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THE EFFECT OF BANANA STEM (*Musa paradisiaca*) FERMENTATION DOSES ON THE MORTALITY OF ECTOPARASITE IN RED TILAPIA (*Oreochromis niloticus*)

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ABSTRACT

Tilapia (*Oreochromis niloticus*) is a freshwater fish widely cultivated due to its fast growth rate. However, tilapia cultivation often meets problems, including ectoparasite attacks. Therefore, it is necessary to have an alternative treatment for ectoparasites by fermenting banana stems. This research aimed to determine the effect of banana stem (*Musa paradisiaca*) fermentation dose on the mortality of ectoparasite in red tilapia. The method used was experimental by applying fermented banana stems A (5 $g.L^{-1}$), B (10 $g.L^{-1}$), and C (15 $g.L^{-1}$); fish samples were obtained from the Cangkringan Aquaculture Technology Development Center (BPTPB) pond measuring 10.2 ± 3.8 cm and the Cangkringan Market pool with a size of 7.5 ± 1.3 cm. The parasite identification results were *Trichodina* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., *Ichtyophtirius multifilis*, and *Oodinium* sp. Tilapia fish from the Cangkringan market pond showed more ectoparasites than BPTPB Cangkringan. Ectoparasites given banana stem fermentation treatment died ranged from 480-840 s (*Trichodina* sp.), followed by *Dactylogyrus* sp. (1380-1920 s) and *Gyrodactylus* sp. (2040-2640 s), respectively. Based on the research results, using fermented banana stems (10-15 $g.L^{-1}$) influences the death of ectoparasites and increases the survival rate by up to 80%. During the research, temperature and dissolved oxygen were not optimal. Environmental conditions affect the presence of ectoparasites in fish, and fermented banana stems can be used to overcome the emergence of parasites in cultivation.

KEYWORDS: banana stem; ectoparasites; survival rate; tannin; tilapia

***ABSTRAK: Pengaruh Dosis Fermentasi Batang Pisang** (Musa paradisiaca) **terhadap Mortalitas Ektoparasit pada Ikan Nila Merah** (Oreochromis niloticus)*

*Ikan nila (**Oreochromis niloticus**) adalah ikan air tawar yang banyak dibudidayakan karena memiliki laju pertumbuhan yang cepat. Namun, budidaya ikan nila sering menghadapi berbagai permasalahan, termasuk serangan ektoparasit. Oleh karena itu, diperlukan alternatif pengobatan ektoparasit dengan fermentasi batang pisang. Penelitian ini bertujuan untuk mengetahui pengaruh dosis fermentasi batang pisang (**Musa paradisiaca**) terhadap mortalitas ektoparasit pada ikan nila merah. Metode yang digunakan adalah metode eksperimen dengan aplikasi batang pisang yang difermentasi, yaitu A (5 $g.L^{-1}$), B (10 $g.L^{-1}$), dan C (15 $g.L^{-1}$). Sampel ikan diperoleh dari kolam Balai Pengembangan Teknologi Perikanan Budidaya (BPTPB) Cangkringan dengan ukuran 10,2 ± 3,8 cm dan dari kolam Pasar Cangkringan dengan ukuran 7,5 ± 1,3 cm. Hasil identifikasi parasit menunjukkan keberadaan **Trichodina** sp., **Dactylogyrus** sp., **Gyrodactylus** sp., **Ichtyophtirius multifilis**, dan **Oodinium** sp. Ikan nila dari kolam Pasar Cangkringan memiliki jumlah ektoparasit lebih banyak dibandingkan* *dengan BPTPB Cangkringan. Ektoparasit yang diberi perlakuan fermentasi batang pisang mengalami kematian dalam rentang waktu 480-840 detik (**Trichodina** sp.), diikuti oleh **Dactylogyrus** sp. (1380-1920 detik) dan **Gyrodactylus** sp. (2040-2640 detik). Berdasarkan hasil penelitian, penggunaan fermentasi batang pisang dengan dosis 10-15 g.L^{-1} berpengaruh terhadap kematian ektoparasit dan meningkatkan tingkat kelangsungan hidup ikan hingga 80%. Selama penelitian, suhu dan kadar oksigen terlarut tidak dalam kondisi optimal. Kondisi lingkungan memengaruhi keberadaan ektoparasit pada ikan, dan fermentasi batang pisang dapat digunakan sebagai solusi untuk mengatasi munculnya parasit dalam budidaya.*

KATA KUNCI: batang pisang; ektoparasit; ikan nila; kelulushidupan; tannin

INTRODUCTION

Tilapia (*Oreochromis niloticus*) is a freshwater fish from the East African region. It is widely cultivated in Indonesia because of its easy cultivation method and relatively fast harvest time. Tilapia production has continued to increase since 2015, with an average annual increase of around 9.2%. Tilapia fish production in 2015 was 1.084.281 tons; in 2019, it increased to 11.474.742 tons (Kementerian Kelautan dan Perikanan, 2020). Tilapia is widely cultivated in various regions because it has high economic value. Red tilapia is a type of freshwater fish that is a superior commodity because it is responsive to feed, has fast growth, has high survival, is resistant to disease attacks, has high tolerance to environmental conditions, and has ease of breeding. It is widely cultivated in tropical and subtropical regions for its nutritional benefits, including high levels of omega-3 fats and vitamins B and D. Red tilapia is known for its fast growth rate, which allows for multiple crops per year, making it an ideal candidate for small-scale aquaculture operations (Ekasari *et al.*, 2023; Mohammadiazarm *et al.*, 2023; Sallam *et al.*, 2024).

The rapid development of tilapia cultivation cannot be separated from the challenges farmers face, including ectoparasite attacks. This ectoparasite lives and develops on the surface of the fish's body. The presence of ectoparasites in tilapia fish significantly negatively affects their condition and overall health. The ectoparasitic burden is also associated with increased gill mucus, which depletes energy in the fish, further exacerbating the adverse effects (Kolia *et* *al*., 2021; Paredes-Trujillo *et al*., 2021). Based on the statement of Firdausi *et al.* (2020), ectoparasite attacks can cause financial losses due to reduced fish productivity and quality, which impacts reducing fish selling prices. Consuming fish infected with parasites can cause human health problems if not processed correctly (Maulana *et al*., 2017; Shamsi *et al*., 2019).

The most common treatment for ectoparasites is by administering antibiotics. Continuous administration of antibiotics in fish treatment can cause negative impacts, such as increasing pathogen resistance and leaving antibiotic residues in the water (Azhar *et al*., 2020; Yang *et al*., 2020). Therefore, it is necessary to carry out alternative treatments for ectoparasites in fish, such as natural ingredients. Banana stems contain tannins, flavonoids, terpenoids, alkaloids, glycosides, and phlobatnin. The tannin compound is an antimicrobial, antiparasitic, antiviral, antioxidant, and anti-inflammatory (Ighodaro, 2012; Rochana *et al*., 2017).

Natural ingredients can produce healing substances through fermentation, and banana stems can be used to treat fish. Fermentation converts organic materials into simpler substances through biochemical processes assisted by microorganisms. This process is well-known and used in the food sector. In medicine, especially animal medicine, fermentation is rarely used, but in several cases, fermentation is used to minimize the negative impact of chemical drugs. Fermentation can help release the nutrients found in banana stems. Banana stems contain suitable substances useful in the healing and treatment process. The antibiotic in banana stems can provide an antioxidant effect, speeding up wound healing (Ananta, 2020; Labatar, 2018). Miranti and Abdul (2018) stated that the fermentation of betel and surian leaves could produce substances that effectively treat wounds caused by parasites and improve the healing process of betta fish. Amalia *et al*., (2023) stated that fermented banana stem is a source of probiotics and helps the growth and survival of *Cyprinus carpio*.

Research on using banana stem fermentation against ectoparasites in red tilapia is rarely conducted in controlled and uncontrolled locations. This research aimed to determine the effect of banana stem (*Musa paradisiaca*) fermentation dose on the mortality of ectoparasite in red tilapia. It is hoped that with this research, fermented banana stems can be used as an alternative treatment for parasites in fish to reduce the use of chemicals that tend to be more dangerous and not environmentally friendly.

MATERIALS AND METHODS

Sampling

The ectoparasite identification process begins with the sampling stage. The method used in sampling was purposive sampling. According to Suharsimi (2006), the purposive sampling method is a technique that considers certain factors. The samples used to observe ectoparasites were fish that looked sick. The number of samples used in observations was 30 fish from the pond of the Aquaculture Technology Development Center (BPTPB) Argomulyo, Cangkringan, with a size range of 10.2 ± 3.8 cm and five fish from the Cangkringan Market pond with a size range of 7.5 ± 1.3 cm. The use of test fish in this experiment refers to national standards based on Badan Standarisasi Nasional (2009) SNI: 7306:2009.

Clinical Symptoms

Observation of clinical symptoms is divided into morphological and behavioral symptoms, which are the initial stages for detecting ectoparasites. Observation of clinical symptoms of fish attacked by ectoparasites is carried out by external observation or observation of the outside of the fish's body, such as skin, gills, and fins. Fish attacked by ectoparasites will show morphological symptoms such as thin fins, ulcers, and excess mucus production. Meanwhile, symptoms of abnormal behavior include swimming on the surface, decreased appetite, and rubbing his body against the pond wall.

Parasite Identification

Observation of ectoparasites begins with making sample preparations. Sample preparation was done using a native method, scraping the skin and gills (right and left). Sample preparation was carried out while the fish were still alive. Sample scraping was carried out using a scalpel. The samples resulting from scraping were placed on a glass object and observed using a microscope with 4x magnification followed by 10x magnification. Morphological observations were carried out on ectoparasites to identify the type of ectoparasite found. Calculations were carried out on the number of ectoparasites found to determine intensity and prevalence values.

The intensity of the ectoparasite was calculated before the treatment. Calculation of the ectoparasite intensity values that have been obtained is calculated using the formula (1) according to Cameron (2002):

$$Intensity = \frac{Total\ Parasite\ found\ in\ fish}{Total\ infected\ fish} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The calculation of the ectoparasite prevalence value that has been obtained is calculated using the formula (2) according to Cameron (2002):

$$Prevalence\ (\%) = \frac{Total\ of\ infected\ fish}{Total\ Fish} \times 100 \ldots\ldots\ldots\ldots (2)$$

Fermentation of Banana Stem

Fermenting banana stems was made by chopping one banana stem into small pieces. The treatment was 5 g (A), 10 g (B), and 15 g of banana stems (C). Then 1 L of water is added to the bottle and closed tightly. Soaking was done for approximately 2-3 weeks until the banana stems formed fibers. Followed by adding 1.5 g of shrimp paste, which has been dissolved in water, to mix with the banana stem solution until homogeneous. The fermentation continues until the solution changes color to golden yellow and has no strong odor.

Treatment of Ectoparasites with Banana Stem Fermentation Solution

The ectoparasites found were then given treatment using banana stem fermentation and observed to determine the level of effectiveness of banana stem fermentation (the length of time the ectoparasites died). The ectoparasites found were dripped with two drops of fermented banana stems and then observed until the ectoparasites died and counted the time (s). To determine whether the ectoparasites have died under a microscope, some characteristics are: (1) Dead ectoparasites will often show signs of disintegration, such as fragmentation or dissolution of their bodies; (2) Live ectoparasites typically exhibit movement when observed under a microscope. If the parasites are no longer moving, it could indicate that they have died; (3) Dead parasites may change color or become more transparent (Kismiyati *et al.*, 2024; Mathison & Pritt, 2014; Wells *et al.*, 2012).

Survival Rate

Infected fish from the BPTPB Cangkringan pond were treated using buckets for 7 days to determine the impact of treatment on fish survival rates. Treatment was carried out using immersion with 10 mL.m^{-3} with slight modifications (Pricilia *et al.*, 2017). The survival rate of sampled tilapia fish was calculated using the formula (3) according to Jaya *et al.* (2013):

$$SR = \frac{Nt}{N0} \times 100\ \% \text{ ....} (3)$$

SR: Degree of survival (%); Nt: Number of survival fish at the end of rearing (ind); No: Number of fish at the initial of rearing (ind).

Water Quality

Water quality observations were carried out every day (morning and evening) at each location, and they included pH using a pH meter and dissolved oxygen (DO) using a DO meter.

Data Analysis

The collected data were analyzed using a descriptive–comparative method with a qualitative approach.

RESULTS AND DISCUSSION

Clinical Symptoms

The sample used in the observations was sick red tilapia. Infected fish show clinical symptoms, both behavioral and external. Figure 1 shows the clinical symptoms of red tilapia attacked by ectoparasites.

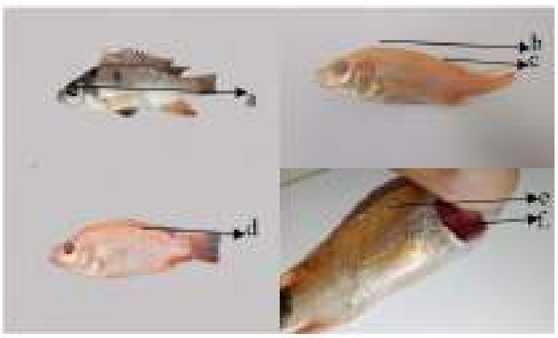

Figure 1. Clinical symptoms of red tilapia attacked by ectoparasites. (a) loose eyes, (b) thin fins, (c) fungus growth, (d) redness of the skin, (e) scales fall off easily, (f) white spots on the gills

Based on Figure 1, ectoparasite-infected fish show clinical symptoms in the form of thin fins, skin redness, scales that come off quickly, white spots on the gills, excessive mucus, fungus growth, and loose eyes. Infected fish also show changes in behavior, such as appearing weak, decreased appetite, abnormal swimming, and often rubbing their bodies on the pond's surface.

Tilapia infected with ectoparasites exhibit several clinical symptoms. The most notable symptom is the presence of excessive mucus on the gills, which can lead to a pale appearance and a marbling effect on the gill leaflets (Radwan *et al.*, 2024). Gill leaflets are thin, branching structures forming aquatic animals' gills, including fish like tilapia. These leaflets are part of the respiratory system and play a crucial role in gas exchange, allowing the animal to extract oxygen from the water. Each gill leaflet is typically composed of several regions with different epithelial coverings, which facilitate the exchange of gases and the removal of waste products (Klocke *et al.*, 2024; Rodriguez *et al.*, 2019). Fish attacked by ectoparasites show external symptoms in the form of wounds on the skin surface, the appearance of white spots, thin fins, scales that come off quickly, and excessive mucus production (Iriansyah *et al.*, 2020; Pujiasatuti *et al.*, 2015). Additionally, the fish may become skinny due to the parasitic burden (Ihsan & Sitinjak, 2023). The severity of the infection can vary significantly, depending on factors such as the types and numbers of infecting ectoparasites, environmental conditions, and fish immunity.

Parasite Identification, Intensity, and Prevalence

Based on the results of examinations of red tilapia at BPTPB Cangkringan and the Cangkringan Market's Pond, five types of ectoparasites were found, including *Trichodina* sp., *Dactylogyrus* sp., *Gyrodactylus* sp., *Ichthyophthirius multifiliis*, and *Oodinium* sp. which can be seen in Table 1.

Table 1. Species and infestation level of ectoparasites on tilapia derived from the Aquaculture Technology Develepment Center Cangkringan and the Cangkringan Market's Pond

No.	Parasites	Location	∑ Sample (Ind)	∑ Parasite	∑ Infected Fish	I (Ind.Fish^{-1})	P (%)

1.	*Trichodina* sp.	BPTPB	30	302	20	15.10	66.66
	Dactylogyrus sp.			19	11	1.72	36.66
	Gyrodactylus sp.			25	6	4.16	20.00
	Ichthyophthirius multifilis			1	1	1.00	3.33
2.	*Trichodina* sp.	Cangkringan Market	5	4589	5	917.80	100.00
	Dactylogyrus sp.			4	2	2.00	40.00
	Gyrodactylus sp.			81	3	27.00	60.00
	Ichthyophthirius multifilis			8	1	8.00	20.00
	Oodinium sp.			102	4	25.50	80.00

Based on Table 1, the most common type of parasite found was *Trichodina* sp. *Trichodina* are commonly found in tilapia due to several factors, such as environmental conditions in the Cangkringan market. The tilapia are farmed in crowded conditions, leading to high stocking densities and poor water quality. These conditions favor the proliferation of parasites like *Trichodina*, which thrive in environments with high organic matter and low oxygen levels. Ihsan and Sitinjak (2023) stated that the relationship between host-parasite and disease transmission also influences the occurrence of *Trichodina* in tilapia. Tilapia are naturally euryhaline, which can adapt to various salinity levels. This adaptability makes them susceptible to different parasites, including Trichodina, which can infect the gills and skin of the fish. Additionally, *Trichodina* can be easily transmitted from one fish to another through direct contact or contaminated water. Ectoparasites are caused by two factors: internal and external factors. According to Rahayu *et al.* (2013), external factors include cultivation pond water quality, pond water sources, pond sanitation, and cultivation pond stocking density. Internal factors include the level of immunity, gender, age, and body size of the fish. According to Hairunnisa *et al.* (2021), ectoparasites have different specifications to determine the host and target organs to be attacked.

The intensity and prevalence values of ectoparasites found in the BPTPB Cangkringan pond were lower than those found in the Cangkringan Market. This can happen because tilapia from BPTPB Cangkringan receive routine treatment for parasitic diseases by fermenting banana stems in cultivation ponds as an anti-parasite. In contrast, tilapia from the market do not receive the same treatment. Providing natural ingredients in the form of fermented banana stems in cultivation ponds plays a role in treating disease so that it can reduce the number of ectoparasites that infect fish and impact fish survival. This was confirmed by Sumantriyadi *et al.* (2023), that the provision of natural ingredients with antibacterial or immunostimulant content given to fish can indirectly improve the fish's immune system, thereby increasing fish survival.

Based on observations, *Trichodina* sp. is a round protozoa that moves in circles. *Trichodina* is a genus of ciliate protozoa that are ectocommensal or parasitic on aquatic animals, mainly fish. Body parts of *Trichodina* sp. consist of cilia, border membranes, and denticles. They are characterized by a ring of interlocking cytoskeletal denticles, which support the cell and allow for adhesion to surfaces, including fish tissue (Figure 2). *Trichodina* sp. was found on the skin and gills.

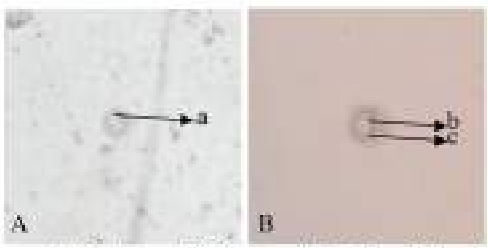

Figure 2. *Trichodina* sp. (A) front view, (B) side view, (a) denticles, (b) border membrane, (c) cilia

Trichodina can be round, disc-shaped, or hemispherical. The body shape varies from cylindrical to discoidal, with some species slightly constricted. A spiral of cilia leads towards the cytostome and several rings of cilia at the cell's periphery. These cilia are responsible for creating adhesive suction and locomotory power. The diameter of *Trichodina* ranges from 40-70 µm, with a height of 35-60 µm. The diameter of the denticulate ring can be 29-46 µm, and the diameter of the basal disk can be 42-79 µm. *Trichodina* is typically found on fish's gills, skin, and fins, though some species parasitize the urogenital system. Transmission occurs by direct contact between infected and uninfected hosts and also by active swimming of *Trichodina* from one host to another (Wang *et al*., 2020).

Morphologically, *Dactylogyrus* sp. is a trematode worm with an elongated body shape. Body parts of *Dactylogyrus* sp. consist of the eye spot (anterior) and opisthaptor (posterior). *Dactylogyrus* sp. was found attacking the gills of fish. Parasite *Dactylogyrus* sp. is presented in Figure 3.

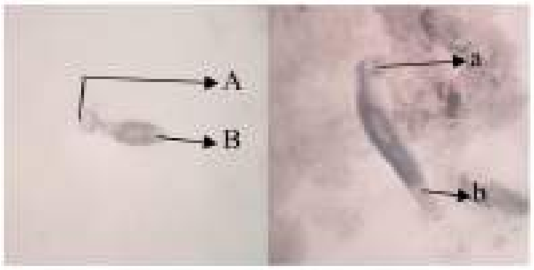

Figure 3. *Dactylogyrus* sp. (A) posterior, (B) anterior, (a) opisthaptor, (b) eye spots

Dactylogyrus is a genus of monogenean flatworms that parasitize the gills of fish. The morphology of *Dactylogyrus* includes several key features: *Dactylogyrus* is typically flat and foliaceous, with a small size ranging from 0.5 to 2 mm in length. The anterior end of the worm is characterized by a glandular attachment organ with four cephalic lobes. The posterior end of the worm is simple and lacks any complex attachment structures. The haptor at the posterior end contains anchors, a dorsal bar, and marginal hooks. These structures help the worm attach to the gill arches of its host. *Dactylogyrus* has cilia on its surface, which are used for movement and feeding. The cilia are arranged in a specific pattern that can vary between species (Acosta *et al*., 2022; Cheng *et al*., 2023; Jalali *et al*., 2020).

Gyrodactylus sp. is an ectoparasite of the monogenean worm class that is elongated and transparent in color. The anterior part has no eye spot, and the posterior part has the opisthaptor and marginal hooks. During observations, *Gyrodactylus* sp. was found attacking the scales. The parasite *Gyrodactylus* sp. can be seen in Figure 4.

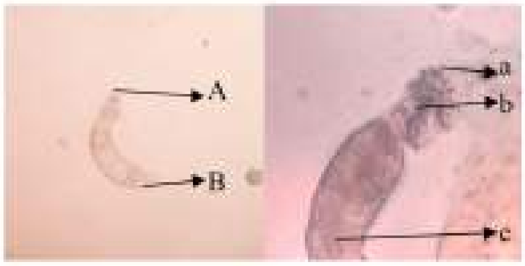

Figure 4. *Gyrodactylus* sp. (A) posterior, (B) anterior, (a) marginal hooks, (b) opisthaptor, (c) vitellaria

Gyrodactylus is a genus of monogenean flatworms that parasitize the skin and gills of freshwater fish. *Gyrodactylus* is typically flat and foliaceous, with a small size ranging from 0.5 to 1 mm in length. The anterior end of the worm is characterized by a bilobed cephalic region containing cephalic glands, a pharynx, and an indistinct esophagus. The posterior end of the worm is equipped with a haptor, which includes anchors, a dorsal bar, and marginal hooks. These structures help the worm attach to the host (Chong, 2021; Lumme et al., 2017).

Ichthyophthirius multifiliis is a round-shaped ectoparasite of the protozoan class with a C-shaped nucleus called the macronucleus. The body parts of *I. multifiliis* consist of the macronucleus, micronucleus, and cilia (movement organs). *Ichthyophthirius multifiliis* was found attacking the gills. The parasite *I. multifiliis* can be seen in Figure 5.

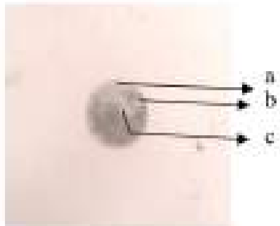

Figure 5. *Ichthyophthirius multifiliis* found in tilapia. (a) cilia, (b) micronucleus, (c) macronucleus

Ichthyophthirius multifiliis is a parasitic ciliate that infects the skin and gills of freshwater fish. The body of *I. multifiliis* is typically ovoid to spherical, measuring about 5-18 µm in length. The parasite forms cysts during its life cycle, and the cyst wall is composed of a thick, multilayered structure that provides protection and support (Ewing *et al.*, 1983; Yang *et al.*, 2023).

Based on observations, *Oodinium* sp. is an ectoparasite of the protozoan group with a round, slightly oval shape. Body parts of *Oodinium* sp. consist of cytoplasm and protoplasm with a granular structure, nucleus, and chloroplasts. During observations, *Oodinium* sp. was found to infect fish's gills and skin (scales). Ectoparasite *Oodinium* sp. can be seen in Figure 6.

Figure 6. *Oodinium* sp. found in tilapia. (a) protoplasm, (b) cytoplasm, (c) nucleus

Oodinium sp. is a genus of dinoflagellate parasites that infect the skin and gills of fish. It has an oval or balloon-like shape and typically measures about 5-18 µm in length. The parasite is equipped with rhizoids, which are specialized structures used for attachment. These rhizoids help the parasite adhere to the host's skin and gills (Cheung *et al.*, 1981).

The Duration of Parasite Death

Preparations were made to take ectoparasites found in fish and use them to test their length of death. Table 2 shows the results of banana stem fermentation testing on the length of death of ectoparasites.

Table 2. Effectiveness of banana steam fermentation in the death of ectoparasites found in red tilapia

Treatment	Period of parasite death (s)		
	***Trichodina* sp.**	***Dactylogyrus* sp.**	***Gyrodactylus* sp.**
A (5 $g.L^{-1}$)	720-840	1800-1920	2520-2640
B (10 $g.L^{-1}$)	660-720	1620-1740	2280-2460
C (15 $g.L^{-1}$)	480-540	1380-1500	2040-2200

The duration of death for ectoparasites given two drops of fermented banana stem ranged from 480-840 s (*Trichodina* sp.), followed by *Dactylogyrus* sp. (1380-1920 s) and *Gyrodactylus* sp. (2040-2640 s), respectively. Treatment C showed the fastest time to kill ectoparasites. The high concentration in treatment C causes this compared to the other two treatments. Based on observations, *Trichodina* sp. was the parasite that died the fastest when given a banana stem fermentation solution, followed by *Dactylogyrus* sp. and *Gyrodactylus* sp. *Trichodina* is highly sensitive to copper, a common ingredient in many antiparasitic treatments. Copper can disrupt the parasite's cell membrane and metabolic processes, leading to rapid death. Besides, *Trichodina* has a direct developmental cycle, meaning it does not require an intermediate host. This simplicity in its life cycle makes it more vulnerable to external factors like bioactive compounds, which can quickly disrupt its life processes. *Trichodina* does not have a protective coating like other parasites, which can help shield them from bioactive compounds. This lack of protection makes it more vulnerable to the effects of these compounds (Koihealth, 2024; Koitalk, 2023; Smith & Schwarz, 2019). In contrast, *Dactylogyrus* and *Gyrodactylus* have more complex life cycles and attachment mechanisms, which can provide some protection against bioactive compounds. Additionally, their ability to adapt to different environments and hosts might make them more resilient to these compounds.

The effect of ectoparasite death is due to the active ingredients contained in fermented banana stems. The fermentation of banana stems produces a variety of bioactive substances, including alkaloids, flavonoids, tannins, saponins, sterols, triterpenes, vitamins, and phenolic compounds (Afzal *et al.*, 2022; Deng *et al.*, 2020; Maya, 2015; Pillai *et al.*, 2024). Tannin is a secondary metabolite compound that can act as an antigen, antidiarrheal, antibacterial, and antioxidant (Malangngi *et al.*, 2012). Strengthened by Wardani *et al.* (2010), tannin inhibits the work of enzymes and eliminates substrates that bind to lipids and proteins, which function to bind protease enzymes that play a role in parasite growth. Fermented banana stems contain bioactive compounds such as saponins, flavonoids, alkaloids, and tannins. These compounds have antimicrobial and antiparasitic properties, which can help inhibit the growth and activity of ectoparasites in fish. Additionally, fermentation can produce probiotics, beneficial microorganisms that can compete with and displace pathogenic organisms, including ectoparasites. Probiotics can also enhance the fish's immune system, making it more infection-resistant. Ectoparasites in fish can die after the fish soak in a fermented banana stem solution due to several mechanisms: Fermented banana stems contain bioactive compounds such as saponins, flavonoids, alkaloids, and tannins, which have antimicrobial properties. These compounds can inhibit the growth and activity of ectoparasites, such as *Trichodina* and *Dactylogyrus*, by disrupting their cell membranes and metabolic processes. The fermented banana stem solution can improve the fish's health, reducing the susceptibility to ectoparasite infections. Healthy fish are better equipped to resist and recover from parasite infestations (Amalia *et al.*, 2023; Dhema *et al.*, 2022; Fitriani *et al.*, 2022; Suryani *et al.*, 2022).

Survival Rate

Tilapia infected with ectoparasites were taken as test samples. Treatment was carried out using the soaking method of fermented banana stems, which was carried out for 7 days. The survival values of fish treated with fermented banana stems are presented in Figure 7.

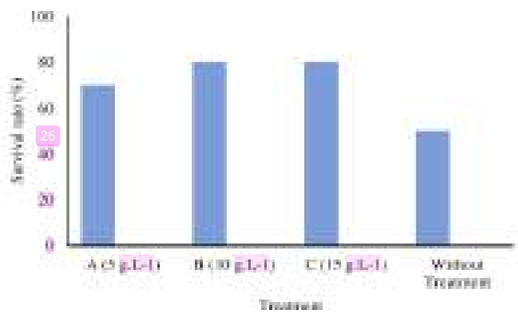

Figure 7. Survival rate of red tilapia treated using fermented banana stems with different concentration

The survival rate of fish given banana stem extract ranged from 70-80%; meanwhile, the survival rate of fish without treatment was 50%. The high survival value of tilapia is thought to be due to the active compounds in fermented banana stems. The inhibitory power provided by fermented banana stems will reduce ectoparasite attacks, thereby increasing fish survival. Sinaga (2011) confirmed that plants containing tannins have high antiparasitic levels because tannin compounds can interfere with developing parasite cell walls. The fermentation process can also improve water quality by reducing the levels of organic matter and ammonia, which can create an environment less conducive to the growth of ectoparasites. This improved water quality can further enhance the health and resistance of the fish to ectoparasites (Amalia *et al.*, 2023).

Water Quality

When checking water quality, temperature, pH, and DO were observed. The results of the water quality in the BTBPB and Cangkringan Market ponds can be seen in Table 3.

Table 3. Water quality of red tilapia ponds used as sampling units

No.	*Parameter*	*Time*	*Location*		*Standard*
			BTBPB	*Market*	
1.	Temperature (°C)	Morning	23.6-26.9	25.20	25-30 Dailami *et al.* (2021)
		Evening	25.5-27.7	28.50	
2.	pH	Morning	7.68-8.02	7.65	6.5-8.5 Badan Standardisasi Nasional (2009)
		Evening	7.75-8.12	8.22	
3.	DO (mg.L^{-1})	Morning	4.10-7.80	2.00	> 5 Badan Standardisasi Nasional (2009)
		Evening	4.20-8.00	5.00	

Based on the results of water quality measurements in Table 3, the temperature parameters in the morning of the BPTPB Cangkringan pond do not comply with the minimum limits for tilapia. The measurement results at the BPTPB Cangkringan ponds in the morning ranged from 23.6–26.9°C. According to Dailami *et al.* (2021), the optimum temperature for the growth of tilapia is 25–30°C. Temperature has an essential role in the fish growth process. Under these temperature conditions, tilapia cannot grow well. Fish metabolic activity is influenced by water temperature. According to Wangni *et al.* (2019), the higher the water temperature, the more the fish's metabolic processes will increase, whereas at low temperatures, fish tend to lose their appetite and become more susceptible to disease attacks.

The pH value in the BPTPB Cangkringan ponds was 7.68–8.02 (morning), 7.75–8.12 (afternoon), and the Cangkringan Market ponds was 7.65 (morning) and 8.22 (afternoon). The results of measuring the water pH in the BPTPB Cangkringan pond and the Cangkringan Market pond are in a good range for fish growth. According to SNI (2009), the optimal pH for the development of tilapia is 6.5–8.5.

Dissolved oxygen levels in the BPTPB Cangkringan ponds and Cangkringan Market ponds were 4.1–7.8 mg.L^{-1} (morning), 4.2–8 mg.L^{-1} (afternoon), and 2 mg.L^{-1} (morning) and 5 mg.L^{-1} (afternoon), respectively. DO content < 5 mg.L^{-1} is not an optimal condition for the life of tilapia. According to SNI (2009), the optimal DO content for the life of tilapia is > 5 mg.L^{-1}. Ectoparasites are often more prevalent in environments with low DO levels. Stagnant or poorly oxygenated waters can create conditions that favor the survival and proliferation of ectoparasites. Low DO levels can induce stress in fish, leading to reduced feeding, impaired growth, and a weakened immune response. This makes fish more susceptible to parasitic infections, as their bodies are less capable of fighting off infestations (Ashmawy *et al*., 2018; Biswas *et al*., 2023; Waruiru *et al*., 2020).

CONCLUSIONS

Environmental conditions influence the presence of ectoparasites in fish. Ectoparasites given banana stem fermentation treatment died ranged from 480-840 s (*Trichodina* sp.), followed by *Dactylogyrus* sp. (1380-1920 s) and *Gyrodactylus* sp. (2040-2640 s), respectively. Based on the research results, using fermented banana stems (10 g-15 g.L^{-1}) influences the death of ectoparasites and enhances the survival rate by up to 80%.

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AUTHOR CONTRIBUTION

YAS: Conceptualization, Formal Analysis, Investigation, Methodology, Writing – original draft; ECY: Data curation, resources; NRMP: Data curation, Software; NDP: Visualization & Funding acquisition; AFP: Formal analysis; SW: Project administration, Supervision, Writing – review & editing.

DECLARATION OF COMPETING INTEREST

The authors declare no competing interests.

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