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Comparative Study of Growth Circle Patterns in Otoliths of Guppy Fish (*Poecilia reticulata*) from Areas Polluted with Domestic Sewage

Studi Komparatif Pola Lingkaran Pertumbuhan pada Otolith Ikan Guppy dari Area yang Tercemar Limbah Domestik

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Abstract

Guppy fish (*Poecilia reticulata*) inhabit polluted water, such as domestic waste-filled ditches in residential areas, as well as in rivers. These two habitats have different water qualities, which affects the growth of the fish; this is reflected in the pattern of growth rings in the otoliths. To determine the differences in growth ring patterns of otoliths in guppies living in ditches versus the river, a study was conducted in March and April 2025. Fish were caught using a scoop net once every 2 weeks, three times. The fish were measured, and otoliths were taken. They were then attached to objects made of glass and manually shaved using a smooth grindstone. The growth rings in the otolith were observed using a microscope. Results showed that 103 fish were caught, 50 from the trench and 53 from Tangkerang River. The size of the fish caught was 18-31 mm from the trench and 17-31 mm from the river. In fish with the same total length, the otoliths from the river were longer and wider (0.5-1 mm in length and 0.4-0.95 mm in width), whereas those from the trench were shorter (0.42-0.85 mm in length and 0.4-0.67 mm in width). The maximum number of dark rings on the otoliths of fish from the ditch was 3, whereas from the river, it was 4. There were 27 fish from the river and 18 fish from the trench that had no dark ring in the otolith. The data obtained show that the growth of guppies in the Tangkerang River is better than in the Purigiam Housing trench.

Keywords: Fish Growth, Ditch, Polluted Water, Dark Ring

Abstrak

Ikan guppy (*Poecilia reticulata*) mendiami perairan yang tercemar limbah domestik seperti selokan di daerah pemukiman dan juga di sungai. Kedua habitat ini memiliki kualitas air yang berbeda, sehingga mempengaruhi pertumbuhan ikan, hal ini tercermin dari pola cincin pertumbuhan pada otolith. Tujuan penelitian adalah mengetahui perbedaan pola cincin pertumbuhan pada otolith ikan guppy yang hidup di parit dan di sungai, maka dilakukan penelitian pada bulan Maret sampai April 2025. Ikan ditangkap dengan menggunakan jaring serok, sekali dalam 2 minggu, sebanyak 3 kali. Ikan diukur, diambil otolithnya, ditempelkan pada kaca objek dan diserut secara manual menggunakan batu asah halus. Cincin pertumbuhan pada otolith diamati dengan menggunakan mikroskop. Hasil penelitian menunjukkan bahwa 103 ikan tertangkap, 50 ekor dari parit dan 53 ekor dari Sungai Tangkerang. Ukuran ikan yang tertangkap adalah 18-31 mm dari parit dan 17-31 mm dari sungai. Pada ikan dengan panjang total yang sama, otolith ikan dari sungai lebih panjang dan lebar (panjang 0,5-1 mm dan lebar 0,4-0,95 mm), dari parit (panjang 0,42-0,85 mm dan lebar 0,4-0,67 mm). Jumlah maksimum cincin hitam pada otolith ikan dari parit adalah 3, sedangkan dari sungai adalah 4. Ada 27 ikan dari sungai, 18 ikan dari parit yang tidak memiliki cincin hitam pada otolith. Data yang diperoleh menunjukkan bahwa pertumbuhan ikan guppy di Sungai Tangkerang lebih baik dibandingkan dengan parit Perumahan Purigiam.

Kata kunci: Pertumbuhan Ikan, Parit, Air Terpolusi, Lingkaran Gelap

1. Introduction

The guppy fish (*Poecilia reticulata*) exhibits a variety of forms that can be distinguished based on their habitats, including ornamental guppies and guppies that inhabit open waters such as ditches and rivers. The differences and characteristics of these two variations can be recognized by their colors and patterns. Ornamental guppies typically possess brighter and more attractive colors, whereas guppies living in ditches tend to have duller or less vibrant colors. Ditch-dwelling guppies must adapt to murky, polluted water conditions that are rich in organic matter. This fish also plays a beneficial role in the ecosystem, particularly as a controller of mosquito larvae. Guppy has been widely used as a biological control agent to manage mosquito larval populations, especially in polluted waters (Dua et al., 2007). Guppy fish have a wide habitat and can adapt to various water conditions, exhibiting effective biological adaptations to unfavorable environmental conditions (Montag et al., 2011).

In the city of Pekanbaru, guppy fish can be found in the Purigiam Housing trench and the Tangkerang River. The Purigiam housing trench serves as the primary conduit for collecting and draining household waste from the entire Purigiam housing area. The waste entering this trench consists of various types of domestic waste. The Tangkerang River also receives different kinds of domestic waste, including household waste, waste from small businesses, and waste from eateries and restaurants along its course. However, the relatively large size of the river, along with the flowing water and currents, suggests that the waste may have been diluted and subjected to some degree of purification. Salmin (2005) states that the introduction of pollutants into a body of water affects the growth of organisms and impacts population decline. The differences in environmental characteristics and water quality in the Purigiam Tuah Karya Housing Canal and the Tangkerang River can influence the livelihood of guppy fish in both areas, which will be evident in the growth ring patterns on the fish's otolith.

Otoliths, also known as ear stones, are small structures composed of calcium carbonate located in the inner ear, specifically within the saccule of all teleost fish (Popper & Fay, 2011). The otolith of fish was initially used to estimate the age of fish, which is an essential parameter for revealing population dynamics and managing fish stocks sustainably (Stransky et al., 2008; Leguá et al., 2013). Otoliths or ear bones are organs that function to detect vibrations and also serve as balance organs in fish. These bones are located in a cavity (sacculus) in the inner ear. The inner ear of fish contains three cavities, each containing an otolith: lapillus, saggita (the largest otolith), and asteriscus (Windarti & Simarmata 2017). The otolith is pure white in color, convex on the dorsal side, with a solid middle section with serrated edges, and is quite large and hard. The nucleus of the otolith is located in the center, shaped solidly and convex (Siahaan 2021).

The differences in environmental characteristics and water quality between the two waters allow for variations in growth patterns among guppy fish living in the Purigiam Housing Trench and the Tangkerang River. This research aims to determine the growth ring patterns in the otoliths of guppy fish from the Purigiam housing trench and Tangkerang River.

2. Material and Method

2.1. Time and Place

This research was conducted in March and April 2025 at the Purigiam Tuah Karya Housing Trench and the Tangkerang River. Fish samples were collected and then placed into a cool box packed with ice. Subsequently, otoliths were analyzed in the Aquatic Biology Laboratory of the Faculty of Fisheries and Marine, Universitas Riau.

2.2. Methods

The method used in this research is the survey method.

2.3. Procedure

2.3.1. Collection and Measurement of Otolith

The stages involved in the collection of otoliths, according to Windarti & Asmika (2017), are as follows: the bones between the operculum are cut, and then the head is bent towards the dorsal side until the connection between the skull bones and the vertebral column is broken. Next, the gills and tissue in the fish's mouth are removed, revealing the white bones. The bones are then opened, after which the otolith is extracted using a small pair of tweezers to prevent the otolith from breaking or being damaged. Subsequently, the otolith is dipped in a bleach solution to remove any remaining tissue, then rinsed with water, dried with a tissue, and placed in a labeled plastic clip.

The otoliths were measured using a micrometer mounted on an Olympus CX 21 binocular microscope. The number of otoliths collected corresponds to the number of fish sampled from each water body. One otolith was taken from each fish to be prepared as a specimen for observing the growth ring patterns on the otoliths.

2.3.2. Adhesion and Polishing of Otoliths

The work procedures for preparing otolith specimens, as outlined by Windarti & Asmika (2017), are as follows: Small otolith polishing (size ≤ 3 mm). Small particles of crystal bond are placed in the center of the labeled object glass, and then the object glass is heated on a hot plate set to approximately 80°C. After the crystal bond has melted, the sliding glass is removed from the hot plate, and the otolith is immediately placed onto the crystal bond while it is still hot. The position of the otolith is adjusted using a needle heated with a Bunsen burner, with the core of the otolith located on top. The crystal bond is allowed to cool and harden.

Once the otolith is firmly attached and the crystal bond has cooled, the otolith begins to be ground, ensuring that the grinding is done in a consistent, forward motion. After achieving the desired position, grinding is halted, and the sliding glass is dried using tissue and reheated. Once the crystal bond is melted, the object glass is lowered from the hotplate, and the otolith is flipped over, allowing it to cool again. The otolith is ground once more until the desired position is reached, ensuring that the core of the otolith is visible. After grinding, the object glass is placed back on the hotplate, and a small amount of crystal bond is placed on top of the otolith, waiting for it to melt and cover the otolith (while adjusting with the heated needle). The object glass is then allowed to cool, and the ground otolith, now covered with crystal bond, is ready for observation.

2.4. Data Analysis

The data obtained includes measurements of the fish's length and weight, the otolith's length and width, and the number of dark growth rings. This data is presented in the form of tables, graphs, and images.

3. Result and Discussion

3.1. The Quantity of Guppy Fish

Samples were taken from the Purigiam Housing Trench and the Tangkerang River in March 2025. Fish were captured using a 3 mm mesh-size scoop net. A total of 103 fish were obtained, with 50 fish from the Purigiam Housing Trench and 53 from the Tangkerang River. The captured fish had a total length (TL) ranging from 17 to 31 mm, with a body weight (BW) between 0.006 and 0.032 g. In this study, the fish were divided into eight size groups based on a modified sampling grouping method from Sudjana (2006). The number of guppy fish caught in the Purigiam Housing Trench and the Tangkerang River is shown in Table 1.

Table 1. The number of guppy fish caught in the Purigiam Housing Trench and the Tangkerang River is based on total length (TL).

Group	Class Size (TL, mm)	Purigiam Housing Trench	Tangkerang River
I	17-18	2	6
II	19-20	14	19
III	21-22	6	9
IV	23-24	14	5
V	25-26	8	5
VI	27-28	3	5
VII	29-30	2	4
VIII	31-32	1	0
Total		50	53

The size group of guppy fish from the Tangkerang River tends to be more abundant in the small size category (17-22 mm). In contrast, in the Purigiam Housing Trench, the size of the fish is more varied and relatively uniform, ranging from 19 to 26 mm. Several environmental factors, including food availability and varying ecological conditions, may contribute to this difference. In favorable environmental conditions, fish can grow well, resulting in larger sizes. This aligns with Siregar's (2018) opinion, which states that factors affecting the stunted growth of fish include poor environmental conditions, inadequate food availability, and diseases. In terms of food availability, the types of food for guppy fish include zooplankton, phytoplankton, larvae or mosquito wrigglers, microworms, protozoa, detritus, algae, and fragments of aquatic plants (Lawal et al., 2012). The drainage of Purigiam Housing has relatively smaller and shallower dimensions, containing numerous mosquito larvae, as well as small pieces of aquatic plants that serve as food sources for guppy fish.

Meanwhile, the Tangkerang River is relatively larger and flows, causing the guppy fish to be more active in movement due to the need to swim against the current. The energy obtained from food is utilized for movement, resulting in fish from the Tangkerang River being smaller in size compared to those from the Purigiam Housing

Trench. Furthermore, the reason why guppy fish measuring less than 17 mm are likely not captured is that their head or body size is smaller than the 3 mm mesh size of the catching net, allowing these fish to pass through the net holes without being trapped.

3.2. Morphology of the Guppy Fish (Poecilia reticulata)

Based on the research results, it is evident that the morphological characteristics of guppy fish from both research areas are not significantly different. The characteristics of these fish are: small-sized fish with a slender cylindrical body (17-31 mm). The head is small and then enlarges at the mid-section of the body before tapering toward the tail. The tail fin is enlarged and rounded or truncated. Male and female guppy fish exhibit different characteristics. The tail fin of male guppy fish features striking patterns and bright colors, including red, yellow, brown, black, blue, and others. These patterns and colors are distinctive features of the guppy fish. In contrast, the tail fin of female guppy fish has a gray or silvery-brown color and lacks prominent patterns. These characteristics align with Lubis's (2014) opinion, which states that male guppy fish possess wide tail fins with varied color patterns and exhibit colors that are significantly more prominent than those of female guppy fish.

3.3. Guppy Fish Otolith (Poecilia reticulata)

The shape of the otoliths of guppy fish observed from the Purigiam Housing Trench and the Tangkerang River is the same. The otoliths of guppy fish are round in shape, white in color, small in size, and relatively thick. After grinding, the center or core of the otolith appears colored (not transparent or opaque), and growth rings are visible around it (Figure 1).

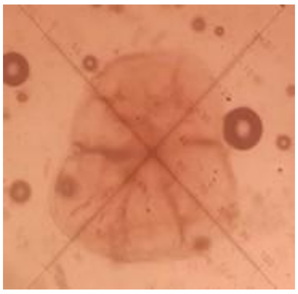
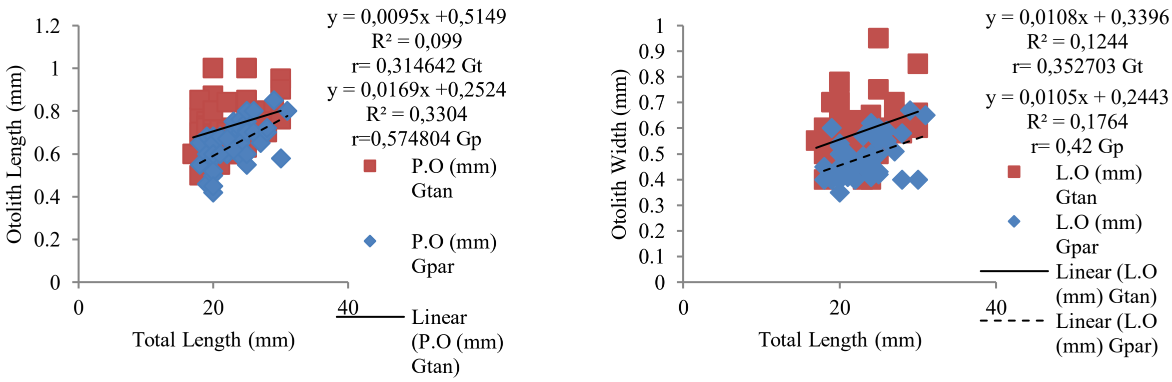


Figure 1. Guppy fish otolith

After being polished and observed under a microscope, it can be seen that the otolith of the guppy fish is round and slightly asymmetric, with a nucleus (the otolith core) located at the center of the otolith, serving as the starting point of growth. This otolith also exhibits a pattern of growth rings on the otolith of the guppy fish. The pattern consists of an arrangement of light and dark growth rings, with a varying number in each guppy fish. There are two types of growth rings depicted on the guppy fish's otolith: the dark, thick growth rings and the light, thin growth rings.

3.4. Correlation Between Total Length and the Length and Width of the Guppy Fish (Poecilia reticulata) Otoliths

The guppy fish in the residential drainage of Purigiam has a total length range of 18-31 mm, with an otolith length of 0.42-0.85 mm and a width of 0.4-0.67 mm. In contrast, the total length range of guppy fish caught in the waters of the Tangkerang River is 17-30 mm, with an otolith length range of 0.5-1 mm and a width of 0.4-0.95 mm (Figure 2).



(a) **(b)**

Figure 2. Correlation between total length and otolith length (a) Relationship between total length and otolith width (b)

Based on Figure 2, it can be observed that guppy fish with the same total length (TL) have otoliths of different sizes. Guppy fish from the Tangkerang River have larger otolith sizes compared to those from the Purigiam Housing Trench. This is due to varying environmental conditions; guppy fish in the Tangkerang River live in waters with currents and are more active in their movements. The energy obtained from food is utilized for movement, resulting in slower growth and leading to larger otoliths in fish residing in rivers. Additionally, the availability of food in the river is less than that in the trench, so although the otolith size is larger, their body size remains the same or smaller compared to guppy fish living in the trench. The growth of otoliths and fish bodies is influenced by food availability; fish with slower body growth have larger otoliths compared to fish of the same size that grow faster, indicating that environmental conditions and food availability affect otolith size (Schulz-Mirbach et al., 2011). Windarti & Asmika (2017) state that several factors affecting fish growth, such as water temperature, general aquatic environmental conditions, and food availability, can influence the growth ring patterns on otoliths.

3.5. The Growth Ring Pattern on the Otolith of Guppy Fish (Poecilia reticulata)

The difference in the number of dark rings in the otoliths of guppy fish caught in Purigiam Housing Trench and Tangkerang River. A higher number of guppy fish with dark circles in their otoliths were found in those from Purigiam Housing Trench compared to those from Tangkerang River (Table 2).

Table 2. The Number of dark circles on the otolith of guppy fish

Location	Number of Fish (piece)					Total Fish
	0 DR	1 DR	2 DR	3 DR	4 DR	
Tangkerang River	27	14	9	2	1	53
Purigiam Housing Trench	18	21	10	1	0	50

Description: DR= Dark Rings

Table 2 illustrates the differences in the number of dark rings on the otoliths of guppy fish caught in the Tangkerang River and the Purigiam Housing Trench. The number of dark rings on the otoliths of guppy fish in the Purigiam Housing Trench is greater than that of those living in the Tangkerang River. This can be attributed to the differences in environmental conditions between the two locations. The canal in the Purigiam Housing area is relatively small and shallow, leading to significant fluctuations in its ecological conditions. This is due to domestic waste generated from household activities around the canal, which causes stress to the fish. Such conditions affect the growth and health of the fish, as evidenced by the count of dark rings on the otolith. Whereas the Tangkerang River has larger and deeper water, resulting in the waste entering the river being more rapidly diluted and flowing well. This leads to lower fluctuations in waste concentration within the river, causing guppy fish to experience lower stress levels and supporting more optimal fish growth, as evidenced by the fewer dark rings on the otolith fish in the Purigiam Housing Trech.

3.6. Water Quality

The water quality in both research locations plays a crucial role in the life of the organisms inhabiting those areas. The quality of the water significantly determines the fertility of a water body. Aquatic life is highly dependent on water quality. The presence or absence of aquatic biota reflects the quality of the aquatic environment and is used as an indicator of ecosystem health (Santos & Ferreira, 2020). Table 3 compares the water quality in the Purigiam Housing Trench and the Tangkerang River.

Table 3. Water quality in the Purigiam Housing Trench and Tangkerang River

Unit Parameter		Measurement Results	
		Purigiam Housing Trench	Tangkerang River
Physics			
Temperature	℃	28	28-29
Current Velocity	m/det	0-0,018	0,436
Chemistry			
Ph		5-6	6
DO	mg/L	3,2	5,8
CO_2	mg/L	5,9	5,5

The results of the temperature measurements at both research locations, Purigiam Housing Ditch and Tangkerang River, were 28 ℃ and 28-29 ℃, respectively. Water temperature is influenced by environmental temperature. Both research locations have shallow waters, causing the water temperature to change easily and follow changes in environmental temperature. The temperature obtained from both research locations can still support the growth of guppy fish. This is following the opinion of Shah et al. (2017), which states that the optimal temperature for guppy fish growth ranges from 28 to 30℃. In the Purigiam Housing Drainage with slow flow, a current velocity of 0-0.018 m/s was recorded. Meanwhile, for the Tangkerang River, the current speed was found to be approximately 0.436 m/s.

The pH measurements obtained during the study from both locations, the Purigiam Housing Trench 5-6 and the Tangkerang River 6, indicate that the shallower trench with slow or stagnant flow often experiences a greater accumulation of organic matter and sedimentation. The slow decomposition process of organic materials generates acids, which decrease the water's pH. The Tangkerang River also receives domestic waste from the surrounding settlements; however, due to the larger water volume and faster flow, pollution from domestic waste is not as concentrated as in the trench. According to Faisol & Wahid (2022), guppy fish can still survive in waters with a pH of 6-7.5. This indicates that the water conditions in both research locations are still suitable for fish life, as evidenced by the numerous guppy fish found in the Purigiam Housing Canal and the Tangkerang River.

The dissolved oxygen content in the Purigiam Housing Trench is 3.2 mg/L, whereas in the Tangkerang River, it is 5.8 mg/L. The shallow drainage water (±20 cm) and slow flow, combined with a high organic matter content and a water surface partially covered by aquatic plants or weeds, hinder the diffusion of oxygen from the air to the water, leading to low dissolved oxygen levels. The ideal dissolved oxygen levels for the growth, metabolic activities, development, and reproduction of guppy fish are 5-8 mg/L. The oxygen requirements vary among different aquatic biota, depending on the species and their ability to tolerate fluctuations in oxygen levels. Generally, all biota are unable to tolerate sudden changes in oxygen (Kordi, 2004).

The free carbon dioxide (CO_2) levels in the Purigiam Housing Trench are 5.9 mg/L, while in the Tangkerang River, 5.5 mg/L. The highest concentration in the Purigiam Housing Trench is caused by the entry of pollutants into the drainage, as aquatic plants and plastic waste cover some surface areas, and the low sunlight entering the trench inhibits phytoplankton from utilizing sunlight for photosynthesis. Effendie (2006) states that water suitable for fisheries should preferably contain free concentrations of at least 5 mg/L. In contrast, free concentrations exceeding 12 mg/L can still be tolerated by fish, provided high dissolved oxygen concentrations support them. The high concentration of free in the Purigiam Housing Trench inhibits the growth process of guppy fish in that trench. This can be observed from the dark ring on the otolith of the guppy fish. However, the high concentration of dissolved oxygen in the Purigiam Housing Trench helps guppy fish survive; thus, guppy fish are still commonly found in that trench.

4. Conclusions

This research indicates that the size of guppy fish from the Purigiam Housing Trench is relatively similar, with guppy fish from the Purigiam Housing Trench measuring 18-31 mm and those from the Tangkerang River measuring 17-30 mm. For fish of the same total length, the otolith size of guppy fish from Tangkerang River is larger than that of guppy fish from Purigiam Housing Trench. Guppy fish with dark rings are found more frequently in the Purigiam Housing Trench than those from the Tangkerang River. The growth ring patterns of guppy fish from this study suggest that the stress level of guppy fish in the Tangkerang River is lower than that of guppy fish living in the Purigiam Housing Trench.

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