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# The Effect of Ectoparasites on Hatchery Business of Red Tilapia *Oreochromis* sp. in Klaten, Central Java

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## Abstract

The tilapia fish hatchery in Klaten utilizes the Dengkeng River as its water source. The poor water quality in the Dengkeng River leads to an increase in the number of ectoparasites that can infest tilapia fry. This study aimed to assess the impact of ectoparasites on red tilapia in the Klaten region, Central Java. The research was carried out at the Freshwater Fish Seed Work Unit, Loka Janti, Klaten. The sample for this study consisted of red tilapia fry (*Oreochromis niloticus*) with an average size of 4–6 cm. Fish sampling was conducted randomly from the Freshwater Fish Seed Work Unit, Loka Janti, Klaten, with 5 samples taken from 28 semi-permanent ponds. Both physical and ectoparasite examinations were carried out on the tilapia fry. The data analyzed included water quality, epidemiology, parasite counts, specific growth rates, financial performance, and sensitivity analysis. Ectoparasites can negatively affect tilapia cultivation and result in losses. Fortunately, the ectoparasites found in Loka Janti did not cause significant damage. The tilapia hatchery, with fry measuring 2–3 cm and a selling price of Rp75.00 per fish, generated an income of Rp426,062.70 and a profit of Rp71,814,554. The R/C ratio was 1.20, and the payback period was 4.4 years.

Keywords: red tilapia, ectoparasites, financial value, hatchery business.

## I. INTRODUCTION

Nile tilapia (*Oreochromis niloticus*) were introduced to developing countries and cultured at a subsistence level to address local protein needs (FAO, 2022). In tilapia hatcheries, the larvae and fry stages are critical points in fish farming. Healthy larvae and fry will result in better overall production. Ensuring the availability of an adequate quantity, quality, and sustainability of fry is essential for the success of the fish farming business. Unfortunately, when farmers adopt super-intensive methods with high fish densities to increase production, it leads to a higher risk of disease outbreaks in the fish (Wang *et al.,* 2023, Machimbirike *et al.,* 2019; Surachetpong *et al.,* 2020).

Disease outbreaks in fish can be caused by both infectious agents (such as bacteria, viruses, fungi,

parasites, and protozoa) and non-infectious factors (including environmental conditions, genetics, and nutrition). The skin and gills of fish serve as major entry points for pathogens, acting as a critical line of defense by secreting a protective mucus layer to maintain the fish's health (Glover *et al.,* 2013; Lazado & Caipang, 2014; Merrifeld & Rodiles, 2015). Ectoparasites are common disease agents that infest fish in hatcheries. These ectoparasites typically target the skin and gills of fish, where they can cause significant damage. The skin and gills of fish are the primary entry points for pathogenic agents to infect the fish. These external surfaces also serve as the first line of defense, helping to maintain the host's health by producing a protective mucus layer that shields against pathogens, including ectoparasites (Depnath *et al.,* 2022). Monogeneans, a group of highly diverse ectoparasites, have a direct life cycle, are widely distributed, and are generally host-specific (Scheilfler *et al.,* 2022). Ectoparasitic infestations in tilapia fry commonly manifest through symptoms such as stunted growth, abnormal behavior, epithelial lesions, blindness, gill deformities, mass mortality, and consumer rejection (Tessema, 2020; Misganaw, 2016; Claude *et al.,* 1998).

Ectoparasites commonly found in tilapia larvae and fry during hatchery activities include *Dactylogyrus* sp., *Gyrodactylus* sp., and *Trichodina* sp. (FAO, 2023; El-Sayed, 2020). These ectoparasites infect the skin, gills, and fins of fish, with contributing factors such as low water temperature, intensive culture practices, poor water quality, and inadequate handling management (El-Sayed, 2020). The presence of parasites can lead to significant economic losses in the fishing industry (Palm *et al.,* 2008), and while they may exist in a carrier state, they do not always cause disease in fish (Barber, 2007). In addition to tilapia, these ectoparasites also affect juvenile common carp and pangasius fish, resulting in economic losses for these species as well (Nematollahi *et al.,* 2012; Ozan *et al.,* 2008; Haque *et al.,* 2004).

The tilapia hatchery business in the Klaten area is a matter of concern due to its reliance on river water sources. The use of river flow for hatchery operations is a critical factor in the success of fish farming. The river in question is the Dengkeng River, which flows from upstream to downstream, eventually merging with the Bengawan Solo River. This river stretches approximately 45 km and drains a watershed area of around 700,000 km². The Dengkeng River also passes through Kebon Village, a center for batik craft businesses. One of the consequences of this industry is the wastewater produced, which negatively impacts the water quality. Several studies have reported a significant decline in water quality in the Dengkeng River, from upstream to downstream. The pollution load in this river has notably increased, with a biological oxygen demand (BOD) value of 25.57 kg per day and a chemical oxygen demand (COD) of 223.43 kg per day (Budianta *et al.,* 2021). The elevated levels of pollution raise concerns about the potential increase in ectoparasites and other disease-causing agents. Consequently, this study aims to evaluate the impact of ectoparasites on red tilapia in the Klaten area, Central Java.

## II. MATERIALS AND METHODS

### *2.1 Time and Location*

This study was conducted from January to April 2022 at the Freshwater Fish Hatchery Working Unit, Loka Janti, located in Polanharjo District, Klaten, Central Java. The water used for the fish hatchery is sourced from the Umbul Nilo and Umbul Wanut Rivers, which are situated 2 km from Loka Janti. These rivers flow into the Dengkeng Bengawan Solo River. Additionally, the water sources are adjacent to an irrigation canal used by local residents for agricultural activities. The temperatures of the Umbul Nilo and Umbul Wanut rivers range from 25–30 °C, with a water discharge of 25–40 L second$^{-1}$.

### *2.2 Ethical approval*

All animal experimental and rearing procedures were conducted in compliance with animal welfare standards under the Indonesian National Standard No. 6141:2009, which relates to the production of black tilapia fry (*Oreochromis niloticus* Bleeker).

### *2.3 Fish Sampling*

The fish sampled were red tilapia fry (*Oreochromis niloticus*) with a size of approximately 4–6 cm. Fish samples were taken randomly at the Freshwater Fish Hatchery Work Unit, Loka Janti, Klaten. Sampling was conducted in 28 semi-permanent ponds, with total pond areas ranging from 133.65 to 952.00 m². Each pond is equipped with a pair of inlet and outlet pipes measuring 6 inches, as well as a pair of inlet and outlet sluice gates, each approximately 40 cm wide. A

total of 5 fish samples were taken from each of the 28 semi-permanent ponds. The fish samples were placed in sample bottles filled with water and oxygen before being transported to the laboratory for observation.

*2.4 Fish Physical Examination*

The physical examination of the fish is conducted to detect the presence of ectoparasite infestations on the gills, mucus, and fins. This involves a thorough inspection from head to tail, carefully looking for any signs of ectoparasites. Such a detailed examination is crucial for maintaining fish health, as untreated ectoparasite infestations can cause significant harm. Physical measurements were also taken to gather data on the standard length, specific growth rate (SGR), and survival rate (SR) by measuring the body length and weight of the fish. The first step of the physical examination is to measure the standard length and weigh the tilapia fry. The second step involves inspecting the fish closely and preparing smears from each organ to check for ectoparasite infestations. This is done by collecting mucus samples and making incisions to examine the gills and fins more closely. This comprehensive process helps detect any signs of ectoparasites, ensuring a thorough assessment of the fish's health. The observation method is the same for both Nursery 1 and Nursery 2.

*2.5 Ectoparasite Examination*

The process of collecting ectoparasites from the fish's gills begins with an incision made on the ventral side of the fish near the operculum, starting from the cloaca area and moving toward the anterior of the fish. A pinch of gill filaments is then carefully taken using surgical scissors. The gill filaments are placed in a disposable petri dish containing 0.9% physiological NaCl. These samples are not stored in a refrigerator (4 °C) but are instead observed immediately under an Olympus CX23 binocular microscope using the 10x objective lens. Prior to observation, the gill filaments are finely chopped to facilitate easier examination. The chopped gill filaments are then placed on a glass slide and covered with a cover glass. To slow down the movement of the ectoparasites and facilitate observation of their body shape and counting, Lugol's iodine solution is added.

*2.6 Parameters*

*2.6.1 Water Quality*

The water quality observed includes both physical and chemical parameters, which are measured during fish hatchery activities. Water samples were collected from a depth of 50-60 cm from the surface using a Lutron DO-5510 Digital Oxygen Meter and a Lutron pH 207. Key water quality parameters, such as dissolved oxygen (DO), water temperature, and pH level, were measured in each pond. Dissolved oxygen (mg $L^{-1}$) was measured using the Lutron DO-5510 Digital Oxygen Meter, which is equipped with a polarographic-type probe and a temperature sensor. This device measures DO in the water, oxygen ($O_2$) in the air, and water temperature. Measurements of DO, water temperature, and pH were carried out directly in each pond. The pH level was measured using the Lutron pH 207 pH meter.

*2.6.2 Measurement amount of parasites*

The number of each parasite species and the total number of all parasites in each pond were calculated to determine the Prevalence (P), Intensity (I), Mean Intensity (mI), and Mean Abundance (mA) using the mathematical formulas outlined by Bush *et al.* (1997). The Prevalence (P) refers to the proportion of hosts infected with one or more individuals of a particular parasite species, calculated by dividing the number of infected hosts by the total number of examined hosts. It indicates the proportion of infected fish with a specific parasite species. Intensity (I) represents the range of parasite numbers, from the lowest to the highest, found in a fish of a particular species. The Mean Intensity (mI) represents the average number of individuals of a particular parasite species that can theoretically be found in an infected host. It is calculated by dividing the total number of parasites by the number of hosts infected with that parasite. The Mean Abundance (mA) refers to the total number of individuals of a specific parasite species in a single fish, regardless of whether the fish is infected. The following formula can be used to calculate the parasite measures:

$$mA = \frac{Total\ number\ of\ one\ parasite\ species}{Number\ of\ examined\ fish\ by\ one\ species}$$

$$P\ (\%) = \frac{Number\ of\ infected\ fish\ with\ one\ parasite\ species}{Number\ of\ examined\ fish}\ x\ 100$$

$$mI = \frac{Total\ number\ of\ one\ parasite\ species}{Number\ of\ fish\ infected\ by\ that\ species}$$

*2.6.3 Fish growth and survival*

Fish growth in the hatchery was measured using the Specific Growth Rate (SGR) and Survival Rate (SR) for one cycle. These parameters were assessed in both Phase I and Phase II nurseries. Phase I nursery involves the maintenance of 1–3 cm-sized fry, growing them to 3–5 cm, while Phase II nursery involves maintaining 3–5 cm-sized fry. Fish body weight was measured using a digital balance with a precision of ± 0.1 g. Fish growth and survival rates were calculated as described by Nimrat *et al.* (2011) using the following formulas:

$$Specific\ growth\ rate\ (SGR) = \frac{(lnW2 - lnW1)}{t2 - t1}\ x\ 100$$

where ln is the logarithmic number, w1 is initial weight at time t1 and w2 is the final weight at time t.

$$Survival\ rate\ (SR) = \frac{Fish\ number\ at\ the\ \ of\ experiment}{Fish\ number\ at\ the\ beginning\ of\ experiment} x\ 100$$

### 2.6.4 *Financial value*

Financial value measurement was conducted for one year of hatchery business activities, which included 10 cycles of fish hatchery. The financial analysis involved calculating business costs, including investment costs, fixed costs, and variable costs. Additionally, business performance indicators such as profit, R/C ratio, break-even point (BEP), and payback period (PP) were calculated. Profit is the difference between revenue and total production costs. If revenue exceeds total production costs, the result is a profit. The R/C ratio is the ratio of total revenue to total production costs and is commonly used to assess the feasibility of a business. A business is considered profitable if the R/C ratio is greater than 1.0. If the ratio equals 1.0, it is referred to as the breakeven point (BEP), where neither profit nor loss is achieved. If the R/C ratio is less than 1.0, the business is operating at a loss. BEP represents the point at which a business's sales reach a level where there is no profit and no loss. The payback period (PP) refers to the time it takes to recover the initial investment capital made at the start of the business. Cost of goods sold (COGS) refers to the direct costs incurred in acquiring or manufacturing the products sold by the company during a specific period. These costs include labor, materials, and manufacturing overhead directly tied to the production process. The following formulas are used to calculate financial value.

$$Profit = total\ revenue - total\ cost \quad ; \quad R/C\ ratio = total\ revenue/total\ cost$$

$$BEP\ (IDR) = \frac{fixed\ cost}{1 - \frac{variable\ cost}{total\ revenue}} \quad ; \quad BEP\ (Unit) = \frac{fixed\ cost}{1 - \frac{variable\ cost}{production\ amount}}$$

$$PP = \frac{investment\ cost}{profit}\ x\ 1\ year \quad ; \quad HPP = \frac{total\ cost}{total\ production}$$

Tabel 1. Water quality data in nursery ponds I and II

| Measured parameters | Results | Indonesian National Standard (INS) |
|---|---|---|
| Temperature | 25,5–29 ℃ | 23–30 ℃ |
| Dissolved oxygen | 3,2–6,0 mg $L^{-1}$ | >5 mg $L^{-1}$ |
| pH | 7,8–9,0 | 6,5–8,5 |

### 2.7 *Data Analysis*

The data on water quality parameters, survival rate (SR), specific growth rate (SGR), parasite counts, and business analysis were organized in Microsoft Excel 2011. All collected data were analyzed descriptively, using tables and figures to present the findings.

## III. RESULTS

### 3.1. *Water Quality*

Measurements indicate that the water temperature (25.5–29.0 °C) complies with Indonesian National Standard No. 6141:2009. However, dissolved oxygen (DO) concentrations vary, with some values falling below the standard (>5 mg $L^{-1}$), potentially causing stress to fish. Furthermore, the water pH (7.8–9.0) slightly exceeds the SNI limit (6.5–8.5). Overall, the pond's environmental conditions require continuous monitoring, particularly for DO and pH levels, to ensure the stability of the aquatic ecosystem.

### 3.2 *Measurement amount of parasites*

The results from the table above indicate that the highest prevalence (P) is 100% for *Trichodina* sp., 60% for *Dactylogyrus* sp., and 80% for *Gyrodactylus* sp. The intensity (I) and mean intensity (mI) for *Trichodina* sp. are 48–211 and 93.6, respectively; for *Dactylogyrus* sp., they are 2–4 and 3.33; and for *Gyrodactylus* sp., they are 1–7 and 3.75. The mean abundance (MA) values for *Trichodina* sp., *Dactylogyrus* sp., and *Gyrodactylus* sp. are 93.6, 2, and 3, respectively. Observations of

Table 2. Data on the results of calculating ectoparasitic parameters on red tilapia seeds *Oreochromis niloticus*

| Ectoparasites | Parameter Value | | | |
|---|---|---|---|---|
| | P (%) | I | MI | MA |
| *Trichodina* sp. | 100.00 | 48.00–211.00 | 93.60 | 93.60 |
| *Gyrodactylus* sp. | 80.00 | 1.00–7.00 | 3.75 | 3.00 |
| *Dactylogyrus* sp. | 60.00 | 2.00–4.00 | 3.33 | 2.00 |

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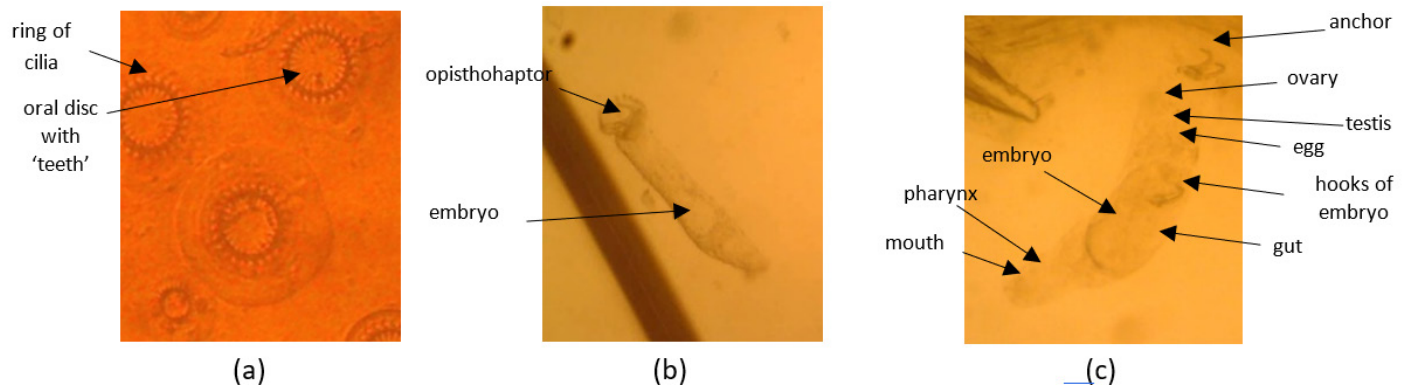


Figure 1. Ectoparasites found in red tilapia fry measuring 4-6 cm in Janti Loka: (a) *Trichodina* sp. (b) *Gyrodactylus* sp. (c) *Dactylogyrus* sp.

ectoparasites under a microscope are presented in Figure 1.

*3.3 Fish growth and survival*

The data indicate that the survival rate (SR) percentage from the first nursery phase in Loka Janti is very low, averaging only 30.3%. In contrast, the SR for the second nursery phase is significantly higher, reaching 63.4%. The specific growth rate (SGR) in the first nursery phase, with a size of ±4–6 cm, was recorded at 15.6%.

*3.4 Financial value*

Based on the calculation results, it was found that red tilapia fry experienced a parasite attack, resulting in a survival rate (SR) of only 30.3%. Despite this, the business still generated a profit of IDR 71,814,554.00 per year. However, with a payback period of 4.4 years, it indicates that the capital invested will be fully recovered within 4.4 years.

## IV. DISCUSION

The results showed that *Trichodina* sp. had the highest prevalence (P) at 100%, intensity (I) ranging from 48 to 211, mean intensity (mI) of 93.6, and mean abundance (mA) of 93.6 compared to other parasites in the fish samples. Among the ectoparasites identified in this study, *Trichodina* sp. was the most frequently observed. This is likely due to the environmental conditions of the rearing ponds and the accumulation of nutrients from feed residues, which promote the rapid growth of ectoparasites (Purbomartono, 2010). Ohoiulun (2002) reported that the surface of a fish's body is directly influenced by environmental factors, making it more susceptible to ectoparasite attacks,

Tabel 3. Survival rate and specific growth rate data for seeds in nursery phases I and II

| Nursury Phase | Average Stocking (ind) | Average Harvest-ing (ind) | SR Aver-age (%) | SGR (% day$^{-1}$) |
|---|---|---|---|---|
| Nursery I | 95.000 | 28.520 | 30,3 | 15.6 |
| Nursery II | 50.600 | 31.248 | 63,4% | 2.2 |

Tabel 4. Analysis of red tilapia fish hatchery at nursery 1 size 4-6 cm

| No | Cost and component calculation | Calculation results |
|---|---|---|
| 1 | Investment cost | Rp315,351,300.00 |
| 2 | Cost of depreciation | Rp 21,775,133.00/year |
| 3 | Fixed cost | Rp256,199,146.00/year |
| 4 | Variable costs | Rp 98,049,000.00/year |
| 5 | Total cost | Rp354,248,146.00/year |
| 6 | SR | 30.3% |
| 7 | Number of harvests 1 cycle | 90,172 fry/cycle |
| 8 | Harvest cycle in 1 year | 63 cycles |
| 9 | Total harvest in 1 year 63 cycles | 5,680,836 fry/year |
| 10 | Selling price of fish | Rp75.00/fry |
| 11 | Total revenue (TR) in 1 year | Rp426,062,700.00/year |
| 12 | Profit | Rp 71,814,554.00/year |
| 13 | R/C ratio | 1.20 |
| 14 | BEP (Rp) | Rp332,781,527.00 |
| 15 | BEP (Unit) | 4,437,087 units |
| 16 | PP | 4.4 years |
| 17 | HPP | Rp 62.00/fry |

including *Trichodina* sp. This type of ectoparasite is more commonly found on the surface of the fish's body than on other organs because it contains abundant mucus and epithelial tissue, which provide an ideal habitat and food source for ectoparasites. However, parasites attacking these fish fry are still considered safe and do not significantly interfere with the production process.

*Trichodina* sp. exhibits various shapes, including a bell-shaped sucker made of chitin, which resembles a circular anchor around the mouth (Gusrina, 2008). This ectoparasite plays a role in suppressing the immune system of fish, leading to secondary infections (Rukmawa, 2005). As shown in Table 1, *Trichodina* sp. frequently attacks the gills, consistent with findings by Handayani (2020), who reported that *Trichodina* sp. consumes red blood cells found in the gills. Although *Trichodina* sp. primarily uses the host as a substrate and feeds on organic particles from bacteria, its attachment often causes injuries (Gusrina, 2008).

Poor water quality promotes the growth of *Trichodina* sp., which disrupts fish appetite and reduces their resistance to bacterial infections, potentially resulting in significant losses. Furthermore, a high infection rate can lead to acute mortality without any preceding symptoms (Bhakti, 2011).

*Gyrodactylus* sp. is an ectoparasite that targets the skin and gills of freshwater fish. These ectoparasites are viviparous, with eggs that develop and hatch within the uterus (Noga, 1996). When *Gyrodactylus* sp. infects the gills, affected fish exhibit symptoms such as gasping for air, excessive mucus production, and swimming near the water's surface, indicating oxygen deficiency. *Gyrodactylus* sp. has a small, elongated body with two ear-like protrusions at its anterior end. Its posterior features an ophisthaptor equipped with 16 marginal hooks, which assist in attachment to the host.

*Dactylogyrus* sp. is commonly found in the fins and gills of fish, which are critical organs for respiration. Classified as a low-level parasitic worm (Trematode), *Dactylogyrus* sp. does not require an intermediate host and spends its entire life as a parasite. Its distinguishing features include two pairs of eyes and four protrusions on the anterior end (Safutra, 2006). Kriswinarto (2002) reported that fish infected with *Dactylogyrus* sp. often become thin, exhibit erratic swimming behavior, and show signs of damaged gills, such as incomplete gill cover closure. Additionally, the fish's skin loses its transparency. Despite the impact of *Dactylogyrus* sp. on red tilapia fry, which resulted in a survival rate (SR) of only 30.3%, the business still yielded a profit of IDR 71,814,554.00 per year. However, with a payback period of 4.4 years, it indicates that the capital invested would be fully recovered within this timeframe.

*Trichodina* sp. is a protozoan parasite that can cause extremely high mortality rates, particularly in tilapia fry. It damages the skin and gill epithelium of the fish, making them susceptible to secondary infections by other pathogens, such as bacteria and fungi, which further stress the host and contribute to mortality (Vallado *et al.,* 2016).

Similarly, *Dactylogyrus* spp. are highly host-specific monogenean ectoparasites commonly found embedded in the gill tissues of farmed cyprinid fish. These parasites pose significant challenges to aquaculture operations (Li *et al.,* 2022).

Infections caused by *Gyrodactylus* and other monogeneans are often linked to outbreaks of infectious diseases in commercial farms, leading to significant morbidity rates in various fish species (Thoney and Hargis, 1991; Kritsky and Heckmann, 2002; Jaruboonyakorn *et al.,* 2022). Monogeneans in the genus *Gyrodactylus* are particularly pathogenic to fish and have become a major challenge to the aquaculture industry. These parasites also pose a potential threat to the survival of wild fish populations (Anshary *et al.,* 2023).

## V. CONCLUSION

The presence of parasites in fish can lead to reduced development and appetite, significantly affecting growth rates. As a result, investment in fish feed becomes disproportionate to the fish's growth, leading to higher maintenance costs and lower profits, especially in Loka Janti, Klaten, Central Java. To address this, it is recommended to maximize production through pond calcification and fertilization, as well as to implement strict biosecurity measures to prevent disease transmission and enhance fish health and profitability.

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## CONFLICT OF INTEREST

We certify that there are no conflicts of interest, including financial, personal, or other relationships with any individuals or organizations related to the material discussed in the manuscript.

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