Distribution of schistosomiasis intermediate snail in Lore Lindu National Park, Central Sulawesi

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Abstract. Schistosomiasis in Indonesia is only found in three locations, namely the Napu Highland and the Bada Highland in Poso District and the Lindu Highland in Sigi District, Central Sulawesi Province. The disease is caused by Schistosoma japonicum with snail Oncomelania hupensis lindoensis as its intermediate host. The previous study found that almost all of this host snail foci area were distributed in the seepage water near the Lore Lindu National Park area. Unfortunately, there was no evidence whether O. h. lindoensis exists in the Lore Lindu National Park Area. The study aimed to map the focus areas of schistosomiasis intermediate host snails in the Lore Lindu National Park. The survey was conducted in February 2018, covering 12 villages belong to Napu Highland, Bada Highland, and Lindu Highland. Data collection included surveys on the snail habitat and the snail density. In both activities, geographic coordinates were determined using Global Positioning System (GPS). The results showed 14 foci areas of O. h. lindoensis were found in the buffer zone of Lore Lindu National Park.

1. Introduction

In Indonesia, schistosomiasis can only be found around the Province of Central Sulawesi, which is in Napu Highland and Bada Highland in Poso Regency, and Lindu Highland in Sigi Regency. Schistosomiasis in Indonesia is caused by Trematoda (fluke worm) belonging to Schistosoma japonicum species with a snail-formed intermediate host so-called Oncomelania hupensis lindoensis. Other than infecting humans, schistosomiasis could also infect other types of mammals, both pets and wildlife [1]. Schistosomiasis adversely causing chronic infections and affecting people’s health and productivity.
The prevalence of schistosomiasis in endemic areas during the last three years (2017-2019) has decreased, but the transmission still occurs due to the presence of snail’s focus. This intermediate snail is widespread in endemic areas but not evenly distributed, limited to certain places called the focal area.

The critical lesson learned from the efforts to control schistosomiasis in Indonesia for more than 35 years, as well as experiences from other endemic countries, is that this disease can only be addressed thoroughly through a multi-sector approach and community empowerment [2][3]. This approach is the right way to degrade and eliminate schistosomiasis in humans, animals, and intermediate snails. In that context, the role of cross-sectoral institutions and village communities is vital in preventing schistosomiasis transmission through the management of livestock and intermediate snail habitat environment.

The 2018-2025 Schistosomiasis Eradication Roadmap can be a reference for taking essential steps that need to be done by each related ministry/institution and local governments, primarily for the Provincial Government of Central Sulawesi, Poso District, and Sigi Regency [4]. The *O. h. lindoensis* is an amphibious snail, meaning that this kind of snail lives around a humid area and cannot live in a watery nor dry land. *O. h. lindoensis* can be found at the entire epidemic highlands, or so-called epidemic focuses. The area of such focuses is ranged from a couple of square meters to thousands of square meters. There are two types of focuses, namely natural focus or undisturbed focus and disturbed focus. Natural focuses are situated at woodland edges, in woods, or at lakesides. These snail’s habitats are almost entirely protected from direct sunlight by big trees and bushes, and the consistently wet condition resulted from waters that flow continuously from the upper slopes. The focuses that have been interfered by humans constitute the lands previously used as rice fields which have been abandoned or unmanaged for a long time, former meadows at cultivated lands, the edges of irrigation channel and dam.[5]

In 2017, a re-mapping toward the focuses of *O. h. lindoensis* was conducted. As many as 301 focuses were found scattered around three highlands, namely Napu, Lindu, and Bada. Several snail focuses are considered to be in the area of Lore Lindu National Park (Taman Nasional Lore Lindu / TNLL), and people might easily access such focuses.

Figure 1. The prevalence of schistosomiasis in Indonesia.
TNLL has very high biodiversity, including endemic species of Sulawesi, an abundant collection of ancient art relics, pluralistic cultural cultures, and magnificent landscapes that can attract tourists, scientists, and anthropologists [6]. TNLL is an area of natural resources conservation in the Province of Central Sulawesi. TNLL plays a vital role as a buffer zone, especially in Palu City, Donggala Regency, and Sigi Regency. TNLL is located at the frontier of Poso and Donggala Regency (recently known as the Regency of Sigi) covering an area of ± 230,000 ha. TNLL belongs to the Poso Regency, specifically to the Sub-district of Lore Utara and Lore Selatan, while the parts situated in Donggala Regency lie in the sub-district Kulawi, Biromaru, and Palolo which are now belong to the Sigi Regency area.

TNLL is divided into the buffer zone, utilization/buffer zone, forest zone, and core zone. According to the result of the survey toward snail focuses conducted by the National Institute Research and Development Donggala, there were several snail focuses in the TNLL area in 2018. These snail focuses were found in the utilization/buffer zone, which the people might freely access. The abundance of snails founded at irrigation channels was presumed originated from the forest and the core zones, constituting those areas that could not be accessed by the people. It was also presumed that deployment of O. h. lindoensis focuses was originated from the forest and the core zones of TNLL area.

The effort to eliminate schistosomiasis has been formulated in the 2018-2025 roadmap, involving the Ministry of Environment and Forestry of the Republic of Indonesia [4]. This study aimed to provide a mapping of the focuses of schistosomiasis intermediate host in TNLL.

2. Method
This study was carried out in February 2018 at Napu, Bada, and Lindu Highlands, specifically in several villages inside the TNLL area. The number of villages surveyed was five in Napu Highland, four in the Bada Highland, and three in Lindu Highland.

Data collecting activities included surveying the focuses/habitats of O. h. lindoensis snails and the density of such snails. In both activities, geographical coordinates were determined using the Global Positioning System (GPS). A recording through GPS was conducted in the areas where O. h. lindoensis snails could be discovered. Each snail focus was photographed to provide ancillary information for the databases [7].

The schistosomiasis intermediate host snails were found through the results of location mapping using the TNLL Zoning Map from Balai Besar TNLL [8]. In the case of O. h. lindoensis discovery, sample collection would be conducted by the free method [7]. The snails from the fields were put on petri dishes with a label corresponding to the sample number attached to the bag to fill the snail, in which one petri dish would be used to accommodate one snail bag. Furthermore, the collected snails were crushed and examined under a microscope with a magnification of 10x to observe and calculate the infection rate of S. japonicum cercariae. The infection rate is calculated as a percentage of positive cercariae snails in the following way [9].

\[
\text{The total number of schistosomiasis-transmitting snail} \times 100\% \quad (1)
\]

The total number of snails examined

This research has already acquired ethical approval from the Ethics Commission of the National Institute of Health Research and Development of the Ministry of Health of the Republic of Indonesia with an approval Number: LB.02.01/2/KE.002/2018.
3. Result and discussion

An overview of the schistosomiasis host snail and zonation of TNLL can be seen in Figure 2. It reveals that the distribution of *O. h. lindoensis* in the TNLL area took place in the utilization zone (green color). This buffer/utilization zone is a zone that could be easily accessed by people. No snail focuses were found in the forest zone and the core zone (yellow and red color). The number of focuses of schistosomiasis host snails found in the surveyed villages in Lore Utara Sub-district at Poso Regency and Lindu Sub-district at Sigi Regency can be seen in the following Table 1.

**Table 1.** The number of *O. h. lindoensis* focus areas in TNLL at Napu, Lindu, and Bada Highlands in 2018.

| No. | Village | Sub-district | Number of surveyed areas | Number of discovered snail focuses | Type of focus |
|-----|---------|--------------|--------------------------|-----------------------------------|---------------|
| 1   | Sedoa   | Lore Utara   | 8                        | 8                                 | Water seepage |
| 2   | Dodolo  | Lore Utara   | 4                        | 2                                 | Water seepage |
| 3   | Watumaeta | Lore Utara  | 10                       | 0                                 | Water seepage |
| 4   | Wanga   | Lore Peore   | 4                        | 0                                 | Water seepage |
| 5   | Siliwanga | Lore Peore  | 11                       | 0                                 | Water seepage |
| 6   | Anca    | Lindu        | 4                        | 4                                 | Water seepage |
| 7   | Puroo   | Lindu        | 2                        | 0                                 | Water seepage |
| 8   | Langko  | Lindu        | 8                        | 0                                 | Water seepage |
| 9   | Lengkeka| Lore Barat   | 12                       | 0                                 | Water seepage |
| 10  | Kageroa | Lore Barat   | 4                        | 0                                 | Water seepage |
| 11  | Tomehipi| Lore Barat   | 12                       | 0                                 | Water seepage |
| 12  | Tuare   | Lore Barat   | 22                       | 0                                 | Water seepage |
|     | **Total** |             | **101**                  | **14**                             |               |

The total number of *O. h. lindoensis* focus area was 14, scattering around Sedoa, Dodolo, and Anca Villages, and the highest number of *O. h. lindoensis* focus area was found in Sedoa Village comprising eight focuses, and the type of focus area of this schistosomiasis host snail was water seepage area. Meanwhile, no snail focus was found in Bada Highland.

In Sedoa, snails were discovered mostly in rotten tree woods. The other focuses, which directly bordered by community plantation, are located under trees and between shrubs. The sources of water at these focuses were the seepages from several slow-flowing water springs. These seepages were merged and been directed downward to be the water source for the local community plantations. Many dry foliages were found at the irrigation, plugging the flow of the water.

**Table 2.** The average of *O. h. lindoensis* density and infection rate of in the TNLL area in 2018.

| No. | Village | Sub-district | Number of | Average of (m²) | Average of % |
|-----|---------|--------------|-----------|----------------|--------------|
| 1   | Sedoa   | Lore Utara   | 8         | 2.1            | 1.4          |
| 2   | Dodolo  | Lore Utara   | 2         | 4              | 18.4         |
| 3   | Anca    | Lindu        | 4         | 6.5            | 3.8          |

As shown in Table 2, the highest average of *O. h. lindoensis* density were found in Anca Village, which was 6.5/m², with the infection rate of *Schistosoma japonicum* worm cercariae of 3.8%, followed by Dodolo Village with snail density of 4/m² and the average of infection snail 18.4%, while the average of snail density in Sedoa Village was 2.1/m² and the average of infection rate was 1.4%. The
map of the focus distribution of the *O. h. lindoensis* snail in the TNLL area was created based on the snail survey as shown as Figure 2, and a focus mapping survey of *O. hupensis lindoensis* snails in Lindu sub-district and Napu Poso District [9].

![Map of Schistosomiasis Foci Distribution in Lore Lindu, National Park](image)

**Figure 2.** Distribution map of schistosomiasis intermediate snails in TNLL area.

Previous mapping of snail focus shows that schistosomiasis host snails are frequently found in water seepage area originated from the area of TNLL [9]. Nonetheless, there has been no evidence that schistosomiasis host snail discovered in TNLL area. Several villages are schistosomiasis endemic areas in the TNLL area. There were four in Napu Highland, namely Sedoa, Dodolo, Watumatea, and Wanga [9][10]. There are three villages directly bordering TNLL in Bada Highland region, namely Tuare, Langkeka dan Kageroa Village, meanwhile there are five villages in Lindu Highlands that were considered as enclave area within TNLL territorial.

Besides humans, wild buffalos also pass this snail focus area quite frequently. All these focuses are covered by large trees, irrigated by water seepages, and full of leaf litter. Decaying leaves could cover
up the snail from the sunlight and they serve as the nutrition for such snail [11]. The effort to decrease the snail focus might be implemented by cleaning and trimming tree branches so the sunlight could directly enter the snail focus. A study by Nurwidayati (2018) reported that the highest average of *O. h. lindoensis* density was found in Anca Village, which was 69.1 count/m², while the average of infection rate of *Schistosoma japonicum cercariae* was 4.4%. These results are in line with the snail density found in the TNLL area, in the adjacent to Anca Village.

Environmental conditions at the snail focus, such as being protected from sunlight and humidity, might result in a high snail density. *O.h lindonesia* snail life will be optimum at temperatures between 14°C - 40°C [12]. The sun’s heat reduces the number of *O.h lindonesia* snails. The focus areas of *O. h. lindoensis* in TNLL at Dodolo and Sedoa Villages have also been discovered for a long time [9][10]. These foci were located nearby the main road at Dodolo Village, contrary to Sedoa. All these foci areas belong to TNLL utilization/buffer zone, where the local farmers may cultivate crops such as cacao.

In Sedoa Village, snail foci were located in the TNLL area where flowing water pass through, and shaded by dense canopies. These sites are often covered by bushes and ferns which are suitable for the snail breeding.

The most significant number of focus (2 foci) was found in Dodolo Village, located on the west of Napu Highland, some of which belongs to TNLL area. The average of *O. h. lindoensis* density in Dodolo Village was 6.7 count/m², while the average infection rate by *S. japonicum cercariae* was 4.7%. Apparently, the local knowledge leads the community not to use these area as farms or paddy fields [9].

The effort to control schistosomiasis, especially by managing the snail foci at TNLL area, should be formulated because these *O. h. lindoensis* foci sites were frequently passed by people and used as farming area. Involvement of Public Work Service is required to manage a proper water irrigation at such foci sites by collaborating with TNLL due to the status of the protected area.

The focus of *O. h. lindoensis* is an area of schistosomiasis transmission to humans and animals. The foci are occupied by the *O. h. lindoensis* infected by cercariae larvae of the flatworm, during miracidium to cercaria stages, occuring in the snails[5]. The next stages will take places in human body. During the survey, *O. h. lindoensis* was not found in the forest zone and core zone of TNLL area related to the lower temperatures in the core zone. The snails can be found at an average 14°C temperature [12]. Soil and vegetation conditions may contribute to the somewhat lower ambient temperature.

This research proved that snails *O. h. lindoensis* require a specific habitat to survive, such as a particular requirement for water temperature, velocity of water flow, and vegetation cover [13]. Besides, snail’s survival is affected by the type of soil, type of vegetation, and water sufficiency, which might promote snail development and cercariae movement [7]. Furthermore, water pH could also impact snail’s life, in which the optimum pH ranges between 5.5-7 [8]. Likewise, the result of the survey in Bada Highland did not indicate the existence of *O. h. lindoensis* foci, especially in villages bordering the forest/core zone of TNLL. TNLL activities to control the focus of the snails *O. h. lindoensis*, such as agro engineering intervention on the buffer zone, area protection, and ecosystem restoration, were aimed to minimize the spread of snails. The purpose of agroforestry development is to dry the focus of the snails in the TNLL buffer area and neglect the planting of perennials. This approach prevents people from cutting down the tree crops in the areas, especially those with snail focuses [4]. This is in line with WHO recommendation, that schistosomiasis control measures is emphasized on the transmission of the intermediate host snails [14];[15];[16].

4. Conclusion
This research concludes that 14 snail’s foci amongst 101 foci areas of *O. h. l. in* TNLL are scattered at three villages, namely Sedoa and Dodolo in the sub-district of Lore Utara (Poso Regency), as well as Anca in the sub-district of Lindu (Sigi Regency). All these snail focuses were found in the utilization/buffer zone.
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