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Ecological Risk Factors of *Strongyloides stercoralis* Infection Sourrounding Desforestration Areas East Kalimantan, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. Author BS designed, managed the study. Author RN performed the statistical analysis. Author ARF prepared instrument the study. Authors VFE and Syamsir approved the final manuscript and managed administration of the study. Author WA supported the based of study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study to assess the prevalence of S*trongyloides stercoralis/ S. stercoralis* infection, and to correlate environmental risk factors with the prevalence of *S. stercoralis* infection**.**
Study Design: We perform a cross-sectional study in rural community in Muarakaman and Marangkayu district to analysis of geography, texture of soil, humidity, hookworm and strongyloides in pet, vegetation, elevation, volume rain, the number of days of rain yearly, temperature and quality of soil as clay content, organic carbon of soil and pH of soil then was correlated with prevalence of strongyloidiasis..

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Place and Duration of Study: The study was carried out in rural area of Muarakaman District and Marangkayu District East Kalimantan Province, Indonesia. This research is a community based, had conducted during 2021-2022.
Methodology: This study would show the infection rates, correlation analysis between environmental risk factors and prevalence of hookworm infection with statistical analysis. We performed a cross-sectional study among 213 participants from rural community. In this study used two diagnostic methods: Kato Katz and Koga agar plate culture/KAP culture for diagnosing of *S. stercoralis* infection. Pearson chi-square analysis was used for study correlation between ecological risk factors *S. stercoralis* infection.
Results: *S. stercoralis* infection was found in this study; 34 (8.0%), Ecological risk factors have significant correlation and high odd ratio of prevalence of *S. stercoralis* infection. Ecological risk factors have significant correlation and high odd ratio of prevalence of *S. stercoralis* infection such as district, humidity, temperature, volume and amount day of rain organic carbon of soil, elevation of location from above a sea
Conclusion: The Ecological risk factors of the infections could be used in preventing program to reduce the prevalence of hookworm and *S. stercoralis* infection.

Keywords: S. stercoralis; ecological factors; rural areas; desforestration areas.

1. INTRODUCTION

[(The prevalence of *S. stercoralis* infection is of serious public health concern globally. strongyloidiasis is prevalent in poor rural community in tropical and subtropical areas in many developing country. They are transmitted through in protected contact with soil are endemic in tropical and temperate regions. The prevalence of hookworm infection and strongyloidiasis was estimated in 2010 that 438.9 million people were infected with hookworm and 100 million with strongyloides. Almost 70% of these infections occur in Asia [1-3].

S. stercoralis infection is transmitted through in protected contact with soil are endemic in tropical and temperate regions. Human acquire the *S. stercoralis* infection through direct skin contact with infective third stage larvae where the soil was contaminated by human feces penetrate the intact human skin and eventually reach small intestine [4]. *S. stercoralis* infection are found among poor people with poor environmental sanitation and where the climate is warm and humid [5]. Factors affecting difference in distribution of *S. stercoralis* infection may include good hygiene practices among population, availability of sewerage system and the length of rainy season. Ecological factors have contributed for transmission of diseases as well as growth and development of the worms [6,7].

Ecological factors especially long rainy season may affect the decrease in prevalence of *S. stercoralis* infection but not for hookworm infection. Prevalence of *S. stercoralis* infection in south Thailand is lower than other parts of the country, in contrast, prevalence of hookworm infection is still high in the south. It is possibly because the failure in the control of hookworm infection due to 10 months long rainy season in southern Thailand contrasted with 4 months long rainy season in other parts [8,9]. The study in Cambodia reported the lower prevalence of strongyloidiasis in area with heavy rainfall than in low rainfall area. Moreover, high amount of soil organic carbon content affect to the lower prevalence of *S. stercoralis* infection [10]. Epidemiology study of hookworm infection and *S. stercoralis* infection in Southern Laos showed 56.1% and 41% respectively where was heavy rainfall and poor sanitation. In this study Baerman and Kato-Katz techniques were used for detecting them [11].

In rural East Kalimantan, Indonesia has ecological risk factors of prevalence of strongyloidiasis that important to exploration association both of them. We perform a cross-sectional study in rural community in Muarakaman and Marangkayu districts to analysis of geography, texture of soil, humidity, vegetation, elevation, volume rain, amount days of rain yearly, temperature and quality of soil as clay content, organic carbon of soil and pH of soil then was correlated with *S. stercoralis* infection.]

2. MATERIALS AND METHODS

2.1 Study Setting and Population

The study was carried out in rural area of Muarakaman District and Marangkayu District

Kutai Kertanegara Regency, Indonesia. This research is a community based, was conducted during 2021-2022. Total of number participant is 213 participants that were counted by equal number of participants who joined and sent stool samples.

2.2 Field Procedures

We collected third stool sample of participant, for collecting stool samples, the first day were requested to head of house hold and member of house hold for requesting stool sample, second day in the morning would start to collect stool samples, were brought to biomedical laboratory, school of Public Health Mulawarman University for diagnosis samples. Others day was done observation ecological condition of houses surrounding village.

2.3 Laboratory Procedures

2.3.1 Agar plate culture and Kato Katz technique

Agar plate culture was done as described by Koga et al., 1991. Briefly, a few grams of stool was placed at the center of nutrient agar and kept at room temperature for five days. Tracks from larva crawling and larvae or adult worms were observed. If positive, 10 ml of 10% formalin was added to agar surface for 5-10 minutes and transferred to centrifuged tube. Centrifugation at 2,500 rpm for 5 minutes and supernatant was discarded. The sediment will be examined for hookworm and *S. stercoralis* larvae or adult worm [12].

For Kato-katz thick smear, 50 mg of stool was placed on slide and covered with a cellophane paper soaked in glycerin solution for 24 hours. The stool was spread out using rubber stick. After 30 minutes was examined and counted for eggs [13].

2.3.2 Risk factors data

Demographic data and personal hygiene of participants were collected by questionnaire, and sanitation facilities each house hold of participants were collected by observation, while environmental data was collected consist such as vegetation, elevation of soil, kind of pets, kind of soil around houses, length of rainy season, humidity and temperature per year. Quality of soil as organic carbon content, clay content and pH were diagnosed by soil laboratory Mulawarman University. Vegetation and kind of soil around houses were collected by observation form, kind of pet would be collected by questioner and observation, and length of rainy season, humidity and temperature per year will collected from Central Bureau of Statistics (https://www.bps.go.id) and Central Bureau of meteorology, climatology and Geophysical of Indonesia (https://www.bmkg.go.id).

2.3.3 Data analysis

The prevalence of hookworm infection and *S. stercoralis* infection was stratified according to demographic data, sanitation facilities and personal hygiene, environmental data, and reported by descriptive statistic. Statistical analysis was performed by Chi-square using SPSS verse 21. The correlation analysis chi-square to evaluate association of S. stercoralis infection with demographic data, sanitation facilities, personal hygiene, and environmental risk factors and the level of significance was considered as $P<0.05$ and the analysis of risk estimate by odds ratio Chi-Square with confidence interval 95%.

3. RESULTS AND DISCUSSION

3.1 Parasitological Findings

Prevalence *S. stercoralis* infection was diagnosed by Kato Katz technique and APC method showed of 213 tested samples from community have 3 (3.2%) cases found positive with *S. stercoralis* in Muarakaman District and 14 (11.9%) cases found positive with strongyloides infection in Marangkayu District. The detail data of prevalence of *S. stercoralis* infection were explained Table 1.

The prevalence Strongyloides stercoralis, Marangkayu District (11.9%) is higher than Muarakaman District (3.2%).. The study similar with south Thailand study where hookworm infection higher than *S. stercoralis* [14]. Deference of ecological factor between Muarakaman District and Marangkayu District should be affected the higher hookworm infection and lower of S. stercoralis in Muarakaman district such as vegetation surrounding area of villages and geographical location where Muarakaman District be located surrounding palm plantation and river area. Similar study in Manufahi District, Timor Leste where is rural area with prevalence of hookworm infection was 62.8% [15].

3.2 Ecology Factors and *S. stercoralis* Infection in East Kalimantan Province

The results statistical analysis between ecological risk factors with *S. stercoralis* infection showed several of ecological risk factors have correlated significant with *S. stercoralis* ($p<0.05$) such as district, organic carbon content in soil, texture of soil, humidity, temperature, elevation, number day of rainfall, rainfall volume, and S. stercoralis infection in dog. While pH of soil, clay content in soil, and dry or wet soil surrounding house vegetation, village areas, and having cat and dog and strongyloides infection in cat. have not significant correlated with prevalence of S. stercoralis infection in Kutai Kertanegara Regency.

Table 1. Prevalence of hookworm, *Strongyloides stercoralis* and co-infection among communities in Kutai Kertanegara Regency

Infections	Muarakaman District		Marangkayu District	
	Positive	Negative	Positive	Negative
Hookworm	58 (61.1%)	37 (38.9%)	35 (37.6%)	83 (70.3%)
S. stercoralis	3 (3.2%)	97 (96.8%)	14 (11.9%)	104 (88.1%)
Co-infection	3 (3.2%)	97 (96.8%)	12 (10.2%)	106 (89.8%)

Table 2. Environmental factors and *S. stercoralis* infection in Kutai Kertanegara Regency

Variable	Category	*S. stercoralis*		P value
		Negative n (%)	Positive n (%)	
District	Muarakaman	97 (96.8)	6 (3.2)	**.001**
	Marangkayu	104 (88.1)	28 (11.9)	
Organic carbon content in soil	<2.47%	78 (85.7)	26(14.3)	**.0001**
	2.47-4.04%	118 (96.7)	8 (3.3)	
pH soil	<5.85	95 (93.1)	14 (6.9)	.414
	5.85-6.92	101 (91.0)	20 (9.0)	
Clay content in soil	<18.5	89 (92.7)	14 (7.3)	.634
	18.5-42.50	107 (91.5)	20 (8.5)	
Temperature	<28.6 ^{0}C	104 (88.1)	28 (11.9)	**.001**
	28.6 -29.5^{0}C	184 (96.8)	6 (3.2)	
Humidity	<65.4	208 (88.1)	28 (11.9)	**.001**
	65.4-66	184 (96.8)	6 (3.2)	
Number day of rainfall	<164	184 (96.8)	6 (3.2)	**.001**
	164-174	208 (88.1)	28 (11.9)	
Rainfall volume	<3549 mm^3	184 (96.8)	6 (3.2)	**.001**
	3549-4000 mm^3	208 (88.1)	28 (11.9)	
Elevation from above of sea	<41.6m	188 (96.9)	6 (3.1)	**.001**
	41.6-50m	204 (87.9)	28 (12.1)	
Texture of soil	Sandy soil with organic material	250 (89.9)	28 (10.1)	**.029**
	Non-sandy soil with organic material	142 (95.9	6 (4.1)	
Vegetation	Surrounding palm plantation and/or rubber plantation	310 (92.8)	24 (7.2)	.248
	Surrounding rice field	82 (89.1)	10 (10.9)	
Village areas	Buffer river/sea	308 (92.8)	24 (7.2)	.282
	Hill area	84 (89.4)	10 (10.6)	
Dry or wet soil surrounding house	Dry soil	308 (91.1)	30 (8.9)	.182
	Wet soil	84 (95.5)	4 (4.5)	

Table 3. Essential risk factors of *S. stercoralis* in Kutai Kertanegara Regency

Essential risk factors	Category	*S. stercoralis*		OR (95%CI)
		Negative n (%)	Positive n(%)	
District	Muarakaman	184 (96.8)	6 (3.2)	0.64 (0.54-0.77)
	Marangkayu	208 (88.1)	28 (11.9)	**2.66 (1.28-5.54)**
Organic carbon content in soil (%)	<2.47	156 (85.7)	26 (14.3)	**2.56 (1.38-4.71)**
	2.47-4.04	236 (96.7)	8 (3.3)	0.52 (0.45-0.65)
Temperature(^{0}C)	<28.6	208 (88.1)	28 (11.9)	**2.66 (1.28-5.54)**
	28.6 -29.5	184 (96.8)	6 (3.2)	0.64 (0.54-0.77)
Humidity	<65.4	208 (88.1)	28 (11.9)	**2.66 (1.28-5.54)**
	65.4-66	184 (96.8)	6 (3.2)	0.64 (0.54-0.77)
Number day of rainfall	<164	184 (96.8)	6 (3.2)	0.64 (0.54-0.77)
	164-174	208 (88.1)	28 (11.9)	**2.66 (1.28-5.54)**
Rainfall volume (mm^3)	<3549	184 (96.8)	6 (3.2)	0.64 (0.54-0.77)
	3549-4000 mm^3	208 (88.1)	28 (11.9)	**2.66 (1.28-5.54)**
Elevation from above of sea (m)	<41.6	188 (96.9)	6 (3.1)	0.63 (0.53-0.76)
	41.6-50	204 (87.9)	28 (12.1)	**2.72 (1.30-5.66)**
Texture of soil	Sandy soil with organic material	250 (89.9)	28(10.1)	**2.05 (0.98-4.29)**
	Non-sandy soil with organic material	142 (95.9	6 (4.1)	0.77 (0.66-0.92)

The results statistical analysis between environmental risk factors with hookworm and *S. stercoralis* co-infection showed several of environmental factors have correlated significant with hookworm and *S. stercoralis* co-infection such as district, organic carbon content in soil, texture of soil, humidity, temperature, elevation, number day of rainfall,and rainfall volume. While pH of soil, clay content in soil, and dry or wet soil surrounding house vegetation, village areashave not significant correlated with prevalence *S. stercoralis* in East Kalimantan Province.

Environmental risk factors which the higher association/correlation hookworm and *S. stercoralis* co-infection were organic carbon content in soil (p=0.000) and live together with human infected with hookworm and *S. stercoralis* co-infection (p=0.000). The category of environmental risk factors which had percentage of positive *S. stercoralis* infection more than 9% and with significant correlation such as elevation from above sea (<41.6m), volume of rainfall (<3549 mm3), number day of rainfall (<164days),humidity (<65.4%), temperature (<28.6 0C), organic carbon content in soil(<2.47%), texture of soil (sandy soil with organic material), and district (Murangkayu District). District, organic carbon content in soil, humidity, temperature, elevation, number day of rainfall, and rainfall volume *S. stercoralis* infection that due to the variables have contribution for surviving of parasitic larvae *S. stercoralis* then potential increase for penetration the larvae to human via soil contact and pet contact. In this study had showed that quality of soil and climatology such as humidity, temperature have correlation with survive of *S. stercoralis* and heavy rainfall effected for reducing and increasing of distribution *S. stercoralis*. In general condition soil surrounding houses more than 80% covering with soil where close the location with plantation and forest that have high position for contamination from plantation and forest. And in addition personal hygiene and sanitation facilities still not save for protection skin from *S. stercoralis* larvae also in file rice and palm or rubber plantation [8]. In poor countries with tropical climate, where have environmental condition favorable for transmission hookworm and *S.stercoralis* infection the prevalence still high [11].

Collaboration many environmental risk factors could support the survival of larvae the worms. Environmental factors of *S. stercoralis* infection in East Kalimantan, Indonesia has similar with south Thailand including long rainy season, temperature and several geography area, then the prevalence of *S. stercoralis* infection in south Thailand was equal for *S.stercoralis* infection [14]. In contrast quote by epidemiology study of *S. stercoralis* infection Southern Laos showed was 41% where has heavy rainfall and poor sanitation [11].

Analysis OR in district explained that Muarakaman District high risk for hookworm infection, in contrast Marangkayu District high risk for *S. stercoralis* and co-infection. Village areas had high risk for hookworm is buffer area (OR=2.54) while *S. stercoralis* and co-infection were higher in surrounding rubber and palm plantation where closed with buffer areas. Temperature in category <28.6 0C become high risk factor for S. stercoralis and co-infection high with OR=2.66 and OR=2.32 respectively. Elevation from above sea in category <41.6m is high risk hookworm infection while S. stercoralis and co-infection were high risk in elevation 41.6-50m. Organic carbon content <2.47% was higher risk for *S. stercoralis* and co-infection, organic carbon content in soil 2.47-4.04% was high risk for hookworm infection. Organic carbon content >2.47% become protective environmental risk factor for *S. stercoralis* and co-infection. The study was similar with study in Cambodia reported the higher of hookworm infection and the lower prevalence of *S. stercoralis* infection in area with heavy rainfall than in low rainfall area. Cambodian study also explained that high amount of soil organic carbon content affect to the lower prevalence of *S. stercoralis* infection [10], equal with study in East Kalimantan which organic carbon soil more in became have effected for reducing *S. stercoralis* infection [16,17].

The volume rainfall 3459-4000mm3 was higher risk for *S.stercoralis* and co-infection. Supporting environmental factor against survival of *S.stercoralis*. When communities defecated in rubber or palm plantation could be spread in village or rice field that condition was caused elevation plantation is higher than village and rice field elevation, run of water from plantation or forest when rainfall maybe bring the eggs or larvae hookworm and *S.stercoralis* from hill to village and field rice. Potential infected together via field rice and rubber and palm plantations adult communities also for children when they were playing around houses [17].

Ecological risk factors have significant correlation with high prevalence of *S. stercoralis* such as district, humidity, temperature, volume and amount day of rain organic carbon of soil, texture of soil and elevation, the ecological risk factors make survive of infective larvae of *S. stercoralis* infection had explained with Garcia (2007) that a significant increase the prevalence of *S. stercoralis* infection with environmental conditions [18]. Changing environmental conditions, specifically deforestation and subsequent silting of locally river, have caused periodic flooding with deposition on layer of sandy loam topsoil could increase soil moisture, and supporting by low quality of sanitation facilities and hygiene personal to add the increasing of *S. stercoralis* infection. These conditions, all of which are conducive to *S. stercoralis* transmissions, have allowed *S. strercoralis* infection to re-emerge as an important human pathogen in this area [19].

4. CONCLUSION

Ecological risk factors have significant correlation and high odd ratio of prevalence of *S. stercoralis* such as district, humidity, temperature, volume and amount day of rain organic carbon of soil, and elevation. Essential environmental risk factors of the infections should use for preventing program of reduction prevalence hookworm and *S stercoralis* infection.

CONSENT

We declare that ‘written informed consent was obtained from the communities (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

The study protocol was approved by the Ethical Clearance committee on human right related to research involving human subjects, Walailak University HE: number WUEc-18-034-01.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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