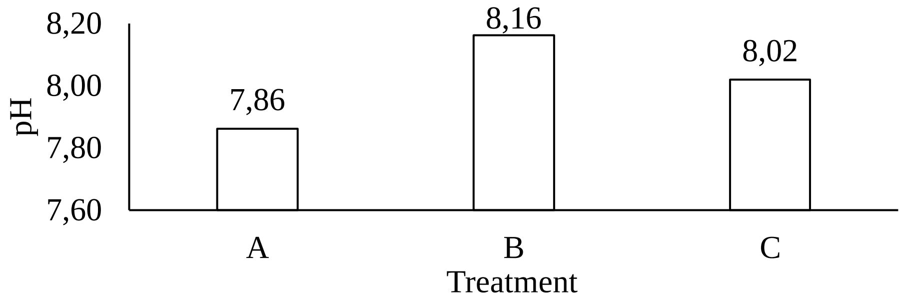

Figure 5. Average water temperature

pH measurements are carried out for 30 days, pH measurements are carried out in the morning, afternoon and evening. on raw water and at the end of the study. The graph above shows that there is a difference in pH influenced by kale and kijing mussels. Figure 5 shows that the lowest water pH is in treatment B (7.86) and the highest is in treatment C (8.16).

Dissolved Oxygen (DO)

The DO content in the cultivation medium measured at the beginning and end of the maintenance showed different results in each treatment. The measurement results can be seen in Figure 6.

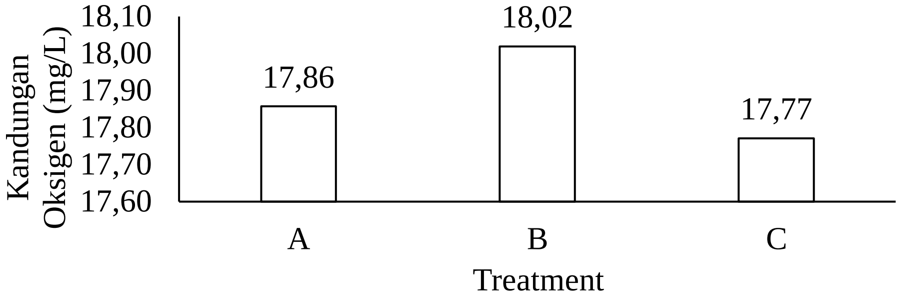

Figure 6. Average dissolved oxygen content (DO)

DO measurements are carried out for 30 days, DO measurements are carried out in the morning, afternoon and evening. on raw water and at the end of the study. The graph above shows that there is a difference in DO influenced by kale and kijing mussels. Figure 5 shows that the lowest water DO is in treatment B (7.86) and the highest is in treatment C (8.16).

DISCUSSION

Based on the results of the research that has been carried out, the addition of kijing mussels to tilapia cultivation media with the yumina bumina system. Kijing mussels as aquatic biota that have the property of suspension feeder absorb all food that is filtered in the form of small particles in the form of feed waste and feces suspended in the water column (Chopin et al., 2012). The mussel itself is a mollusk that can utilize organic apricot derived from aquaculture waste for its growth process (Sara et al., 2009). The addition of kijing mussels in the yumina bumina system yields ammonia, nitrite and nitrate. After the calculation, parameters A, B and C had significant results ($P<0.05$).

The results of the ammonia statistical test on H-30, stated that there was a real difference in each treatment ($P<0.05$). This happens because kijing clams, although they function as suspension feeders, also expel feces that also become ammonia. Ammonia is formed from feed waste and feces containing nitrogen and phosphorus (Marda et al., 2015). So that the more kijing mussels are used, the more dirt is released. The manure also comes from tilapia and there is no water change during the maintenance process. Organic waste at the bottom of the water settles and becomes toxic to fish. Chen et al. (2006) explained that the level of ammonia that can be toxic for fish farming is at concentrations above 1.5 mg/l, even in extreme conditions the acceptable concentration is only 0.025 mg/l.

The results showed that the value of ammonia levels in treatment A, B and C <1 mg/L was included in raw water. This value is considered good for the survival of tilapia. The results of the ammonia statistical test can be seen in the Table 1.

Table 1. Ammonia statistical test results

Treatment	Statistical Test Results	Unit
A	0,10±0,043[a]	mg/L
B	0,25±0,035[b]	mg/L
C	0,22±0,016[b]	mg/L

Based on the results of these statistics, it can be seen that there is a difference between treatment A and treatment B and C, this means that with the addition of kale and kijing mussels, there is a difference in the ammonia content. Treatment B had the highest ammonia content, which was 0.25±0.0035 mg/L. The increase in ammonia content in treatment B was one of the factors for the low survival rate of fish (86.67%). The increase in treatment B was due to the occurrence of death in several unknown kijing mussels, the results of kijing mussel metabolism, tilapia metabolism results, feed residue deposits and the absence of water change processes which all accumulated at the base of the maintenance medium. The high ammonia content can cause death in fish. In line with the statement of Agustiani & Mirwan (2024), the presence of ammonia in high concentrations can cause poisoning in fish and other aquatic organisms, as well as affect the nitrification process in the aquatic environment.

The lowest ammonia value was in treatment A. ammonia content in treatment A was 0.10±0.043a. The low ammonia content is due to the absence of 1) the addition of kijing mussels, but ammonia still occurs due to the results of fish metabolism and feed residues. 2) The active nitrification process carried out by nitrosomonas bacteria converts ammonia into nitrite which is one of the causes of low ammonia content. This process is carried out by oxidizing the sediment at the base of the maintenance medium as an energy source (Fadillah et al., 2022)

Nitrite is a compound formed from nitrification with the help of nitrosomonas bacteria. Nitrosomonas bacteria utilize the results of ammonia nitrification to produce nitrites. Based on the results of statistical tests, the nitrite content in each treatment can be seen in the Table 2.

Table 2. Nitrite statistical test results

Treatment	Statistical Test Results	Unit
A	0,10±0,012[a]	mg/L
B	0,24±0,048[b]	mg/L
C	1,03±0,744[b]	mg/L

Based on the results of these statistics, it can be seen that there is a difference between treatment A and treatment B and C, this means that with the addition of kale and kijing mussels, there is a difference in nitrite content. The high nitrite content in treatment C is suspected to be the activity of nitrosomonas bacteria in decomposing ammonia into nitrites and the lack of nitrobacter bacteria in decomposing nitrites into nitrates. The high nitrite content is also caused by the lack of nitrite absorption by kale. This is supported by the statement of Sari et al., (2015) where plants can only absorb ammonium and nitrate ions in the form of a solution, but nitrites cannot be absorbed by plant roots.

Nitrites that are not absorbed by plants will have a toxic impact on the maintenance medium, even causing death for tilapia. The nitrite content must be immediately converted into nitrate by the nitrification process of nitrite into nitrate. The nitrification process makes kale plants absorb nitrates as a source of energy for growth in kale. The nitrate content in the preservation medium ranged from 3.97±1.95a mg/L to 9.26±0.349a mg/L. The nitrate content in the preservation medium was caused by the activity of nitrobacter bacteria in the nitric nitrate to nitrate process. The lack of absorption of ammonia and nitrate by kale is also one of the factors for the high nitrate levels. The content of ammonia, nitrite and nitrate is inseparable from other water quality parameters such as pH, DO and water temperature.

The nitrification process from ammonia to nitrate requires a large amount of oxgen content of 1.5 mg/L in the ammonia to nitrite process and requires 0.5 mg/L (Robertson, 2007 in Marda et al., 2015). In addition to nitrification needs, the oxygen content in water is also used by other aquatic biota such as phytoplankton and zooplankton, so high dissolved oxygen levels are needed. The dissolved oxygen content in the study ranged from 17.77±0.96 mg/L to 18.02±1.09 mg/L. The value of dissolved oxygen content was very high compared to some studies using tilapia, such as 6 mg/L (Hernayanti et al., 2024) and 10.32 mg/L (Adi & Suryana, 2023). The high level of dissolved oxygen makes the preservation medium suitable for tilapia maintenance.

pH is an important indicator in the fisheries sector, if the pH value leads to acid, it will inhibit the growth of fish until death, as well as if the pH value leads to alkaline. Based on the results of statistical tests, the pH value between the treatments was significantly different ($P<0.05$). This means that the addition of kijing mussels to the yumina bumina system has an effect on the pH value. The pH value in the results of this study ranged from 7.86±0.26 to 8.16±0.34. The pH value is still in the neutral pH range for fish, which means it is not acidic and not alkaline. Some studies related to tilapia have the following pH values: 7.30-7.65 (Adi & Suryana, 2023), 6.7-7.5 (Ridoanrisna et al., 2024) and 8 (Hernayanti et al., 2024). Based on the results of previous researchers, the pH value is included in the pH value range, so that the pH is ideal for tilapia cultivation activities with the yumina bumina system.

Based on the results of the statistical test, there was no real difference in temperature values between the treatments ($P>0.05$) this occurred because the research model was outdoors which was directly exposed to sunlight, so that weather factors had an effect on the temperature conditions in the yumina bumina system. The water temperature range starts from 30.16oC to 30.79oC, which is still ideal for tilapia cultivation activities. Temperature results during the maintenance period are still included in the ideal category, which refers to Adi & Suryana, (2023) which is included in the temperature range from 28.7 – 31.7oC.

The results of all water quality will greatly affect the survival and growth of tilapia, both from heavy and long growth. The survival rate of tilapia during the rearing period gives a yield of >80%. The results are very good, because the average survival rate of tilapia during the research process is 86.67% – 91.67%. The results of the statistical test showed that the survival rate of tilapia did not differ significantly ($P>0.05$). There was no significant difference in the results of statistical tests, indicating that the average survival rate in each treatment and replicate had a value that was not much different. One of the things that affects the survival rate of tilapia is carrying capacity. In the aquaculture business, it is very important to consider the carrying capacity of the environment to be able to ensure the continuation of ecological balance (positive interaction) between aquaculture biota, pathogens, and the environment, through dense stocking that is still in accordance with the carrying capacity of the environment (Latuconsina, 2020). The high survival rate has an impact on the growth rate of tilapia, where the growth of tilapia in this study is seen from two sides, namely long growth and heavy growth.

The growth value of length and weight in tilapia can be seen in the following Table 3:

Table 3. Specific growth rate and weight values in tilapia.

Treatment	Specific Length Growth Rate	Specific Length Growth Rate
A	0,98±0,11a	2,79±0,08a
B	1,01±0,09a	3,75±0,30b
C	1,05±0,12a	3,56±0,35b

Based on Table 3, it can be seen that the highest value in the highest length growth rate is in treatment C (1.05±0.12) while the highest value in the specific weight growth rate is in treatment B (3.75±0.30). The difference in the highest results in LPPS and LPBS was due to the difference in the weight and length of the fish at the beginning of the study. The difference in weight and length at the beginning of the study resulted in different feed values given, where feed was given based on a percentage of the total weight of the fish in each rearing container.

CONCLUSION

The best treatment in this study was treatment C, which was treatment with 20 tilapia and 50 kijing/15L clams. The water quality in the form of ammonia, nitrite and nitrate in C treatment was higher than that of B treatment, where the content of ammonia (0.24mg/L, nitrite 1.08 mg/L and nitrate 8.82 mg/L with a survival rate of 91.67%, specific weight growth rate of 3.56%, specific length growth rate of 1.05%.

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