HOOKWORM IN STRAY CATS (*FELIS SILVESTRIS CATUS*) AS CUTANEOUS LARVA MIGRANT AGENT (CLM) IN HUMANS

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ABSTRACT

Background: Cats are a host of wide variety of microorganisms including ectoparasites and endoparasites. One of the endoparasite that infect cats is hookworm. The hookworm consist of two groups, animal hookworm and the human hookworm. The manifestation that can be caused by animal hookworm to humans is Cutaneous Larva Migrant (CLM). **Purpose:** To find out that the hookworm in stray cats (*Felis silvestris catus*) can cause CLM in humans. **Methods:** This papers was written using literature review method by taking references from 49 international journals indexed Q1-Q3 on Scimagojr and 5 national journal indexed S1-S3 as well as 8 textbooks published no later than 2016. The libraries in form of journals and textbooks are obtained from search engines Google, Google Scholar, Pubmed, ScienceDirect, and NCBI. **Results:** The results of the analysis show that the high level of hookworm infection in stray cats can increase the risk of CLM in humans. **Conclusion:** The high prevalence of hookworm infection in cats plays an important role in the increased risk of zoonoses in humans which in turn can increase the prevalence of CLM in humans.

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1. INTRODUCTION

Cutaneous Larva Migrant (CLM) is a skin disease caused by filariform larvae of animal hookworms. [1] The prevalence of CLM is very high, especially in developing countries with tropical-subtropical climates. [2] The incidence rate of CLM can increase up to fifteen times higher in the rainy season. [3] The prevalence of hookworm infection in Thailand varies from 0.6% to 13.4%, while in Indonesia it is 2.4%; 0.6%; 5.1%; 1.6%; and 1.0% in 2002 to 2006 with one of its manifestation is CLM. [4,5]

Stray cats that live freely around human habitations are more often in dirty places, making them a habitat for various kinds of parasites, one of its is animal hookworm. [6,7] The population of stray cats is also very large and continues to increase, based on the World Society for the Protection of Animals (WSPA) in 2008 there were 15 million cats in Indonesia, which is the third largest in the world. [8] The large population and the habitats of stray cats close to humans increase the risk of spreading parasites from cats to humans and causing zoonotic diseases. [9-10]

Research conducted by Silva et al. (2020) stated that there was a relationship between the presence of animal hookworm eggs in stray cat feces and 59 cases of CLM in humans in Votuporanga, Sao Paulo, Brazil.

Based on research conducted by Pumidonming et al. (2016) also said that the high prevalence of hookworm infection in cats affects the incidence of zoonotic diseases in humans.

Based on the description above, the authors want to know and analyze more deeply related to hookworm in stray cats as the cause of CLM in humans.

2. METHOD

This papers was written using literature review method by taking references from 49 international journals indexed Q1-Q3 on Scimagojr and 5 national journal indexed S1-S3 as well as 8 textbooks published no later than 2016. The libraries in form of journals and textbooks are obtained from search engines Google, Google Scholar, Pubmed, ScienceDirect, and NCBI which were then processed into new information according to the purpose of writing a literature review.

3. RESULTS AND DISCUSSION

There are several studies that show the prevalence rate of stray cats infected by hookworm. The results of a study conducted by Szwabe and Blaszkowka (2017) using the sedimentation technique on a total of 68 faecal samples from stray cats in Poland showed that only 3% of the stool samples studied were positive for hookworm. Another study conducted by Korkmaz et al. (2016) on 100 faecal samples from stray cats in Kirikkale, Turkey using the flotation technique. The results of the study by Korkmaz et al. (2016) were as much as 47% of the total samples found parasites, of which only 2 samples were positive for hookworm (4.2%). Another study using the flotation technique was also conducted by Yeqi Fu et al. (2019). In this study, 308 stray cat feces samples were collected from 8 cities in Guangdong Province, China. The results obtained were as many as 47 positive stool samples contained hookworm (15.26%), as we can see on table 1.

Table 1 Prevalence of Stray Cats Infected by Hookworm

Researcher	Method	Sample	Result
Szwabe and Blaszkowka (2017)	Sedimenta-tion technique	68 faecal samples from stray cats in Poland	As many as 3% of the total samples were detected positive for hookworm
Korkmaz et al. (2016)	Flotation technique	100 faecal samples from stray cats in Kirikkale, Turkey	As many as 47% of all samples were found to be parasitic, only 2 samples were positive for hookworm (4.2%)
Yeqi Fu et al. (2019)	Flotation technique	308 stray cat feces samples from 8 cities in Guangdong Province, China	A total of 47 stool samples were positive for hookworm (15.26%)

The next research will discuss about the risk factors that affect hookworm infection to cats. The results of research conducted by Wahyudi et al. (2017) using direct smear, sedimentation, flotation, and McMaster techniques on 180 samples of stray cat feces in Surabaya showed that there were 68 samples (37.8%) positive for worm eggs with 42 samples (23.3%) positive for hookworm eggs. Research using a similar technique was conducted by Rabbani et al. (2020) on 120 samples of stray cat and domestic cat feces in Lumajang. The results of the study showed that 68.33% of cat feces samples were positive for gastrointestinal parasites with 18.33% of them being hookworms. A total of 7/60 samples of domestic cat feces and 15/60 samples of stray cat feces were positive for hookworm. Then it was found that 2 domestic cats <1 year old and 5 domestic cats >1 year old were infected by hookworm, while 4 stray cats <1 year old and 11 cats >1 year old were positively infected by hookworm. Another study conducted by Oktaviana et al. (2014) using the flotation technique on 80 samples of stray cat and domestic cat feces. The results obtained were as many as 19/40 samples of stray cat feces (47.5%) and 10/40 samples of domestic cat feces (25%) positive for hookworm. Then it was found that 17/45 male cats (37.8%) and 12/35 female cats (34.3%) were infected by hookworm. The results of research Yeqi Fu et al. (2019) showed that of the 47 stray cats, 8/47 aged <1 year (17.02%) and 7/47 >1 year (14.89%) were positively infected by hookworm, in addition 19,14% of male cats and 12.76% of female cats were positively infected by hookworm (See table 2).

Table 2 Risk Factors that Affect Hookworm Infection to Cats

Researcher	Method	Sample	Result	
Wahyudi et al. (2017)	Direct smear, sedimentation, flotation, and McMaster	180 samples of stray cat feces in Surabaya	42 samples (23.3%) were positive for hookworm eggs	
Rabbani et al. (2020)	Direct smear, sedimentation, flotation, and McMaster	120 samples of stray cat and domestic cat feces in Lumajang	Cat Infected by Hookworm	
			Domestic Cat (n=60)	Stray Cat

				(n=60)
			Number of cat • 7 (11,6%) Age • <1 th: 2 (28,57%) • ≥1 th: 5 (71,42%)	• 15 (25,0%) • <1 th: 4 (26,66%) • ≥1 th: 11 (73,33%)
Oktaviana et al. (2014)	Flotation	80 samples of stray cat and domestic cat feces in Denpasar	Cat Infected by Hookworm	
			Domestic Cat (n=40)	Stray Cat (n=40)
			• 10 (25,0%)	• 19 (47,5%)
			Female (n=35)	Male (n=45)
			• 12 (34,3%)	• 17 (37,8%)
Yeqi Fu et al. (2019)	Flotation	47 stray cat	Cat Infected by Hookworm	
			Age • <1 th: 8 (17,02%) • ≥1 th: 7 (14,89%) Gender • Female: 12,76% • Male: 19,14%	

Subsequent research will discuss about the risk factors that most affect hookworm infection to cats. The results of research conducted by Rabbani et al. (2020) using a cross-sectional study method showed that the physical environment which includes soil texture, temperature, humidity, hygiene, and sanitation are risk factors that can affect the level of hookworm infection in cats. Based on the statistical analysis of the study, it was obtained the following data: sandy soil texture had an infection prevalence of 33.1% with a p-value of 0.764, wet soil had an infection prevalence of 47.7% with a p-value of 0.028, a temperature of > 28.6-29.5C has an infection prevalence of 55.8% with a p-value = 0.000, a humidity of 66% has an infection prevalence of 55.8% with a p-value = 0.000, and poor water sanitation has an infection prevalence of 43.8% with p-value = 0.000. A similar study was conducted by Yeqi Fu et al. (2019), the data obtained from statistical analysis are as follows: sandy soil texture has an infection prevalence of 47.2% with a p-value of 0.537, temperature has an infection prevalence of 61.1% with a p-value of 0.000, and humidity has an infection prevalence of 61.1% with p-value = 0.000 (See table 3).

Table 3 Risk Factors that Most Affect Hookworm Infection to Cats

Researcher	Variable	Prevalence of Infection	*p-value*
Rabbani et al. (2020)	Sandy soil	33,1%	0,764
	Wet soil	47,7%	0,028
	Temperature >28,6-29,5C	55,8%	0,000
	Humidity 66%	55,8%	0,000
	Poor water sanitation	43,8%	0,000
Yeqi Fu et al. (2019)	Sandy clay loam	47,2%	0,537
	Temperature	61,1%	0,000
	Humidity	61,1%	0,000

The next studies will discuss about the prevalence of CLM in humans in several countries. The results of research by Sow et al. (2017) using a retrospective study method showed that the prevalence of CLM in France was 1-3% found in people who recently returned from endemic countries. The case study conducted by Giudice et al. (2019) found that there were 5 cases of autochthonous CLM (patients with no history of travel to tropical countries or CLM that occurs in the local area) in France in the last 25 years. Another study conducted by Reichert et al. in 2016 and 2018 showed that the prevalence of CLM in Brazil was around 0.2% to 4.4-14.9% of the total general population, in the dry season and rainy season, respectively.

Subsequent studies will discuss about the risk factors that increase the incidence of CLM in humans. Factors that will be discussed include gender, age, economic conditions, daily behavior, and environmental conditions. The research results of Reichert et al. (2016) in Manaus, Brazil showed data on the number of CLM

infections in humans on several factors such as gender, including males as many as 44 (13.4%) and females as many as 22 (4.6%) cases; Based on age, namely aged < 4 years, 5-9 years, 10-14 years, 15-19 years, and > 20 years with 15 (8.6%), 23 (14.4%), 16 (18.2%), 1 (2.2%), and 11 (3.3%) cases respectively; Regarding the economic conditions of the people, included poor, intermediate, and rich with 37 (11.5%), 21 (8%), and 8 (4%) cases respectively; Regarding daily behavior such as walking on the ground without using footwear, with using footwear, walking on the sandy ground by never using footwear, often using footwear, and always using footwear with 14/58 (24.1%), 52/731 (7.1%), 29/111 (26.1%), 33/420 (7.9%), and 4/269 (1.5%) respectively; Regarding environmental conditions which include whether or not the soil is contaminated with cat feces, as many as 17/103 cases (16.5%) were found in an environment where cat feces were present and 49/702 cases (7%) were found in an environment where there was no cat feces. The results of another study conducted by Reichert et al. (2018) shows data on the incidence of CLM per year on several factors such as gender, including male (0.86) and female (0.25); Regarding the economic conditions of the people, including poor (0.68), intermediate (0.47), and rich (0.31); Regarding daily behavior such as walking on the ground barefoot (0.78) and using footwear (0.48), walking on the sandy ground by never using footwear (0.90), often using footwear (0.49), and always using footwear (0.29). Another study conducted by Sow et al. (2017) have obtained data on the number of CLM infections in humans toward several factors such as gender, including 22 cases (51.2%) in males and 21 cases (48.8%) in females; Based on age, namely aged <25 years, 25-50 years, and >50 years with 9 (20.9%), 29 (67.5%), and 5 (11.6%) cases respectively. Similar research was also conducted by Heryantoro et al. (2012) in Kulon Progo, Indonesia and obtained data on the number of CLM infections in humans toward several factors such as gender, namely in males as many as 54 cases (67.5%) and in women as many as 26 cases (32.5%); Based on age, namely aged <15 and >15 years with 46 (57.5%) and 34 (42.5%) cases, respectively (See table 4).

Table 4 Risk Factors that Increase the Incidence of CLM in Humans

	Variable		CLM (%)	OR (CI 95%)	*p-value*
Reichert et al. (2016)	Gender	Male	44 (13,4)	3,21	<0,001
		Female	22 (4,6)	1	
	Age	≤ 4 years old	15 (8,6)	2,80	0,012
		5-9 years old	23 (14,4)	4,99	<0,001
		10-14 years old	16 (18,2)	6,61	<0,001
		15-19 years old	1 (2,2)	0,66	0,695
		≥ 20 years old	11 (3,3)	1	
	Economic condition	Poor	37 (11,5)	3,16	0,004
		Intermediate	21 (8,0)	2,10	0,081
		Rich	8 (4,0)	1	
	Daily behavior	Walking on the ground			
		Barefoot	14/58 (24,1)	4,16	<0,001
		With using footwear	52/731 (7,1)	1	
		Walking on the sandy ground			
		Never using footwear	29/111 (26,1)	23,43	<0,001
		Often using footwear	33/420 (7,9)	5,65	0,001
		Always use footwear	4/269 (1,5)	1	
	Environmental condition	Animal feces on compound	17/103 (16,5)	2,63	0,001
		No animal feces on compound	49/702 (7,0)	1	
Reichert et al. (2018)	Gender	Male	57	0,86	3,41
		Female	21	0,25	1
	Economic condition	Poor	41	0,68	2,15
		Intermediate	23	0,47	1,51
		Rich	11	0,31	1
	Daily behavior	Walking on the ground			
		Barefoot	14	0,78	1,57

		With using footwear	64	0,48	1
		Walking on the sandy ground Never using footwear	25	0,90	3,24
		Often using footwear	44	0,49	1,66
		Always use footwear	9	0,29	1
	Gender	Male	57	0,86	3,41
		Female	21	0,25	1
	Economic condition	Poor	41	0,68	2,15

Sow et al. (2017)	Variable		CLM (%)
	Gender	Male	22 cases (51,2)
		Female	21 cases (48,8)
	Age	<25 years old	9 (20,9)
		25-50 years old	29 (67,5)
		>50 years old	5 (11,6)
Heryantoro et al. (2012)	Gender	Male	54 cases (67,5)
		Female	26 cases (32,5)
	Age	<15 years old	46 (57,5)
		≥15 years old	34 (42,5)

The next research will discusses about the risk factors that most affect in increasing the incidence of CLM in humans. Factors that will be discussed include gender, age, economic conditions, daily behavior, and environmental conditions. The results of statistical analysis from the research of Reichert et al. (2016) are as follows: gender include male (OR = 3.21) and female (OR = 1); age < 4 years (OR = 2.80), 5-9 years (OR = 4.99), 10-14 years (OR = 6.61), 15-19 years (OR = 0.66), and > 20 years (OR = 1); The economic condition of the people which includes poor (OR = 3.16), intermediate (OR = 2.10), and rich (OR = 1); Daily behavior such as walking on the ground barefoot (OR = 4.16), using footwear (OR = 1), walking on the sand with never wearing footwear (OR = 23.43), often use footwear (OR = 5.65), and always use footwear (OR = 1); The environmental which included whether or not the soil was contaminated with cat feces, the environment that did contained cat feces (OR = 2.63) and the environment that did not contain cat feces (OR = 1). A similar study was conducted by Reichert et al. (2018), the data obtained from statistical analysis based on the percentage of CLM incidence of each individual per year are as follows, gender include male (0.86) and female (0.25); Age <4 years (0.38), 5-9 years (0.46), 10-14 years (0.93), and 15-18 years (0.26); The economic condition of the people which includes the poor (0.68), intermediate (0.47) and rich (0.31); Daily behavior such as walking on the ground barefoot (0.78), with using footwear (0.48), walking on sand with never using footwear (0.90), growth, and help infective larvae to survive on the ground.

3.1 Prevalence of Stray Cats Infected by Hookworm

The difference in the prevalence of hookworm infection in cats that obtained from Poland (3%) and Turkey (4.2%) compared to China (15.26%) were quite far (See table 1), this is because Poland and Turkey are not tropical countries, while China especially Guangdong Province is an area with a tropical climate. Based on these three studies, it can be concluded that the climatic conditions of an area affect the prevalence of hookworm infection in cats. Tropical climates have a higher prevalence of hookworm infection in cats than non-tropical areas. This is because areas with tropical climates tend to have warm temperatures between 23-30°C, humidity levels of 80-100%, and the existence of a long rainy season that can maintain the scale of infection in endemic proportions, support larval growth, and help infective larvae to survive on the ground.

3.2 Risk Factors that Affect Hookworm Infection to Cats

Based on those four studies (See table 2), it is known that stray cats are more at risk for hookworm infection, than domestic cats. This is because stray cats live untreated, eat food that is not nutritious, and live in a dirty, humid, and poor sanitation environment which are ideal conditions for the development of infective larvae of hookworms. The prevalence of hookworm infection in cats aged <1 year and >1 year did not have a significant difference, as well as the prevalence of hookworm infection in male and female cats. So it can be concluded

that the most important factor influencing the level of hookworm infection to cats is the physical environmental conditions which include hygiene, temperature, humidity, and sanitation, with the risk factors that most affect the level of hookworm infection in cats are temperature and humidity with a P value of 0.000 as we can see on table 3.

3.4 Prevalence and Risk Factors of CLM in Humans

Based on table 4, from those four studies, it is known that male are more at risk of developing CLM than female, this is because males are more likely to have contact with the ground than females. Boys tend to like to play outdoors and some adult males also work as farmers, exterminators, and gardeners. Research conducted by Reichert et al. (2016) and Heryantoro, et al. (2012) stated that the age most at risk for CLM is children or individuals aged <15 years, this is because children tend to like to play outdoors without using footwear, resulting in direct contact between the skin and the ground or sand. Different statements were obtained from the research of Sow et al. (2017) which states that the age most at risk for CLM is individuals aged 25-50 years. This difference can occur because the research conducted by Sow is in France, which is not a CLM endemic country, so the data collected comes from people who have traveled or have just returned from a CLM endemic country, besides the age range of 25-50 years is an ideal and productive age to travel or to find work abroad. Another factor that can increase the risk of getting CLM is economic conditions, the poor tend to be at risk for CLM, this is because people with low economics usually live simply and limited because they are less able to meet their needs. People with low economics tend to live in dirty and slum environments and eat less nutritious food, this causes them to be vulnerable to get CLM. Another factor that is most influential in increasing the risk of developing CLM is not wearing shoes when walking outdoors, especially on sand. Sandy soil is one of the physical environmental factors that support the development of hookworm larvae, by not wearing footwear when walking outside the house it will increase direct contact between sand or soil with the skin which then allows infective larvae to penetrate directly into the skin, causing the occurrence of CLM.

Based on the table 4, it can be concluded that the most influential risk factor in increasing the incidence of CLM in humans is daily behavior such as walking on sand by never using footwear with an OR value of 23.43 and an incidence percentage of each individual per year of 0,90.

The obstacle experienced by the author when conducting journal searching is that currently there are not many studies that discuss hookworm and CLM. There is also very little data on the prevalence of CLM, especially data on the prevalence of CLM in Indonesia. Many researchers have discussed the number of hookworm eggs in cat or dog feces, but only a few have associated it with the prevalence of CLM. Therefore, it can be proposed to conduct a direct research that discusses the relationship between the presence of animal hookworm eggs in stray cat feces and the incidence of CLM on that area.

4. CONCLUSION

According to the results of the study analysis that has been done, the researchers can conclude that hookworm in stray cats (*Felis silvestris catus*) can cause CLM in humans. Thus, the high prevalence of hookworm infection in cats plays an important role in the increased risk of zoonoses in humans which in turn can increase the prevalence of CLM in humans.

Also based on the discussion that has been done, it can be conclude that the tropical climate, sandy soil and physical environmental conditions including temperature, humidity, hygiene, and sanitation affect the level of hookworm infection in cats and humans; There is a relationship between the level of hookworm infection in stray cats and the incidence of CLM in an area; Risk factors that can increase the incidence of CLM in humans include male sex, children aged <15 years, low-income people, and daily behaviour of walking outdoors without using footwear, especially on the sand; And the risk factors that play the most role in increasing hookworm infection in stray cats are temperature and humidity, while the risk factors that play the most role in increasing the incidence of CLM in humans are walking outdoors without using footwear, especially on the sand.

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