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Habitat Characteristics and Distribution of *Oncomelania hupensis lindoensis* in Schistosomiasis-Endemic Region of Central Sulawesi, Indonesia

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Abstract

Oncomelania hupensis lindoensis is the only intermediate snail host of *Schistosoma japonicum* in Indonesia and plays a crucial role in maintaining schistosomiasis transmission in endemic areas. Updated information on habitat characteristics and snail distribution is essential for supporting effective surveillance and control programs. This study aimed to characterize the habitats of *O. h. lindoensis* and to analyze its distribution and population density in the schistosomiasis-endemic Lindu Highlands, Central Sulawesi, Indonesia. Field surveys were conducted in four endemic villages, namely Anca, Langko, Tomado, and Puroo. Snail foci were identified through field observations and information obtained from local residents and field officers. Habitat characteristics were assessed based on topographical, physicochemical, and biotic factors, while the number of snail foci, habitat area, and population density were analyzed descriptively. A total of 16 snail foci were identified across the study area. *O. h. lindoensis* was predominantly associated with humid habitats characterized by continuous water seepage or slow-flowing water, permanently moist soil, dense vegetation, and shaded microhabitats. The snails were recorded from irrigation channels, streams, springs, marshes, abandoned rice fields, plantations, forest margins, and protected forests. Snail population density varied among villages, with the highest density recorded in Tomado (65.6 individuals/m²) and the lowest in Puroo (3.0 individuals/m²), while the overall mean density was 29.8 individuals/m^2. The findings demonstrate that habitat characteristics strongly influence the distribution and persistence of *O. h. lindoensis* populations. These results provide updated ecological information that can support schistosomiasis surveillance and habitat-based control strategies in the Lindu Highlands.

Keywords: *Oncomelania hupensis lindoensis*; habitat characteristics; snail foci; population density; schistosomiasis.

INTRODUCTION

Schistosomiasis is one of the neglected tropical diseases that continues to pose a significant public health challenge in many tropical and subtropical countries. The disease is caused by trematode parasites of the genus *Schistosoma*, which require specific freshwater snails as intermediate hosts to complete their life cycle (Colley et al., 2014; Li et al., 2023). In Indonesia, schistosomiasis is endemic only in the highland areas of Napu, Bada, and Lindu in Central Sulawesi Province, where *Schistosoma japonicum* is the only causative species and transmission remains geographically restricted (Mulyani et al., 2025). Unlike other endemic regions worldwide, transmission in Indonesia depends exclusively on *Oncomelania hupensis lindoensis* (currently recognized by some authors as *O. lindoensis*), the only intermediate snail host capable of supporting the development of *S. japonicum* (Attwood et al., 2015). Consequently, the occurrence, abundance, and spatial distribution of this snail are critical determinants of schistosomiasis transmission and are therefore central to surveillance and elimination strategies (Kamel et al., 2021).

Oncomelania hupensis lindoensis occupies habitats with distinct ecological characteristics. The species is commonly associated with humid environments that provide continuous water flow or seepage throughout the year and are protected by dense vegetation that maintains favorable microclimatic conditions (Liu et al., 2021). Habitat suitability is influenced by several environmental factors, including topography, substrate type, vegetation cover, light intensity, soil moisture, temperature, and water availability (Yang et al., 2022). Suitable habitats include irrigation channels, marshes, springs, abandoned rice fields, forest margins, and agricultural lands where adequate moisture is maintained (Koraag et al., 2024). Changes in land use, vegetation cover, or hydrological conditions resulting from natural processes or human

activities may alter habitat suitability, ultimately affecting the distribution and population density of *O. h. lindoensis* (Zhang et al., 2024).

Schistosomiasis control programs in Indonesia have been implemented through integrated strategies, including mass drug administration, snail surveillance, snail control, environmental management, and community-based health education in endemic areas (Gray et al., 2021). These interventions have been accompanied by substantial environmental changes in several transmission foci, driven by land-use conversion, irrigation development, agricultural practices, and vegetation succession, all of which may influence the persistence and distribution of *Oncomelania* habitats (Perez-Saez et al., 2022). As a result, the number, location, and ecological characteristics of snail habitats have changed over time, leading to shifts in schistosomiasis transmission foci (Nursafingi et al., 2024). Updated information on habitat characteristics and the spatial distribution of snail foci obtained through systematic field surveys is therefore essential for monitoring transmission risk, detecting residual transmission, and improving the effectiveness of schistosomiasis surveillance and elimination programs in Indonesia (Ross et al., 2023).

The Lindu Highlands remain one of the persistent schistosomiasis-endemic areas in Central Sulawesi despite long-term control efforts (Widjaja et al., 2022). Although routine surveillance has been conducted for many years, current information regarding the habitat characteristics of *Oncomelania hupensis lindoensis* following recent environmental and land-use changes remains limited. A comprehensive assessment of habitat characteristics, focus types, habitat extent, and snail population density is therefore needed to provide an updated description of the ecological conditions that sustain disease transmission (Xu et al., 2023). This study aimed to characterize the habitat of *O. h. lindoensis* based on topographical, physicochemical, and biotic factors and to analyze the distribution and population density of the snail in transmission foci across the Lindu Highlands. The findings will provide baseline ecological information for strengthening field surveillance and supporting evidence-based schistosomiasis control in endemic areas.

MATERIALS AND METHODS

Study area

This study was conducted from July to August 2026 in the Lindu Highlands, Central Sulawesi Province, Indonesia (Figure 1). Field surveys were carried out in four schistosomiasis-endemic villages, namely Anca, Langko, Tomado, and Puroo. The study area is located at an elevation of approximately 900–1,200 m above sea level and is characterized by a tropical montane climate with high rainfall and humidity. The landscape consists of forests, agricultural lands, abandoned rice fields, marshes, irrigation channels, springs, and slow-flowing streams that provide suitable habitats for *Oncomelania hupensis lindoensis*. Habitat surveys were conducted at all identified snail foci in the four villages to characterize habitat conditions and assess the distribution and population density of *O. h. lindoensis*.

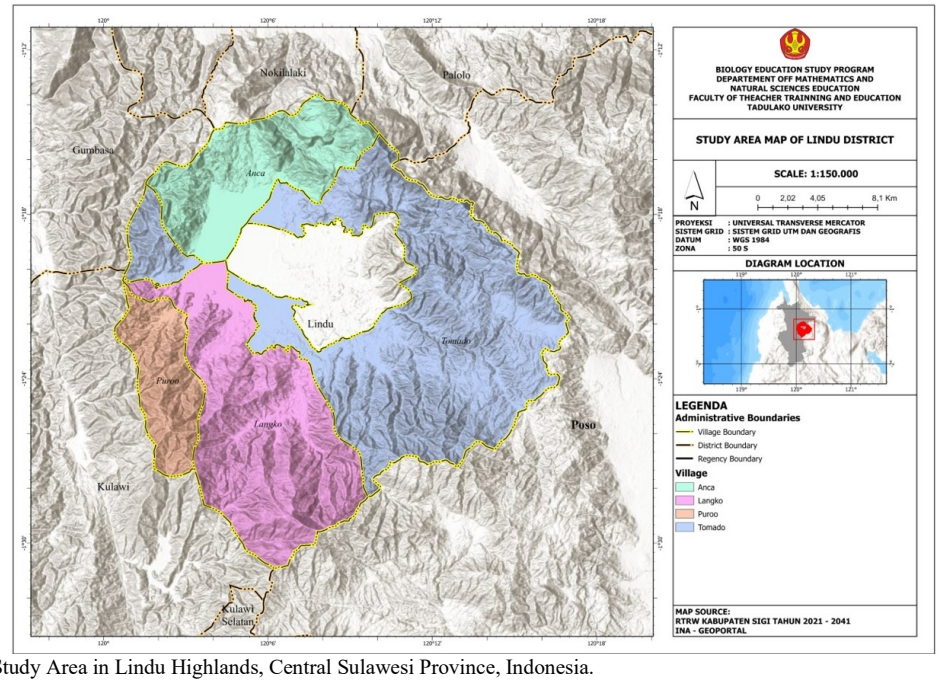


Figure 1. Map of the Study Area in Lindu Highlands, Central Sulawesi Province, Indonesia.

Procedures

Snail Focus Survey

The survey was conducted to identify active foci of *Oncomelania hupensis lindoensis* within the study area. Potential snail foci were initially identified based on information obtained from local residents and field officers with knowledge of the endemic areas. Each reported location was subsequently verified through direct field observation to confirm the presence of *O. h. lindoensis*. The boundaries of each snail focus were determined based on the observed distribution of snail populations and surrounding habitat characteristics. Each focus was then classified according to its dominant habitat type, including irrigation channels, marshes, springs, abandoned rice fields, forest margins, and agricultural lands.

Snail Sampling

Representative specimens of *Oncomelania hupensis lindoensis* were collected manually from each identified snail focus following the standard field survey procedures used in schistosomiasis surveillance. Snails were searched for on moist soil, leaf litter, grass bases, irrigation channels, springs, marshes, and other suitable microhabitats within each focus. Representative individuals were collected to confirm the presence of *O. h. lindoensis*, while field observations were used to assess the distribution and relative density of snail populations across the surveyed foci.

Habitat Characterization

Habitat characteristics were evaluated by observing topographical, physicochemical, and biotic variables at every snail focus. Topographical observations included elevation, landform, and habitat type. Physicochemical characteristics consisted of soil moisture, water availability, substrate condition, and exposure to sunlight. Biotic characteristics included vegetation type, canopy cover, and dominant plant species surrounding the snail habitat. Habitat descriptions were recorded using standardized field observation sheets.

Data analysis

The collected data were compiled and tabulated using Microsoft Excel. Habitat characteristics were analyzed descriptively based on topographical, physicochemical, and biotic factors observed at each snail focus. The distribution of *Oncomelania hupensis lindoensis* was described according to the number and spatial distribution of snail foci in each study village. Snail density was calculated as the number of individuals per square meter (individuals/m²) by dividing the total number of snails collected by the surveyed habitat area. Differences in habitat characteristics and snail density among villages were compared descriptively and presented in tables and figures to illustrate the ecological conditions of the snail habitats in the Lindu Highlands.

RESULTS AND DISCUSSION

Habitat Characteristics of *Oncomelania hupensis lindoensis*

Habitat is one of the primary factors influencing the occurrence, abundance, and distribution of *Oncomelania hupensis lindoensis*, the intermediate snail host of *Schistosoma japonicum*. This species occupies habitats with specific ecological requirements, including high moisture levels, continuous water availability, and vegetation that maintains stable microclimatic conditions. Habitat suitability is determined by the interaction of topographical, physicochemical, and biotic factors that collectively provide favorable conditions for the survival and persistence of the snail population. Field observations in the Lindu Highlands showed that *O. h. lindoensis* occurred in several habitat types with relatively similar environmental characteristics, particularly in moist, shaded areas located near permanent water sources. The habitat characteristics observed in this study are presented in Figure 2, while detailed descriptions based on environmental factors and habitat types are provided in Tables 1 and 2.



Figure 2. Habitat Characteristics of *Oncomelania hupensis lindoensis* in the Schistosomiasis-Endemic Lindu Highlands.

Table 1. Habitat Characteristics of *Oncomelania hupensis lindoensis* Based on Environmental Factors.

Topographical Factors	Physicochemical Factors	Biotic Factors
Occurs in the schistosomiasis-endemic highlands of Napu, Bada, and Lindu at elevations of approximately 900–1,200 m above sea level. Typical habitats include hillslopes, valleys, forest margins, and poorly drained areas.	Characterized by high humidity, permanently moist soil, continuous water flow or seepage, protection from direct sunlight, and the absence of permanent flooding, reflecting the amphibious nature of the snail.	Dense vegetation consisting of large trees, shrubs, grasses (*Phragmites* spp.; locally known as *parapa*), cocoa plantations, coffee plantations, maize fields, onion fields, vegetable crops, and natural forest vegetation that maintains habitat humidity.
Habitats include irrigation channels, streams, water seepage areas, springs, drainage ditches, marshes, abandoned ponds, uncultivated rice fields, forest margins, plantations, and abandoned grasslands.	The substrate consists of muddy or water-saturated soil with high moisture content and poor drainage. Most habitats are located near springs or perennial seepage areas that provide a continuous water supply throughout the year.	Natural habitats are primarily located within or along forest margins, whereas disturbed habitats occur in abandoned rice fields, plantations, irrigation channels, and former agricultural lands.
Habitats are commonly located near permanent water sources and areas with slow-flowing water.	The snail is unable to survive under excessively dry conditions or in habitats that remain permanently inundated.	Preferred microhabitats include the bases of grasses, shrubs, leaf litter, the edges of irrigation channels, seepage areas, and shaded sites protected by surrounding vegetation.

Table 2. Habitat Characteristics of *Oncomelania hupensis lindoensis* Based on Snail Focus Types.

Habitat Type	Main Characteristics	Occurrence of *O. h. lindoensis*
Abandoned rice fields	Permanently moist soil with shallow standing water, overgrown with wild grasses and aquatic vegetation.	Snails are commonly found in wet soil, around the bases of grasses, and along the margins of shallow water.
Irrigation channels and drainage ditches	Slow-flowing water with abundant vegetation and leaf litter.	This is the most common snail focus type recorded in the Napu, Bada, and Lindu Highlands.
Springs and seepage areas	Continuous water flow throughout the year, high humidity, and dense vegetation cover.	Snail populations are relatively abundant because the habitat remains moist and environmentally stable year-round.
Shrublands	Dense shrub vegetation, thick leaf litter, and low light intensity.	Snails are frequently found in moist soil beneath shrubs and accumulated leaf litter.
Plantations (cocoa, coffee, maize, onion, and vegetable fields)	Presence of irrigation channels or water seepage, moist soil, and partial vegetation cover.	These habitats represent one of the dominant snail habitats, particularly along irrigation channels and seepage areas.
Forests and protected forests	Dense canopy cover, high humidity, and the presence of springs or seepage areas.	Snails occur along small watercourses, seepage areas, and the permanently moist forest floor.
Marshes and abandoned ponds	Stagnant water with abundant aquatic vegetation and muddy substrates.	These habitats are important snail foci, particularly in the Bada and Lindu Highlands, where snails are commonly found along the margins of marshes and abandoned ponds.

Distribution and Population Density of *Oncomelania hupensis lindoensis*

The distribution and population density of *Oncomelania hupensis lindoensis* are important indicators for assessing the risk of schistosomiasis transmission in endemic areas. The spatial distribution of the snail is influenced not only by habitat suitability but also by land-use changes, environmental conditions, and previous control interventions. Analysis of the number of snail foci, habitat area, and snail population density provides valuable information on the current status of transmission foci and the potential for continued *Schistosoma japonicum* transmission. Field surveys conducted in the Lindu Highlands revealed considerable variation in the number of snail foci and population density among villages, reflecting differences in habitat characteristics and local environmental conditions. The distribution of snail foci, habitat area, and population density of *O. h. lindoensis* in each village are presented in Table 3, Figure 3, and Figure 4.

Table 3. Abiotic Environmental Conditions of *Oncomelania hupensis lindoensis* Habitats in the Lindu Highlands.

Village	Number of Snail Foci	Habitat/Focus Type	Focus Area (m^2)	Snail Density (individuals/m^2)
Anca	6	Streams in protected forests, streams in plantations, and irrigation channels near forests	16.784	47.1
Langko	1	Streams along forest margins and marshes	3.762	3.5
Tomado	7	Rice fields, cocoa plantations, and marshes	24.421	65.6
Puroo	2	Marshes and rice fields	253.321	3.0
Total/Average	16		298.288	29.8



Figure 3. Distribution of *Oncomelania hupensis lindoensis* in Lindu Highlands.



Figure 4. Morphological of *Oncomelania hupensis* (Liu et al., 2024).

Discussion

Habitat suitability was determined not only by water availability but also by the interaction between topography, substrate characteristics, and vegetation cover. The highland landscape of Lindu, situated at approximately 900–1,200 m above sea level, provides relatively cool temperatures and high annual rainfall that favor the establishment of suitable snail habitats (Gray et al., 2021). Dense canopy cover and shrubs reduce soil evaporation, while muddy substrates retain sufficient moisture to support snail activity. These environmental characteristics explain why *O. h. lindoensis* was encountered across different habitat types, including forest margins, plantations, irrigation systems, and abandoned agricultural land, provided that adequate shade and moisture were maintained. Such findings indicate that habitat suitability results from interactions among climatic, topographic, and environmental variables rather than from a single ecological factor (Wang et al., 2024).

Marked variation in snail density among villages indicates that habitat quality plays a greater role than habitat size alone (Colley et al., 2014). Tomado supported the highest snail density despite having a smaller habitat area than Puroo, whereas Puroo contained the largest focus area but exhibited the lowest density. This pattern suggests that suitable environmental conditions were concentrated within relatively small areas in Tomado, allowing snail populations to become more abundant. In contrast, extensive habitats do not necessarily provide uniform ecological conditions capable of supporting large snail populations. Local differences in vegetation structure, soil moisture, water seepage, and habitat disturbance are likely responsible for these variations. Long-term field observations have demonstrated that snail density responds dynamically to environmental conditions, with rainfall, temperature, and moisture exerting delayed and interactive effects on population abundance (Wang et al., 2024).

The occurrence of active snail foci in plantations, irrigation channels, and abandoned rice fields further illustrates the ability of *O. h. lindoensis* to persist in landscapes modified by human activities. Agricultural practices frequently create environmental conditions that resemble natural snail habitats through irrigation

networks, slow-moving water, and dense secondary vegetation. When agricultural land is abandoned, grasses and shrubs rapidly develop, increasing canopy cover and maintaining soil moisture that favor snail colonization (Nursafingi et al., 2024). Consequently, anthropogenic landscape changes may unintentionally contribute to the maintenance of schistosomiasis transmission by providing additional habitats for the intermediate host. Similar observations have been reported in studies demonstrating that large-scale landscape modification and hydrological infrastructure substantially influence the distribution of *Oncomelania* habitats and should therefore be incorporated into surveillance and control programs (Chen et al., 2024).

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CONCLUSIONS

Oncomelania hupensis lindoensis in the Lindu Highlands occupies habitats characterized by high humidity, continuous water availability, dense vegetation, and shaded microhabitats. A total of 16 active snail foci were identified, with differences in habitat type and population density among villages. These findings provide updated ecological information that can support schistosomiasis surveillance and habitat-based control strategies in endemic areas.

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