

Preplanned Studies

Distribution and Ecological Habitat Characteristics of *Biomphalaria straminea* — Shenzhen City, Guangdong Province, China, August–December 2023

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Summary

What is already known about this topic?

Biomphalaria straminea (*B. straminea*) is an invasive snail and a key intermediate host of *Schistosoma mansoni* (*S. mansoni*), which was previously widespread in Shenzhen's major rivers.

What is added by this report?

In contrast to historical records, no live snails were detected in rivers or reservoirs, whereas stable populations persisted in agricultural areas. Infested habitats show eutrophication and higher levels of Ca^{2+} , HCO_3^- , and PO_4^{3-} . All the samples tested negative for *S. mansoni*.

What are the implications for public health practice?

B. straminea shows apparent redistribution into agricultural environments, increasing spatial overlap with human activities and raising a theoretical transmission risk of *S. mansoni*. Surveillance and control efforts should prioritize agricultural ecosystems over urban waterways.

established in agricultural areas. Infested habitats had heavy organic deposition and significantly higher Ca^{2+} , HCO_3^- , and PO_4^{3-} levels than snail-free areas ($P < 0.05$). Molecular testing of 64 snail samples confirmed the absence of *S. mansoni* infection.

Conclusion: This survey revealed an apparent redistribution of *B. straminea* in Shenzhen, where the snail is apparently absent from urban rivers but has colonized polluted agricultural waters. Although the samples tested negative, dense colonization of this competent host in agricultural landscapes with frequent human-water contact enables potential local transmission if the pathogen is introduced. Future monitoring and control efforts should prioritize agricultural ecosystems.

ABSTRACT

Introduction: *Biomphalaria straminea* (*B. straminea*) is an intermediate host of *Schistosoma mansoni* (*S. mansoni*), and its distribution in Shenzhen threatens public health. This study aimed to investigate the distribution patterns and ecological habitat characteristics of *B. straminea* to inform public health prevention and control strategies.

Methods: Sampling was conducted across major natural water systems (rivers and reservoirs) and vegetable-planting areas in Shenzhen. Species were identified using morphological and molecular methods. *S. mansoni* infection and water quality were analyzed to compare infested and snail-free habitats.

Results: No live *B. straminea* were detected in major rivers or reservoirs. Instead, stable populations were

Schistosoma mansoni (*S. mansoni*) is a global public health threat, with 54 million annual infections worldwide. Its transmission range is determined by the dispersal of its intermediate host, *Biomphalaria straminea* (*B. straminea*) (1–2). In China, while *Schistosoma japonicum* is under control, increased exchange and trade with schistosomiasis-endemic regions under the Belt and Road Initiative have made imported *S. mansoni* control increasingly critical (3). Multiple imported cases were reported in China, predominantly among travelers and workers returning from *S. mansoni* endemic regions (4), indicating a persistent cross-border introduction risk. Systematic surveillance and early warning for imported *S. mansoni* remain insufficient in China, and control capacity needs further improvement. As a major port city, Shenzhen faces introduction risks from frequent cross-border personnel, trade, and ballast water (5).

Since 1981, *B. straminea* has spread to Dongguan, Huizhou, and other Pearl River Delta cities (2). Systematic historical surveillance has documented the widespread distribution of the snail in Shenzhen's

major urban rivers and reservoir flood channels during 2012–2013, with multiple high-density breeding populations detected in these lotic river habitats (6–7). Previous studies mainly focused on its distribution and dispersal, with limited analysis of its adaptive mechanisms, environmental drivers, and niche dynamics across habitats. In recent years, river restoration and channel-hardening projects in Shenzhen have drastically altered its original habitats. However, its response to these changes and the colonization of new habitats remain unclear. Therefore, this study aimed to assess these ecological changes to inform public health strategies.

This study was conducted from August to December 2023 in Shenzhen, a coastal city in southern China. Shenzhen has a subtropical monsoon climate (annual mean temperature about 23 °C, abundant rainfall) and extensive river networks. Surveys covered diverse freshwater habitats in Shenzhen, including major rivers, reservoirs, and agricultural sites. Sampling points were established at the upper, middle, and lower reaches of waterways to ensure geographical representation.

Targeting stagnant waters and aquatic vegetation, we searched within 20–50 m of each site. Snails were collected using dip nets and hand-picking and then transported to the laboratory in ventilated containers with moist gauze. For molecular analysis, 20 mg of soft tissue was dissected and preserved in absolute ethanol at –80 °C. Surface water samples were collected from 12 sites using portable samplers for water quality analysis (Supplementary Table S1, available at <https://weekly.chinacdc.cn/>), with the sampling basis following the Technical Specifications for Environmental Quality Monitoring of Surface Water (HJ 91.2-2022). Statistical analyses were performed using R (version 4.3.1, R Foundation for Statistical Computing, Vienna, Austria). Differences between snail-infested and snail-free habitats were analyzed using the Mann-Whitney U test. The significance level was set at $\alpha=0.05$, and $P<0.05$ was considered statistically significant.

All the collected specimens were black morphotypes, measuring 4–12 mm in diameter and 1–3 mm in height. The shells were dextral and discoid, with four rapidly expanding whorls and a typical horseshoe-shaped aperture. The flattened dorsal, deeply concave apex, and prominent umbilicus matched the taxonomic description of *B. straminea*.

Field surveys showed significant differences in *B. straminea* distribution across Shenzhen's main water

systems. No live *B. straminea* were found in Shenzhen's main rivers or the Shenzhen Reservoir flood channel, with only a few empty shells discovered at some sites. In contrast, the snail was prolifically breeding in the vegetable-planting areas of Longgang and Pingshan, forming stable communities (Table 1).

The environmental characteristics differed significantly between snail-infested and snail-free habitats (Table 2). In snail-free rivers and reservoirs, water was odorless, clear, or slightly turbid, with minimal humus and debris. However, snail-present vegetable areas had stagnant, shallow, turbid, and malodorous water, with heavy humus deposits and dense vegetation covering the water surface.

Water quality analysis showed that snail-infested waters had high hardness and eutrophication (Table 3). Specifically, Ca^{2+} , Mg^{2+} , HCO_3^- , and PO_4^{3-} concentrations were significantly higher in snail-infested areas ($P<0.05$). Mean Ca^{2+} reached 132.23 mg/L in snail-infested areas, compared with 31.38 mg/L in snail-free areas. Similarly, HCO_3^- and PO_4^{3-} differed markedly, with snail-infested values being significantly higher. Moreover, PO_4^{3-} in snail-infested areas severely exceeded the surface water standard (total phosphorus ≤ 0.1 mg/L), indicating heavy organic pollution. In contrast, pH, Na^+ , Cl^- , DO, and $\text{NH}_3\text{-N}$ showed no significant differences ($P>0.05$). These results confirm that *B. straminea* prefers calcium-rich, eutrophic, and polluted stagnant waters. All the 64 samples tested negative for *S. mansoni* by PCR. Molecular evidence confirmed that none of the *B. straminea* samples harbored *S. mansoni*.

DISCUSSION

Historical surveys consistently recorded widespread *B. straminea* populations in Shenzhen's urban rivers and reservoir flood channels (6–7). In contrast, our survey found no live snails in these habitats. Compared with historical data, this cross-sectional survey suggests an indicative spatial distribution shift of *B. straminea* in Shenzhen. Their apparent absence from urban rivers aligns with riverbed hardening and restoration that eliminated the organic-rich substrates essential for their survival (8). In addition, we observed that *B. straminea* has invaded agricultural irrigation systems with stagnant, calcium-rich water. This environment favors shell calcification and population establishment (9) and increases the likelihood of schistosomes being close to agricultural areas with frequent human activities.

Although this study adopted a cross-sectional design

TABLE 1. Distribution survey of *Biomphalaria straminea* in Shenzhen.

Water system	Location	<i>B. straminea</i>	Other freshwater snails
Longgang River	Puluobei Middle Bridge	Not found	<i>P. striatulus</i> , <i>B. aeruginosa</i>
	Ailian New Bridge	Shells present	<i>P. canaliculata</i>
	Longcheng Blvd Viaduct	Shells present	<i>P. canaliculata</i> , <i>P. striatulus</i>
	Shihuw Community Park	Not found	<i>B. aeruginosa</i>
	Xinsheng Kindergarten	Few shells	<i>C. chinensis</i>
	Longyuan	Shells present	<i>Bithynia</i> sp.
Dasha River	Shenzhen University Lihu Campus	Not found	<i>P. striatulus</i>
	Nanshan Talent Apt. Riverside	Not found	<i>S. quadrata</i>
	Dasha River Park	Not found	None
	Binhai Shahexi Viaduct	Shells present	<i>C. chinensis</i> , <i>P. canaliculata</i>
Guanlan River	Yousong Waterfront Park	Not found	<i>P. striatulus</i> , <i>Bithynia</i> sp
	Guanlan River Artificial Wetland	Not found	<i>C. chinensis</i>
	Guanhu Culture, Art & Sports Center	Shells present	<i>B. aeruginosa</i> , <i>Bithynia</i> sp
	Guanlan River Overhead Bridge	Not found	<i>P. canaliculata</i> , <i>P. striatulus</i>
	Miaoxi New Village	Shells present	<i>P. striatulus</i>
	Guihua Riverside Park	Shells present	<i>P. striatulus</i>
Shenzhen Reservoir	Discharge Channel 1	Shells present	<i>P. striatulus</i> , <i>Bithynia</i> sp.
	Discharge Channel 2	Not found	<i>P. striatulus</i> , <i>Bithynia</i> sp.
Vegetable-Planting Areas	Pingshi Liuwu Vegetable Field	Live individuals dominant	<i>P. striatulus</i> , <i>C. chinensis</i> , <i>P. canaliculata</i>
	Hutian Rd. Liulian Bridge Field	Live individuals dominant	<i>P. striatulus</i> , <i>C. chinensis</i> , <i>P. canaliculata</i>
	Next to Agri-Tech Industry Park	Live individuals dominant	<i>C. chinensis</i>

and lacked data from neighboring cities, it demonstrated that environmental changes have reshaped the distribution of *B. straminea*. Notably, as a key international hub, Shenzhen has frequent cross-border exchanges with *S. mansoni* endemic areas (10), which may elevate the probability of pathogen introduction. Although no infected snails were found and no epidemiological linkage exists between imported cases and local agricultural settings, if *S. mansoni* is introduced into these agricultural landscapes, the co-occurrence of the pathogen, a competent intermediate host, and human water contact could form a biologically plausible transmission cycle. The current situation of "snails without schistosomes" provides a valuable opportunity for disrupting potential transmission chains. Prevention and control efforts should focus on vector control, pathogen surveillance, and protection of high-risk populations.

Implications for public health arising from the apparent redistribution of *B. straminea* into agricultural ecosystems necessitate a strategic adjustment of schistosomiasis control in Shenzhen. Prevention efforts should focus on the irrigation networks; for example,

dredging sediment and controlling Ca^{2+} and PO_4^{3-} levels to reduce eutrophication can disrupt snail breeding habitats and reduce reliance on chemical molluscicides. Routine malacological surveys should be linked with active stool screening for high-risk groups, including agricultural workers and laborers returning from endemic areas, to enable timely response through the existing reporting mechanisms. In addition, health education targeting farming communities and a joint prevention framework involving Shenzhen, Dongguan, and Huizhou are essential for bridging surveillance gaps and reducing the risk of a localized *S. mansoni* outbreak across shared watersheds.

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TABLE 2. Physical and sensory characteristics of biomphalaria straminea survey sites.

Location	Odor	Transparency	Water flow	Organic matter	Floating debris
Longgang River					
Puluobei Middle Bridge	None	Turbid	Relatively fast	Low	Small amount
Ailian New Bridge	None	Clear	Slow	Low	None
Longcheng Blvd Viaduct	None	Clear	Relatively fast	Low	None
Shihuw Community Park	None	Clear	Slow	Low	None
Xinsheng Kindergarten	None	Clear	Slow	Low	None
Longyuan	None	Clear	Slow	Low	None
Dasha River					
Shenzhen University Lihu Campus	None	Clear	Slow	Low	None
Ecological Corridor Children's Park	None	Clear	Slow	Low	None
Dasha River Park	None	Clear	Slow	Low	None
Binhai Shahevi Viaduct	None	Clear	Relatively fast	Low	None
Guanlan River					
Yousong Waterfront Park	None	Clear	Slow	Low	None
Guanlan River Artificial Wetland	None	Clear	Slow	Low	None
Guanhu Culture, Art & Sports Center	None	Clear	Slow	Low	None
Guanlan River Overhead Bridge	None	Clear	Relatively fast	Low	None
Miaoxi New Village	None	Clear	Slow	Low	None
Guihua Riverside Park	None	Clear	Slow	Low	None
Shenzhen Reservoir					
Discharge Channel 1	Foul odor	Heavily polluted	Relatively fast	Relatively high	Present
Discharge Channel 2	None	Turbid	Slow	Relatively high	Present
Vegetable-Planting Areas					
Pingdi Liuwu Vegetable Field	None	Turbid	Stagnant	Relatively high	Relatively high
Hutian Rd. Liulian Vegetable Field	None	Turbid	Stagnant	Relatively high	Relatively high
Shenzhen Pingshan Agri-Tech Park Side	Foul odor	Turbid	Stagnant	Relatively high	Relatively high

TABLE 3. Water chemistry characteristics of biomphalaria straminea survey sites.

Variable	Sites with Snails	Sites without Snails	Mann-whitney U (W/U)	P
	Median (Q1–Q3)	Median (Q1–Q3)		
Ca ²⁺ (mg/L)	109.00 (96.22–145.00)	33.70 (28.18–37.35)	0.0	0.004
Mg ²⁺ (mg/L)	16.90 (15.38–21.83)	3.95 (3.30–7.24)	3.0	0.028
Na ⁺ (mg/L)	32.05 (23.92–38.23)	34.55 (8.95–57.78)	16.0	1.000
HCO ₃ ³⁻ (mg/L)	292.00 (238.5–322.00)	68.50 (65.75–80.00)	2.0	0.016
CO ₃ ²⁻ (mg/L)	<5 (LOD)	<5 (LOD)	NA	NA
Cl ⁻ (mg/L)	74.55 (59.75–81.50)	79.10 (48.38–134.00)	19.0	0.683
PO ₄ ³⁻ (mg/L)	0.42 (0.35–1.31)	0.05 (0.045–0.083)	3.0	0.033
pH	6.90 (6.65–7.53)	7.45 (7.18–7.53)	21.5	0.394
DO (mg/L)	8.97 (8.20–9.73)	7.42 (6.97–7.62)	5.0	0.074
NH ₃ -N (mg/L)	0.92 (0.37–7.075)	0.44 (0.30–1.14)	13.0	0.683

Abbreviation: Q1=25th percentile; Q3=75th percentile; LOD=limit of detection; NA=not available.

Prevention, Shenzhen City, Guangdong Province, China.

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SUPPLEMENTARY MATERIAL

Analytical Methods, Instruments, and Detection Limits for Water Quality

SUPPLEMENTARY TABLE S1. Test methods, analytical instruments, and detection limits.

Test item	Test standard (method) and number (including year)	Analytical instrument model	Detection limit	Unit
Ca ²⁺	Determination of 32 Elements in Water by Inductively Coupled Plasma Optical Emission Spectrometry HJ 776-2015	Inductively Coupled Plasma Optical Emission Spectrometer (Avio 200)	0.02	mg/L
Mg ²⁺	Determination of 32 Elements in Water by Inductively Coupled Plasma Optical Emission Spectrometry HJ 776-2015	Inductively Coupled Plasma Optical Emission Spectrometer (Avio 200)	0.003	mg/L
Na ⁺	Determination of 32 Elements in Water by Inductively Coupled Plasma Optical Emission Spectrometry HJ 776-2015	Inductively Coupled Plasma Optical Emission Spectrometer (Avio 200)	0.12	mg/L
HCO ₃ ⁻	Acid-Base Indicator Titration Method 3.1.12.1, <i>Standard Methods for the Examination of Water and Wastewater</i> (Fourth Edition, Supplemented Version, 2002), State Environmental Protection Administration of China	Stoppered Burette (Dual-Purpose Acid-Base Burette)	5	mg/L
CO ₃ ²⁻	Acid-Base Indicator Titration Method 3.1.12.1, <i>Standard Methods for the Examination of Water and Wastewater</i> (Fourth Edition, Supplemented Version, 2002), State Environmental Protection Administration of China	Stoppered Burette (Dual-Purpose Acid-Base Burette)	5	mg/L
Cl ⁻	Determination of Inorganic Anions in Water (F ⁻ , Cl ⁻ , NO ₂ ⁻ , Br ⁻ , NO ₃ ⁻ , PO ₄ ³⁻ , SO ₃ ²⁻ , SO ₄ ²⁻) by Ion Chromatography HJ 84-2016	Ion Chromatograph (ICS-90)	0.007	mg/L
PO ₄ ³⁻	Determination of Total Phosphorus in Water by Ammonium Molybdate Spectrophotometry GB/T 11893-1989	UV-Visible Spectrophotometer (Blue star A)	0.01	mg/L
pH	Determination of pH Value in Water by Electrode Method HJ 1147-2020	Portable pH/Electrical Conductivity/Dissolved Oxygen Meter (SX836)	Dimensionless	—
DO	Determination of Dissolved Oxygen in Water by Electrochemical Probe Method HJ 506-2009	Portable pH/Electrical Conductivity/Dissolved Oxygen Meter (SX836)	—	mg/L
NH ₃ -N	Determination of Ammonia Nitrogen in Water by Nessler's Reagent Spectrophotometry HJ 535-2000	UV-Visible Spectrophotometer (Blue star A)	0.025	mg/L