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Characteristics of the Physical Environment Habitat and Infection Rate of Schistosomiasis Intermediate Host Snail (*Oncomelania hupensis lindoensis*) in Poso District, Indonesia

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ABSTRACT

Schistosomiasis is a neglected tropical disease that is transmitted by freshwater and snails, The intermediate snail that transmits schistosomiasis in Indonesia is *O.h. lindoensis*. The snail is amphibian. The survival of the *O.h. lindoensis* snail is supported by the appropriate climate and environmental habitat. Climate change towards schistosomiasis infection has important implications for the production, survival and fertility of schistosomiasis snails. This paper aims to describe the condition of the physical environment and the infection rate of *Sistosoma* japonicum cercariae in schistosomiasis intermediate snails in Dodolo Village, Poso Regency. The survey results from 25 habitats showed that the water temperature was between 200C-300C, 84% pH of the water was at a neutral acidity level (7), the soil pH of the snail habitat varied from 4.0 - 7, and 60% of the habitat type was found in the cacao plantation waterways. inhabitant. Cercarial infection rates range from 0-50%. Physical environmental factors such as water temperature, water pH, soil pH and habitat type support the breeding of the *O.h. lindoensis* snail. The level of cercarial infection in *O.h. lindoensis* snails differed between each habitat.

1. Introduction

Schistosomiasis is a neglected tropical disease that is transmitted by freshwater and snails. Many are found in developing countries with tropical and subtropical climates, the Middle East, Asia, and Latin America. The disease is prevalent in low-income rural communities without access to drinking water, proper

sanitation and proper medical facilities. Sub-Saharan Africa (SSA) approximately 13% of the world population accounts for up to 90% of cases with an estimated 280,000 deaths from Schistosomiasis each year [1].

Schistosomiasis is a zoonotic disease, so the source of transmission is not only human sufferers, but also several infected mammals, including cattle, goats, pigs, sheep, deer, dogs, rats, and other rodents [2]. Life cycle of Schistosomiasis sp. they are all similar but very complex as the parasite alternates between two hosts: an intermediate host (Snail) and a definitive host (such as Humans and Cows) [3].

Central Sulawesi is the only province out of 34 provinces in Indonesia that is endemic for schistosomiasis. This disease is found in 2 districts, namely Sigi Regency (Lindu Plateau) and Poso Regency (Napu Plateau and Bada Plateau). (Central Sulawesi Provincial Health Office, 2020). Schistosomiasis in Indonesiacaused by a trematode worm of the type *Schistosoma japonicum* with the snail Oncomelania hupensis lindoensis as an intermediate host [5].

The intermediate snail that transmits schistosomiasis in Indonesia is *O.h. lindoensis*. The snail is amphibian, meaning that it lives in wet places and cannot live in water or in dry places. The *O.h. lindoensis* snail is found in all highland endemic areas in pockets called foci (focus) [6].

The prevalence of schistosomiasis in humans in Central Sulawesi Province from 2018 to 2021 is 0.36%, 0.10%, 0.11% and 0.3%(Directorate of Prevention and Control of Vector-Infected and Zoonotic Diseases, 2021). Dodolo Village is one of the schistosomiasis endemic villages in the Napu Highlands, Poso Regency. The prevalence of schistosomiasis cases in Dodolo Village in 2017 – 2021 is 3.36%, 2.07%, 0.38%, 1.04% and 1.72% respectively [8], while the focus in Dodolo village in 2021 will be 26 foci with an area of 130,238.5 m2, a conch density of 1.07 with an IR of 10.99% found in waterways and seepage of water in cocoa gardens, onion gardens, bushes and paddy fields which is not processed [9], [10].

The survival of the Oh lindoensis snail is supported by the appropriate climate and environmental habitat. Climate change towards schistosomiasis infection has important implications for the production, survival and fertility of schistosomiasis snails [11]. In several habitats where the *O.h. lindoensis* snail is also affected by conditions of water level, water pH and soil pH, water and soil temperature, soil moisture, air humidity, geographical factors, microhabitat, cover and vegetation [12- 14]. The survival of the snails depends on the existence of a suitable habitat for the snails to live in [15], [16].

Many efforts have been made every year to control the development of the *O.h. lindoensis* snail, one of which is the activity of mapping the *O.h. lindoensis* snail habitat [13]. Surveys of the distribution of O. hupensis lindoensis in all endemic areas were conducted in 2008, 2016-2017. In 2021 another mapping will be carried out in all villages in schistosomiasis endemic areas. The mapping results show a significant change in the distribution of the snail foci [9]. This paper aims to describe the Physical Environmental Conditions and Infection Rate (IR) of Sistosoma japonicum cercariae in schistosomiasis intermediate snails in Dodolo Village, Poso Regency.

2. METHOD

The research was carried out using a quantitative descriptive approach. Descriptive method with a quantitative approach in this study is used to describe environmental characteristics in the form of water temperature, water pH, soil pH, habitat type and calculate *Infection Rate* conch *O.h. lindoensis*. The research was conducted in November 2022 in Dodolo Village, Poso Regency. The sampling technique used

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was the total population in which all *O.h. lindoensis* snail habitats were sampled, namely in 25 *O.h. lindoensis* snail habitats.

Data Retrieval Techniques

2.1 In the field

Sampling of the *O.h. lindoensis* snail.

1. Survey of schistosomiasis intermediate snails using the man per minute method [17].
2. The survey was conducted for 2 days from 08.00-12.00, and at 14.00-17.00
3. Measure the temperature of the water using a thermometer by immersing it in water for about 10-15 minutes and then removing it.
4. The pH of the water is measured using litmus paper, the litmus paper is dipped in water in the focus area of the snail, the color change occurs to match the color of the pH indicator to determine the degree of acidity of the puddles in the focus area.
5. Soil pH is measured using a pH meter, by sticking the tip of the pH meter rod into the soil for 10-15 minutes, then looking at the numbers on the indicators and recording the numbers as supporting data.
6. Habitat type was observed in the snail habitat when carrying out the survey.

2.2 In the Laboratory

Examination of snails in the laboratory with the crushing method [18].

1. The collected snails are placed on top of the object glass as many as three snails.
2. Next, the conch is broken with medium tweezers.
3. Add 1-2 drops of water to each snail that has been solved.
4. Snails that had been broken on a glass object were examined under a dissecting microscope with a magnification of 10x, to see systosoma japonicum cercariae.
5. infection rate in snails is calculated in the following way:

$$\frac{\text{Jumlah keong positif serkaria}}{\text{Jumlah keong yang diperiksa}} \text{x100\%}$$

3. RESULTS

3.1 Environmental Characteristics Examination.

Based on the results of measuring the characteristics of the physical environment in the habitat of the *O.h. lindoensis* snail in Dodolo Village which includes water temperature, water pH, soil pH and habitat type as a whole can be seen in table 1 below:

Table 1. The results of a survey of the *O.h. lindoensis* snail habitat in Dodolo Village, Napu Highlands, Poso Regency in 2022

No.	Focus Code	Water Temperature	Water pH	Soil pH	Habitat Type
1	A042021.01	22	5	7	Community pond water canals, corn plants and shrubs
2	A042021.02	20	7	7	Aqueducts in the Cocoa Plantation
3	A042021.03	25	6	7	Aqueducts in the Cocoa Plantation
4	A042021.04	27	7	7	Aqueducts in the Cocoa Plantation
5	A042021.05	26	7	5,5	Aqueducts in the Cocoa Plantation

6	A042021.06	25	7	5.0	Aqueducts in the Cocoa Plantation
7	A042021.07	27	6	7	Drains in corn and Parapa plantations.
9	A042021.08	25	6	6,5	Drains in a Corn Plantation
10	A042021.09	27	7	4,5	Aqueducts in the Cocoa Plantation
11	A042021.10	30	7	4.0	Aqueducts in the Cocoa Plantation
12	A042021.11	26	7	5.0	Aqueducts in the Cocoa Plantation
13	A042021.12	24	7	7	Aqueducts in the Cocoa Plantation
14	A042021.13	25	7	6	Aqueducts in the Cocoa Plantation
15	A042021.14	26	7	6,5	Aqueducts in the Cocoa Plantation
16	A042021.15	28	7	5.0	Aqueducts in the Cocoa Plantation
17	A042021.16	24	7	5.0	Abandoned waterways in the rice fields
18	A042021.17	24	7	5.0	Aqueducts in the Cocoa Plantation
19	A042021.18	24	7	7	Aqueducts in the Cocoa Plantation
20	A042021.19	24	7	7	Parapa and abandoned rice fields
21	A042021.20	24	7	5.0	Parapa, abandoned rice fields and residents' pond waterways
22	A042021.21	29	7	5.0	Parapa and abandoned rice fields
23	A042021.22	26	7	5,5	Parapa, abandoned rice fields and residents' pond waterways
24	A042021.23	28	7	6.0	Water canal and corn garden
25	A042021.24	29	7	4,5	Water canal and corn garden
25	A042021.25	25	7	5.0	Aqueducts in the Cocoa Plantation

Table 1. The measurement results show the measured environmental parameter values, the lowest water temperature value in Dodolo Village is at point A042021.02 (200C), and the highest value is recorded at point A202104.10 (300C). The degree of acidity (pH) of the snail habitat water in Dodolo Village is 84% neutral (7) while the soil pH value of the snail habitat varies from 4.0 - 7, and as much as 60% of the habitat type is found in the waterways of the residents' cocoa plantations.

3.2 Examination of snails in the Laboratory.

Figure 1 shows the infection rate of S. japonicum cercariae in schstosomiasis intermediate snails in Dodolo Village. Snail cercariae infection was found in habitat A042021.02, namely 50%, at least in habitat A042021.19, namely 1.2%, while in 11 habitats, cercariae were not found in snails.

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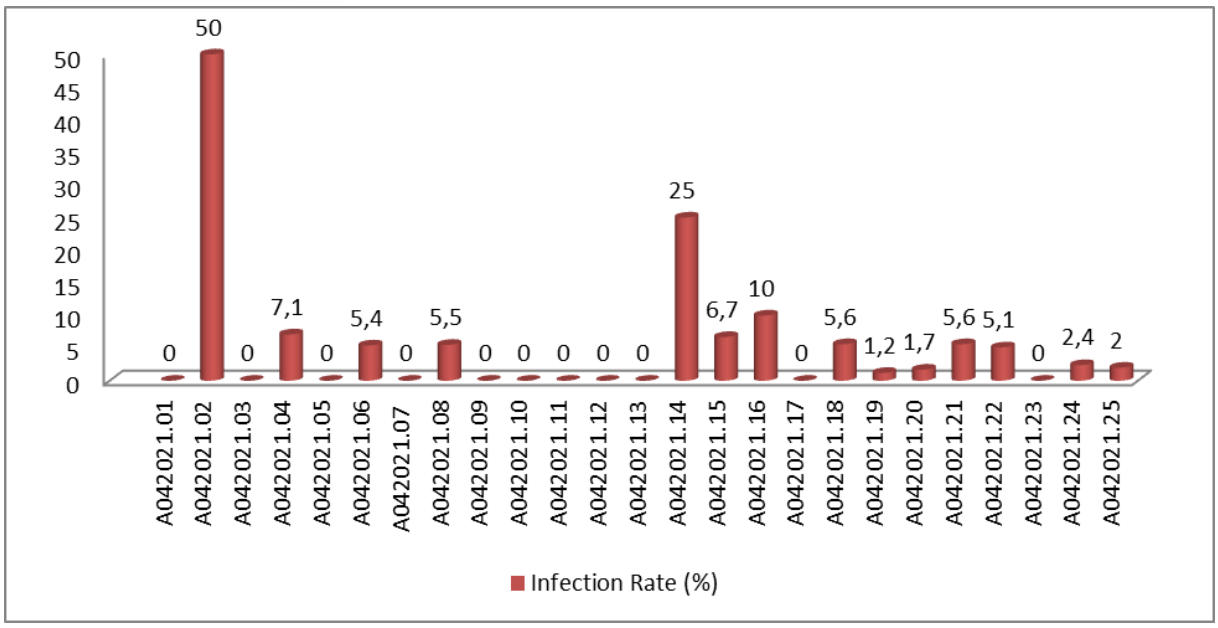

Figure 1. Infection Rate (IR) of S. japonicum serkaria in Oh lindoensis snails in Dodolo Village, Napu Highlands, Poso Regency, 2022

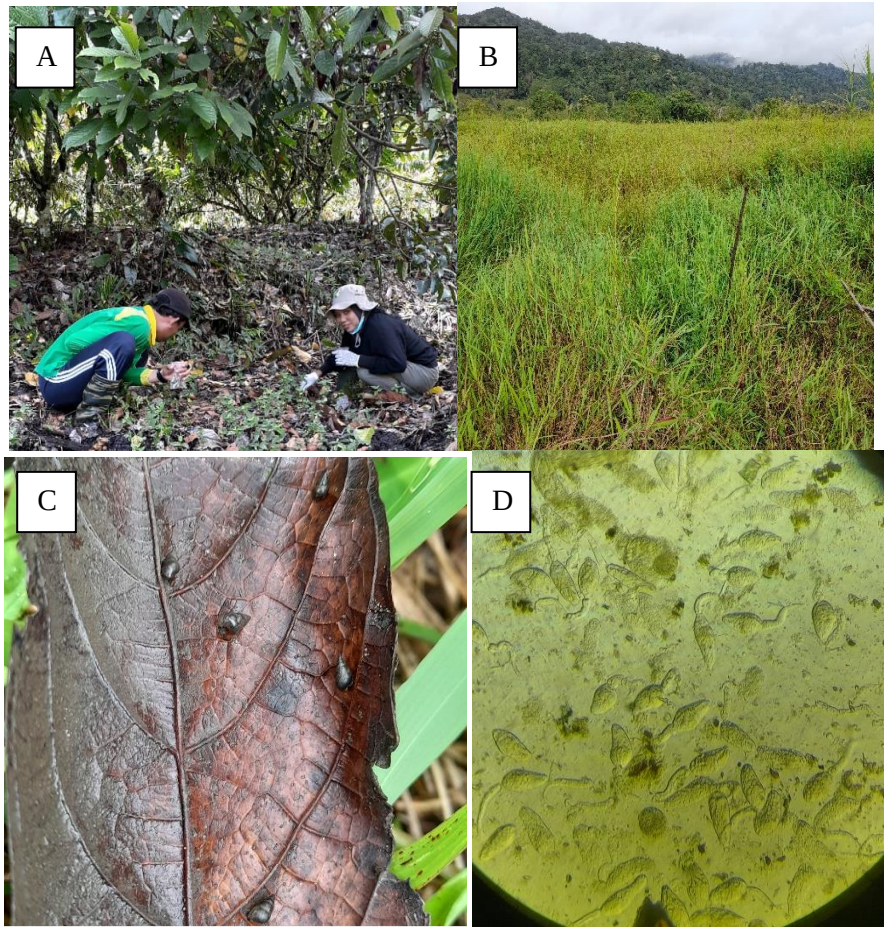

Figure 2. (A) The snail survey was carried out in the residents' cocoa plantations. (B) Habitat of the *O.h. lindoensis* snail in uncultivated/abandoned rice fields. (C) *O.h. lindoensis* snail attached to a brown pod leaf. (E) Examination results of Schistosoma japonicum worm cercariae in *O.h. lindoensis* snails in the Laboratory.

4. DISCUSSION

Oncomelania hupensis lindoensis is a schistosomiasis intermediate snail in Indonesia. This snail plays an important role in the epidemiology of schistosomiasis. This is due to the development of the larval stage of the schistosoma worm from miracidium to sporocysts, cercariae that occur in the snail's body [19], [20]. Environmental conditions which include physico-chemical parameters can affect the life of an organism either directly or indirectly. The environmental conditions can be in the form of physical, chemical factors. In addition, the abiotic components are organic matter, organic compounds and factors that affect the distribution of organisms in the form of temperature, water, soil and minerals [14].

4.1 Water temperature

Schistosomiasis intermediate snails require an aquatic environment with certain water temperature conditions, certain water flow rates, vegetation that can affect the metabolism and ability of snails in a habitat [21]. Temperature was identified as an important factor that has a direct effect on the distribution and abundance of freshwater snails [22]. The snails that transmit schistosomiasis mansoni survive at temperatures of 150C - 310C, outside of this temperature the number of snails decreases drastically and the snail population cannot survive [23], [24].

Research at the Hong Kong Jiangsu Institute stated that the development rate of S. japonicum worms in *O. hupensis* snails showed a positive relationship with temperature, the average development rate of snails per day maintained at temperatures of 21°C, 24°C, 27°C and 30°C [19]. In addition, temperature affects fertility, growth, survival and development of parasites in schistosomiasis haematobium intermediate snails [25].

S. japonicum intermediate snails were found in habitats with water temperatures between 20°C - 30°C, in contrast to research conducted in 2018, water temperatures in snail habitats ranged from 27^0C - 28^0C [26], the difference in the results of the research indicates that the difference in temperature in the habitats found depends on the time, situation, weather and season at the time of conducting the research.

4.2 water pH

The pH of the water provides ideal conditions for the survival and reproduction of *Biomphalaria glabrata* snails thereby increasing the density and infection of the snails which act as hosts for Schistosomiasis mansoni [27]. Snail activity and population increase are ideal in the pH range of 7.2-7.5 [28]. pH 3.5 Snail intermediate between schistosomiasis haematobium (*bulinus truncatus*) experienced inhibition of acetylcholinesterase activity in hemolymph, muscle, hepatopangreas and snail intestine as a result of hemolymph acidification [29]. A study of the effectiveness of chlorination against shistosomiasis mansoni-mediated snail cercariae showed that cercaria were sensitive to chlorine, and a higher chlorine value required a higher water pH [30].

The results of the research on the pH of the water in the snail habitat showed an average pH of 7, in contrast to research conducted in 2018 which stated that the pH of the water in the snail habitat was 96.5% acidic [26] and pH 6 [14]. The difference in pH is influenced by the solubility of CO2, where when water gets a lot of heat intensity from sunlight, the temperature on the surface of the water will rise, when the temperature rises, the solubility of CO2 will decrease so that the pH will rise [31]. The water temperature at the research location has increased, in 2009 the water temperature in Dodolo Village ranged from 19^0C-21^0C [14].

4.3 soil pH

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Based on the survey results of schistosomiasis intermediate snail habitat, soil pH data were mostly acidic in line with research on Bohol Island, the Philippines which stated that snail populations prefer slightly acidic conditions with a pH value of 5.2-6.5 and alkaline soil is unfavorable for survival. conch life [32]. Research in China states that soil pH indirectly affects the density of snails, this is because soil pH is influenced by the presence of soil algae(*Chlorophyta, Cyanophyta and Bacillariophyta*) [33]. However, it is different from a study conducted in Calartava Village in the Philippines where the soil pH was 4.8 and did not find snails in places that were suspected of being snail habitat [34].

The implementation of this research was carried out with high rainfall intensity, one of the factors that affect soil pH is the soil system that is optimized by H^+ ions which will be acidic, the cause of soil acidity is H^+ and Al_3^+ ions in rainwater [35] and overuse of pesticides [36].

4.4 Habitat Type

The habitat distribution of the Ohlindoensis snail in Dodolo Village is 25 habitats, of which 60% are identified as being in the waterways of the residents' cacao plantations. The large number of leaves in the habitat area causes schistosomiasis intermediate snails to live and reproduce well. The feel of the leaves provides protection for the snails from the sun, so the temperature doesn't get too high [37]. Feels like decomposed leaves provide nutrients for the survival of the snails. With the presence of leaves that cover the surface of the water so as to create suitable vegetation for the survival of schistosomiasis intermediate snails.

Research conducted in Gambia states that aquatic vegetation has a statistically significant positive relationship with the abundance of *Bulinus truncatus* snails [38]. In addition to leaves, in the waterways there were many rotting remains of cacao rinds which were thought to be a food source because the decomposed remains of cacao rinds contained elements of potassium and calcium. [39], [40] needed by the snail in the formation of the shell.

A study using remote sensing models has shown that snails need a specific habitat, or what is called a niche. Schistosomiasis intermediate snails require an aquatic environment with specific water temperature conditions, specific water flow rates, and vegetation cover that affects the metabolism and ability of snails to reside in one place [21].

A 2001 study showed that Brazilian schistosomiasis intermediate snails were found in all aquatic habitats except well water. Most snails live in stagnant water. There are also snails in seepage ponds and waterways, at least in springs, rice fields and fish ponds. Physical environmental factors such as water substrate, water velocity, and biotic factors (ie vegetation density) were also recorded in this study as factors for the presence of S. brasiliensis intermedius [41].

Environmental factors that affect the spread of snails that can be modified to control snails include soil acidity, temperature, water chemical composition, dissolved oxygen and calcium concentration, one of which is by increasing the salinity of the water in the snail habitat. Research on schistosomiasis intermediate snails in Saudi Arabia showed that *biomphalaria arabika* snails at a concentration of 5‰ NaCL still survived, but at a concentration of 7.2‰ NaCL, *biomphalaria arabika* snails died by 100% in 24 hours of observation [42].

4.5 infection rate

The high or low cercarial *infection rate* in snails is influenced by the large number of positive

schistosomiasis mammals as a source of S. japonicum eggs that pass through the snail habitat area [43]. The more schistosomiasis positive animals that defecate in the snail habitat area, the higher the *infection rate* of S. japonicum cercariae in snails. This is because the eggs that come out together with animal feces, after contact with water will hatch into a miracidium and penetrate the body of the intermediate host, then develop asexually, including the development of sporocysts of mother and child which lead to cercariae [44]. High snail infection rates indicate intense fecal contamination from infected people and animals due to poor sanitation or inadequate processing of livestock manure [45].

The infection rate of snails is an important indicator of the likelihood of the existence and spread of disease and the occurrence of transmission. Snail infection rates varied even with the same type of habitat with ecological characteristics waterways in a cacao plantation with good vegetation. For this reason, snail surveys must be routinely carried out in schistosomiasis endemic villages and limit human and pet access to their habitat to break the chain of transmission of schistosomiasis.

5. CONCLUSION

This study found that physical environmental factors such as water temperature, water pH, soil pH and habitat type support the breeding of the *O.h. lindoensis* snail. The level of cercarial infection in *O.h. lindoensis* snails differed between each habitat.

6. Reference

[1] Aula OP, McManus DP, Jones MK, Gordon CA. Schistosomiasis with a focus on Africa. Trop Med Infect Dis. 2021;6(3):1-40. doi:10.3390/tropicalmed6030109

[2] Sudomo M, Pretty M.D S. Schistosomiasis Control In Indonesia. Bul Penelit Kesehat. 2007;35:36-45.

[3] Oyinloye B, Adenowo F, Gxaba N, Kappo A. The Promise of Antimicrobial Peptides for Treatment of Human Schistosomiasis. Curr Drug Targets. 2014;15(9):852-859. doi:10.2174/1389450115666140807154810

[4] Dinas Kesehatan Provinsi Sulawesi Tengah. Profil Kesehatan Provinsi Sulawesi Tengah.; 2020.

[5] Hadidjaja P. Schistosomiasis Di Sulawesi Tengah, Indonesia. Jakarta: Fakultas Kedokteran Universitas Indonesia; 1985.

[6] Sudomo M. Penyakit parasitik yang kurang diperhatikan di Indonesia, Makalah Orasi Pengukuhan Gelar Profesor Riset bidang Entomologi dan Moluska. 2008.

[7] Direktorat Pencegahan dan Pengendalian Penyakit Tular Vektor dan Zoonotik. Laporan Kinerja Tahun 2021. Jakarta; 2021. https://ptvz.kemkes.go.id/storage/laporan/laporan_1649920485.pdf.

[8] Dinas Kesehatan Provinsi Sulawesi Tengah. Laporan Survey Prevalensi Schistosomiasis Sulawesi Tengah Tahun 2021. Palu; 2021.

[9] Jumriani, Fauzan M, Afuad, et al. Pemetaan Sebaran Daerah Fokus Keong Perntara Schistosomiasi Oncomelania Hupensis Lindoensis Di Kabupaten Poso Dan Sigi Sulawesi Tengah. Donggala; 2021.

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[10] Widjaja J, Anastasia H, Widayati AN, et al. Fokus Keong Perantara Schistosomiasis Serta Rencana Aksi Pengendalian Dalam Rangka Eliminasi Schistosomiasis 2020. Vol 1.; 2019.

[11] Adekiya TA, Aruleba RT, Oyinloye BE, Okosun KO, Kappo AP. The effect of climate change and the snail-schistosome cycle in transmission and bio-control of schistosomiasis in sub-saharan africa. Int J Environ Res Public Health. 2020;17(1):1-22. doi:10.3390/ijerph17010181

[12] Liu MM, Feng Y, Yang K. Impact of micro-environmental factors on survival, reproduction and distribution of Oncomelania hupensis snails. Infect Dis Poverty. 2021;10(1):1-10. doi:10.1186/s40249-021-00826-3

[13] Garjito TA, Jastal, Mujiyanto, et al. Habitats Distribusion Of Oncomelania hupensis lindoensis, Snail Intermediate Hosts Of Schistosoma japonicum In Lindu Valley, Sigi District, Province Of Central Sulawesi. Bul Penelit Kesehat. 2014;42(3):139-152.

[14] Mujiyanto, Triwobowo GA, Hayani A, Yusran U, Ade K. Kondisi Iklim dan Mikrohabitat Fisik Daerah Endemis Schistosomiasis di Dataran Tinggi Napu Kab.Poso. In: Prosiding Seminar Penginderaan Jauh 2014. ; 2016:978-979.

[15] Rosmini R, Garjito TA, Erlan A, Gunawan G. Infection Rate of The Intermediate Host and The Prevalence of Schistosoma Japonicum reservoirs in Bada Highland Sulawesi Tengah. J Ekol Kesehat. 2014;13(1):43-49.

[16] Syamsuar Manyullei, Steven Silalahi, Andi Murni Alwi Paluseri, et al. Environment factors affecting cockroach density: A systematic review. Int J Life Sci Res Arch. 2022;3(1):001-012. doi:10.53771/ijlsra.2022.3.1.0048

[17] Siahaan HA. Studi Akselerasi Pencapaian Eliminasi Schistosomiasis Di Daerah Endemis Tahun 2020. Donggala; 2020.

[18] Direktorat Jenderal P2 dan PL. Pedoman Teknis Pengendalian Schistosomiasis. Jakarta; 2015.

[19] Yang GJ, Utzinger J, Sun LP, et al. Effect of temperature on the development of Schistosoma japonicum within Oncomelania hupensis, and hibernation of O. hupensis. Parasitol Res. 2007;100(4):695-700. doi:10.1007/s00436-006-0315-8

[20] Anastasia H, Widjaja J, ... Prevalence of Schistosoma japonicum Cercaria among Oncomelania hupensis lindoensis Snails, Snails Density, and Foci Area in Schistosomiasis Endemic Area, Indonesia. J Vektor …. 2022:33-42. http://ejournal2.litbang.kemkes.go.id/index.php/vektorp/article/view/6015.

[21] Walz Y, Wegmann M, Dech S, et al. Modeling and Validation of Environmental Suitability for Schistosomiasis Transmission Using Remote Sensing. PLoS Negl Trop Dis. 2015;9(11):1-22. doi:10.1371/journal.pntd.0004217

[22] Brown DS. A review of the freshwater Mollusca of Natal and their distribution. Ann Natal Museum. 1967;18(3):477-494. http://content.ajarchive.org/cgi-bin/showfile.exe?CISOROOT=/03040798&CISOPTR=732%5Cnhttp://hdl.handle.net/10499/AJ712.

[23] McCreesh N, Booth M. Challenges in predicting the effects of climate change on Schistosoma mansoni and Schistosoma haematobium transmission potential. Trends Parasitol. 2013;29(11):548-555. doi:10.1016/j.pt.2013.08.007

[24] McCreesh N, Booth M. The effect of increasing water temperatures on Schistosoma mansoni transmission and Biomphalaria pfeifferi population dynamics: An agent-based modelling study. PLoS One. 2014;9(7). doi:10.1371/journal.pone.0101462

[25] Kalinda C, Chimbari MJ, Mukaratirwa S. Effect of temperature on the Bulinus globosus - Schistosoma haematobium system. Infect Dis Poverty. 2017;6(1):4-10. doi:10.1186/s40249-017-0260-z

[26] Pawakkangi S, Nurwidayati A, Sumolang PPF, Lobo LT, Gunawan G, Murni M. Focus Conditions of Schistosomiasis Oncomelania hupensis lindoensis in Four Villages Integration Area of Cross Sectoral Program,Central Sulawesi. Balaba J Litbang Pengendali Penyakit Bersumber Binatang Banjarnegara. 2018;14 No 2:117-126. doi:10.22435/blb.v14i2.273

[27] Leal Neto OB, Gomes EC de S, Oliveira Junior FJM de, et al. Biological and environmental factors associated with risk of schistosomiasis mansoni transmission in Porto de Galinhas, Pernambuco State, Brazil. Cad Saude Publica. 2013;29(2):357-367. doi:10.1590/s0102-311x2013000200022

[28] Karimi GR, Derakhshanfar M, Paykari H. Population density, trematodal infection and ecology of Lymnaea Snails in Shadegan , Iran. Arch Razi Inst. 2004;58:125-129.

[29] Eze JC, Okafor F, Nwankwo NE, Okeke ES, Onwudiwe NN. Schistosomiasis prevention option: toxicological evaluation of Vernonia amygdalina on the tissues of Bulinus truncatus at different pH conditions. Heliyon. 2020;6(8):e04796. doi:10.1016/j.heliyon.2020.e04796

[30] Braun L, Sylivester YD, Zerefa MD, et al. Chlorination of schistosoma mansoni cercariae. PLoS Negl Trop Dis. 2020;14(8):1-16. doi:10.1371/journal.pntd.0008665

[31] Hyprowira. 4 faktor yang Berpengaruh Pada pH. Hyprowira. https://hyprowira.com/blog/faktor-yang-mempengaruhi-ph. Published 2020.

[32] Nihei N, Kanazawa T, Blas BL, et al. Soil factors influencing the distribution of Oncomelania quadrasi , the intermediate host of Schistosoma japonicum , on Bohol Island, Philippines . Ann Trop Med Parasitol. 1998;92(6):699-710. doi:10.1080/00034983.1998.11813330

[33] Yang X, Zhang Q, Ma L, Sun QX, Liang S, Zhou JX. Afforestation suppresses oncomelania hupensis snail density through influencing algae in beaches of the dongting lake. PLoS Negl Trop Dis. 2021;15(2):1-17. doi:10.1371/journal.pntd.0009100

[34] Leonardo L, Varona G, Fornillos RJ, et al. Oncomelania hupensis quadrasi: Snail intermediate host of Schistosoma japonicum in the Philippines. Acta Trop. 2020;210(September 2019):105547. doi:10.1016/j.actatropica.2020.105547

[35] Hasibuan NW, Afrianti S. Kajian Sifat Kimia Tanah Pada Perkebun Sawit Dengan Menggunakan Mucuna bracteata PT . PP London Sumatra Indonesia , Tbk Unit. Agriprimatech. 2020;4(1):34-41.

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[36] Supriatna S, Siahaan S, Restiaty I. Pencemaran Tanah Oleh Pestisida Di Perkebunan Sayur Kelurahan Eka Jaya Kecamatan Jambi Selatan Kota Jambi (Studi Keberadaan Jamur Makroza dan Cacing Tanah). J Ilm Univ Batanghari Jambi. 2021;21(1):460. doi:10.33087/jiubj.v21i1.1348

[37] McCreesh N, Arinaitwe M, Arineitwe W, Tukahebwa EM, Booth M. Effect of water temperature and population density on the population dynamics of Schistosoma mansoni intermediate host snails. Parasites and Vectors. 2014;7(1):1-9. doi:10.1186/s13071-014-0503-9

[38] Joof E, Sanneh B, Sambou SM, Wade CM. Species diversity and distribution of schistosome intermediate snail hosts in the Gambia. PLoS Negl Trop Dis. 2021;15(10):1-18. doi:10.1371/journal.pntd.0009823

[39] Junaidi J, Kahar K, Alwi A. Utiliztion Of Cococa Skin Waste Against The Growth Of OF Nutmeg Seedlings (Myristica fragrans). J Agrokompleks Tolis. 2021;1(2):27. doi:10.56630/jago.v1i2.142

[40] Juradi MA, Tando E, Suwitra K. Inovasi Teknologi Pemanfaatan Limbah Kulit Buah Kakao (Theobroma cacao L.) Sebagai Pupuk Organik Ramah Lingkungan. AGRORADIX J Ilmu Pertan. 2019;2(2):9-17. doi:10.52166/agroteknologi.v2i2.1586

[41] Kloos H, De Souza C, Gazzinelli A, et al. The Distribution of Biomphalaria spp. in Different Habitats in Relation to Physical, Biological, Water Contact and Cognitive Factors in a Rural Area in Minas Gerais, Brazil. Mem Inst Oswaldo Cruz. 2001;96(SUPPL.):57-66. doi:10.1590/s0074-02762001000900008

[42] Mostafa O. Effect of salinity and drought on the survival of Biomphalaria arabica, the intermediate host of Schistosoma mansoni in Saudi Arabia. Egypt Acad J Biol Sci B Zool. 2009;1(1):1-6. doi:10.21608/eajbsz.2009.16017

[43] Nurwidayati A, Widjaja J, Samarang S, Nurjana MA, Tolistiawaty I, PFS P. The Density and Infection Rate Of S. japonicum Cercariae On Intermediate Snail, Oncomelania hupensis lindoensis Towards The Schistosomiasis Infection In Endemic Area, Central Sulawesi. Bul Penelit Kesehat. 2018;46(1):69-76. doi:10.22435/bpk.v46i1.59

[44] Gordon CA, Kurscheid J, Williams GM, et al. Asian schistosomiasis: Current status and prospects for control leading to elimination. Trop Med Infect Dis. 2019;4(1). doi:10.3390/tropicalmed4010040

[45] Fornillos RJC, Fontanilla IKC, Chigusa Y, et al. Infection rate of schistosoma japonicum in the snail oncomelania hupensis quadrasi in endemic villages in the philippines: Need for snail surveillance technique. Trop Biomed. 2019;36(2):402-411.