

Preplanned Studies

Distribution Patterns of the Snail Intermediate Host of *Schistosoma japonicum* — China, 2015–2019

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Summary

What is already known about this topic?

The endemic status of schistosomiasis appeared to continuously decrease in China from 2015 to 2019. The snail species *Oncomelania hupensis* is the only intermediate host involved in the transmission of *Schistosoma japonicum*, and this snail's geographic distribution is strictly consistent with that of schistosomiasis.

What is added by this report?

The snail's habitats did not decrease significantly in China from 2015 to 2019, and some habitats have been newly detected or recurrent in some regions. Snail habitats among nine counties in Hunan and Jiangxi covered nearly half of the areas with snails.

What are the implications for public health practice?

Considering the situation of snail distribution, strategies and measures on snail control should focus on key areas. In addition, study of the origin and causes of the newly-detected snail habitats and recurrent areas with snails needs to be strengthened, and comprehensive measures should be taken to prevent the spread of snails.

Schistosomiasis remains a public health problem in developing regions, including Africa, Asia, and Latin America. Of three major human-infecting *Schistosoma* spp., *Schistosoma japonicum* (*S. japonicum*) is the only one distributed in China (1–2). It was endemic in 12 provincial-level administrative divisions (PLADs) in the southern Yangtze River Basin. In 2019, Shanghai, Zhejiang, Fujian, Guangdong, and Guangxi continually maintained the status of schistosomiasis elimination; Sichuan and Jiangsu achieved transmission interruption; and the 5 provinces of Yunnan, Hubei, Anhui, Jiangxi, and Hunan maintained the status of transmission control (3). As the only intermediate host of *S. japonicum*, the snail's distribution is strictly consistent with that of schistosomiasis japonica (4), and surveys are an

important part of routine work for schistosomiasis prevention and control. To know the characteristics and trends of snail distribution after achieving the standard of transmission control in China, data on snail habitat surveys were collected and analyzed from 2015 to 2019. According to the results, the areas deemed as snail habitats did not decrease during the five years, fluctuating from 356,287.55 hectares (hm²) to 363,069.38 hm², and newly-detected snail habitats and recurrent snail habitats were found from 2015 to 2019.

In the study, data of the annual snail survey at the provincial level and county level from 2015 to 2019 were collected through the National Parasitic Diseases Control Information Management System (NPDCIMS) among 12 PLADs. All data were transferred to Microsoft Excel software (version 2013, Microsoft Office, CA, USA) for data compilation. Variables reflecting the distribution of snails including the total area of snail habitats, area of newly detected snail habitats (environments with no snails initially), area of recurrent snail habitats (snails being found in environments that previously eliminated snails), and other data from the snail survey were described and analyzed. Descriptive statistics and mapping were conducted to analyze the snail distribution at the provincial and county levels, the environmental type of snail habitats, and the distribution of snail habitats at the county level.

From 2015 to 2019, all counties reporting schistosomiasis conducted snail surveys each year. There were 253 counties (55.85%) with snails infested among 453 counties with schistosomiasis endemic in 2015, compared with 270 out of 450 in 2019 (number declined for the changes of administrative divisions). The proportion of counties with snails increased slightly (Figure 1A). The total areas of snail habitats were 356,287.55 hm² in 2015 and 362,367.87 hm² in 2019 (Figure 1B). During the 5 years, the main environmental type of snail habitats was marshland and lake regions (94.65%–96.57%), mountainous and

hilly regions (3.40%–5.31%), and plains with waterway networks (0.03%–0.06%). The proportion of snail habitats in mountainous and hilly regions increased gradually (Table 1). Hunan, Jiangxi, and Hubei were the top 3 PLADs for total area of snail habitats in 2019 (Figure 1D), accounting for 47.75% of the total area (173,027.27 hm²/362,367.87 hm²), 23.05% (83,530.52 hm²/362,367.87 hm²), and 18.61% (67,433.58 hm²/362,367.87 hm²), respectively.

From 2015 to 2019, 2,346.54 hm² areas of snail habitats were newly found among the 12 PLADs. The

newly detected areas with snails were found in 9 PLADs except Fujian, Guangdong, and Sichuan. Among the 9 PLADs, Anhui accounted for 64.06% (1,503.31 hm²/2,346.54 hm²) and Hunan accounted for 29.36% (689.02 hm²/2,346.54 hm²). A total of 12,293.57 hm² of snail habitats were recurrent among the 12 PLADs at the same time. Sichuan accounted for 29.89% (3,674.79 hm²/12,293.57 hm²), Jiangxi accounted for 19.63% (2,413.37 hm²/12,293.57 hm²), Yunnan accounted for 17.69% (2,175.10 hm²/12,293.57 hm²), and Anhui accounted for 12.75%

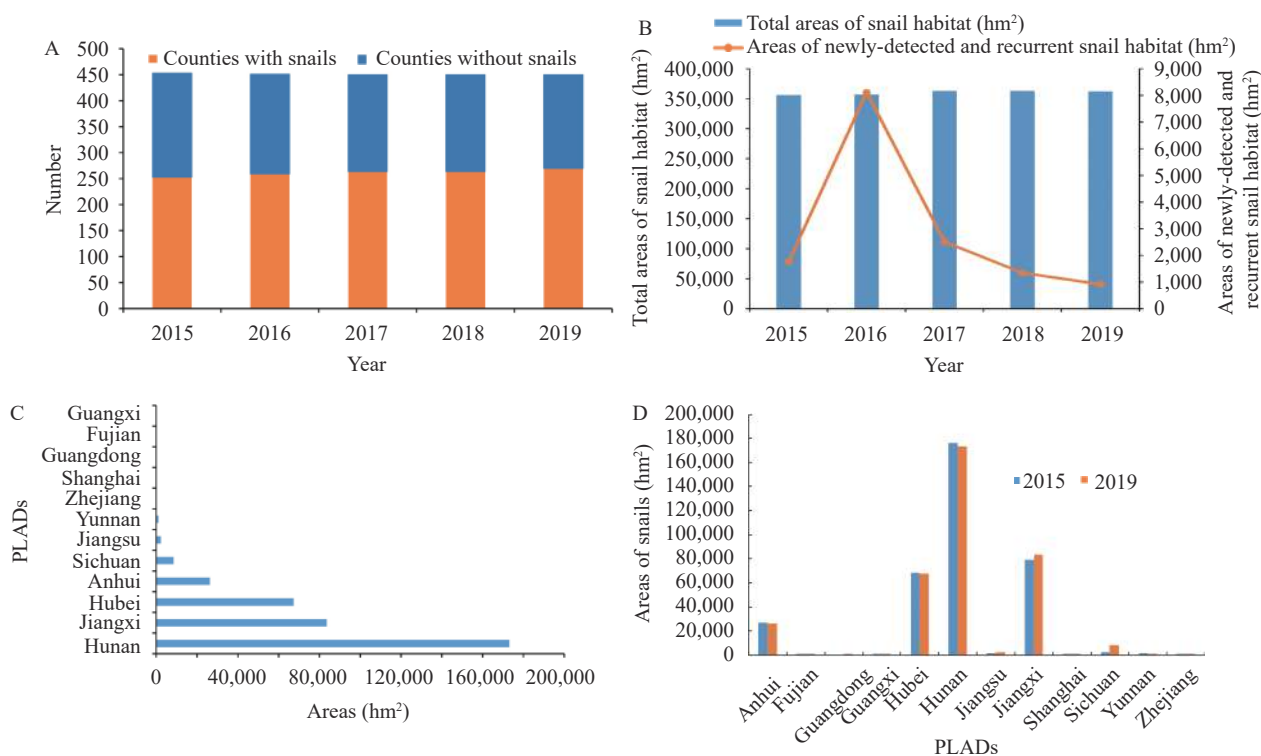


FIGURE 1. Distribution characteristics of snail habitats among the 12 PLADs in China from 2015 to 2019. (A) The changes of county number with snail infested from 2015 to 2019; (B) The change trend of total snail habitat and newly-detected and recurrent snail habitat from 2015 to 2019; (C) The areas of snail habitat in each PLAD in 2019 (hm²); (D) The areas of snail habitat in 12 PLADs in 2015 and 2019 (hm²).

Abbreviation: PLADs=Provincial-level administrative divisions.

TABLE 1. The changes of different environmental snail habitats, newly detected and recurrent snail habitats in China from 2015 to 2019 (hm²).

Year	Area of snail habitat				Area of newly detected snail habitat	Area of recurrent snail habitat
	Total	Marshland and lake	Plain	Hilly and mountainous region		
2015	356,287.57	344,076.05(96.57%)	112.69(0.03%)	12,098.83(3.40%)	666.04	1,094.16
2016	356,834.59	339,174.56(95.05%)	135.62(0.04%)	17,524.41(4.91%)	1,346.48	6,767.50
2017	363,069.47	344,337.41(94.84%)	108.965(0.03%)	18,623.10(5.13%)	208.54	2,299.19
2018	363,014.40	343,874.04(94.73%)	220.92(0.06%)	18,919.44(5.21%)	61.28	1,281.48
2019	362,367.87	342,987.74(94.65%)	154.10(0.04%)	19,226.03(5.31%)	64.20	851.24

Note: the percentage in brackets stands for the percent of each type of snail habitat among the total snail habitat in the same year.

(1,568 hm²/12,293.57 hm²). In addition, more newly detected and recurrent snail habitats were found in 2016 than any other years during the 5 years.

According to the latest data in 2019, among the 450 counties with endemic schistosomiasis, there were 9 counties with area of snail habitats exceeding 10,000 hm², including 5 counties in Hunan (Yuanjiang, Hanshou, Yueyang, Xiangyin, and Junshan) and 4 counties in Jiangxi (Duchang, Poyang, Nanchang, and Yugan). The total area of snail habitats among these 9 counties were 172,907.34 hm², accounting for 47.72% (172,907.34 hm²/362,367.87 hm²) of the total area of snail habitats; the area of snail habitats in 46 counties were between 1,000 hm² and 10,000 hm², including 9 counties in Anhui, 7 counties in Jiangxi, 18 counties in Hubei, 11 counties in Hunan, and 1 county in Sichuan; the area of snail habitats in 89 counties were between 100 hm² and 1,000 hm², the area in 97 counties were between 1 hm² and 100 hm², and in 209 counties were less than 1 hm² or no snails detected (Table 2).

DISCUSSION

Data on snail surveys from 2015 to 2019 suggested that the total areas of snail habitats in China decreased slowly or rebounded in some PLADs. Though more counties with endemic schistosomiasis entered the stage of elimination, the distribution of snails increased and more counties were found with infested snails. Sichuan had achieved the standard of transmission interruption in 2017 (5); however, the areas of snail habitats increased from 2537.55 hm² in 2015 to 8509.06 hm² in 2019. As the only intermediate host of *S. japonicum*, the increase and recurrence of snails will bring more challenges to work on schistosomiasis control, especially in the elimination of schistosomiasis. In addition, no snails were found in Guangdong for

more than 30 years after the announcement of schistosomiasis eradication in 1985 (6). However, the snail habitat was found again in Qujiang District and Yingde County in Guangdong in 2019. Because there is a floating population of humans from regions with endemic schistosomiasis, the risk of schistosomiasis transmission among these regions cannot be neglected (7). County-level analysis showed that 9 counties had snail areas that exceeded 10,000 hm², accounting for 47.72% of all snail habitats, indicating a concentrating of snail habitats.

This study was subject to some limitations. First, data on types of newly-detected and recurrent snail habitats were not collected and analyzed, which was helpful to analyze the cause and origin. Second, the study was mainly on the natural distribution of snail habitats, and other factors such as activities of humans and domestic animals were not considered. So key susceptible snail habitats could not be distinguished. This report requires future study of detailed data analysis on snail habitats for accurate snail control.

Based on the results of the study, surveillance should be strengthened on snails, especially among regions that currently do not have snails but are neighboring areas with snails. Snail survey and control is an essential factor in the process of schistosomiasis elimination (8), which cannot be neglected especially among areas with schistosomiasis elimination. Moreover, the quality of snail surveys should be improved to detect some snail habitats. Traditional methods for snail surveys are time and resource consuming, and new technologies such as remote sensing should be applied to snail surveillance (4). With increasing attention on environmental protection, snail control by molluscicide was restricted in the environmental protection zone, which brought difficulties to snail control and an increased risk of schistosomiasis transmission. Strategies and measures

TABLE 2. Levels on areas of snail habitat among counties with schistosomiasis endemic in 12 provincial-level administrative divisions in 2019.

Area of snail habitat(hm ²)	Number of counties												
	Shanghai	Jiangsu	Zhejiang	Anhui	Fujian	Jiangxi	Hubei	Hunan	Guangdong	Guangxi	Sichuan	Yunnan	Total
≤1	7	39	44	12	13	14	16	8	12	18	18	8	209
1.01–100	1	19	10	8	3	9	9	7	2	2	20	7	97
100.01–1,000	0	6	0	21	0	5	20	10	0	0	24	3	89
1,000.01–10,000	0	0	0	9	0	7	18	11	0	0	1	0	46
>10,000	0	0	0	0	0	4	0	5	0	0	0	0	9
Total	8	64	54	50	16	39	63	41	14	20	63	18	450

of snail control should be studied and focused on areas with concentrated snail habitats. Comprehensive measures for snail control should be implemented among these areas combined with agricultural, forestry, or water conservancy projects to compress the areas of snail habitats. In addition, newly detected and recurrent snail habitats should be handled promptly. The cause and origin of newly-detected snails should be investigated. Snail surveys should be expanded and strengthened after flooding (9), transplantation of plants from snail habitats, and the construction of wetland parks.

In conclusion, with the promotion of schistosomiasis prevention and control, schistosomiasis control in China will enter the stage of elimination before 2030 (10). Snail control is an important part in the process of schistosomiasis control. Overall, to achieve the goal of elimination, snail surveillance should be strengthened especially among those areas with the risk of snail spread.

Acknowledgements: Participants of the survey.

Fundings: National Science Foundation of China (Grant No. 82073619).

Conflicts of interest: The authors declare no competing interests.

doi: 10.46234/ccdcw2021.021

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Submitted: December 20, 2020; Accepted: January 27, 2021

REFERENCES

- McManus DP, Dunne DW, Sacko M, Utzinger J, Vennervald BJ, Zhou XN. Schistosomiasis. *Nat Rev Dis Primers* 2018;4:13. <http://dx.doi.org/10.1038/s41572-018-0013-8>.
- Xu J, Li SZ, Zhang LJ, Bergquist R, Dang H, Wang Q, et al. Surveillance-based evidence: elimination of schistosomiasis as a public health problem in the People's Republic of China. *Infect Dis Poverty* 2020;9(1):63. <http://dx.doi.org/10.1186/s40249-020-00676-5>.
- Zhang LJ, Xu ZM, Dang H, Li YL, Lv S, Xu J, et al. Endemic status of schistosomiasis in People's Republic of China in 2019. *Chin J Schisto Control* 2020;32(6):551 – 8. <http://dx.doi.org/10.16250/j.32.1374.2020263>. (In Chinese).
- Jiang TT, Yang K. Progresses of research on patterns and monitoring approaches of *Oncomelania hupensis* spread. *Chin J Schisto Control* 2020;32(2):208 – 12. <http://dx.doi.org/10.16250/j.32.1374.2019124>. (In Chinese).
- Zhang LJ, Xu ZM, Dai SM, Dang H, Lü S, Xu J, et al. Endemic status of schistosomiasis in People's Republic of China in 2017. *Chin J Schisto Control* 2018;30(5):481 – 8. <http://dx.doi.org/10.16250/j.32.1374.2018219>. (In Chinese).
- Guo JY, Xu J, Zhang LJ, Lv S, Cao CL, Li SZ, et al. Surveillance on schistosomiasis in five provincial-level administrative divisions of the People's Republic of China in the post-elimination era. *Infect Dis Poverty* 2020;9:136. <http://dx.doi.org/10.1186/s40249-020-00758-4>.
- Guan Z, Lü S, Li SZ, Dang H, Zhang LJ, Xu J. Analysis on the situation of schistosome infections in floating population in national schistosomiasis surveillance sites of China. *Chin J Schisto Control* 2018;30(2):124 – 30. <http://dx.doi.org/10.16250/j.32.1374.2017246>. (In Chinese).
- Sun LP, Wang W, Zuo YP, Hong QB, Du GL, Ma YC, et al. A multidisciplinary, integrated approach for the elimination of schistosomiasis: a longitudinal study in a historically hyper-endemic region in the lower reaches of the Yangtze River, China from 2005 to 2014. *Infect Dis Poverty* 2017;6(1):56. <http://dx.doi.org/10.1186/s40249-017-0270-x>.
- Zhang LJ, Zhu HQ, Wang Q, Lü S, Xu J, Li SZ. Assessment of schistosomiasis transmission risk along the Yangtze River basin after the flood disaster in 2020. *Chin J Schisto Control* 2020;32(5):464 – 8,475. <http://dx.doi.org/10.16250/j.32.1374.2020242>. (In Chinese).
- Xu J, Lü S, Cao CL, Li SZ, Zhou XN. Progress and challenges of schistosomiasis elimination in China. *Chin J Schisto Control* 2018;30(6):605 – 9. <http://dx.doi.org/10.16250/j.32.1374.2018249>. (In Chinese).