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Endoparasites of Wild Javan Gibbon (*Hylobates moloch*) At Gunung Halimun Salak National Park, Indonesia

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ABSTRACT

Infections of endoparasites in primates in natural habitats are highly prevalent and can cause disease, reduce health quality, and disrupt their life. This study investigated endoparasites prevalence value in the endangered Javan gibbon (*Hylobates moloch*) in Citalahab Forest, Gunung Halimun Salak National Park, Indonesia, from June to August 2022 by collected fecal samples (N = 10) and analyzed it using floatation methods. As a result, we found five genera of nematodes *Trichuris trichiura* (10% egg worm prevalence, *Oesophagostomum* spp. (50%), *Trichostrongylus* spp. (60%), *Ancylostoma* spp. (80%), and *Strongyloides* spp. (100%). The prevalence value of the worms in the larvae stage of *Trichostrongylus* spp. 20% and *Strongyloides* spp. 70%. Nematode infection status successively is *Strongyloides* spp., which is, frequently; *Trichostrongylus* spp. and *Ancylostoma* spp., which is, often; *Oesophagostomum* spp. and *Trichuris trichiura* which is, occasionally. Four species of nematode were found in both ages, and only *Trichuris trichiura* was found in one adolescent individual. The threat posed by this parasite deserves attention; further research is needed to fill the gap in our knowledge of their pathogenicity and transmission in Javan gibbon.

1. Introduction

Parasitism is essential in the behavior, interactions, and evolution of primates in ecosystems (Huffman and Chapman 2009; Frias *et al.* 2021). Parasites that infect primates are divided into two: ectoparasite and endoparasite. Ectoparasites are organisms that live on the surface of the body's organisms (Kupfer and Fessler 2018). While endoparasites live in the body's organisms, the immune response of the infected organism will affect the number of endoparasites in the body (Wen *et al.* 2021). This parasite can infect wild species like primates and is known to threaten the decline of primate populations in their natural habitat (Murdayasa *et al.* 2019). Based on several studies, endoparasites were found in primates with various proportions of the population or prevalence. In the Northern brown howler monkey (*Alouatta guariba clamitans*; Lopes *et al.* (2021)); the Bonet macaque (*Macaca radiata*; Kumar *et al.* (2018)). In apes are found in the Bornean Orangutan (*Pongo pygmaeus wurmbii*; Ulda *et al.* (2022)). The potential for endoparasite infection in primates is related to parasites known to attack primates across multiple habitat types (Lima *et al.* 2021).

Endoparasites infections are frequently identified in terrestrial primates compared to arboreal primates (White *et al.* 2019) because worms can infect terrestrial primates through soil during their movement and activity on the ground. However, the potential for endoparasite infection was also found in arboreal primates (Kharismawan *et al.* 2022), such as Javan gibbon (*Hylobates moloch*). This endangered primate can only be found in the remaining forests of Java Island, Indonesia, roughly in 30-50 fragmented forests in Western and Central Java (Nijman 2004). While it has been protected in the country (Regulation of The Minister of Environment and Forestry Number P.106/MENLHK/SETJEN/KUM.1/12/2018). Several threats are threatening

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its existence from poaching, illegal wildlife trade and habitat loss, thus causing to a decrease in the population of the Javan gibbon in its natural habitat, therefore, this primate is also considered Endangered on the IUCN Red List (Nijman 2020). Apart from these threats, health problems caused by endoparasites can also be another threat to the life of the Javan gibbon. Endoparasite research in Javan gibbon is conducted *ex-situ*, like in primate rehabilitation centers (Nurhara 2017; Fauzi *et al.* 2021). Meanwhile, endoparasite research on the Javan gibbon in its natural habitat was only carried out by Kharismawan *et al.* (2022) in the Petungkriyono Forest, Central Java.

Information on the status of endoparasites on the Javan gibbon in its natural habitat is vital, especially in immature individuals, which is still very limited. At this age, the Javan gibbon can experience high endoparasite infections because the level of parasitism from endoparasites will be more dominant in young individuals than in other age classes. Here, we examined the endoparasites on the immature individuals of adolescent and pre-adult Javan gibbon in Gunung Halimun Salak National Park (GHSNP), one of the remaining submontane forests in Java, Indonesia. This study added baseline information regarding the endoparasites infected with wild Javan gibbon and served as a conservation measure for the Javan gibbon from a health perspective.

2. Materials and Methods

2.1. Study Area

From June to August 2022, we conducted this study on the long-term research site of the Javan Gibbon Research and Conservation Project in Citalahab Forest, GHSNP, West Java, Indonesia (6°44'45.9"S, 106°32'18.0" E). Ewha Womans University initiated this project by collaborating with IPB University, and currently, it is operated by Yayasan Konservasi Ekosistem Alam Nusantara (KIARA). Citalahab Forest is a part of the administrative management unit of Resort Cikaniki GHSNP in West Java, Indonesia, in the primary hill and sub-montane forest (950-1,100 m a.s.l). The research area adjacent to the forest meets the village, a road, and the Nirmala Tea Estate. Citalahab has variations in temperature and high rainfall. minimum temperature was 17.4±1.2°C and maximum temperature 28.4±1.9°C. Rainfall at Citalahab is 3,235-4,777 mm/year (Lappan *et al.* 2023).

2.2. Data Collection

We collected ten fecal samples from five immature individuals from three habituated Javan gibbon groups (Figure 1), one individual from Group A (sub-adult), two individuals from Group B (adolescent and sub-adult), and two individuals from Group S (adolescent and sub-adult). Based on Brockelman *et al.* (1998), immature individuals are adolescents (5-8 years) and sub-adults (8-10 years). Assisted by three field assistants, we followed the group on the first day until we could locate the sleeping trees. After the gibbon woke up the next day, we collected fresh fecal samples from individuals following the previous day. The fecal samples can be taken on the second day because they will only be taken once in the morning after waking up. The first feces excreted from one individual in each group of Javan gibbons will be taken, which usually happens between 05:30–07:00. We used the flotation method following the research procedure Winarso (2019). One gram of fecal is mixed with 10 ml of saturated NaCl. Then, it is filtered and put into a test tube. Next, add the saturated NaCl liquid back until the test tube is full and forms a convex at the top of the solution. Cover the top of the test tube with a cover slip and let it sit for 10 minutes to allow the parasite eggs to float to the top of the tube. Lift the cover glass and stick it on the object glass. We scanned the sediments for eggs and larvae and conducted a detailed examination at x40 objective power. We did not bring the samples out of the GHSNP area, and all the extractions were conducted in our laboratory at the Citalahab Field Station.

2.3. Data Analysis

Data analysis was carried out descriptively based on the identification and prevalence of parasites. Prevalence is the percentage of infected samples from samples that have been examined. The prevalence of helminthiasis is calculated according to Bush *et al.* (1997).

$$\text{Prevalence} = \frac{\text{Number of samples infected by endoparasite}}{\text{Total sample}} \times 100\%$$

According to Williams and Williams (1996), infection status is calculated based on percentage.

$$\text{Frequency} = \frac{\text{The number of each species of endoparasite}}{\text{Total species endoparasite}} \times 100\%$$

3. Results

We found that 100% of Javan gibbon fecal samples contained endoparasites from the phylum of Nematoda. The highest type of endoparasite phase found was eggs, and the lowest was larvae. There were 13 egg forms with egg shape and two forms with larvae, measurement, and characteristics (Table 1 and 2).

The prevalence of eggs and larvae endoparasite is shown in Table 3.

We also calculated the percentage of endoparasites based on the age class of the Javan gibbon, and

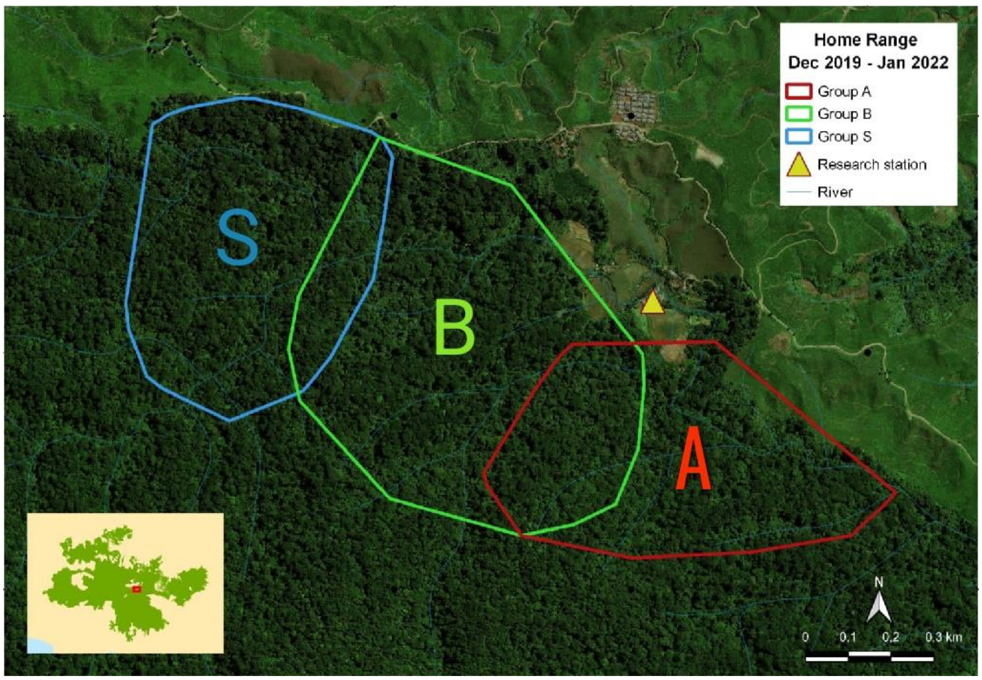


Figure 1. The research area of three groups of Javan gibbons in Citalahab Forest, GHSNP (map source: KIARA)

Table 1. Endoparasite eggs from gibbon in Gunung Halimun Salak National Park, Indonesia between June and August 2022

Code	Egg-shape	Egg type	Measurement	Characteristic	Previous records
A		Strongylid	52.2 × 70 µm	•Ellipsoid shape •Thin, clear shell •Egg contains the morula	CDC (2019b); Wulandari *et al.* (2022)
B		Strongylid	47 × 76 µm	•Ellipsoid shape •Thin, clear shell •Egg contains yolk	CDC (2019b); Wulandari *et al.* (2022)

Table 1. Continued

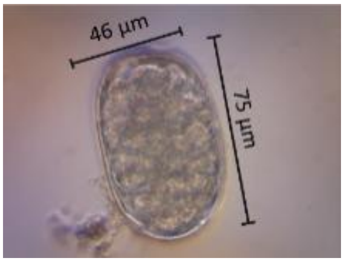
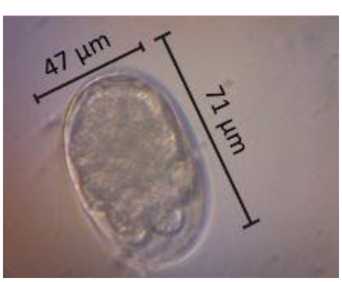
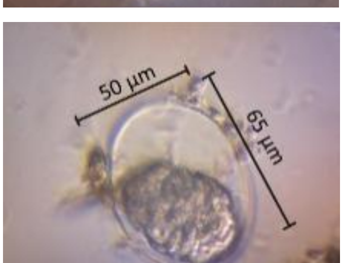
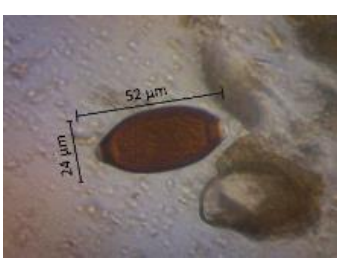
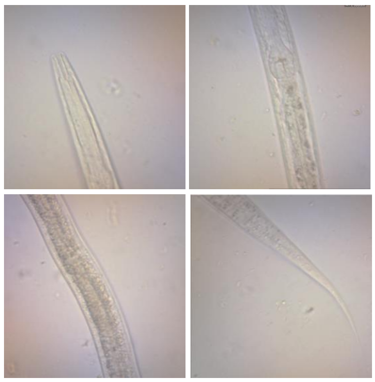
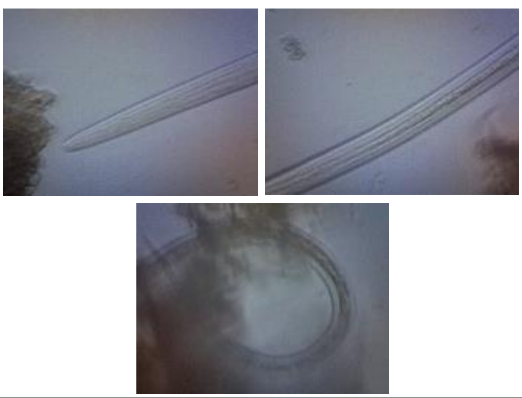
Code	Egg-shape	Egg type	Measurement	Characteristic	Previous records
C		Strongylid	46 × 75 µm	•Elliptical shape •Thin, clear shell •Egg contains morula	CDC (2019b); Wulandari *et al.* (2022)
D		Strongylid	46 × 82 µm	•Elliptical shape •Thin, clear shell •The egg contains morula (contents of the egg do not fill the egg chamber)	CDC (2017a); Kharismawan *et al.* (2022); Elshazly *et al.* (2006)
E		Strongylid	41 × 85 µm	•Elliptical shape •Thin, clear shell •Egg contains morula (space between morula and eggshell)	CDC (2017a); Kharismawan *et al.* (2022); Elshazly *et al.* (2006)
F		Strongylid	47 × 82 µm	•Elliptical shape •Thin, clear shell •Egg contains: yolk (space between morula and eggshell)	CDC (2017a); Kharismawan *et al.* (2022); Elshazly *et al.* (2006)
G		Strongylid	47 × 71 µm	•Ellipsoid shape •Thin, clear shell •Eggs contain morula	CDC (2017b); Kharismawan *et al.* (2022); Klaus *et al.* (2017)
H		Strongylid	50 × 65 µm	•Ellipsoid shape •Thin, clear shell •Eggs contain morula (only fills half of the egg chamber)	Kharismawan *et al.* (2022); Klaus *et al.* (2017)

Table 1. Continued

Code	Egg-shape	Egg type	Measurement	Characteristic	Previous records
I		Strongylid	32 × 42 µm	•Ellipsoid shape •Thin, clear shell •Eggs contain larvae	CDC (2019a); Klaus *et al.* (2017)
J		Strongylid	29 × 49 µm	•Oval shape •Thin, clear shell •Eggs contain larvae	CDC (2019a); Klaus *et al.* (2017)
K		Strongylid	29 × 48 µm	•Oval shape •Thin, clear shell •Egg contains gastrula	CDC (2019a); Klaus *et al.* (2017)
L		Strongylid	26 × 54 µm	•Oblong shape (longer than the other eggs observed) •Thin, clear shell •Egg contains gastrula	CDC (2019a); Klaus *et al.* (2017)
M		Strongylid	24 × 52 µm	•Lemon shape •Brown eggshell •Clear operculum plugs at the poles •Egg contains: the cells have not yet entered the division stage	CDC (2017c); Kharismawan *et al.* (2022)

A-C: *Ancylostoma* spp., D-F: *Trichostrongylus* spp., G-H: *Oesophagostomum* spp., I-L: *Strongyloides* spp., M: *Trichuris trichiura*

Table 2. Endoparasite larvae from Javan gibbon in Gunung Halimun Salak National Park, Indonesia between June and August 2022

Code	shape	Measurement	Characteristic	Previous records
N		600 × 34 µm	•Straight digestive •Rounded head tip •The outer body: smooth, no pattern •Tail short and conical	Van Wyk and Mayhew (2013), Knoll *et al.* (2021)
O		420 × 14 µm	•Pointed head •Blunt mouth •Esophagus shorter than the digestive tract •The digestive tract is straight •Pointed tail	Gugosyan *et al.* (2019), (Gugosyan *et al.* 2018)

N: *Strongyloides* spp., O: *Trichostrongylus* spp.

Table 3. Prevalence of endoparasites in the Javan gibbon in Gunung Halimun Salak National Park, Indonesia, between June and August 2022

Endoparasite	Eggs (%)	Larvae
Strongyloides spp.	100	70%
Ancylostoma spp.	80	-
Trichostrongylus spp.	60	20%
Oesophagostomum spp.	50	-
Trichuris trichiura	10	-

there are different percentages in sub-adults and adolescents, as shown in Table 4 below.

4. Discussion

4.1. Identification and Prevalence of Egg and Larvae Endoparasite

Endoparasites found in Javan gibbon in Gunung Halimun Salak National Park, Indonesia, include eggs and larvae *Trichuris trichiura, Oesophagostomum* spp., *Trichostrongylus* spp., *Ancylostoma* spp., and *Strongyloides* spp. The prevalence of endoparasite eggs identified were *Trichuris trichiura* 10%, *Oesophagostomum* spp. 50%, *Trichostrongylus* spp. 60%, *Ancylostoma* spp. 80%, and *Strongyloides* spp. 100%. It is similar to the study by Kharismawan *et al.* (2022) on Javan gibbon in the Petungkriyono Forest, Central Java which tested positive for endoparasite eggs from the order Rhabditida (*Strongyloides* sp., prevalence: 5.5%), order Strongylida (*Oesophagostomum* spp., *Ancylostoma* spp. and *Trichostrongylus* spp., prevalence: 25%) and the order Enoplida (*Trichuris* sp., prevalence: 8.33%). Types of *Strongyloides* spp., *Ancylostoma* spp., *Oesophagostomum* spp, and *Trichostrongylus* spp. is an endoparasite that is commonly found infecting humans, great apes, small apes, proboscis monkeys and langurs (Kouassi *et al.* 2015; Bradbury 2019; Yalcindag *et al.* 2021; Ilík *et al.* 2023).

The Bornean Orangutan (*Pongo pygmaeus wurmbii*), which is another arboreal primate also infected with the same endoparasites, is Ancylostomatidae (hookworms) (prevalence: 61%), *Strongyloides stercoralis* (prevalence: 61%), *Trichuris trichiura* (prevalence: 15%) and *Trichostrongylus* sp. (prevalence: 8%) (Ulda *et al.* 2022). Other research states that there are several types of endoparasites

Table 4. Percentage of endoparasites based on the age class of the Javan gibbon in Gunung Halimun Salak National Park, Indonesia, between June and August 2022

Individu	Species Endoparasite	Percentage (%)	Infection status*
Sub adults 1	*Trichostrongylus* spp.	11.4	Of
	Oesophagostomum spp.	4.5	Oc
	Strongiloides spp.	61.4	Fr
	Ancylostoma spp.	22.7	Of
Sub adults 2	*Trichostrongylus* spp.	25.4	Of
	Oesophagostomum spp.	3.0	Oc
	Strongiloides spp.	53.7	Fr
	Ancylostoma spp.	17.9	Of
Sub adults 3	*Trichostrongylus* spp.	7.8	Oc
	Oesophagostomum spp.	7.8	Oc
	Strongiloides spp.	64.7	Fr
	Ancylostoma spp.	19.7	Of
Adolescent 2	*Trichostrongylus* spp.	21.2	Of
	Oesophagostomum spp.	4.0	Oc
	Strongiloides spp.	55.9	Fr
	Ancylostoma spp.	18.9	Of
Adolescent 3	*Trichostrongylus* spp.	19.0	Of
	Oesophagostomum spp.	3.0	Oc
	Strongiloides spp.	59.0	Fr
	Ancylostoma spp.	19.0	Of
	Trichuris trichiura	7.0	Oc

*Fr: Frequently, Oc: Occasionally, Of: Often

found in semi-arboreal primates, such as the Silver langur (*Trachypithecus cristatus*) infected with *Trichuris* sp. (prevalence: 74.2%), *Strongyloides* spp. (prevalence: 28.5%) and Proboscis monkey (*Nasalis larvatus*) infected with *Oesophagostomum*/*Ternidens* spp. (prevalence: 22.8%) (Klaus *et al.* 2017; Frias *et al.* 2021).

Apart from natural habitats, research on endoparasites on Javan gibbon has also been found at the Aspinall Foundation Indonesia Program Javan Primate Rehabilitation Center (PRPJ). Two studies at rehabilitation centers found that only one type of endoparasite in the Javan gibbon is *Trichuris trichiura*. In Fauzi *et al.* (2021), the prevalence of this species was 26.3%, while Nurhara's study (2017) only mentioned one type of endoparasite in the form of *Trichuris trichiura* eggs in juvenile Javan gibbon. No other types of endoparasites were found in the two studies, indicating that management and maintenance biosecurity at the PRPJ Aspinall Foundation are well implemented so that the life cycle of the worms can be interrupted (Adisaputra 2019). The comparison of endoparasites in previous studies shows that the five types of endoparasites can potentially infect the Javan gibbon in its natural habitat or rehabilitation areas.

In this study, only *Trichuris trichiura* was found in one adolescent individual. This different pattern of infection could be due to the activity the Javan gibbon occasionally performs playing activities on the ground, even though it is rare. This activity has the potential for transmission of *Trichuris trichiura*. In proboscis monkeys, arboreal primates were found occasionally walking on the ground and *Trichuris* sp. in the feces. The transmission of *Trichuris trichiura* to the Javan gibbon can still occur despite the tendency for the Javanese gibbon to live in trees. Moist soil can be a good place for egg development for *Trichuris* spp., thereby facilitating egg development (Hussein *et al.* 2022).

The larva phase was also found in this study (Table 2). We identified two types of nematode larvae: *Strongyloides* spp. and *Trichostrongylus* spp. In five individuals, Javan gibbon is positive for *Strongyloides* spp. with a prevalence of 70%, while only two individuals were positive for *Trichostrongylus* spp. with a prevalence of 20%. Based on the report of Toure *et al.* (2022), *Strongyloidiasis cases* were found in Chimpanzees (*Pan troglodytes*). *Strongyloides sterocarlis* larvae are located in the large intestine, small intestine, lungs, and liver. In another study by Dibakou *et al.*

(2022), *Strongiloides* sp. was also found in the Sun-tailed monkey (*Allochrocebus solatus*). Factors such as host characteristics and the parasite species involved can affect the prevalence of Strongyloides in primates (Mati *et al.* 2013). Meanwhile, the results of research on *Trichostrongylus* spp. larvae have not yet been found in primates, but there have been cases of infection with this parasite in humans. Ten species of the genus *Trichostrongylus* have been reported to be found in humans in Iran (Ashrafi *et al.* 2020). This infection mainly occurs in humans who consume fresh vegetables contaminated with infective filariform larvae (Sharifdini *et al.* 2017). Trichostrongylosis usually does not show symptoms at low infection. General symptoms of severe infection are caused by abdominal pain, diarrhea, nausea, and mild anemia (Buonfrate *et al.* 2017).

The presence of larvae in the feces of the Javan gibbon is possibly the result of conditions in the digestive tract that are high in larvae, so the larvae migrate out of the host's body through the fecal (Nurcahyo and Prastowo 2013). Based on the research by Pecorella *et al.* (2022), other types of nematode larvae will turn into infective filariform larvae when outside the host. *Strongyloides sterocarlis* larva capable of completing its life cycle in the host's body (Page *et al.* 2018). The same as the life cycle of Trichostrongylus spp directly and without an intermediate host, with optimal temperature and humidity, rhabditiform larvae will develop 5–10 days into infective filariform larvae (Ghatee *et al.* 2020).

Environmental conditions such as temperature and rainfall can affect the prevalence of this type of endoparasite (Wulandari *et al.* 2022). The average rainfall in June–August 2022 was 450.23 mm during the study period, even though Indonesia entered the dry season in April and ended in September (Rahayu *et al.* 2018). Referring to the KIARA Foundation's long-term rainfall data from June-August 2017–2021 shows that the average rainfall decreased by 497.39 mm. So, based on these data, the dry season period in the GHSNP area occurs that month. The humidity during the GHSNP area's dry season reaches 90%. This factor allows the Javan gibbon to be infected with endoparasites. Most primates in moist habitats are more at risk of being infected with endoparasites than those in dry areas (Joesoef *et al.* 2018). Temperature is another factor that supports the development of endoparasites. The lowest average temperature was 17.45°C, and the highest was 27.01°C. Some endoparasites will live in specific temperature ranges, such as *Strongyloides* sp. larvae. which will develop optimally at a temperature of 25–30°C (Gugosyan *et al.* 2018) and *Trichostrongylus* sp., which requires a temperature of 13–18°C for transmission of larvae (Dhewiyanty *et al.* 2015). This result supports the discovery of *Trichostrongylus* spp. in this research. However, further research regarding endoparasites in the rainy season is needed as complementary data.

4.2. Status of Endoparasite in Javan gibbon

The type of endoparasite can have different effects on the host's body. Thus, the percentage of parasites in this study was categorized into several sections to show the degree of infection of the endoparasites (Williams and Williams 1996). Based on Table 4, we obtained three infection statuses: the parasite frequently, occasionally infects, and often infects each type of endoparasite found in immature Javan gibbon individuals. *Strongiloides* spp. was the highest in sub-adult 3 and the lowest in sub-adult 2. The infection status of *Strongyloides* spp. shows that this type frequently infects the Javan gibbon. This is in accordance with Viney and Lok (2015), which mention relatively commonly found in wild animals, including primates. However, it is expected that infections due to this type can cause complications in the digestive tract, kidneys, lungs, and even death. Infection is also known to cause death for orangutans during reintroduction programs (Nurcahyo and Prastowo 2013). The high number of *Strongyloides* spp. compared to the number of types of endoparasites found in this study, it can be caused by auto-infection, which is an infection that involves the transfer of stages of the parasite's life cycle from one place to another in the same host, accompanied by morphological transformation (Zimmermann *et al.* 2015). *Strongyloides* spp. rhabditiform larvae in the intestine transform into infective filariform larvae, which can penetrate the intestinal mucosa or skin. After the filariform larvae re-infect their host, they are carried with the blood to the lungs, pharynx, and small intestine and return to infect the rest of the body (CDC 2019a).

The next type of endoparasite found is *Trichostrongylus* spp., this type was found highest in adolescent 2, showing parasites often infecting, and lowest in sub-adult three individuals indicating parasites occasionally infecting. Generally, the infections are asymptomatic or show no symptoms, but severe infections can cause abdominal pain, diarrhea, and urticaria (allergies) (Rifai 2022). As a result, animals infected with *Trichostrongylus* have characteristics that look inactive (Marta *et al.* 2018). Endoparasite can spread or be transmitted through contaminated feed or individual interactions (Ghatee *et al.* 2020).

Ancylostoma spp. found the highest in sub-adult one and the lowest in sub-adult 3, with both percentages indicating parasites often infect. Severe infections of *Ancylostoma* spp. causes nutritional deficiencies due to loss of appetite, iron deficiency due to anemia, and death (Aziz and Ramphul 2022). *Trichuris trichiura* was only found in adolescent 3, the percentage results indicating that this parasite infects occasionally, the infection of this type is not very significant in causing disease. However, if the infection is severe, it will cause colitis and malabsorption of nutrients (Viswanath *et al.* 2022). *Oesophagostomum* spp. The highest was found in sub-adult three individuals and the lowest in sub-adult two and adolescents 3. Both percentages show that this parasite infects sometimes or occasionally. Mild infection of *Oesophagostomum* spp. in primates usually does not show symptoms, but if severe infection occurs, it can cause diarrhea and weight loss to interfere with developmental stages (NAS 2003). In addition, massive infections in the host's body can cause anemia, lack of blood, dehydration, and death (Macedo *et al.* 2022).

The results of the percentage of endoparasites based on the age of the Javan gibbon show that sub-adult individuals can also have the highest proportion of parasitic infection status and vice versa. The number of endoparasites in this study did not depend on the age of the Javan gibbon. The absence of a relationship between age and the number of endoparasites was also found in the study of Dibakou *et al.* (2022), which stated that the period did not affect the presence of each parasite in the Sun-tailed monkey (*Allochrocebus solatus*). Another study on the Yellow baboon (*Papio cynocephalus*) found no relationship between age and parasite abundance (Mason *et al.* 2022). However, it was mentioned in research on endoparasites on the White Armed Gibbon (*Hylobates lar*) that one species was found, *Trichuris* sp., which decreases with age (Gillespie *et al.* 2013).

Other studies suggest parasitism can occur more frequently as an individual gets older. Conversely, the lack of immunity to parasite exposure can increase the risk of infection in younger individuals (Alegre *et al.* 2021). Meanwhile, more mature individuals can gain immunity to certain parasites through repeated exposure (Mason *et al.* 2022). Increasing the host's age will shape the immune system's or immunity's maturity against parasite exposure (Peters *et al.* 2019). Apart from an underdeveloped immune system, the increased risk of exposure in adolescents is shown to be due to avoidance behavior towards parasites that are still less active (Kleinschmidt *et al.* 2018). In this study, adolescent 2 and sub-adult 2 had more eggs and larvae than individuals from other groups. The high number of endoparasites in both individuals could have occurred due to the existence of a vector, which was the cause of the high number of endoparasites. Vectors have a role as carrier animals that transmit endoparasites between or across species. Vectors such as insects, rodents, and bats can easily transmit disease if one of these animals carries a specific type of endoparasite (Mitchell and Rocket 2017; Morcatty *et al.* 2022). Another factor that can cause high endoparasites is a decrease in the health of the body of the infected organism.

The fit condition of each individual can cause differences in the number of endoparasites in the body. The host's immune level becomes more susceptible to infection if conditions are not optimal (Izhar and Ben-Ami 2015). For most primates, eating plants aims to fulfill the nutrients needed for survival (Petroni *et al.* 2017). Through food, energy needs will be met so that they can maintain health (Viviano *et al.* 2022). The results of Shurkin (2014) stated that eating activity can help heal pain in primates. This method is referred to as self-medication, which can help primates treat infections caused by endoparasites. During the study, pre-adult Javan gibbon individuals were often not seen in groups or far from their parent trees. This behavior will benefit pre-adult individuals because they can reach further home ranges than adolescents. This allows pre-adult individuals to find more resources or food to be used as natural medicine, compared to adolescents, whose range is still close to both parents. However, further research is needed regarding the eating behavior of the Javan gibbon as a form of self-medication activity.

In a study on self-medication in primates, it was found that bonobos (*Pan paniscus*) consumed Manniophyton fulvum leaves at certain times during the study period, and endoparasites were not found during the examination process (Fruth *et al.* 2014). Other primates, such as Chimpanzees, also show activity in eating the pith of *Vernonia amygdalina* and *Ficus fruits* (Huffman 2016) and the White-handed gibbon (*Hylobates lar*), which eats leaves as a form of self-medication when infected with endoparasites (Barelli and Huffman 2017). Plants do not only have nutrients but also provide secondary metabolites that function as medicines for primates (Petroni *et al.* 2017). It is known that Ficus fruit contains antiparasitic substances that are effective against *Ascaris* and *Trichuris* types.

Ficus fruit contains proteolytic enzymes, active ingredients that break down the Ascarid worm cuticle and can kill parasites (Huffman 2016). The secondary metabolites in plants consumed by primates include alkaloids, flavonoids, tannins, and saponins (Huffman 2016). The secondary metabolites in plants consumed by primates include alkaloids, flavonoids, tannins, and saponins (Setianingarum 2016). Tannin compounds are one of the secondary metabolites that have been shown to reduce the viability of several nematode larvae (Karonen *et al.* 2020). This compound functions as an anti-bacterial, antioxidant, and anti-diarrheal (Setianingarum 2016). The anthelmintic reaction by tannins gives a nematocidal effect, which inhibits egg hatching, larval motility, and larval release (Greiffer *et al.* 2022). In the food list for the Javan gibbon in GHSNP, 17 plant species contain tannin compounds. Parts of plants that contain tannins include 13 types of leaves and four types of fruit (Zulfa *et al.* 2021). The selection of the type of feed also depends on the needs of the primates. According to Safitri (2022), adult female orangutans prefer types of feed that contain low tannins because excessive tannins consumed can inhibit the work of bacteria in absorbing feed in the digestive system. Following this statement, only one green sample was found in this study, and it was green in color, and the green sample contained more leaf fiber than grains. This is likely a form of self-medication process carried out by the Javan gibbon. Further research is needed regarding the relationship between feeding activity, feed content, and the number of endoparasites in the Javan gibbon.

4.3. Strategy Conservation for Javan Gibbon

The relationship between endoparasites and the Javan gibbon can depend on the activities of the Javan gibbon and its habitat. Endoparasites can be transmitted from animals to humans-humans to animals or zoonoses. The types of endoparasites found in the study are potentially zoonotic, namely *Strongyloides* spp., *Ancylostoma* spp., and *Trichostrongylus* spp. Based on our study, all of the visitors and researchers must follow the best practice guidelines when working with primates: strict sanitation, no littering, and no interaction with animals, which must be carried out to avoid the potential spread of endoparasites.

In summary, the result of this study shows that five species of endoparasite in the form of eggs and larvae were found in Javan gibbons at Citalahab Forest. Only *Trichuris trichiura* was found in one adolescent individual. The highest prevalence of 100% is *Strongyloides* spp., and the lowest of 10% is *Trichuris trichiura.* Future studies need to investigate the feeding behavior for self-medication against the presence of endoparasites.

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