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1. First submission in email (7-2-2022)

2. First revision: the format of the article (9-2-2022)

3. First revision submitted (23-2-2022)

4. Second revision : the contents of the article include title, abstract, results and discussion (20-6-2022)

5. Second revision submitted (4-7-2022)

6. Reply has submitted article revision (7-7-2022)

7. Adjustments approved (26-7-2022)

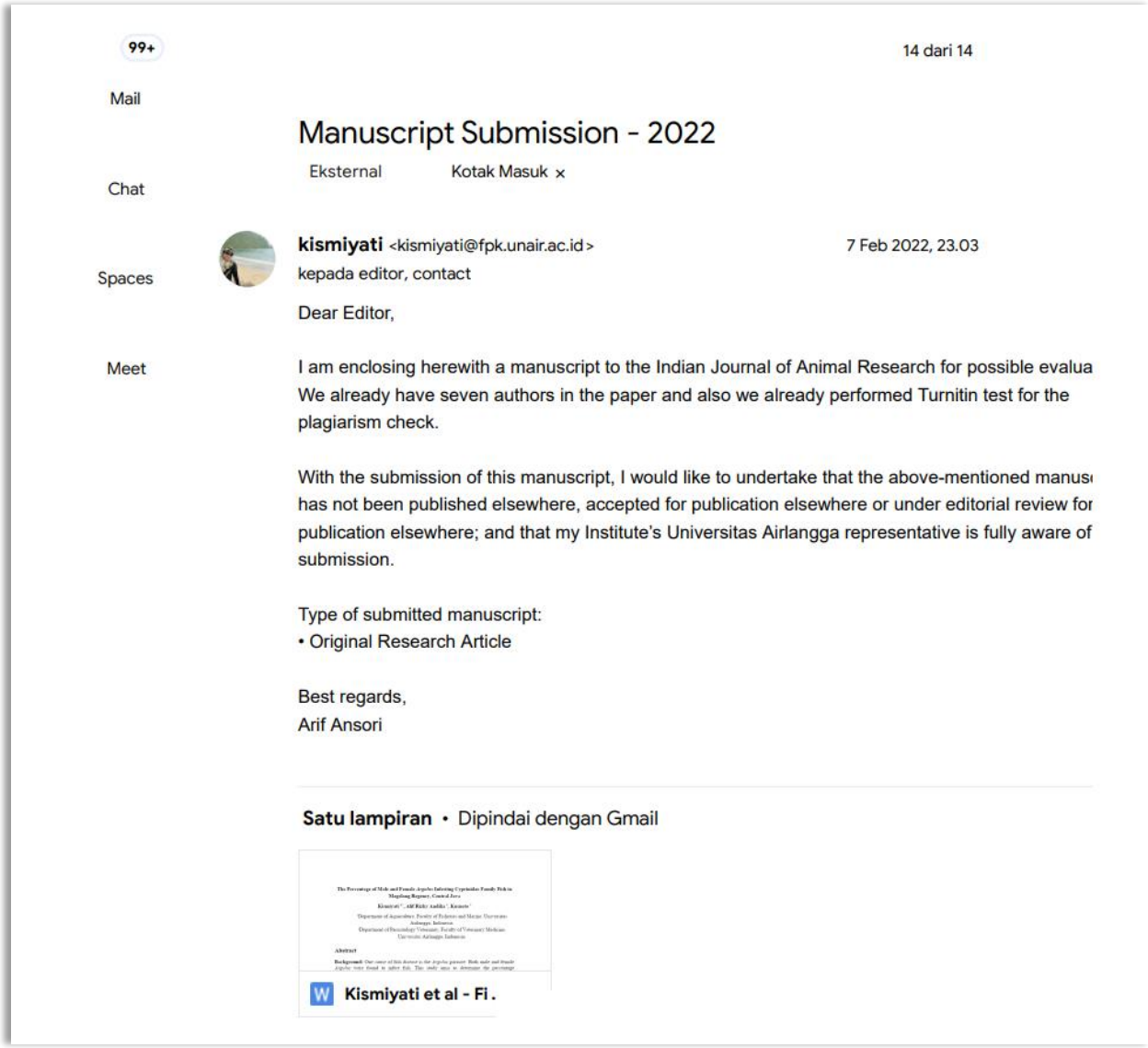
8. Replies from reviewers for Revisions to the Bibliography and Conclusion (30-7-2022)

9. Revision submitted (18-8-2022)

10. Paper Published (23-8-2022)

1. First Submission (February 7, 2022)

Note: Author contact the journal publisher via email on 7 February 2022 for the first submission (Sender email: kismiyati@fpk.unair.ac.id, recipient email: contact@arccjournals.com)



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Kismiyati et al - Fi .

The Percentage of Male and Female *Argulus* Infesting Cyprinidae Family Fish in Magelang Regency, Central Java

Kismiyati [1,*], Alif Rizky Andika [1], Kusnoto [2]

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Abstract

Background: One cause of fish disease is the *Argulus* parasite. Both male and female *Argulus* were found to infect fish. This study aims to determine the percentage difference of male and female *Argulus* that infect Cyprinidae in Magelang Regency.
Methods: The research was studied using a survey method. The independent variables in this study are carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), comet goldfish (*Carassius auratus auratus*), koi fish (C. *carpio* koi), and the sex of the *Argulus* parasite. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The data analysis was done using analysis of variance (ANOVA) then followed by Duncan's Multiple Range Test to find out the differences between treatments.
Result: The first ANOVA result showed no significant difference ($p > 0.05$), the second ANOVA showed significantly different results ($p < 0.05$), and the third ANOVA reveals no significantly different percentage ($p > 0.05$). The highest infestation rate of male *Argulus japonicus* is found in koi fish (C. *carpio* koi) is 60%, and the lowest is in comet goldfish, which is 38.46%. Whereas infestation of female *A. japonicus* in carp, goldfish, comet goldfish, and koi fish also obtained a similar result.

Key words: *Argulus*, Cyprinidae, Parasite, Fisheries.

INTRODUCTION

Magelang Regency is one of the areas that has undergone aquaculture-based development, prioritizing the principle of efficiency, quality, and sustainability (Wibowo *et al.,* 2015). The area consists of Ngluwar Sub-District, Mungkid Sub-District, and Muntilan Sub-District. Cyprinidae family fish species that are cultivated in Magelang Regency are common carp (C. *carpio*), goldfish (C. *auratus*), comet fish (C. *auratus auratus*), and koi fish (C. *carpio* koi) (Badan Pusat Statistik Kab. Magelang, 2014). The main problem in cultivating fish in Indonesia to date revolves around parasites and infectious diseases. The disease causes economic losses because it can result in less optimal fish harvest (Carella and Sirri, 2017; Das and Chandra, 2018). One cause of the disease is the infestation of parasites (Picard-Sánchez *et al.,* 2020). The quality of

freshwater ornamental fishes decreased due to attacks from parasites such as *Argulus* sp. (Alifuddin *et al.,* 2002).

Argulus is a crustacean branchiuran parasite that causes severe problems in aquaculture throughout the world. Around 129 species of *Argulus* (family: Argulidae) are distributed worldwide, and 12 species have been described in various freshwater, brackish water, marine and ornamental fish in India (Kumar *et al.,* 2017). Among them, *A. japonicus* are considered as emerging pathogens of freshwater, brackish water and coldwater fish worldwide (Tandel *et al.,* 2021).

Morphological identification of *Argulus* sp. are mostly based on distinguishing features of an adult male such as carapace and abdominal length or width, dorsal ridges of the carapace, respiratory areas, leg pigments, abdominal lobes and incision, and the presence of a small coxal at the swimming appendages (Sahoo *et al.,* 2012; Soes *et al.,* 2010), requiring experienced taxonomists.

Argulus is one of the ectoparasites that attacks the Cyprinidae (Wardany and Kurniawan, 2014). *Argulus* attacks the fins, skin, gill, and the entire surface of the host body (Pramujirini, 2016). Fish that has been infested by *Argulus* looks thin, with red spots appearing on its body, causing it often to rub its body on the edge of the pool. This parasitic attack is more often deadly in some young fish because the body's defense system has not yet developed (Bandilla, 2007). Male and female *Argulus* usually attack carp (*C. carpio*) (Ebrahimi *et al.,* 2018). Male and female *Argulus* is also found to attack the goldfish (*C. auratus*). Male and female *Argulus* have the same properties as goldfish (*C. auratus*) (Yıldız and Kumantas, 2002). Based on these descriptions, this study aims to determine the percentage difference of *Argulus* male and *Argulus* females infesting carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi), as well as to find the amount of male and female *Argulus* infestation on the Cyprinidae family.

MATERIALS AND METHODS

Procedures

The research was studied using the survey method. The survey method used in this study was a survey of research locations and *Argulus* parasites in fish samples. The data were collected using the descriptive method. The description of events in this study is the male and female *Argulus* parasite infestations in Cyprinidae of Magelang Regency.

This study used a Completely Randomized Factorial Design. The Completely Randomized Factorial Design was applied because the study had two different factors; (1) the *Argulus* sex and (2) the Cyprinidae fish. The independent variables in this study consist of carp (C. *carpio*), goldfish (C. *auratus*), comet goldfish (C. *auratus auratus*), and koi fish (C. *carpio* koi), and the sex of *Argulus*. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The control variables of this study were fish size, location, and environmental conditions in Magelang. The number of samples taken was 10% of the total population. The collected sample amounted to 200 fish.

Data analysis

Analysis of the data used in this study was ANOVA (analysis of variance) using SPSS v16.0. If there are significant differences, further tests would be conducted using Duncan's Multiple Range Test (Santoso, 2008).

RESULTS AND DISCUSSION

Result

Identification results of *Argulus* sp. which infested in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C.* carpio koi) in Magelang Regency is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the morphology. *A. japonicus* is identified as having a length of 3-5 mm and a width of 2-4 mm. In the Maxilla I, there is a supporting rod totaling five to nine pieces, and the Maxilla II is equipped with three hooks.

The male and female *A. japonicus* can also be distinguished based on their morphology. The males are identified as having an abdominal testis. In comparison, the females are identified by their cephalothorax ovaries and seminal receptacle in the abdomen. *A. japonicus* are found in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). *A. japonicus* is one of the ectoparasites that attacks the Cyprinidae family (Wardany and Kurniawan, 2014). *A. japonicus* that infest in the Cyprinidae family in Magelang are observed in Figure 1.

Figure 1. *Argulus japonicus* infested common carp (*C. Carpio*), goldfish (*C. auratus*), comet fish (*C. auratus auratus*), and koi fish (*C. carpio* koi). a. Female *Argulus japonicus*; b. Male *Argulus japonicus*.

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Male *A. japonicus* infest goldfish (*C. auratus*) is 50%, with the female having the same percentage. 38.46% of male *A. japonicus* infest comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. 60% of male *A. japonicus* infests koi fish (*C. carpio koi*), while the female is 40%.

Data differences between the infestations of male and female *A. japonicus* in four different species of Cyprinidae were analyzed by analysis of variance (ANOVA). The results of the first ANOVA showed results that were not significantly different ($p > 0.05$) between the average numbers of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). The second ANOVA showed significantly different results ($p < 0.05$) between carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) which have been infected by *A. japonicus*. The infestations analyzed using the third ANOVA were not significantly different ($p > 0.05$) between the male and female *A. japonicus* females in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

Based on the data from the analysis, the two treatments did not show any interaction. Thus, the data was included in the simple treatment. The simple treatment in question involves the male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

Duncan's Multiple Range Test was done to assess the different types of fish used in the study because they showed significantly different results. The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C.*

auratus) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* were least found in comet goldfish (*C. auratus auratus*), but in a number that is not significantly different from carp (*C. carpio*). In contrast, in the female infestation of *A. japonicus*, no differences were found between the four types of fish.

Discussion

It has been identified that the *Argulus* sp. infest in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) in Magelang is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the range of length (3-9 mm) and width of 2-6 mm (Møller, 2009). The respiratory area in the anterior is small, with the posterior being larger, five to nine supporting rods can be found in the Maxilla I, and the Maxilla II is equipped with a total of three hooks. Male *A. japonicus* is equipped with testicles in the abdomen, whereas females have ovaries. The physical difference between the male and female *A. japonicus* can be seen in the abdomen located in the posterior part of the body (Kismiyati et al., 2011). Female *A. japonicus* has spermatheca and ovaries, while males have seminal testicles and vascular (Wardany and Kurniawan, 2014).

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Both male and female *A. japonicus* are known to infect fish (Walker et al., 2011). The percentage of male and female *A. japonicus* found to infest carp (*C. carpio*) is almost the same. That is because carp (*C. carpio*) is one of the preferred hosts of both male and female *Argulus japonicas* (Poly, 2008).

The male and female *A. japonicus* that infest goldfish (*C. auratus*) have the same percentage of 50%. Both male and female *A. japonicus* were found to infest goldfish (*C. auratus*) (Wafer *et al.,* 2015). That is because of their same parasitic properties (Mikheev *et al.,* 2015). 38.46% of male *A. japonicus* infects comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. Female *A. japonicus* is found in comet goldfish fins (*C. auratus auratus*). This is due to the wide surface and slow movement of the fins (Pramujirini, 2016). The slow-motion of fish fins makes it easy for female *A. japonicus* to break away when oviposition (Kismiyati *et al.*, 2011).

There are 60% of male *A. japonicus* infest koi fish (*C. carpio* koi) while the female is 40%. Male *A. japonicus* can be found on the surface of koi fish (*C. carpio* koi). Koi fish (*C. carpio* koi) has a broad body surface that becomes the preferred predilection for male *A. japonicus*. Male *A. japonicus* prefers large areas (Taylor *et al.,* 2006).

The average number of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) is not significantly different ($p > 0.05$). That is because of their same parasitic properties (Mikheev *et al.*, 2015). Male and female *A. japonicus* are found to attack the Cyprinidae family (Wardany and Kurniawan, 2014).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* least infests comet goldfish (*C. auratus auratus*), but in a number that is not substantially different from carp (*C. carpio*). That is because all four types of fish have other body surface areas. Male *A. japonicus* favors large areas (Taylor *et al.*, 2006). Duncan's Multiple Range Test results also showed that no differences were found between the four types of fish infested by female *A. japonicus*. Female *A. japonicus* is often found in fish fins (Pramujirini, 2016). The female chooses fins as a place of predilection because the fin movements of carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) are languid. The slow movement of fish fins makes it easy for female *A. japonicus* to break away. Female *A. japonicus* will escape from the host when oviposition (Kismiyati *et al.*, 2010).

ACKNOWLEDGEMENTS

Acknowledgments are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

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Balas Teruskan

The Percentage of Male and Female *Argulus* Infesting Cyprinidae Family Fish in Magelang Regency, Central Java

Kismiyati[1,*], Alif Rizky Andika[1], Kusnoto[2]

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Result

Identification results of *Argulus* sp. which infested in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C.* carpio koi) in Magelang Regency is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the morphology. *A. japonicus* is identified as having a length of 3-5 mm and a width of 2-4 mm. In the Maxilla I, there is a supporting rod totaling five to nine pieces, and the Maxilla II is equipped with three hooks.

The male and female *A. japonicus* can also be distinguished based on their morphology. The males are identified as having an abdominal testis. In comparison, the females are identified by their cephalothorax ovaries and seminal receptacle in the abdomen. *A. japonicus* are found in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). *A. japonicus* is one of the ectoparasites that attacks the Cyprinidae family (Wardany and Kurniawan, 2014). *A. japonicus* that infest in the Cyprinidae family in Magelang are observed in Figure 1.

Figure 1. *Argulus japonicus* infested common carp (*C. Carpio*), goldfish (*C. auratus*), comet fish (*C. auratus auratus*), and koi fish (*C. carpio* koi). a. Female *Argulus japonicus*; b. Male *Argulus japonicus*.

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Male *A. japonicus* infest goldfish (*C. auratus*) is 50%, with the female having the same percentage. 38.46% of male *A. japonicus* infest comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. 60% of male *A. japonicus* infests koi fish (*C. carpio koi*), while the female is 40%.

Data differences between the infestations of male and female *A. japonicus* in four different species of Cyprinidae were analyzed by analysis of variance (ANOVA). The results of the first ANOVA showed results that were not significantly different ($p > 0.05$) between the average numbers of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). The second ANOVA showed significantly different results ($p < 0.05$) between carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) which have been infected by *A. japonicus*. The infestations analyzed using the third ANOVA were not significantly different ($p > 0.05$) between the male and female *A. japonicus* females in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

Based on the data from the analysis, the two treatments did not show any interaction. Thus, the data was included in the simple treatment. The simple treatment in question involves the male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

Duncan's Multiple Range Test was done to assess the different types of fish used in the study because they showed significantly different results. The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C.*

auratus) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* were least found in comet goldfish (*C. auratus auratus*), but in a number that is not significantly different from carp (*C. carpio*). In contrast, in the female infestation of *A. japonicus*, no differences were found between the four types of fish.

Discussion

It has been identified that the *Argulus* sp. infest in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) in Magelang is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the range of length (3-9 mm) and width of 2-6 mm (Møller, 2009). The respiratory area in the anterior is small, with the posterior being larger, five to nine supporting rods can be found in the Maxilla I, and the Maxilla II is equipped with a total of three hooks. Male *A. japonicus* is equipped with testicles in the abdomen, whereas females have ovaries. The physical difference between the male and female *A. japonicus* can be seen in the abdomen located in the posterior part of the body (Kismiyati et al., 2011). Female *A. japonicus* has spermatheca and ovaries, while males have seminal testicles and vascular (Wardany and Kurniawan, 2014).

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Both male and female *A. japonicus* are known to infect fish (Walker et al., 2011). The percentage of male and female *A. japonicus* found to infest carp (*C. carpio*) is almost the same. That is because carp (*C. carpio*) is one of the preferred hosts of both male and female *Argulus japonicas* (Poly, 2008).

The male and female *A. japonicus* that infest goldfish (*C. auratus*) have the same percentage of 50%. Both male and female *A. japonicus* were found to infest goldfish (*C. auratus*) (Wafer *et al.,* 2015). That is because of their same parasitic properties (Mikheev *et al.,* 2015). 38.46% of male *A. japonicus* infects comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. Female *A. japonicus* is found in comet goldfish fins (*C. auratus auratus*). This is due to the wide surface and slow movement of the fins (Pramujirini, 2016). The slow-motion of fish fins makes it easy for female *A. japonicus* to break away when oviposition (Kismiyati *et al.*, 2011).

There are 60% of male *A. japonicus* infest koi fish (*C. carpio* koi) while the female is 40%. Male *A. japonicus* can be found on the surface of koi fish (*C. carpio* koi). Koi fish (*C. carpio* koi) has a broad body surface that becomes the preferred predilection for male *A. japonicus*. Male *A. japonicus* prefers large areas (Taylor *et al.,* 2006).

The average number of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) is not significantly different ($p > 0.05$). That is because of their same parasitic properties (Mikheev *et al.*, 2015). Male and female *A. japonicus* are found to attack the Cyprinidae family (Wardany and Kurniawan, 2014).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* least infests comet goldfish (*C. auratus auratus*), but in a number that is not substantially different from carp (*C. carpio*). That is because all four types of fish have other body surface areas. Male *A. japonicus* favors large areas (Taylor *et al.*, 2006). Duncan's Multiple Range Test results also showed that no differences were found between the four types of fish infested by female *A. japonicus*. Female *A. japonicus* is often found in fish fins (Pramujirini, 2016). The female chooses fins as a place of predilection because the fin movements of carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) are languid. The slow movement of fish fins makes it easy for female *A. japonicus* to break away. Female *A. japonicus* will escape from the host when oviposition (Kismiyati *et al.*, 2010).

ACKNOWLEDGEMENTS

Acknowledgments are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

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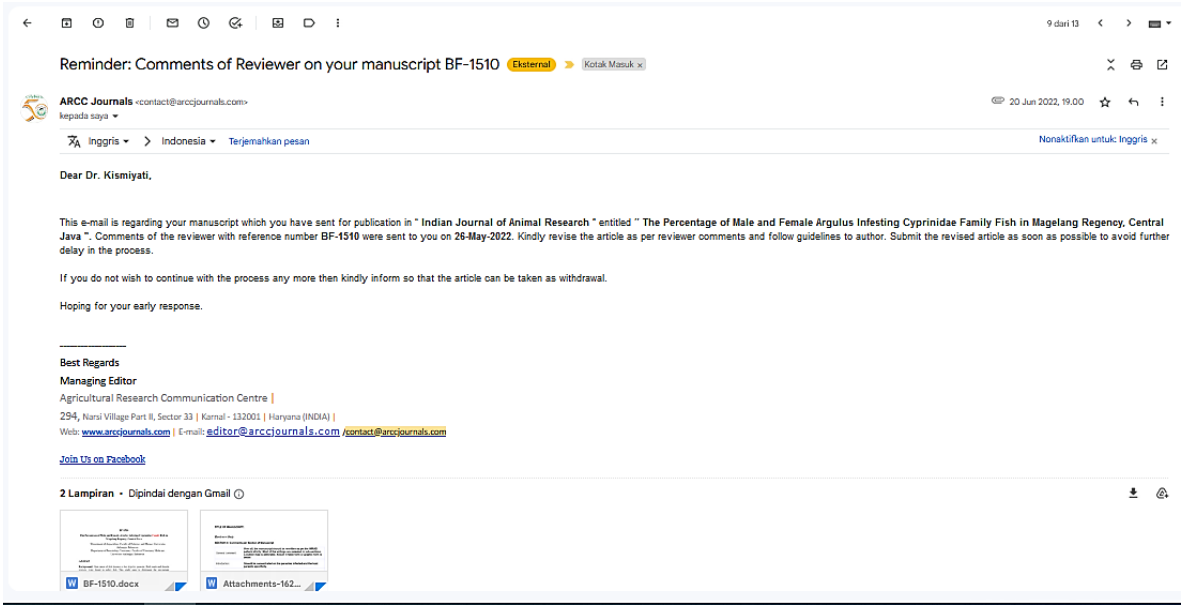
4. Second Revision (June 20, 2022)

Note: Email reply containing articles that have been revised by reviewer on June 20, 2022. The revised sections include: title, abstract, results and discussion.



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The Percentage of Male and Female *Argulus* Infesting Cyprinidae Family Fish in Magelang Regency, Central Java

[1]Department of Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga, Indonesia.
[2]Department of Parasitology Veterinary, Faculty of Veterinary Medicine, Universitas Airlangga, Indonesia.

Abstract

Background: One cause of fish disease is the *Argulus* parasite. Both male and female *Argulus* were found to infect fish. This study aims to determine the percentage difference of male and female *Argulus* that infect Cyprinidae in Magelang Regency.
Methods: The research was studied using a survey method. The independent variables in this study are carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), comet goldfish (*Carassius auratus auratus*), koi fish (C. *carpio* koi), and the sex of the *Argulus* parasite. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The data analysis was done using analysis of variance (ANOVA) then followed by Duncan's Multiple Range Test to find out the differences between treatments.
Result: The first ANOVA result showed no significant difference ($p > 0.05$), the second ANOVA showed significantly different results ($p < 0.05$), and the third ANOVA reveals no significantly different percentage ($p > 0.05$). The highest infestation rate of male *Argulus japonicus* is found in koi fish (C. *carpio* koi) is 60%, and the lowest is in comet goldfish, which is 38.46%. Whereas infestation of female *A. japonicus* in carp, goldfish, comet goldfish, and koi fish also obtained a similar result.

Key words: *Argulus*, Cyprinidae, Parasite, Fisheries.

INTRODUCTION

Magelang Regency is one of the areas that has undergone aquaculture-based development, prioritizing the principle of efficiency, quality, and sustainability (Wibowo *et al.*, 2015). The area consists of Ngluwar Sub-District, Mungkid Sub-District, and Muntilan Sub-District. Cyprinidae family fish species that are cultivated in Magelang Regency are common carp (C. *carpio*), goldfish (C. *auratus*), comet fish (C. *auratus auratus*), and koi fish (C. *carpio* koi) (Badan Pusat Statistik Kab. Magelang, 2014). The main problem in cultivating fish in Indonesia to date revolves around parasites and infectious diseases. The disease causes economic losses because it can result in less

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optimal fish harvest (Carella and Sirri, 2017; Das and Chandra, 2018). One cause of the disease is the infestation of parasites (Picard-Sánchez *et al.,* 2020). The quality of freshwater ornamental fishes decreased due to attacks from parasites such as *Argulus* sp. (Alifuddin *et al.,* 2002).

Argulus is a crustacean branchiuran parasite that causes severe problems in aquaculture throughout the world. Around 129 species of *Argulus* (family: Argulidae) are distributed worldwide, and 12 species have been described in various freshwater, brackish water, marine and ornamental fish in India (Kumar *et al.,* 2017). Among them, *A. japonicus* are considered as emerging pathogens of freshwater, brackish water and coldwater fish worldwide (Tandel *et al.,* 2021).

Morphological identification of *Argulus* sp. are mostly based on distinguishing features of an adult male such as carapace and abdominal length or width, dorsal ridges of the carapace, respiratory areas, leg pigments, abdominal lobes and incision, and the presence of a small coxal at the swimming appendages (Sahoo *et al.,* 2012; Soes *et al.,* 2010), requiring experienced taxonomists.

Argulus is one of the ectoparasites that attacks the Cyprinidae (Wardany and Kurniawan, 2014). *Argulus* attacks the fins, skin, gill, and the entire surface of the host body (Pramujirini, 2016). Fish that has been infested by *Argulus* looks thin, with red spots appearing on its body, causing it often to rub its body on the edge of the pool. This parasitic attack is more often deadly in some young fish because the body's defense system has not yet developed (Bandilla, 2007). Male and female *Argulus* usually attack carp (*C. carpio*) (Ebrahimi *et al.,* 2018). Male and female *Argulus* is also found to attack the goldfish (*C. auratus*). Male and female *Argulus* have the same properties as goldfish (*C. auratus*) (Yıldız and Kumantas, 2002). Based on these descriptions, this study aims to determine the percentage difference of *Argulus* male and *Argulus* females infesting carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi), as well as to find the amount of male and female *Argulus* infestation on the Cyprinidae family.

MATERIALS AND METHODS

Procedures

The research was studied using the survey method. The survey method used in this study was a survey of research locations and *Argulus* parasites in fish samples. The data were collected using the descriptive method. The description of events in this study is the male and female *Argulus* parasite infestations in Cyprinidae of Magelang Regency. This study used a Completely Randomized Factorial Design. The Completely Randomized Factorial Design was applied because the study had two different factors; (1) the *Argulus* sex and (2) the Cyprinidae fish. The independent variables in this study consist of carp (C. *carpio*), goldfish (C. *auratus*), comet goldfish (C. *auratus auratus*), and koi fish (C. *carpio* koi), and the sex of *Argulus*. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The control variables of this study were fish size, location, and environmental conditions in Magelang. The number of samples taken was 10% of the total population. The collected sample amounted to 200 fish.

Data analysis

Analysis of the data used in this study was ANOVA (analysis of variance) using SPSS v16.0. If there are significant differences, further tests would be conducted using Duncan's Multiple Range Test (Santoso, 2008).

RESULTS AND DISCUSSION

Result

Identification results of *Argulus* sp. which infested in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C.* carpio koi) in Magelang Regency is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the morphology. *A. japonicus* is identified as having a length of 3-5 mm and a width of 2-4 mm. In the Maxilla I, there is a supporting rod totaling five to nine pieces, and the Maxilla II is equipped with three hooks.

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Figure 1. *Argulus japonicus* infested common carp (*C. Carpio*), goldfish (*C. auratus*), comet fish (*C. auratus auratus*), and koi fish (*C. carpio* koi). a. Female *Argulus japonicus*; b. Male *Argulus japonicus*.

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Discussion

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The male and female *A. japonicus* that infest goldfish (*C. auratus*) have the same percentage of 50%. Both male and female *A. japonicus* were found to infest goldfish (*C. auratus*) (Wafer *et al.*, 2015). That is because of their same parasitic properties (Mikheev *et al.*, 2015). 38.46% of male *A. japonicus* infects comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. Female *A. japonicus* is found in comet goldfish fins (*C. auratus auratus*). This is due to the wide surface and slow movement of the fins (Pramujirini, 2016). The slow-motion of fish fins makes it easy for female *A. japonicus* to break away when oviposition (Kismiyati *et al.*, 2011).

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The average number of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) is not significantly different ($p > 0.05$). That is because of their same parasitic properties (Mikheev *et al.*, 2015). Male and female *A. japonicus* are found to attack the Cyprinidae family (Wardany and Kurniawan, 2014).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* least infests comet goldfish (*C. auratus auratus*), but in a number that is not substantially different from carp (*C. carpio*). That is because all four types of fish have other body surface areas. Male *A. japonicus* favors large areas (Taylor *et al.*, 2006). Duncan's Multiple Range Test results also showed that no differences were found between the four types of fish infested by female *A. japonicus*. Female *A. japonicus* is often found in fish fins (Pramujirini, 2016). The female chooses fins as a place of predilection because the fin movements of carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) are languid. The slow movement of fish fins makes it easy for female *A. japonicus* to break away. Female *A. japonicus* will escape from the host when oviposition (Kismiyati *et al.*, 2010).

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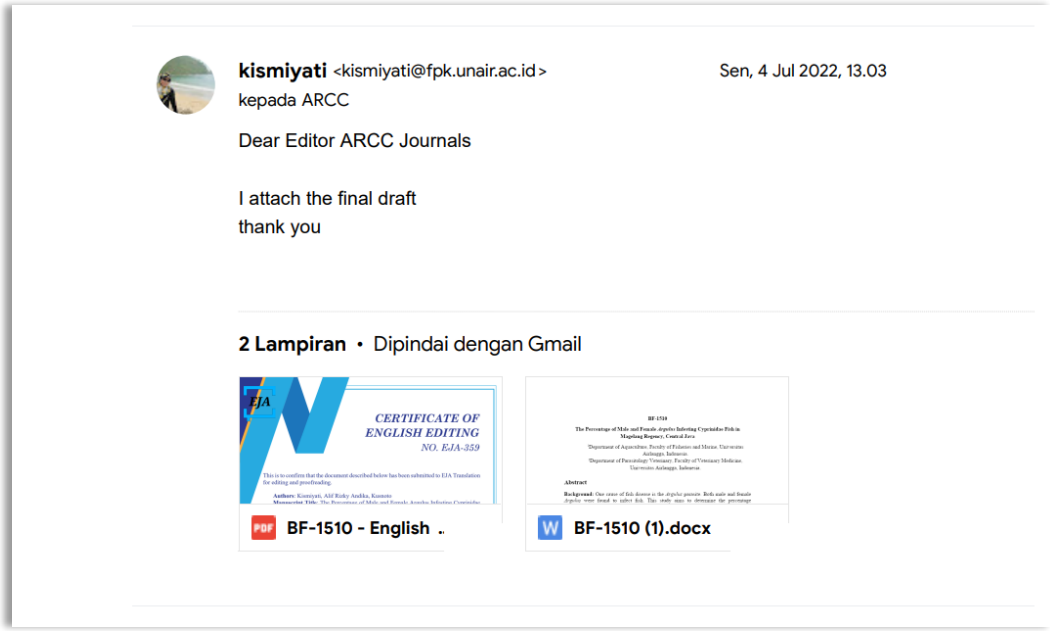
5. Second Revision Submitted (July 4, 2022)

Note: Sending article revision on July 4, 2022 via email.



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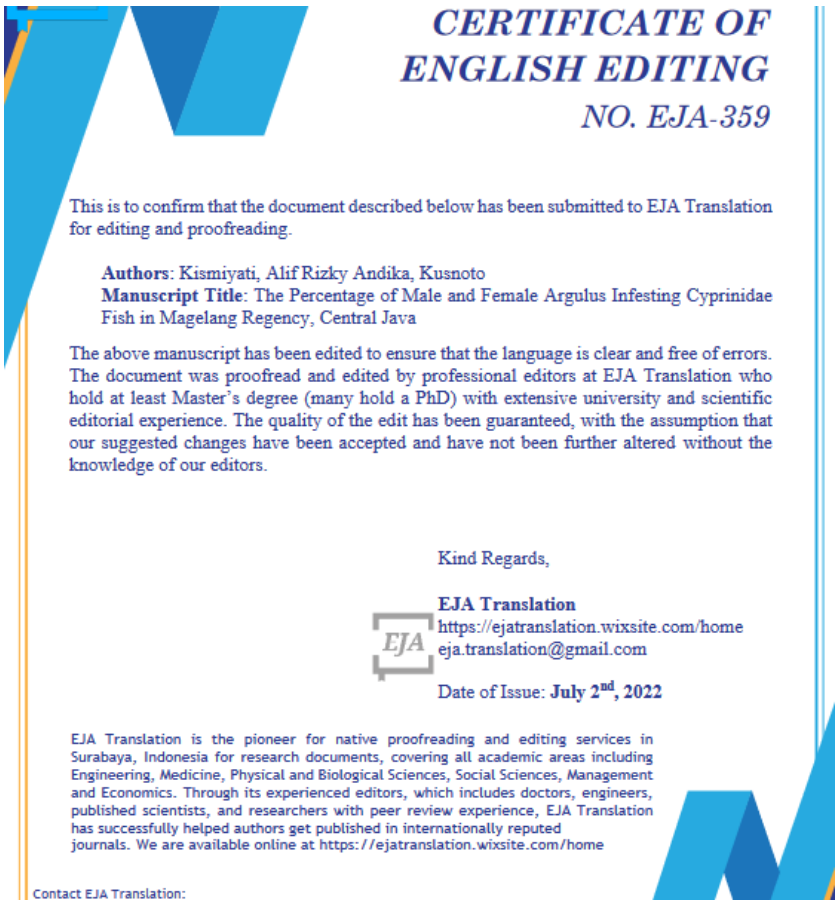

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The Percentage of Male and Female *Argulus* Infesting Cyprinidae Fish in Magelang Regency, Central Java

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Abstract

Background: One cause of fish disease is the *Argulus* parasite. Both male and female *Argulus* were found to infect fish. This study aims to determine the percentage difference of male and female *Argulus* that infect Cyprinidae in Magelang Regency.
Methods: The present study used a survey method. The independent variables in this study are carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), comet goldfish (*Carassius auratus auratus*), koi fish (C. *carpio* koi), and the sex of the *Argulus* parasite. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The data analysis was done using analysis of variance (ANOVA) then followed by Duncan's Multiple Range Test to find out the differences between treatments.
Result: The first ANOVA result showed no significant difference ($p > 0.05$), the second ANOVA showed significantly different results ($p < 0.05$), and the third ANOVA reveals no significantly different percentage ($p > 0.05$). The highest infestation rate of male *Argulus japonicus* is found in koi fish (C. *carpio* koi) is 60%, and the lowest is in comet goldfish, which is 38.46%. Whereas infestation of female *A. japonicus* in carp, goldfish, comet goldfish, and koi fish also obtained a similar result.

Key words: *Argulus*, Cyprinidae, Parasite, Fisheries.

INTRODUCTION

Magelang Regency is one of the areas that has undergone aquaculture-based development, prioritizing the principle of efficiency, quality, and sustainability (Wibowo *et al.,* 2015). The area consists of Ngluwar Sub-District, Mungkid Sub-District, and Muntilan Sub-District. Cyprinidae family fish species that are cultivated in Magelang Regency are common carp (C. *carpio*), goldfish (C. *auratus*), comet fish (C. *auratus auratus*), and koi fish (C. *carpio* koi) (Badan Pusat Statistik Kab. Magelang, 2014). The main problem in cultivating fish in Indonesia to date revolves around parasites and infectious diseases. The disease causes economic losses because it can result in less

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optimal fish harvest (Carella and Sirri, 2017; Das and Chandra, 2018). One cause of the disease is the infestation of parasites (Picard-Sánchez *et al.,* 2020). The quality of freshwater ornamental fishes decreased due to attacks from parasites such as *Argulus* sp. (Alifuddin *et al.,* 2002).

Argulus is a crustacean branchiuran parasite that causes severe problems in aquaculture throughout the world. Around 129 species of *Argulus* (family: Argulidae) are distributed worldwide, and 12 species have been described in various freshwater, brackish water, marine and ornamental fish in India (Kumar *et al.,* 2017). Among them, *A. japonicus* are considered as emerging pathogens of freshwater, brackish water and coldwater fish worldwide (Tandel *et al.,* 2021).

Morphological identification of *Argulus* sp. is mostly based on distinguishing features of an adult male such as carapace and abdominal length or width, dorsal ridges of the carapace, respiratory areas, leg pigments, abdominal lobes and incision, and the presence of a small coxal at the swimming appendages (Sahoo *et al.,* 2012; Soes *et al.,* 2010), requiring experienced taxonomists.

Argulus is one of the ectoparasites that attacks the Cyprinidae (Wardany and Kurniawan, 2014). *Argulus* attacks the fins, skin, gill, and the entire surface of the host body (Pramujirini, 2016). Fish that has been infested by *Argulus* looks thin, with red spots appearing on its body, causing it often to rub its body on the edge of the pool. This parasitic attack is more often deadly in young fish because the body's defense system has not yet developed (Bandilla, 2007). Male and female *Argulus* usually attack carp (*C. carpio*) (Ebrahimi *et al.,* 2018). Male and female *Argulus* is also found to attack the goldfish (*C. auratus*). Male and female *Argulus* have the same properties as goldfish (*C. auratus*) (Yıldız and Kumantas, 2002). Based on these descriptions, this study aims to determine the percentage difference of *Argulus* male and *Argulus* females infesting carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi), as well as to find the amount of male and female *Argulus* infestation on the Cyprinidae family.

MATERIALS AND METHODS

Procedures

The research used the survey method. The survey method used in this study was a survey of research locations and *Argulus* parasites in fish samples. The data were collected using the descriptive method. The description of events in this study is the male and female *Argulus* parasite infestations in Cyprinidae of Magelang Regency. This study used a Completely Randomized Factorial Design. The Completely Randomized Factorial Design was applied because the study had two different factors; (1) the *Argulus* sex and (2) the Cyprinidae fish. The independent variables in this study consist of carp (C. *carpio*), goldfish (C. *auratus*), comet goldfish (C. *auratus auratus*), and koi fish (C. *carpio* koi), and the sex of *Argulus*. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The control variables of this study were fish size, location, and environmental conditions in Magelang. The collected sample amounted to 200 fish.

Data analysis

Analysis of the data used in this study was ANOVA (analysis of variance) using SPSS v16.0. If there are significant differences, further tests would be conducted using Duncan's Multiple Range Test (Santoso, 2008).

RESULTS AND DISCUSSION

Result

Identification results of *Argulus* sp. which infested in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C.* carpio koi) in Magelang Regency is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the morphology. *A. japonicus* is identified as having a length of 3-5 mm and a width of 2-4 mm. In the Maxilla I, there is a supporting rod totaling five to nine pieces, and the Maxilla II is equipped with three hooks.

The male and female *A. japonicus* can also be distinguished based on their morphology. The males are identified as having an abdominal testis. In comparison, the females are identified by their cephalothorax ovaries and seminal receptacle in the abdomen. *A. japonicus* are found in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). *A. japonicus* is one of the

ectoparasites that attacks the Cyprinidae family (Wardany and Kurniawan, 2014). *A. japonicus* that infest in the Cyprinidae family in Magelang are observed in Figure 1.

Figure 1. *Argulus japonicus* infested common carp (*C. Carpio*), goldfish (*C. auratus*), comet fish (*C. auratus auratus*), and koi fish (*C. carpio* koi). a. Female *Argulus japonicus*; b. Male *Argulus japonicus*.

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Male *A. japonicus* infest goldfish (*C. auratus*) is 50%, with the female having the same percentage. 38.46% of male *A. japonicus* infest comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. 60% of male *A. japonicus* infests koi fish (*C. carpio koi*), while the female is 40%.

Data differences between the infestations of male and female *A. japonicus* in four different species of Cyprinidae were analyzed by analysis of variance (ANOVA). The results of the first ANOVA showed results that were not significantly different ($p > 0.05$) between the average numbers of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). The second ANOVA showed significantly different results ($p < 0.05$) between carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) which have been infected by *A. japonicus*. The infestations analyzed using the third ANOVA were not significantly different ($p > 0.05$) between the male and female *A. japonicus* females in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

Based on the data from the analysis, the two treatments did not show any interaction. Thus, the data was included in the simple treatment. The simple treatment in question involves the male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* were least found in comet goldfish (*C. auratus auratus*), but in a number that is not significantly different from carp (*C. carpio*). In contrast, in the female infestation of *A. japonicus*, no differences were found between the four types of fish.

Discussion

It has been identified that the *Argulus* sp. infest in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) in Magelang is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the range of length (3-9 mm) and width of 2-6 mm (Møller, 2009). The respiratory area in the anterior is small, with the posterior being larger, five to nine supporting rods can be found in the Maxilla I, and the Maxilla II is equipped with a total of three hooks. Male *A. japonicus* is equipped with testicles in the abdomen, whereas females have ovaries. The physical difference between the male and female *A. japonicus* can be seen in the abdomen located in the posterior part of the body (Kismiyati et al., 2011). Female *A. japonicus* has spermatheca and ovaries, while males have seminal testicles and vascular (Wardany and Kurniawan, 2014).

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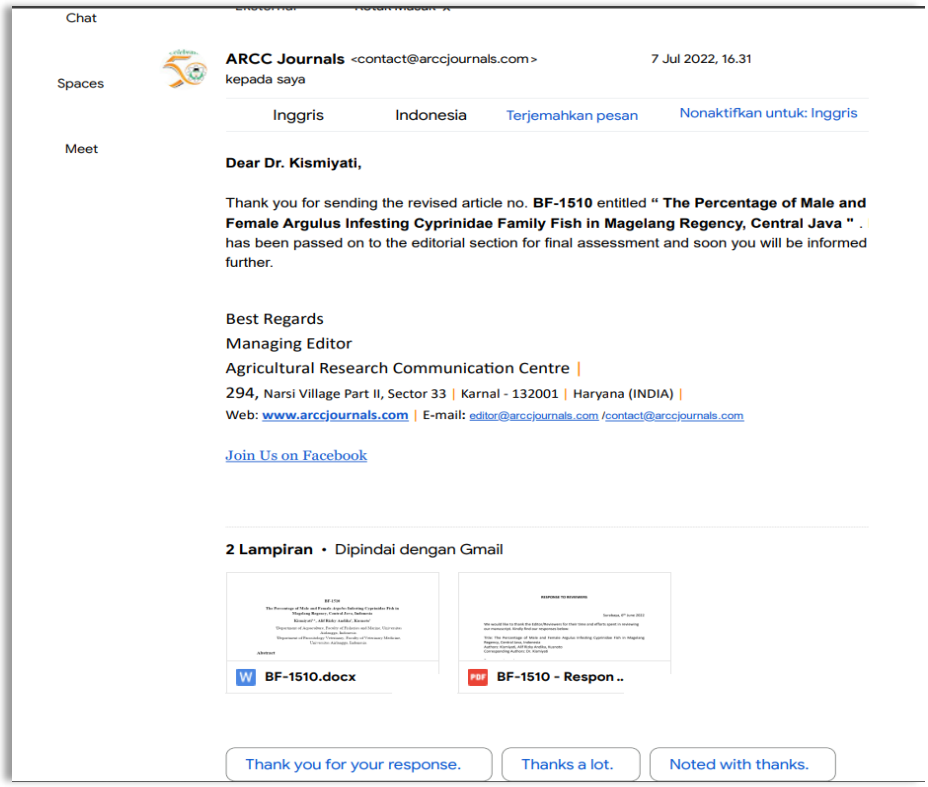

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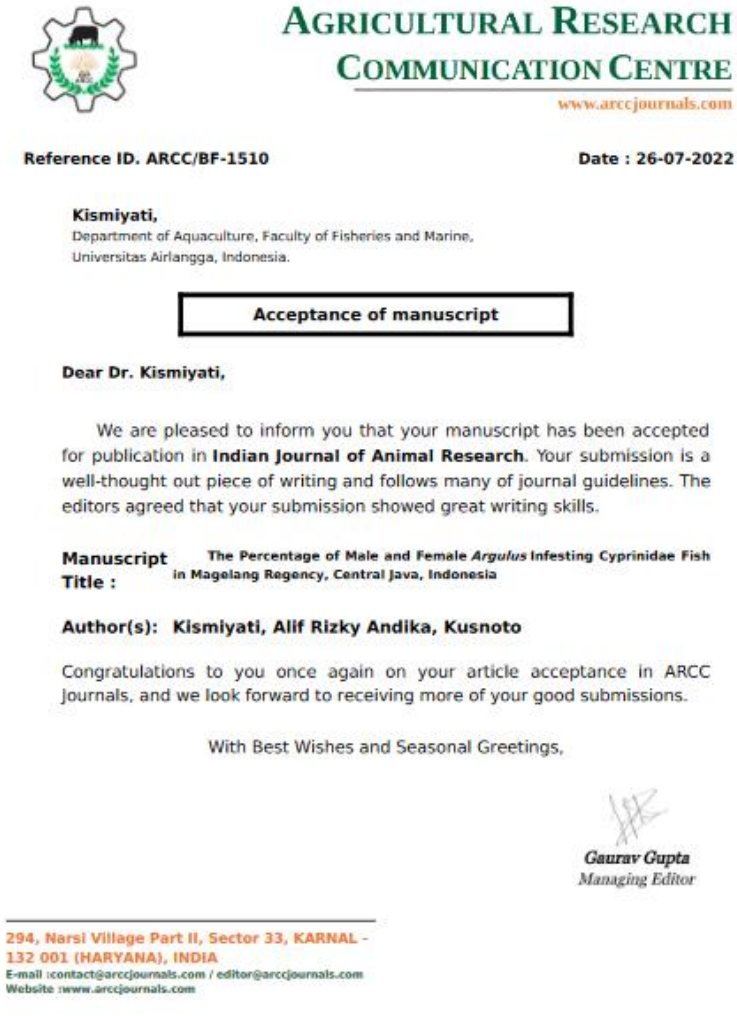

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Department of Aquaculture, Faculty of Fisheries and Marine,
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Acceptance of manuscript

Dear Dr. Kismiyati,

We are pleased to inform you that your manuscript has been accepted for publication in **Indian Journal of Animal Research**. Your submission is a well-thought out piece of writing and follows many of journal guidelines. The editors agreed that your submission showed great writing skills.

Manuscript Title : **The Percentage of Male and Female *Argulus* Infesting Cyprinidae Fish in Magelang Regency, Central Java, Indonesia**

Author(s): Kismiyati, Alif Rizky Andika, Kusnoto

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BF-1510

The Percentage of Male and Female *Argulus* Infesting Cyprinidae Fish in Magelang Regency, Central Java, Indonesia

Kismiyati[1,*], Alif Rizky Andika[1], Kusnoto[2]

[1]Department of Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga, Indonesia.
[2]Department of Parasitology Veterinary, Faculty of Veterinary Medicine, Universitas Airlangga, Indonesia.

Abstract

Background: One cause of fish disease is the *Argulus* parasite. Both male and female *Argulus* were found to infect fish. This study aims to determine the percentage difference of male and female *Argulus* that infect Cyprinidae in Magelang Regency.
Methods: The present study used a survey method. The independent variables in this study are carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), comet goldfish (*Carassius auratus auratus*), koi fish (C. *carpio* koi), and the sex of the *Argulus* parasite. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The data analysis was done using analysis of variance (ANOVA) then followed by Duncan's Multiple Range Test to find out the differences between treatments.
Result: The first ANOVA result showed no significant difference ($p > 0.05$), the second ANOVA showed significantly different results ($p < 0.05$), and the third ANOVA reveals no significantly different percentage ($p > 0.05$). The highest infestation rate of male *Argulus japonicus* is found in koi fish (C. *carpio* koi) is 60%, and the lowest is in comet goldfish, which is 38.46%. Whereas infestation of female *A. japonicus* in carp, goldfish, comet goldfish, and koi fish also obtained a similar result.

Key words: *Argulus,* Cyprinidae, Parasite, Fisheries.

INTRODUCTION

Magelang Regency is one of the areas that has undergone aquaculture-based development, prioritizing the principle of efficiency, quality, and sustainability (Wibowo *et al.,* 2015). The area consists of Ngluwar Sub-District, Mungkid Sub-District, and Muntilan Sub-District. Cyprinidae family fish species that are cultivated in Magelang Regency are common carp (C. *carpio*), goldfish (C. *auratus*), comet fish (C. *auratus auratus*), and koi fish (C. *carpio* koi) (Badan Pusat Statistik Kab. Magelang, 2014).

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The main problem in cultivating fish in Indonesia to date revolves around parasites and infectious diseases. The disease causes economic losses because it can result in less optimal fish harvest (Carella and Sirri, 2017; Das and Chandra, 2018). One cause of the disease is the infestation of parasites (Picard-Sánchez *et al.,* 2020). The quality of freshwater ornamental fishes decreased due to attacks from parasites such as *Argulus* sp. (Alifuddin *et al.,* 2002).

Argulus is a crustacean branchiuran parasite that causes severe problems in aquaculture throughout the world. Around 129 species of *Argulus* (family: Argulidae) are distributed worldwide, and 12 species have been described in various freshwater, brackish water, marine and ornamental fish in India (Kumar *et al.,* 2017). Among them, *A. japonicus* are considered as emerging pathogens of freshwater, brackish water and coldwater fish worldwide (Tandel *et al.,* 2021).

Morphological identification of *Argulus* sp. is mostly based on distinguishing features of an adult male such as carapace and abdominal length or width, dorsal ridges of the carapace, respiratory areas, leg pigments, abdominal lobes and incision, and the presence of a small coxal at the swimming appendages (Sahoo *et al.,* 2013; Soes *et al.,* 2010), requiring experienced taxonomists.

Argulus is one of the ectoparasites that attacks the Cyprinidae (Wardany and Kurniawan, 2014). *Argulus* attacks the fins, skin, gill, and the entire surface of the host body (Pramujirini, 2016). Fish that has been infested by *Argulus* looks thin, with red spots appearing on its body, causing it often to rub its body on the edge of the pool. This parasitic attack is more often deadly in young fish because the body's defense system has not yet developed (Bandilla, 2007). Male and female *Argulus* usually attack carp (*C. carpio*) (Ebrahimi *et al.,* 2018). Male and female *Argulus* is also found to attack the goldfish (*C. auratus*). Male and female *Argulus* have the same properties as goldfish (*C. auratus*) (Yıldız and Kumantas, 2002). Based on these descriptions, this study aims to determine the percentage difference of *Argulus* male and *Argulus* females infesting carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi), as well as to find the amount of male and female *Argulus* infestation on the Cyprinidae family.

MATERIALS AND METHODS

Procedures

The research used the survey method. The survey method used in this study was a survey of research locations and *Argulus* parasites in fish samples. The collected specimens were labeled and fixed in 96% alcohol solution (Hasan and Tamam, 2019; Hasan *et al*., 2021). The data were collected using the descriptive method. The description of events in this study is the male and female *Argulus* parasite infestations in Cyprinidae of Magelang Regency. This study used a Completely Randomized Factorial Design. The Completely Randomized Factorial Design was applied because the study had two different factors; (1) the *Argulus* sex and (2) the Cyprinidae fish. The independent variables in this study consist of carp (C. *carpio*), goldfish (C. *auratus*), comet goldfish (C. *auratus auratus*), and koi fish (C. *carpio* koi), and the sex of *Argulus*. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The control variables of this study were fish size, location, and environmental conditions in Magelang. The collected sample amounted to 200 fish.

Data analysis

Analysis of the data used in this study was ANOVA (analysis of variance) using SPSS v16.0. If there are significant differences, further tests would be conducted using Duncan's Multiple Range Test (Santoso, 2008).

RESULTS AND DISCUSSION

Identification results of *Argulus* sp. which infested in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C.* carpio koi) in Magelang Regency is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the morphology. *A. japonicus* is identified as having a length of 3-5 mm and a width of 2-4 mm. In the Maxilla I, there is a supporting rod totaling five to nine pieces, and the Maxilla II is equipped with three hooks.

The male and female *A. japonicus* can also be distinguished based on their morphology. The males are identified as having an abdominal testis. In comparison, the females are identified by their cephalothorax ovaries and seminal receptacle in the abdomen. *A. japonicus* are found in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). *A. japonicus* is one of the

ectoparasites that attacks the Cyprinidae family (Wardany and Kurniawan, 2014). *A. japonicus* that infest in the Cyprinidae family in Magelang are observed in Figure 1.

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Male *A. japonicus* infest goldfish (*C. auratus*) is 50%, with the female having the same percentage. 38.46% of male *A. japonicus* infest comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. 60% of male *A. japonicus* infests koi fish (*C. carpio koi*), while the female is 40%.

Data differences between the infestations of male and female *A. japonicus* in four different species of Cyprinidae were analyzed by analysis of variance (ANOVA). The results of the first ANOVA showed results that were not significantly different ($p > 0.05$) between the average numbers of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi). The second ANOVA showed significantly different results ($p < 0.05$) between carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) which have been infected by *A. japonicus*. The infestations analyzed using the third ANOVA were not significantly different ($p > 0.05$) between the male and female *A. japonicus* females in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

Based on the data from the analysis, the two treatments did not show any interaction. Thus, the data was included in the simple treatment. The simple treatment in question involves the male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* were least found in comet goldfish (*C. auratus auratus*), but in a number that is not significantly different from carp (*C. carpio*). In contrast, in the female infestation of *A. japonicus*, no differences were found between the four types of fish.

It has been identified that the *Argulus* sp. infest in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) in Magelang is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the range of length (3-9 mm) and width of 2-6 mm (Møller, 2009). The respiratory area in the anterior is small, with the posterior being larger, five to nine

supporting rods can be found in the Maxilla I, and the Maxilla II is equipped with a total of three hooks. Male *A. japonicus* is equipped with testicles in the abdomen, whereas females have ovaries. The physical difference between the male and female *A. japonicus* can be seen in the abdomen located in the posterior part of the body (Kismiyati et al., 2011). Female *A. japonicus* has spermatheca and ovaries, while males have seminal testicles and vascular (Wardany and Kurniawan, 2014).

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Both male and female *A. japonicus* are known to infect fish (Walker et al., 2011). The percentage of male and female *A. japonicus* found to infest carp (*C. carpio*) is almost the same. That is because carp (*C. carpio*) is one of the preferred hosts of both male and female *Argulus japonicas* (Poly, 2008).

The male and female *A. japonicus* that infest goldfish (*C. auratus*) have the same percentage of 50%. Both male and female *A. japonicus* were found to infest goldfish (*C. auratus*) (Wafer *et al.,* 2015). That is because of their same parasitic properties (Mikheev *et al.,* 2015). 38.46% of male *A. japonicus* infects comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. Female *A. japonicus* is found in comet goldfish fins (*C. auratus auratus*). This is due to the wide surface and slow movement of the fins (Pramujirini, 2016). The slow-motion of fish fins makes it easy for female *A. japonicus* to break away when oviposition (Kismiyati *et al.,* 2011).

There are 60% of male *A. japonicus* infest koi fish (*C. carpio* koi) while the female is 40%. Male *A. japonicus* can be found on the surface of koi fish (*C. carpio* koi). Koi fish (*C. carpio* koi) has a broad body surface that becomes the preferred predilection for male *A. japonicus*. Male *A. japonicus* prefers large areas (Taylor *et al.,* 2006).

The average number of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) is not significantly different ($p > 0.05$). That is because of their same parasitic properties (Mikheev *et al.,* 2015). Male and female *A. japonicus* are found to attack the Cyprinidae family (Wardany and Kurniawan, 2014).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* least infests comet goldfish (*C. auratus auratus*), but in a number that is not substantially different from carp (*C. carpio*). That is because all four types of fish have other body surface areas. Male *A. japonicus* favors

large areas (Taylor *et al.,* 2006). Duncan's Multiple Range Test results also showed that no differences were found between the four types of fish infested by female *A. japonicus*. Female *A. japonicus* is often found in fish fins (Pramujirini, 2016). The female chooses fins as a place of predilection because the fin movements of carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*), and koi fish (*C. carpio* koi) are languid. The slow movement of fish fins makes it easy for female *A. japonicus* to break away. Female *A. japonicus* will escape from the host when oviposition (Kismiyati *et al.,* 2010).

CONCLUSION

Argulus is capable of infecting cyprinid fish with different percentages for each host genus. In carp (*C. carpio*), the percentage of male *A. japonicus* infects more than female *A. japonicus*. In goldfish (*C. auratus*), male and female *A. japonicus* have the same percentage, while in comet goldfish (*C. auratus auratus*), the percentage of female *A. japonicus* is higher than female *A. japonicus*. Although there is a difference in the percentage of male and female *A. japonicus* in a host, both have the same detrimental effect on the host fish.

ACKNOWLEDGEMENTS

Acknowledgments are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

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Figure 1. *Argulus japonicus* infested common carp (*C. Carpio*), goldfish (*C. auratus*), comet fish (*C. auratus auratus*), and koi fish (*C. carpio* koi). a. Female *Argulus japonicus*; b. Male *Argulus japonicus*.

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RESEARCH ARTICLE Indian Journal of Animal Research

The Percentage of Male and Female *Argulus* Infesting Cyprinidae Fish in Magelang Regency, Central Java, Indonesia

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10.18805/IJAR.BF-1510

ABSTRACT

Background: One cause of fish disease is the *Argulus* parasite. Both male and female *Argulus* were found to infect fish. This study aims to determine the percentage difference of male and female *Argulus* that infect Cyprinidae in Magelang Regency.

Methods: The present study used a survey method. The independent variables in this study are carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), comet goldfish (*Carassius auratus*), koi fish (C. *carpio* koi) and the sex of the *Argulus* parasite. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The data analysis was done using analysis of variance (ANOVA) then followed by Duncan's multiple range test to find out the differences between treatments.

Result: The first ANOVA result showed no significant difference ($p>0.05$), the second ANOVA showed significantly different results ($p<0.05$) and the third ANOVA reveals no significantly different percentage ($p>0.05$). The highest infestation rate of male *Argulus japonicus* is found in koi fish (C. *carpio* koi) is 60% and the lowest is in comet goldfish, which is 38.46%. Whereas infestation of female *A. japonicus* in carp, goldfish, comet goldfish and koi fish also obtained a similar result.

Key words: *Argulus,* Cyprinidae, Fisheries, Parasite.

INTRODUCTION

Magelang Regency is one of the areas that has undergone aquaculture-based development, prioritizing the principle of efficiency, quality and sustainability (Wibowo *et al.,* 2015). The area consists of Ngluwar Sub-District, Mungkid Sub-District and Muntilan Sub-District. Cyprinidae family fish species that are cultivated in Magelang Regency are common carp (C. *carpio*), goldfish (C. *auratus*), comet fish (C. *auratus auratus*) and koi fish (C. *carpio* koi) (Badan Pusat Statistik Kab. Magelang, 2014).

The main problem in cultivating fish in Indonesia to date revolves around parasites and infectious diseases. The disease causes economic losses because it can result in less optimal fish harvest (Carella and Sirri, 2017; Das and Chandra, 2018). One cause of the disease is the infestation of parasites (Picard Sánchez *et al.,* 2020). The quality of freshwater ornamental fishes decreased due to attacks from parasites such as *Argulus* sp. (Alifuddin *et al.,* 2002).

Argulus is a crustacean branchiuran parasite that causes severe problems in aquaculture throughout the world. Around 129 species of *Argulus* (family: Argulidae) are distributed worldwide and 12 species have been described in various freshwater, brackish water, marine and ornamental fish in India (Kumar *et al.,* 2017). Among them, *A. japonicus* are considered as emerging pathogens of freshwater, brackish water and coldwater fish worldwide (Tandel *et al.,* 2021).

Morphological identification of *Argulus* sp. is mostly based on distinguishing features of an adult male such as carapace and abdominal length or width, dorsal ridges of the carapace, respiratory areas, leg pigments, abdominal lobes and incision and the presence of a small coxal at the swimming appendages (Sahoo *et al.,* 2013; Soes *et al.,* 2010), requiring experienced taxonomists.

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How to cite this article: Kismiyati, Andika, A.R. and Kusnoto (2022). The Percentage of Male and Female *Argulus* Infesting Cyprinidae Fish in Magelang Regency, Central Java, Indonesia. Indian Journal of Animal Research. DOI: 10.18805/IJAR.BF-1510.

Submitted: 04-03-2022 **Accepted:** 26-07-2022 **Online:** 23-08-2022

Argulus is one of the ectoparasites that attacks the Cyprinidae (Wardany and Kurniawan, 2014). *Argulus* attacks the fins, skin, gill and the entire surface of the host body (Pramujirini, 2016). Fish that has been infested by *Argulus* looks thin, with red spots appearing on its body, causing it often to rub its body on the edge of the pool. This parasitic attack is more often deadly in young fish because the body's defense system has not yet developed (Bandilla, 2007). Male and female *Argulus* usually attack carp (*C. carpio*) (Ebrahimi *et al.,* 2018). Male and female *Argulus* is also found to attack the goldfish (*C. auratus*). Male and female *Argulus* have the same properties as goldfish (*C. auratus*) (Yıldız and Kumantas, 2002). Based on these descriptions, this study aims to determine the percentage difference of *Argulus* male and *Argulus* females infesting carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi), as well as to find the amount of male and female *Argulus* infestation on the Cyprinidae family.

MATERIALS AND METHODS

Procedures

The research used the survey method. The survey method used in this study was a survey of research locations and *Argulus* parasites in fish samples. The data were collected using the descriptive method. The description of events in this study is the male and female *Argulus* parasite infestations in Cyprinidae of Magelang Regency. This study used a completely randomized factorial design. The completely randomized factorial design was applied because the study had two different factors; (1) the *Argulus* sex and (2) the Cyprinidae fish. The independent variables in this study consist of carp (C. *carpio*), goldfish (C. *auratus*), comet goldfish (C. *auratus auratus*) and koi fish (C. *carpio* koi) and the sex of *Argulus*. The dependent variable of this study was the sex percentage of the *Argulus* parasite. The control variables of this study were fish size, location and environmental conditions in Magelang. The collected sample amounted to 200 fish.

Data analysis

Analysis of the data used in this study was ANOVA (analysis of variance) using SPSS v16.0. If there are significant differences, further tests would be conducted using Duncan's multiple range test (Santoso, 2008).

RESULTS AND DISCUSSION

Identification results of *Argulus* sp. which infested in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C.* carpio koi) in Magelang Regency is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the morphology. *A. japonicus* is identified as having a length of 3-5 mm and a width of 2-4 mm. In the Maxilla I, there is a supporting rod totaling five to nine pieces and the Maxilla II is equipped with three hooks.

The male and female *A. japonicus* can also be distinguished based on their morphology. The males are identified as having an abdominal testis. In comparison, the females are identified by their cephalothorax ovaries and seminal receptacle in the abdomen. *A. japonicus* are found in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi). *A. japonicus* is one of the ectoparasites that attacks the Cyprinidae family (Wardany and Kurniawan, 2014). *A. japonicus* that infest in the Cyprinidae family in Magelang are observed in Fig 1.

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Male *A. japonicus* infest goldfish (*C. auratus*) is 50%, with the female having the same percentage. 38.46% of male *A. japonicus* infest comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. 60% of male *A. japonicus* infests koi fish (*C. carpio koi*), while the female is 40%.

Data differences between the infestations of male and female *A. japonicus* in four different species of Cyprinidae were analyzed by analysis of variance (ANOVA). The results of the first ANOVA showed results that were not significantly different ($p>0.05$) between the average numbers of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi). The second ANOVA showed significantly different results ($p<0.05$) between carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi) which have been infected by *A. japonicus*. The infestations analyzed using the third ANOVA were not significantly different ($p>0.05$) between the male and female *A. japonicus* females in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi).

Based on the data from the analysis, the two treatments did not show any interaction. Thus, the data was included in the simple treatment. The simple treatment in question involves the male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* were least found in comet goldfish (*C. auratus auratus*), but in a number that is not significantly different from carp (*C. carpio*). In contrast, in the female infestation of *A. japonicus*, no differences were found between the four types of fish.

It has been identified that the *Argulus* sp. infest in carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi) in Magelang is *A. japonicus*. *A. japonicus* can be distinguished from other *Argulus* sp. by looking at the range of length (3-9 mm) and width of 2-6 mm (Møller, 2009). The respiratory area in the anterior is small, with the posterior being larger, five to nine supporting rods can be found in the Maxilla I and the Maxilla II is equipped with a total of three hooks. Male *A. japonicus* is equipped with testicles in the abdomen, whereas females have ovaries. The physical difference between the male and female *A. japonicus* can be seen in the abdomen located in the posterior part of the body (Kismiyati *et al*., 2011). Female

Fig 1: *Argulus japonicus* infested common carp (*C. Carpio*), goldfish (*C. auratus*), comet fish (*C. auratus auratus*) and koi fish (*C. carpio* koi). a. Female *Argulus japonicus*; b. Male *Argulus japonicus*.

A. japonicus has spermatheca and ovaries, while males have seminal testicles and vascular (Wardany and Kurniawan, 2014).

The percentage of male *A. japonicus* infests carp (*C. carpio*) is 51.51%, while female *A. japonicus* is 48.49%. Both male and female *A. japonicus* are known to infect fish (Walker *et al*., 2011). The percentage of male and female *A. japonicus* found to infest carp (*C. carpio*) is almost the same. That is because carp (*C. carpio*) is one of the preferred hosts of both male and female *Argulus japonicas* (Poly, 2008).

The male and female *A. japonicus* that infest goldfish (*C. auratus*) have the same percentage of 50%. Both male and female *A. japonicus* were found to infest goldfish (*C. auratus*) (Wafer *et al.,* 2015). That is because of their same parasitic properties (Mikheev *et al.,* 2015). 38.46% of male *A. japonicus* infects comet goldfish (*C. auratus auratus*), with the female infestation percentage of 61.54%. Female *A. japonicus* is found in comet goldfish fins (*C. auratus auratus*). This is due to the wide surface and slow movement of the fins (Pramujirini, 2016). The slow-motion of fish fins makes it easy for female *A. japonicus* to break away when oviposition (Kismiyati *et al.,* 2011).

There are 60% of male *A. japonicus* infest koi fish (*C. carpio* koi) while the female is 40%. Male *A. japonicus* can be found on the surface of koi fish (*C. carpio* koi). Koi fish (*C. carpio* koi) has a broad body surface that becomes the preferred predilection for male *A. japonicus*. Male *A. japonicus* prefers large areas (Taylor *et al.,* 2006).

The average number of male and female *A. japonicus* that infest carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi) is not significantly different ($p > 0.05$). That is because of their same parasitic properties (Mikheev *et al.,* 2015). Male and female *A. japonicus* are found to attack the Cyprinidae family (Wardany and Kurniawan, 2014).

The test results show that male *A. japonicus* dominantly infests koi fish (*C. carpio* koi) and goldfish (*C. auratus*) but in a number that is not significantly different from carp (*C. carpio*). Male *A. japonicus* least infests comet goldfish (*C. auratus auratus*), but in a number that is not substantially different from carp (*C. carpio*). That is because all four types of fish have other body surface areas. Male *A. japonicus* favors large areas (Taylor *et al.,* 2006). Duncan's Multiple Range Test results also showed that no differences were found between the four types of fish infested by female *A. japonicus*. Female *A. japonicus* is often found in fish fins (Pramujirini, 2016). The female chooses fins as a place of predilection because the fin movements of carp (*C. carpio*), goldfish (*C. auratus*), comet goldfish (*C. auratus auratus*) and koi fish (*C. carpio* koi) are languid. The slow movement of fish fins makes it easy for female *A. japonicus* to break away. Female *A. japonicus* will escape from the host when oviposition (Kismiyati *et al.,* 2010).

CONCLUSION

Argulus is capable of infecting cyprinid fish with different percentages for each host genus. In carp (*C. carpio*), the percentage of male *A. japonicus* infects more than female *A. japonicus*. In goldfish (*C. auratus*), male and female *A. japonicus* have the same percentage, while in comet goldfish (*C. auratus auratus*), the percentage of female *A. japonicus* is higher than female *A. japonicus*. Although there is a difference in the percentage of male and female *A. japonicus* in a host, both have the same detrimental effect on the host fish.

ACKNOWLEDGEMENT

Acknowledgments are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged and any potential conflicts of interest are noted.

Conflict of interest: None.

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