Prevalence of Ectoparasites in Tilapia (*Oreochromis niloticus*) in Sidoarjo, Indonesia

Aulia Puspita Sari[1], Setiawan Koesdarto[2], Tita Damayanti Lestari[3]*, Poedji Hastutiek[2], Muchammad Yunus[2], Eduardus Bimo Aksono Herupradoto[4], Aswin Rafif Khairullah[5], Siti Rani Ayuti[6], Abdullah Hasib[7], Suhita Aryaloka[8], Ikechukwu Benjamin Moses[9]

[1]Profession Program of Veterinary Medicine, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya 60115, East Java, Indonesia, [2]Division of Veterinary Parasitology, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya 60115, East Java, Indonesia, [3]Division of Veterinary Reproduction, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya 60115, East Java, Indonesia, [4]Division of Basic Veterinary Medicine, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya 60115, East Java, Indonesia, [5]Research Center for Veterinary Science, National Research and Innovation Agency (BRIN), Bogor 16911, West Java, Indonesia, [6]Faculty of Veterinary Medicine, Universitas Syiah Kuala, Kota Banda Aceh, 23111, Aceh, Indonesia, [7]School of Agriculture and Food Sustainability, The University of Queensland, Gatton, QLD, 4343, Queensland, Australia, [8]Master Program of Veterinary Agribusiness, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya 60115, East Java, Indonesia, [9]Department of Applied Microbiology, Faculty of Science, Ebonyi State University, Abakaliki 480211, Nigeria.
*Corresponding author: titadlestari@fkh.unair.ac.id

Abstract

The problem most often encountered in fish farming is disease which can cause a decrease in fish production levels. Parasites cause one of the infectious diseases found in fish farming. The presence of parasites can cause a decrease in the quality of the growth of fish production. The purpose of this study was to identify the prevalence of ectoparasites on Nile tilapia in Sidoarjo, Indonesia. Ninety-six samples from two ponds were examined under the microscope to find out the presence of ectoparasite that exists in the outside body part of the fish. Samples were collected from skin, fins, tail, and gills using native methods and observed under a microscope in the Division of Parasitology Laboratory, Faculty of Veterinary Medicine, Universitas Airlangga. The results of this study showed 86 samples positively infected by ectoparasite and 10 showed negative. The ectoparasites found in this study were *Trichodina* sp., *Chilodonella* sp., *Ichthyophthirius multifillis*, *Gyrodactylus* sp., and *Dactylogyrus* sp. The highest prevalence is *Trichodina* sp. and *Dactylogyrus* sp. The number of fish infested by ectoparasite is 89.56%, this is classified in the usual category. The highest prevalence occurs in infestations of *Trichodina* sp. i.e.72.91% which were contained in the 70 samples. While the lowest prevalence was in *Gyrodactylus* sp. by 8.32% in 8 fish samples. Double infections from two different ponds were 70% within 33 samples which were included in the usual category.

Keywords: ectoparasite, fish, prevalence, protozoa, tilapia

Received: 7 May 2024 **Revised:** 24 May 2024 **Accepted:** 22 July 2024

INTRODUCTION

Tilapia (*Oreochromis niloticus*) is one of the main commodities of national freshwater aquaculture. This fish is a type of fish that lives in fresh water and has high economic value for cultivation and is widely consumed by the public (Fuadi *et al*., 2021). Tilapia fish are known for having a long and slender body shape with large scales, large and prominent eyes with white on the edges, black dorsal, and chest fins, and lines with the same pattern on both sides of the tilapia's body (Mehar *et al*., 2023). The advantages of farming tilapia are it is quite easy to cultivate, the growth process is relatively faster, and it is an affordable source of animal protein for humans, having a protein value of 17% (Coppola *et al*., 2021; Safira *et al*., 2022; Rani *et al*., 2022).

The problem most often encountered in fish farming is disease which can cause a decrease in fish production levels. One of the infectious diseases found in fish farming is caused by

parasites (Shamsi, 2019). The presence of parasites can cause a decrease in quality and the growth of fish production. Parts of the fish's body where parasites were found included the gills, skin, and fish muscle tissue which caused irritation and weight loss (Omeji *et al*., 2011). The presence of zoonotic parasites in fish is a threat to human health (Shamsi, 2019). Zoonoses are diseases and infectious agents that are naturally transmitted between vertebrate animals and humans (Fikri *et al*., 2022; Singh *et al*., 2023). Studies on fish zoonotic disease are still limited so far and therefore, they need to be continually conducted for public health purposes.

Apart from zoonotic parasites, non-zoonotic parasites in freshwater fish can also affect fish life (Ziarati *et al*., 2022). Based on where they live, parasites that live outside the fish's body are called ectoparasites (Iriansyah *et al*., 2020). The external parts of the fish's body where ectoparasites tend to be found include the fins, body surface, and gill lamellae (Nur *et al*., 2020). A high number of ectoparasite infections in fish will reduce the fish's immunity (Binning *et al*., 2013). The types of ectoparasites that can infest tilapia are protozoa, namely *Trichodina* sp., *Oodinium* sp., and Ichthyophthirius multifilis, while other ectoparasites from platyhelminthes such as *Dactylogyrus* sp. and *Gyrodactylus* sp. (Kolia *et al*., 2021).

Sidoarjo is one of the areas where fisheries are its main natural resources. The large size of the ponds in the Sidoarjo area means that most of the population makes a living as pond farmers (Pratama *et al*., 2019). Public interest in tilapia fish is quite high because the price is affordable, high protein content, and is easy to cultivate. Therefore, the general public is encouraged to cultivate tilapia fish (Mutyaba *et al*., 2024). However, losses can occur for tilapia fish farming owners if many fish are infected with parasites. The large number of fish infected with parasites can cause death decrease productivity and affect economic value.

Diseases in fish can result in lower productivity, and economic losses, and harm the development of aquaculture in a region. This study aimed to determine the prevalence of ectoparasites in Tilapia fish in Sidoarjo, Indonesia.

MATERIALS AND METHODS

Ethical Approval

This study was approved by the ethics committee of the Faculty of Veterinary Medicine at Universitas Airlangga, Indonesia provided consent for the use of animals with number: 1.KEH.033.02.2023.

Study Period and Location

This study was conducted from September to November 2023. Sampling was carried out in two ponds in Kalipecabean Village, Candi District, Sidoarjo, Indonesia (-7.4849269, 112.7435171). Ectoparasite identification was carried out at the Parasitology Laboratory, Faculty of Veterinary Medicine, Universitas Airlangga.

Samples

A total of 96 tilapia were collected in this study following the sample size formula from Martins *et al*. (2015). Samples were collected directly and periodically over three months using a scoop or net from the pond. Tilapia samples taken measuring 15–30 cm from Pond 1 were 46 samples and Pond 2 was 50 samples were then put into a bucket accompanied by an oxygen pump so the sampled fish could survive until they were examined in the laboratory for research.

Ectoparasite Identification

Examination of ectoparasites in tilapia was carried out using a native method. Identification of ectoparasites was done by scraping the skin, head to tail, and fins on the fish's body using a scalpel to obtain mucus. The mucus resulting from scrapping was immediately transferred to a glass object and dripped with physiological sodium chloride (NaCl), then covered with a cover glass and then observed under a microscope with 100× and 400× magnification (Ihsan and Sitinjak, 2023).

Identification of ectoparasites on the gills was done by cutting the operculum so that the gills were visible. The gill sheets were taken using

tweezers, then each sheet was placed on a glass object dripped with physiological sodium chloride (NaCl) and flattened to avoid accumulation of filaments on the fish's gills. Cover the preparation with a covered glass and observe under a microscope with 400× magnification (Nimah *et al*., 2022).

Statistical Analysis

The data collected was analyzed descriptively based on the prevalence criteria by Zelmer *et al*. (1998) which was presented in Table 1.

RESULTS AND DISCUSSION

This study reported tilapia fish measuring 15–30 cm from pond 1 were 46 samples and pond 2 was 50 samples obtained from ponds in Kalipecabean Village, Candi District, Sidoarjo. The population in each pond of tilapia is approximately 300. Protozoa ectoparasites were found which infested tilapia namely, *Trichodina* sp., *Chilodonella* sp., and *I. multifillis*. In addition, ectoparasites of Platyhelmithes, such as *Gyrodactylus* sp. and *Dactylogyrus* sp. were also found infected the fish (Table 2).

From pond 1, there were 46 samples of tilapia fish, 41 of which were infested with ectoparasites. From pond 2, 50 samples of tilapia fish were found to be 45 fish infested with ectoparasites.

Tilapia fish have a body shape that tends to be slender, elongated, and full, with relatively large scales, and protruding eyes. The jaws of tilapia fish are parallel between the upper and lower. The body color of tilapia fish is gray on the upper half of the body, while the lower body is silver. The dorsal fin, pelvic fin, and anal fin have weak rays but are hard and sharp like spines. Apart from that, there is a very clear pattern of vertical lines on the tail fin and dorsal fin of the tilapia fish and on both sides of the tilapia's body, there are dark horizontal lines from the front to the back of the tilapia's body (Osman *et al*., 2017).

Based on the results of the study conducted on 96 samples of tilapia fish, 86 samples were infested with parasites with a total prevalence of 89.56%. There are 7 prevalence categories i.e. occasionally, often, commonly, frequently, usually, almost always, and always (Zelmer *et al*., 1998). The results of this study were included in the usual category. The three ectoparasites identified are protozoa from the Ciliophora phylum, Ciliata class, and are divided into three species, namely *Trichodina* sp., *Chilodonella* sp., and I. multifilis. Two other ectoparasites from the phylum Platyhelminthes, class Trematoda, subclass Monogenea, namely *Gyrodactylus* sp. and *Dactylogyrus* sp. Ectoparasitic infections in this fish are not zoonotic. However, infected fish will worsen its external appearance, thereby reducing people's interest in consuming the fish.

In Kalipecabean Village ponds, the forms of ectoparasite infestation are divided into three, namely single infestation, double infestation, and mixed infestation. The condition of the research pond does not pay much attention to cleanliness, for example, there are dead fish but they are left alone and there is a lot of rubbish around the pond. A single infestation is an attack of only one type of ectoparasite on each individual. Double infestation is an attack of two types of ectoparasites on each and mixed infestation is an attack of three or more types of ectoparasites on each individual (Dargent *et al*., 2013).

Based on the examination results, the highest prevalence of ectoparasites was in *Trichodina* sp. amounting to 72.91% or 70 samples while the lowest prevalence occurred in *Gyrodactylus* sp at 8.32% in 8 samples included in the usual category or usually occurs. In a single infestation of *Trichodina* sp. had a prevalence of 4.17% in 4 samples. *Trichodina* sp. infests fish simultaneously with other ectoparasites, including double infestation of *Trichodina* sp. + *Chilodonella* sp. had a prevalence of 12.5% in 12 animals, *Trichodina* sp. + *I. multifillis* prevalence 4.17% in 4 animals, and *Trichodina* sp. + *Dactylogyrus* sp. as many as 33 individuals with a prevalence of 34.37%, while in mixed infestations of *Trichodina* sp. + *Chilodonella* sp. + *Dactylogyrus* sp. as many as 17 individuals with a prevalence of 17.7% (Table 2).

Table 1. Prevalence criteria

Prevalence category	Prevalence (%)
Occasionally	1–9
Often	10–29
Commonly	30–49
Frequently	50–69
Usually	70–89
Almost always	90–99
Always	99–100

Table 2. Data on the type and number of tilapia (*O. niloticus*) samples infested with ectoparasites

Types of ectoparasites	Number of the ectoparasites infested in tilapia fish	
	Pond 1	Pond 2
Trichodina sp.	2	2
Trichodina sp. + *Chilodonella* sp.	5	7
Trichodina sp. + *Ichthyophthirius multifillis*	2	2
Gyrodactylus sp.	1	2
Dactylogyrus sp.	3	5
Gyrodactylus sp. + *Dactylogyrus* sp.	2	3
Trichodina sp. + *Dactylogyrus* sp.	18	15
Trichodina sp. + *Chilodonella* sp. + *Dactylogyrus* sp.	8	9
Total	41	45

Table 3. Results of calculating the prevalence of ectoparasites found in tilapia (*O. niloticus*)

Types of ectoparasites	Number of infested tilapia fish	Prevalence (%)	Category
Trichodina sp.	4	4.17	Occasionally
Trichodina sp. + *Chilodonella* sp.	12	12.5	Often
Trichodina sp. + *Ichthyophthirius multifillis*	4	4.17	Occasionally
Gyrodactylus sp.	3	3.12	Occasionally
Dactylogyrus sp.	8	8.33	Occasionally
Gyrodactylus sp. + *Dactylogyrus* sp.	5	5.2	Occasionally
Trichodina sp. + *Dactylogyrus* sp.	33	34.37	Commonly
Trichodina sp. + *Chilodonella* sp. + *Dactylogyrus* sp.	17	17.7	Often
Total	86	89.56	Usually

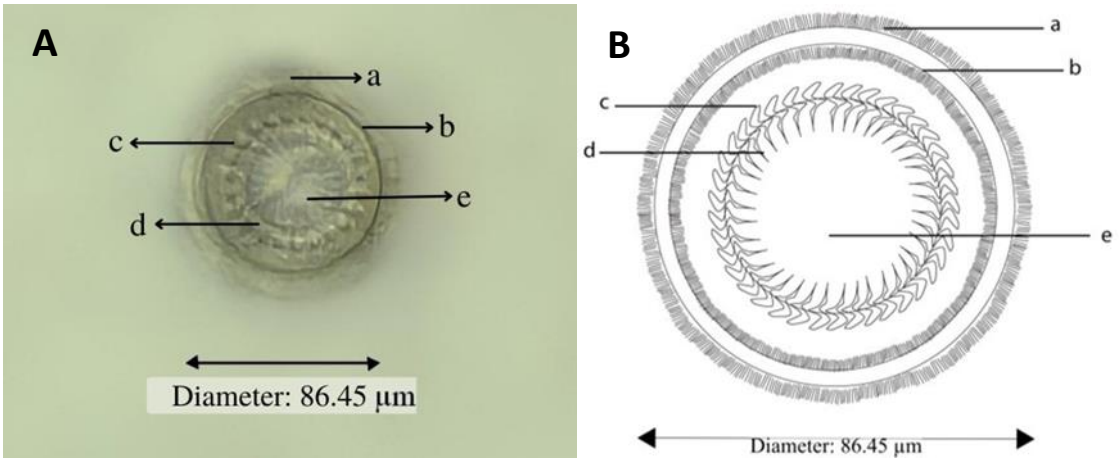

Figure 1. *Trichodina* sp. was observed using (A) Binocular microscope and (B) Lucida camera with 400× magnification. (a) Cilia, (b) border membranes, (c) radial pins, (d) ray, (e) adhesive disks.

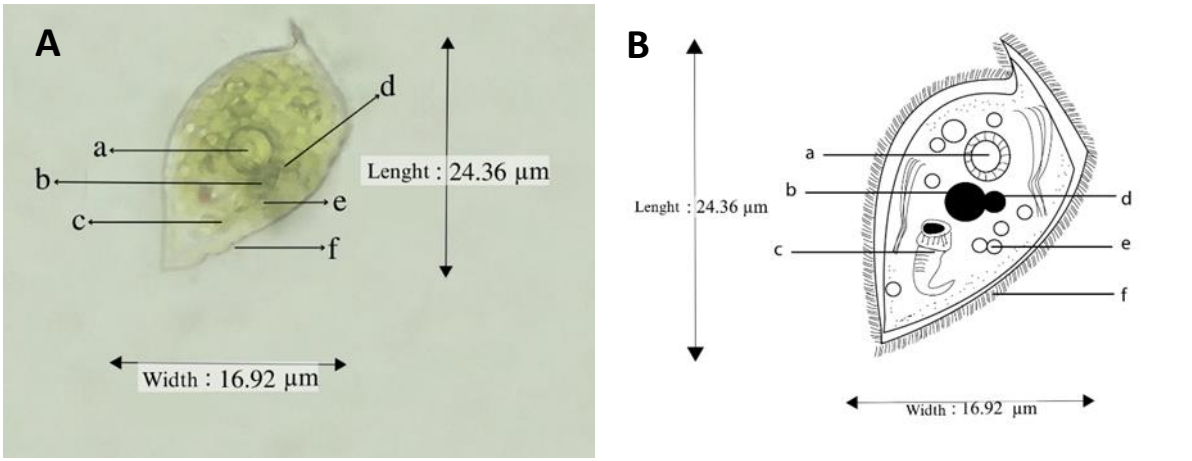

Figure 2. *Chilodonella* sp. was observed using (A) Binocular microscope and (B) Lucida camera with 1000× magnification. (a) Macronucleus, (b) micronucleus, (c) cytopharynx, (d) digestion vacuole, (e) contractile vacuole, (f) cilia.

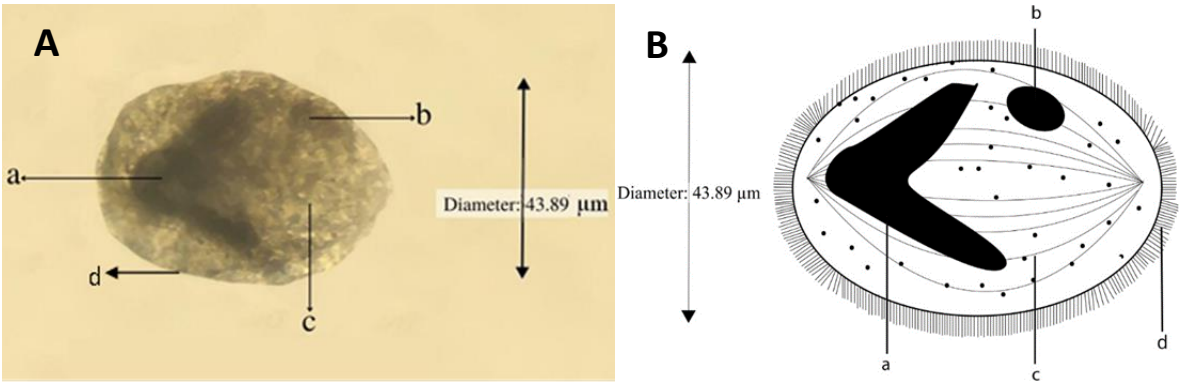

Figure 3. *Ichthyophthirius multifillis* was observed using (A) Binocular microscope and (B) Lucida camera with 400× magnification. (a) Macronucleus, (b) micronucleus, (c) digestive vacuole, (d) cilia.

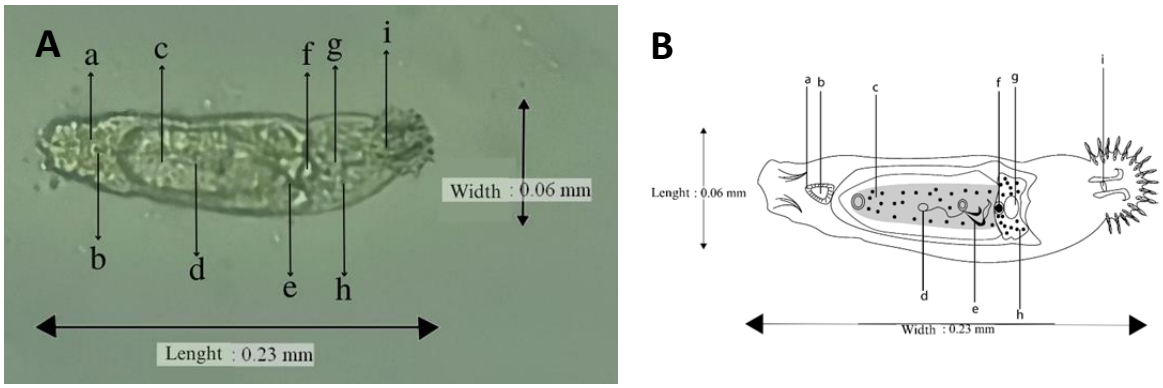

Figure 4. *Gyrodactylus* sp. was observed using (A) Binocular microscope and (B) Lucida camera with 100× magnification. (a) Mouth, (b) pharynx, (c) caecum, (d) embryo, (e) hooks of embryo, (f) eggs, (g) testicles, (h) ovaries, (i) bar, (j) marginal hook, (k) anchor.

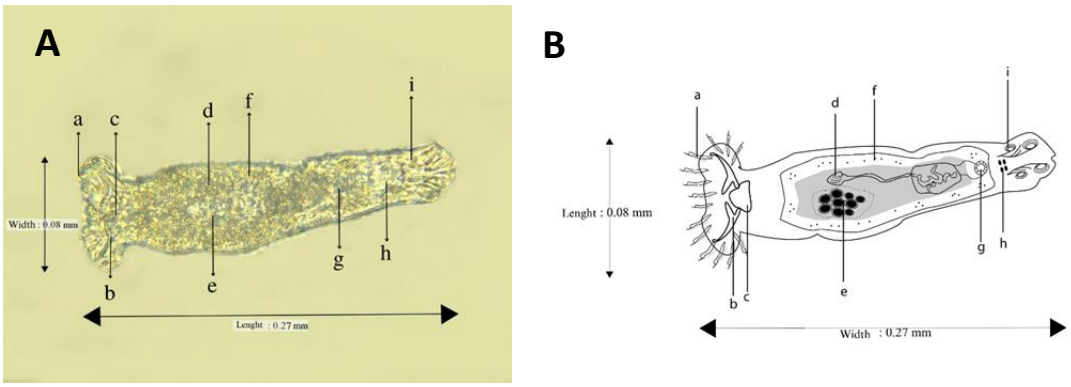

Figure 5. *Dactylogyrus* sp. was observed using (A) Binocular microscope and (B) Lucida camera with 100× magnification. (a) Marginal hook, (b) anchor, (c) dorsal bar, (d) testicles, (e) ovaries, (f) vitellaria, (g) pharynx, (h) eyespot, (i) head organs.

***Trichodina* sp.**

Trichodina sp. is found on the surface of the fish's body from the head to the caudal fin and in the gill mucus of the fish. The dorsal part of the parasite is around disc like a bowl with teeth (denticles) in the middle and cilia that are not very clearly visible around the outer body surface, while the ventral part is concave and has plates to attach itself to the host (Rokhmani *et al*., 2020). Transmission of this ectoparasite occurs directly through low-quality water or infected fish. In this study, observations with a binocular microscope at 400× magnification showed *Trichodina* sp. circular shape with a diameter of 86.45 µm (Iriansyah *et al*., 2020). Observation results of *Trichodina* sp. are shown in Figure 1.

The protozoan *Trichodina* sp was frequently identified in this study. The high prevalence of *Trichodina* sp. is due to its ability to reproduce quickly by dividing itself and throughout its life it resides in the fish's body and often attaches to fish that have been infected with other parasites (Rokhmani *et al*., 2020; Arumugam *et al*., 2024). *Trichodina* sp. will first attack the epidermis. From its life cycle, this parasite is classified as an obligate parasite, that is, once it lives on a host, it will remain on the host throughout its life until the host dies and the parasite will automatically die (Rokhmani *et al*., 2020).

Trichodina sp. is the cause of Trichodiniasis in freshwater fish with clinical signs of the infected fish swimming unsteadily, increased respiratory frequency, change in fish color from bright to darker, stunted growth, excessive mucus production resulting in exhaustion and even death due to disruption of the oxygen exchange system (Valladão *et al*., 2016). Low levels of infection do not result in significant losses. However, if the fish experience stress or the water quality decreases, it supports the growth of *Trichodina* sp. Infestation of ectoparasites can cause big losses because high infection can cause acute death without any symptoms first (Ihsan and Sitinjak, 2023). Trichodiniasis can be treated by administering a copper oxychloride solution of 50% with a dose of 15–30 kg per ha (if the average pond depth is 1 m). Trichodiniasis can be prevented by maintaining pond cleanliness, increasing the frequency of water changes, and stabilizing the water temperature above 29°C.

***Chilodonella* sp.**

The results of the examination showed that the ectoparasite *Chilodonella* sp. tends to be predilected on the surface of the fish's body. *Chilodonella* sp. has an oval shape like a heart with a line of cilia along the body axis. It is also dorsoventrally flat and transparent and has cytoplasmic granules and several small vacuoles (Bakri *et al*., 2020). This ectoparasite moves freely using the cilia on the surface of its body. In this study, observations with a binocular microscope with 1000× magnification showed *Chilodonella* sp. with a body length of 24.36 µm and a width of 16.92 µm as shown in Figure 2. The morphology of *Chilodonella* sp. is depicted using a binocular microscope with 1000× magnification equipped with a Lucida camera (Figure 2).

In this study, ectoparasite *Chilodonella* sp. was identified in a double infestation with the species *Trichodina* sp. with a prevalence of 12.5% or a total of 12 tilapia fish samples and in mixed infestations of *Trichodina* sp. + *Chilodonella* sp. + *Dactylogyrus* sp. as many as 17 individuals with a prevalence of 17.7%.

Chilodonella sp. reproduces using longitudinal division, attacking the surface of the fish's body, fins, and gills (Deák *et al*., 2024). This protozoa has two contractile vacuoles, one on the right anterior side and the other on the posterior side. When the host dies or the parasite is destroyed, the cilia can still survive for up to 24 hours at a temperature of 5°C, whereas at a temperature of 20°C they can only survive for one hour (Bakri *et al*., 2020; Ihsan and Sitinjak, 2023).

Chilodonella sp. causes Chilodonelliasis which causes damage to the skin and produces excess mucus, the infected fish appears hypoxic and thin, the eyes become blurry, and the most obvious clinical sign is skin abrasion. Localized infection in the skin and gill epithelium in acute cases can cause death (Minggawati *et al*., 2022). Treatment for Chilodonelliasis can be done by administering a solution of malachite green to infected fish ponds. Prevention of this disease can be done by quarantining new fish that are going to be introduced into cultivation ponds, reducing pond density, and maintaining pond sanitation.

Ichthyophthirius multifillis

The results of the examination for ectoparasite protozoa also showed *I. multifillis* which was found on the surface of the fish's body which was scraped to obtain fish body mucus and examined natively. *I. multifillis* has a round shape surrounded by cilia on the surface of its body, has a horseshoe-shaped macronucleus, and at least one round micronucleus. In this study, observations with a binocular microscope at 400× magnification showed *I. multifillis* with a body diameter of 43.89 µm as shown in Figure 3. The morphology of *I. multifillis* depicted using a binocular microscope at 400× magnification equipped with a camera lucida is shown in Figure 3.

Another ectoparasite from the Ciliata class that was found to infest tilapia was *I. multifillis* in a double infestation with the species *Trichodina* sp., which had a prevalence of 4.17% or found in a total of 4 samples of tilapia fish. *I. multifillis* is an ectoparasite that is rarely found in this study due to multiple infestations, thereby reducing the number of one other ectoparasite species that infests fish. The life cycle of *I. multifillis* is divided into several phases and lengths, if *I. multifillis* has reached the final phase this parasite will look for fish to become its host but if within 48 hours it does not find fish then this parasite will immediately die (Huang *et al*., 2022). *I. multifillis* usually occurs in the rainy season (20–24°C), while in the dry season, the attacks are sporadic (Sunarto, 2019). This protozoan infection the outermost surface of the fish's body, especially the mucous layer of the skin, fins, and gills. This protozoa has vibrating cilia and is an obligate parasite in freshwater fish. Cilia measuring up to 1.5 mm can be seen clearly with the naked eye. This parasite reproduces by dividing itself. An adult cell can divide up to 2,000 juveniles (Mahasri *et al*., 2012).

The impact of *I. multifillis* infection includes the physiological function of the fish being disturbed, causing gas exchange (O_2, CO_2, and ammonia) to be hampered, the fish becomes lazy about swimming and tends to float in the water, white spots are visible on the external part and the fish often rubs his body on the bottom of the pond or hard objects in the pond. To prevent this infection, long-term soaking can be done in a solution of quinine (1 gr / 50 L of water) or trypoflavin (1 gr / 100 L of water), although this cannot kill the cyst stages, at cold temperatures the infective elements can still hatch within 20 days (Rahman *et al*., 2016).

***Gyrodactylus* sp.**

The results of the examination found the ectoparasitic worm *Gyrodactylus* sp. which is found on the body and fins of fish, has hooks-like anchors and does not have eyespots. *Gyrodactylus* sp. there is a typical organ such as a crown, namely the opisthaptor which consists of 16 hooks and 1–2 pairs of anchors in its posterior

part. *Gyrodactylus* sp. is attached to the fish using marginal hooks and anchors to attach the marginal hooks (Huyse and Volckaert, 2002). The morphological body of the parasite is long oval and has a head shaped like a letter V. Observations with a binocular microscope with 100× magnification showed *Gyrodactylus* sp. had a body length of 0.23 μm and a width of 0.06 μm (Figure 4). The image result of *Gyrodactylus* sp. using a binocular microscope with 100× magnification equipped with a Lucida camera is shown in Figure 4.

Trematode *Gyrodactylus* sp. had the lowest prevalence and was rarely found in this study, with only 8.32% found or in 8 fish samples. *Gyrodactylus* sp. single infestation with a prevalence of 3.12% in 3 animals, while double infestation with *Dactylogyrus* sp. had a prevalence of 5.2% in 5 animals. All prevalence values are included in the occasional or sometimes category (Zelmer *et al*., 1998). The low level of infestation of *Gyrodactylus* sp. in fish is caused by competition between species in taking nutrients from the host. Its microdistribution is limited by other ectoparasites that infect the gills as well. Several species of parasites live in an organ, their micro-distribution is limited by the presence of other parasites by releasing a kind of pheromone from their bodies to indicate their attachment location and prevent other parasites from living in that area (Romano *et al*., 2015). *Gyrodactylus* sp. has a long life cycle starting from producing eggs. The eggs are equipped with long filaments to attach to the substrate. Then in about five days the eggs will mature and hatch producing onchomyracidia which have vibrating cilia as a swimming tool to find a host. After finding a host, the cilia will disappear and the onchomyracidia will develop into an adult (Deák *et al*., 2024).

Gyrodactylus sp. is found on the gills and skin surface. This parasite can cause Gyrodactyliasis with clinical symptoms of decreased appetite, the fish's body becomes pale, wounds on the body surface, bleeding, and tail fins falling out and the fish is often seen rubbing its body deliberately against the bottom of the pond (Grano-Maldonado, 2018). Gyrodactyliasis can be cured by administering Niclosamide or Hydrogen Peroxide. Prevention of Gyrodactyliasis can be done by maintaining a clean pond environment, reducing fish stocking density, and immediately separating fish that look sick to avoid spreading the disease more widely (Schelkle *et al*., 2009).

***Dactylogyrus* sp.**

The results of the examination also found other parasites from the Trematoda class, namely *Dactylogyrus* sp. on fish gills according to their predilection. Morphological characteristics of *Dactylogyrus* sp. have a flat head shape that tapers at the most anterior part, four spots which are eye spots, and the mouth is located near the anterior end of the body. At the end of its posterior, there are two pairs of large hooks (anchors) surrounded by 14 smaller hooks called opisthaptors. In this study, observations with a binocular microscope with 100× magnification showed *Dactylogyrus* sp. with a body length of 0.27 μm and a width of 0.08 μm (Figure 5). Morphology of *Dactylogyrus* sp. which is depicted using a binocular microscope with 100× magnification equipped with a lucida camera is in Figure 5.

Dactylogyrus sp. became the most frequently identified trematode during the study with a prevalence of 65.6%, included in the frequently occurring category (Zelmer *et al*., 1998). In this study, the prevalence was lower than in the study by Manurung and Gaghenggang (2016) with a prevalence of 86.67%. Apart from *Dactylogyrus* sp., other parasite species were also found in the gills of tilapia fish, such as *Trichodina* sp. and *Chilodonella* sp. *Dactylogyrus* sp. single infestation had a prevalence of 8.33% or found in 8 animals. Meanwhile, in double infestation with *Gyrodactylus* sp. the prevalence was 5.2% or found to be infested in 5 of the total individual samples.

Dactylogyrus sp. lives without an intermediate host so its entire life functions as a parasite (Shafiq *et al*., 2023) and its transmission is through direct contact with organisms in water and it will be spread faster at high population densities of the hosts. Adult worms *Dactylogyrus* sp. in the gills begin to lay eggs in spring and

reproduce, the hottest months will be the peak of infection. If *Dactylogyrus* sp. infection occurs. In small amounts it will not cause damage to the fish and the fish will look normal, however if it is severe it can cause Dactylogyriasis disease with symptoms of the fish becoming weak, the skin looking pale, hyperplasia, and damage to the gill lamellae until the operculum is open and excessive mucus produced. Dactylogyriasis can be treated by administering potassium permanganate solution and can be prevented by maintaining a clean pond environment and reducing fish stocking density (Rahayu *et al*., 2013).

Prevalence of Ectoparasites in Tilapia

Prevalence is the percentage of fish infected by parasites in a sample of all fish examined. The parasite infection level or prevalence determines the impact on the fish. The greater the prevalence value, the more severe the level of infection as well as the impact it causes. The results of the study from 96 samples of tilapia obtained from ponds in Kalipecabean Village, Candi District, Sidoarjo showed a prevalence of 89.56% (Table 3).

Double infestation of ectoparasites is synergistic or mutually supports the life of each parasite species which can cause obstacles to the development of the fish (López-Pérez *et al*., 2022). The presence of multiple and mixed infestations of ectoparasites on tilapia usually causes the affected host to experience a reduced immune system. Therefore, the possibility of next infestation by other ectoparasites is very likely (Anshary *et al*., 2023).

None of the parasites found in tilapia in this study were zoonotic. However, it cannot be said that it is safe to consume the fish. If the number of parasites is too large to infest a fish, it can trigger secondary infections caused by bacteria or viruses due to wounds caused by lowered immune system (Omeji *et al*., 2011). Parasite infestation can cause economic losses for the fishing industry. The economic effects caused by parasites on fish include reducing the fish population, fish productivity, and mass death (Davidovich *et al*., 2023).

CONCLUSION

The types of ectoparasites that infest tilapia fish obtained from ponds in Kalipecabean Village, Candi District, Sidoarjo are protozoa from the Ciliata class, namely *Trichodina* sp., *Chilodonella* sp., *I. multifillis* and from the Trematoda class, namely the species *Gyrodactylus* sp. and *Dactylogyrus* sp. The prevalence of the total number of fish infested with ectoparasites was 89.56% with the prevalence criteria level included in the usual category. The highest prevalence of ectoparasites in *Trichodina* sp. which infested singly, multiply, and mixedly, was 72.91% in 70 samples, while the lowest prevalence was infestation with *Gyrodactylus* sp. which infested fish singly and multiply was 8.32% in 8 fish samples. Suggestions for pond farmers to raise fish in a clean and controlled environment. So that people as consumers can get healthy animal protein intake from fish.

ACKNOWLEDGEMENTS

The authors thank Universitas Airlangga and the National Research and Innovation Agency (BRIN) for supporting this study.

AUTHORS' CONTRIBUTIONS

APS and SK: Conceived, designed, and coordinated the study. MY and PH: Designed data collections tools, supervised the field sample and data collection, and laboratory work as well as data entry. TDL and EBAH: Validation, supervision, and formal analysis. SA and SRA: Contributed reagents, materials, and analysis tools. AH, IBM, and ARK: Carried out the statistical analysis and interpretation and participated in the preparation of the manuscript. All authors have read, reviewed, and approved the final manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

REFERENCES

Anshary, H., Sriwulan, S., & Amriana, A. (2023). High prevalence and mean intensity of trichodinids and monogeneans on Nile tilapia (*Oreochromis niloticus*) in Indonesian hatcheries. *Veterinary Parasitology: Regional Studies and Reports*, 43(1), 100898.

Arumugam, K., Budiono, N. G., & Widyananta, B. J. (2024). Isolation and Identification of Aspergillus sp. in Tilapia (*Oreochromis* sp.) Sold for Consumption in Bogor. *Jurnal Medik Veteriner*, 7(1), 187–204.

Bakri, M., Asy'ari, I. M., Eliawardani, Hambal, M., Winaruddin, Darmawi, Azhari, & Novita, A. (2020). Identification of Parasites on the Shark Fish (*Selachimorpha*) in Peunayong Fish Market Banda Aceh City. *Jurnal Medika Veterinaria*, 14(2), 147–150.

Binning, S. A., Roche, D. G., & Layton, C. (2013). Ectoparasites increase swimming costs in a coral reef fish. *Biology Letters*, 9(1), 20120927.

Coppola, D., Lauritano, C., Esposito, F. P., Riccio, G., Rizzo, C., & de Pascale, D. (2021). Fish Waste: From Problem to Valuable Resource. *Marine Drugs*, 19(2), 116.

Dargent, F., Torres-Dowdall, J., Scott, M. E., Ramnarine, I., & Fussmann, G. F. (2013). Can mixed-species groups reduce individual parasite load? A field test with two closely related poeciliid fishes (*Poecilia reticulata* and *Poecilia picta*). *PLoS One*, 8(2), e56789.

Davidovich, N., Yasur-Landau, D., Behar, A., Pretto, T., & Scholz, T. (2023). Invasive parasites and global change: Evidence for the recent and rapid spillover of a potential pathogen of tilapias with a complex, three-host life cycle. *Heliyon*, 9(9), e18831.

Deák, G., Holban, E., Sadîca, I., & Jawdhari, A. (2024). Sturgeon Parasites: A Review of Their Diversity and Distribution. *Diversity*, 16(3), 163.

Fikri, F., Wardhana, D. K., Purnomo, A., Khairani, S., Chhetri, S., & Purnama, M. T. E. (2022). Aerolysin gene characterization and antimicrobial resistance profile of *Aeromonas hydrophila* isolated from milkfish (*Chanos chanos*) in Gresik, Indonesia. *Veterinary World*, 15(7), 1759.

Fuadi, A. A., Hasly, I. R. J., Azkia, L. I., & Irham, M. (2021). Response of tilapia (*Oreochromis niloticus*) behaviour to salinity differences: a laboratory scale study. *IOP Conference Series: Earth and Environmental Science*, 674(1), 012060.

Grano-Maldonado, M. I. (2018). Ultrastructure Study of the Stored Lipid Reserves in *Gyrodactylus gasterostei* (Monogenea) Using Confocal and Transmission Electron Microscopy. *Journal of Microscopy and Ultrastructure*, 6(2), 65–71.

Huang, K., Hu, G., Wang, R., Zeng, Q., Li, W., Zou, H., Wu, S., Wang, G., & Li, M. (2022). In Vitro Assessment of Berberine against *Ichthyophthirius multifiliis* in Goldfish. *Pathogens*, 11(10), 1207.

Huyse, T., & Volckaert, F. A. (2002). Identification of a host-associated species complex using molecular and morphometric analyses, with the description of *Gyrodactylus rugiensoides* n. sp. (Gyrodactylidae, Monogenea). *International Journal for Parasitology*, 32(7), 907–919.

Ihsan, B., & Sitinjak, R. S. (2023). Prevalence of Ectoparasites in Tilapia (*Oreochromis niloticus*) in Tarakan. *Jurnal Medik Veteriner*, 6(2), 185–190.

Iriansyah, A. H., Budiharjo, A., & Sugiyarto. (2020). Parasites prevalence infecting freshwater fishes in Mulur Reservoir of Sukoharjo District, Indonesia. *Bonorowo Wetlands*, 10(2), 92–97.

Kolia, W. S. K., Sunarto, & Widiyani, T. (2021). The infection of ectoparasitic protozoa on farmed Nile tilapia (*Oreochromis niloticus*) at three reservoirs in Central Java, Indonesia. *Biodiversitas*, 22(4), 1975–1980.

López-Pérez, A. M., Pesapane, R., Clifford, D. L., Backus, L., Foley, P., Voll, A., Silva, R. B., & Foley, J. (2022). Host species and environment drivers of ectoparasite community of rodents in a Mojave Desert wetlands. *PLoS One*, 17(6), e0269160.

Mahasri, G., Aris, D. H., & Kusdarwati, R. (2012). Derajat Infestasi dan Intensitas *Ichthyophthirius multifiliis* pada Ikan Koi (*Cyprinus carpio*) dengan Metode Kohabitasi. *Jurnal Ilmiah Perikanan dan Kelautan*, 4(1), 15–20.

Manurung, U. N. & Gaghenggang, F. (2016). Identification and prevalence of ectoparasite on nile tilapia (*Oreochromis niloticus*) cultured in Kampung Hiung, Manganitu District, Sangihe Island Regency. *Budidaya Perairan*, 4(2), 26–30.

Martins, M. L., Cardoso, L., Marchiori, N., & Benites de Pádua, S. (2015). Protozoan infections in farmed fish from Brazil: diagnosis and pathogenesis. *Revista Brasileira de Parasitologia Veterinária*, 24(1), 1–20.

Mehar, M., Mekkawy, W., McDougall, C., & Benzie, J. A. H. (2023). Tilapia (*Oreochromis niloticus*) trait preferences by women and men farmers in Jessore and Mymensingh districts of Bangladesh. *Aquaculture*, 562(1), 738799.

Minggawati, I., Agustinus, F., Augusta, T. S., Pahawang, C. P., & Francisco, T. (2022). Identification and prevalence of ectoparasites and endoparasites in kerandang fish *Channa pleurophtalma* and catfish *Clarias batrachus* captured from Sebangau River. *Indonesian Journal of Aquaculture*, 21(2), 152–160.

Mutyaba, J. L., Ngigi, M. W., & Ayuya, O. I. (2024). Determinants of knowledge, attitude and perception towards cage fish farming technologies among smallholder farmers in Uganda. *Cogent Food & Agriculture*, 10(1), 1.

Nimah, A., Ardhya, G. S., Plumeriastuti, H., Koesdarto, S., & Budiarto. (2022). Identification of Ectoparasites in Pearl Catfish (*Clarias gariepinus*) with One and Three Months Age in Maclele Cultivation, Tuban District, Tuban Regency. *Journal of Parasite Science*, 6(2), 60–66.

Nur, I., Yusnaini, Idris, M., & Sari, A. I. (2020). Study on the impact of environmental pollution: Parasitic infestation andconditionsfactorof fish livingin amalgamation ponds. *IOP Conference Series: Earth and Environmental Science*, 465(1), 012042.

Omeji, S., Solomon, S. G., & Idoga, E. S. (2011). A Comparative Study of the Common Protozoan Parasites of Clarias gariepinus from the Wild and Cultured Environments in Benue State, Nigeria. *Journal of Parasitology Research*, 2011(1), 916489.

Osman, K. M., Al-Maary, K. S., Mubarak, A. S., Dawoud, T. M., Moussa, I. M. I., Ibrahim, M. D. S., Hessain, A. M., Orabi, A., & Fawzy, N. M. (2017). Characterization and susceptibility of streptococci and enterococci isolated from Nile tilapia (*Oreochromis niloticus*) showing septicaemia in aquaculture and wild sites in Egypt. *BMC Veterinary Research*, 13(1), 357.

Pratama, B. B., Hasibuan, H. S., & Supriatna. (2019). Social adaptation and resilience on disaster, the case of Sidoarjo mudflow. *IOP Conference Series: Earth and Environmental Science*, 243(1), 012010.

Rahayu, F. D., Ekastuti, D. R., & Tiuria, R. (2013). Infestation of Parasitic Worm at Mujair's Gills (*Oreochromis mossambicus*). *Acta Veterinaria Indonesiana*, 1(1), 8–14.

Rahman, Sukenda, Nuryati, S., & Hidayatullah, D. (2016). The infectivity of *Ichtyophthirius multifiliis* against low temperature storage. *Indonesian Journal of Aquaculture*, 5(2), 93–98.

Rani, C. A. M., Safira, A., Suryadiningrat, M., Fikri, F., Wardhana, D. K., & Purnama, M. T. E. (2022). Characterization of Tilapia collagen-loaded chitosan nanofibers synthesized by electrospinning method for wound dressing. *IOP Conference Series: Earth and Environmental Science*, 1036(1), 012034.

Rokhmani, Darsono, & Riwidiharso, E. (2020). Diversity of *Trichodina* spp. on The Larvae of Freshwater Fish in Banyumas and Surrounding Areas of Central Java. *IOP Conference Series: Earth and Environmental Science*, 593(1), 012039.

Romano, M. C., Jiménez, P., Miranda-Brito, C., & Valdez, R. A. (2015). Parasites and steroid hormones: corticosteroid and sex steroid synthesis, their role in the parasite physiology and development. *Frontiers in Neuroscience*, 9(1), 224.

Safira, A., Rani, C. A. M., Puspitasari, R. A., Ayuningtyas, A. K. P., Mahendra, Y. A., Purnomo, A., Fikri, F., Chhetri, S., & Purnama, M. T. E. (2022). Amino Acid and Proximate Analysis of Type-1 Collagen from Sea Cucumber and Tilapia-Skin and its Potential Application as Artificial Tendon. *Pharmacognosy Journal*, 14(4), 358–361.

Schelkle, B., Shinn, A. P., Peeler, E., & Cable, J. (2009). Treatment of Gyrodactylid Infections in Fish. *Diseases of Aquatic Organisms*, 86(1), 65–75.

Shafiq, A., Abbas, F., Hafeez-Ur-Rehman, M., Khan, B. N., Aihetasham, A., Amin, I., Hmidullah, Mothana, R. A., Alharbi, M. S., Khan, I., Khalil, A. A. K., Ahmad, B., Mubeen, N., & Akram, M. (2023). Parasite Diversity in a Freshwater Ecosystem. *Microorganisms*, 11(8), 1940.

Shamsi, S. (2019). Seafood-Borne Parasitic Diseases: A “One-Health” Approach Is Needed. *Fishes*, 4(1), 9.

Singh, B. B., Ward, M. P., Kostoulas, P., & Dhand, N. K. (2023). Zoonosis-Why we should reconsider "What's in a name?". *Frontiers in Public Health*, 11(1), 1133330.

Sunarto, D. (2019). Ectoparasites Identification of Indigo Red Fish (*Oreochromis nilotica*) Cultivated in The Center of The Fish Fry (BBI) Ranomeeto. *Journal of Biological Science & Education*, 1(1), 1–8.

Valladão, G. M. R., Alves, L. O., & Pilarski, F. (2016). Trichodiniasis in Nile tilapia hatcheries: Diagnosis, parasite:host-stage relationship and treatment. *Aquaculture*, 451(1), 444–450.

Zelmer, D. A., Williams, E. H., & Williams, L. B. (1998). Parasites of Offshore Big Game Fishes of Puerto Rico and the Western Atlantic. *Journal of Parasitology*, 84(2), 283.

Ziarati, M., Zorriehzahra, M. J., Hassantabar, F., Mehrabi, Z., Dhawan, M., Sharun, K., Emran, T. B., Dhama, K., Chaicumpa, W., & Shamsi, S. (2022). Zoonotic diseases of fish and their prevention and control. *Veterinary Quarterly*, 42(1), 95–118.

***