The relationship between water quality and prevalence of ectoparasites on cultured Nile tilapia at two reservoirs in Central Java, Indonesia

W S K Kolia1,3, Sunarto2, and T Widiyani 2

1Graduate Program of Bioscience, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia.
2Department of Biological Science, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret.
3Corresponding author: waleed_biosain@student.uns.ac.id

Abstract. Besides environmental impacts, climate change is likely to cause a profound disruption to aquatic organisms. Therefore, parasitic infections could become more detrimental to host fish due to climate change in the future. This study aims to assess the relationship between the prevalence of ectoparasites Gyrodactylus spp., Dactylogyrus spp., and Trichodina spp. on cultured Nile tilapia and the water quality parameters of the Gajah Mungkur and Cengklik reservoirs. The standard parasitological procedure was used to determine the prevalence of these ectoparasites species. The water quality parameters conductivity, pH, dissolved oxygen, transparency, ammonia level, and temperature were measured. The results showed a high prevalence of 73% recorded by protozoan Trichodina spp followed by 30.1% and 25.3 % for Dactylogyrus spp., and Gyrodactylus spp., respectively. Furthermore, the findings showed that the prevalence of ectoparasites correlated with water quality in different ways in each reservoir. The presence of ectoparasites in the Gajah Mungkur reservoir was primarily influenced by ammonia level and temperature. Besides, in the Cengklik reservoir, ectoparasites were the most influenced by water pH. There was no fish mortality recorded despite the parasitic infection. The water quality parameters were within the recommended range for tilapia culture under cage systems.

1. Introduction
Climate change, and more specifically, global warming, has a substantial impact on aquatic environments, whose condition depends on water resources [1]. Aquatic environments are particularly exposed to changes in atmospheric temperatures and waterways to intensify extreme events, leading to sudden variations in inflow and water level [2]. Besides, in water scarcity, climate change causes the concentration of pollution, modifying the water's biological and chemical balance, leading to significant mortality on various species [3]. In the climate change face, species can either adapt and modify their distribution, migrate, or disappear [4].

Species dependent on environmental conditions and water temperature, such as fish, undergo physiological changes such as disruption of growth and reproduction. Parasitic infections could become more detrimental to host fish due to the water temperature’s change [3]. While studies evaluating the effects of parasite infection on host physiology in controlled conditions are required to untangle the effects of biotic and abiotic factors, it is equally critical to characterize the integrated host response in
the natural environment to understand and predict the physiological impacts of parasitism in wild populations in the context of climate change [5].

The distribution of ectoparasites and their prevalence can be very high in specific wild and cultured Nile tilapia populations in the future due to concerns about the high temperature resulting from climate change [5]. Climate change can indirectly affect fish by increasing the growth and spread of parasites that can be impacting physiological, behavioral, and morphological traits [1]. These indirect effects can cause economic losses to the communities via the reduced market value of fish, treatment expenses, and fish mortality [6, 7].

The prevalence of ectoparasites generally influenced by biotic and abiotic factors in the water environment. The prevalence of ectoparasites in cultured fish ranges from 33.3 – 84.8% in Nigeria, 4.7 – 20.9% in Tanzania, and 3.3 – 31% in Kenya [6]. In Indonesia, the prevalence of ectoparasites on cultured Nile tilapia is 70% - 100% [8] and 90.4% [9]. However, with the increase in the problems of climate change, there are concerns of increase the prevalence rates in the future in a way that may lead to a decrease in fish production.

Globally, parasitic diseases are among the essentially unsolved problems in the fishery sector [10]. Ignore water quality control, and parasitic diseases would contribute to the low fish production levels. Therefore, the research on fish parasites must provide critical elements for their control with positive effects on productivity and awareness among fish farmers. In this context, this study was carried out to determine the relationship between water quality and prevalence of *Gyrodactylus* spp., *Dactylogyrus* spp., and *Trichodina* spp. on cultured Nile tilapia (*O. niloticus*) at two reservoirs in Central Java, Indonesia.

2. Materials and method

2.1. study area

The study was conducted at two reservoirs in Central Java Province, namely; The Cengklik reservoir in Boyolali District at geographical coordinates of S 07°31'1.11" and E 110°43'58.22" and Gajah Mungkur reservoir in Wonogiri District at S 07°85'50.76" and E 110°91'19.74" (Figure 1).

![Map of Indonesia in the top and the study area at two reservoirs in Central Java in bellow. a) Cengklik Reservoir, b) Gajah Mungkur Reservoir [11].](image-url)
2.2. Study period and sample collection:
The study was conducted from July to November 2020. Fish samples were collected randomly from floating cages in two reservoirs using scoop nets following the protocol [12]. A total of 126 samples of Nile tilapia were obtained and immediately transported to the Laboratory of Biology, Faculty of Mathematics and Natural Science (FMIPA), Sebelas Maret University, for identification.

2.3. Measurements of fish samples and sex identification:
The measurements of fish samples were identified using the guide provided by Molnár et al. [13]. The total length (TL) and standard length (SL) were measured with a ruler meter, while the body weight was measured using electronic weight balance. We based on the external and internal examination of the testes and ovaries [14] to determine the fish sex.

2.4. Smear's preparation of and microscopic examination for ectoparasites
The smears from external organs were done using the protocol of Bruno et al. [14]. The light microscope connected with a camera (Nikon ECLIPSS 80i) was used to identifying the parasites. The identification of the ectoparasites was carried out using reference keys for taxa of fish parasites based on distinctive morphological features [12, 14]. To determine the prevalence, we used the mathematical calculation formulated by Bush et al. [15] as follow;

\[
\text{Prevalence } (P) = \frac{\text{Number of infected with particular parasite species}}{\text{Total number of hostes examined}} \times 100 \tag{1}
\]

2.5. Analysis of water quality
A water sampler was used to collect reservoir water samples, 60 cm in depth from the water surface. Water quality parameters pH, dissolved oxygen, transparency, temperature, and conductivity were measured using multi-purpose probes. Water transparency was determined by using the Sachi disk. The dissolved oxygen was measured using a digital oxygen meter (OXYGEN METER, Model DO-5510), while the water temperature was measured using a thermometer. Electrical conductivity was determined by using a digital conductivity meter (Conductivity STARTER 300c, OHAUS). Water pH was measured using a pH meter (pH meter STARTER, OHAUS, version 300). A 700 ml of water sample was frozen for ammonia level analysis in the chemical laboratory.

2.6. Data analysis
The Statistical significance was set up at (p<0.05) to compare the physicochemical parameters data. These analyses were performed on Statistical Product and Service Solutions (SPSS) v. 21.0 software. The correlation between the ectoparasites prevalence and physicochemical water parameters was identified using Canonical Correspondence Analysis (CCA) for Windows v. 4.5.

3. Results and discussion
We found that from 126 examined fish samples (63 samples in each reservoir), these three ectoparasites were present on all infected fishes. Both Nile tilapia fishes from two reservoirs were infected by *Trichodina* spp. (prevalence above 50%) and followed by *Dactylogyrus* spp. and *Gyrodactylus* spp. Respectively ‘Figure 1’and ‘Table 1’. Nile tilapia fishes from the Cengklik reservoir were infected by the highest total number of parasites (1650), while the Gajah Mungkur reservoir was infected with lower (414 parasites).
Figure 2. The morphology of the ectoparasites on farmed Nile tilapia at the two reservoirs a. *Trichodina* spp, b. *Gyrodactylus* spp, c. *Dactylogyrus* spp.

Table 1. The species of parasite and the prevalence of each parasite at the two reservoirs

| Reservoir   | Gajah Mungkur | Cengklik |
|-------------|---------------|----------|
| Parasite species | PF | P (%) | TNP | PF | P (%) | TNP |
| *Dactylogyrus* spp. | 19 | 30.1 | 33 | 15 | 23.8 | 28 |
| *Trichodina* spp. | 32 | 50.7 | 354 | 46 | 73 | 1600 |
| *Gyrodactylus* spp. | 16 | 25.3 | 27 | 12 | 19 | 22 |
| TNP          | 414 |       |     | 1650 |     |       |

*Note: PF = parasitized fish; P = Prevalence; TNP = Total number of parasites.*
Figure 3. Prevalence of ectoparasites infected on the Nile tilapia at the two reservoirs.

The physicochemical water parameters were insignificantly different among the two reservoirs (Table 2). On the other hand, there was a significant difference (p<0.05) in water conductivity and transparency, with Cengklik Reservoir had higher conductivity and transparency. Overall, the mean values of water quality parameters are within the optimum range for Nile tilapia culture in the floating cage systems [16].

Table 2. Mean values of water physicochemical parameters of the two reservoirs

| No | Parameters       | Unit     | Reservoir site | Significant |
|----|------------------|----------|----------------|-------------|
|    |                  |          | Cengklik       | Gajah Mungkur |
| 1  | DO               | Mg L⁻¹   | 8.13±0.73      | 7.63±0.38   | NS          |
| 2  | Temperature      | °C       | 28.07±0.32     | 28.70±0.26  | NS          |
| 3  | Ammonia level    | Mg L⁻¹   | 0.48±0.26      | 1.13±0.44   | NS          |
| 4  | Conductivity     | μ s cm⁻¹ | 251.00±18.50   | 147.90±4.28 | **a         |
| 5  | Transparency     | cm       | 84.67±2.33     | 59.00±1.73  | **a         |
| 6  | PH               | -        | 7.48±0.29      | 7.10±0.08   | NS          |

*Note: * =significant at p<0.05, NS=no significant differences.

The correlation between ectoparasites prevalence and water quality at the Gajah Mungkur reservoir is shown in ‘Figure 4’. The presence of ectoparasites in the Gajah Mungkur reservoir was most influenced by water ammonia level and temperature, as revealed by the CCA vector. The temperature showed a negative correlation to *Gyrodactylus* spp. and a positive correlation to *Trichodina* spp. A positive correlation also exists between *Dactylogyrus* spp. and ammonia level. On the other hand, pH, DO, and transparency showed a negative correlation to *Trichodina* spp. and a positive correlation to *Gyrodactylus* spp.

The correlation between ectoparasites prevalence and water quality at Cengklik reservoir is shown in ‘Figure 5’. The presence of parasites in the Cengklik reservoir was the most influenced by water pH, as revealed by the CCA vector. The transparency and pH clearly showed a negative correlation to *Dactylogyrus* spp. and a positive correlation to *Trichodina* spp. A positive correlation also existed between *Gyrodactylus* spp. Ammonia level and DO. On the other hand, temperature and conductivity negatively correlated to *Trichodina* spp. and positively to *Dactylogyrus* spp.
Figure 4. CCA ordination showing the correlation between water quality parameters and ectoparasites in the Gajah Mungkur reservoir.

Figure 5. CCA ordination showing the correlation between water quality parameters and ectoparasites in the Cengklik reservoir.

The presence of ectoparasites acts as biological indicators. They lead, in the end, to predispose to disease outbreaks on cultured fish, while the occurrence of concurrent parasitic infections can be devastating in cultured fishes [17]. Outweighing the parasitic infection can cause a significant impact on the culture system [14]. However, Paladini et al. [18] concluded that parasitic infection development in an aquaculture system is a complex process that depends on the interactions of the hosts, pathogens, and environment. Thus, understanding these aspects is imperative for preventive measures in the cages aquaculture systems.

Our findings demonstrated that the prevalence of ectoparasites was higher in the Cengklik than in the Gajah Mungkur. The Cengklik has shallow depth, high stocking density in the floating cages, and the presence of aquatic plants, which indicates a higher risk of infection to ectoparasites. The distribution of ectoparasites often varies from one habitat to another due to the host-parasite relationship and the influences of biotic and abiotic factors. However, the reason was not understood, which requires further studies to investigate.

The protozoan parasite *Trichodina* spp. in water bodies is a biological indicator of poor water quality. Our study found that *Trichodina* spp. was the most prevalent parasite across the two reservoirs. A similar
result was shown by Indahsari et al. [8], in another area of Indonesia where their study concluded that the *Trichodina* spp. was the most common parasite among the other parasite species, and the prevalence was higher at the Cengklik reservoir (73%) than in the Gajah Mungkur (50.7%) ‘Table 1’. Moreover, our results are in line with the study of Banu and Khan [19], which indicated Trichodiniidae were the most frequent parasites, with a prevalence ranging from 24.2 to 90.2%. However, the prevalence of this parasite correlated to the water quality parameters and the high stocking fish density. On the other hand, two monogeneans, *Dactylogyrids* spp. and *Gyrodactylids* spp. were observed. *Gyrodactylids* spp. was found in the skin, while *Dactylogyrids* spp. was found in the gills at the two reservoirs. The prevalence of *Gyrodactylids* spp. was lower than *Dactylogyrids* spp. However, the prevalence of these monogeneans' parasites was lower than the prevalence of *Trichodina* spp. This information is consistent with the study of Banu and Khan [19], who indicated that the monogeneans are the second common parasites after Trichodinidae. However, disease severity caused by these parasites depends on the pathogen species, the nutritional conditions of the host, and the immunity of the host.

Based on the correlation analysis, we found that the presence of parasites in the Gajah Mungkur was most influenced by ammonia level and temperature, while in the Cengklik was most influenced by water pH. Water temperature is generally considered the most vital abiotic factor which affects fish physiology, including immune functions. However, the infection dynamics of pathogens are also strongly influenced by water pH values and ammonia level [20].

4. Conclusion
Abiotic factors are determinant of the aquatic ecosystem since it is essential for the reproduction of fishes and parasites species and the formation of an ideal living environment. In this study, the presence of ectoparasites in the Gajah Mungkur reservoir was primarily influenced by ammonia level and temperature. Besides, in the Cengklik reservoir, ectoparasites were the most influenced by water pH. The parasitic infection was higher in the Cengklik than in the Gajah Mungkur reservoir, since different habitats of the fish lead to the difference in the performance of the host immune system. The differences in parasitic infestation could be influenced the depth, water productivity, stocking density, fish feed, source of fingerlings, and climate change. Climate change is almost unavoidable therefore we need to step up our efforts and investment to make aquaculture productive despite climate change.

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