

Original Research Article
**Ecological Risk Factors of *Strongyloides stercoralis*
infection Surrounding Deforestation areas East
Kalimantan, Indonesia**

ABSTRACT

Aims: The study to assess the prevalence of *Strongyloides 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, 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 prevalence of strongyloidiasis..

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: In 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: Ecological risk factors of the infections should use for preventing program of reduction prevalence hookworm and *S. stercoralis* infection.

Keywords: [*S. stercoralis*, Ecological factors, Rural areas, Deforestation 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)(2)(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 there 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. MATERIAL AND METHODS

[2.1 Ethical consideration

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.

2.2 Study Setting and Population

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

2.3 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.

2.4 Laboratory Procedures

2.4.1 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)

2.4.2 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>).

2.4.3 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 below:

Table 1 Prevalence of Hookworm, *Strongyloidesstercoralis* and Co-infection among Communities in KutaiKertanegara Regency

| Infections | Muarakaman District | | Marangkayu District | |
|-----------------------|---------------------|------------|---------------------|-------------|
| | Positive | Negative | Positive | Negative |
| Hookworm | 58 (61.1%) | 37 (38.9%) | 35 (37.6%) | 83 (70.3%) |
| <i>S. stercoralis</i> | 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%) |

The prevalence *Strongyloidesstercoralis*, 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 KutaiKertanegara Regency.

Table 2 Environmental Factors and *S. stercoralis* Infection in KutaiKertanegara Regency

| Variable | Category | <i>S. stercoralis</i> | | 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 °C | 104 (88.1) | 28 (11.9) | .001 |
| | 28.6 -29.5 °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 | Dry soil | 308 (91.1) | 30 (8.9) | .182 |

| | | | |
|-------------------|----------|-----------|---------|
| surrounding house | Wet soil | 84 (95.5) | 4 (4.5) |
|-------------------|----------|-----------|---------|

Table 3 Essential Risk Factors of *S.stercoralis* in KutaiKertanegara Regency

| Essential risk factors | Category | <i>S. stercoralis</i> | | 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(°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 area have 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 °C), 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 °C 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. stercoralis* 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

We hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee"

We hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki."

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