The Pharma Innovation Journal 2025; 14(8): 23-29

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
Impact Factor (RJIF): 6.34
TPI 2025; 14(8): 23-29

www.thepharmajournal.com
Received: 17-05-2025
Accepted: 21-06-2025

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Freshwater snails in Misan water bodies southern Iraq

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DOI: https://www.doi.org/10.22271/tpi.2025.v14.i8a.26218

Abstract
This study was conducted to determine the types of freshwater snails in the bodies of water of the Tigris river passing through Misan Governorate in southern Iraq. Samples were collected monthly from four study stations from the north, east, west and south of Misan Governorate: (Kamit, Al-Musharrah, Al-Salam and Qal'at Saleh) in order to collect the largest number of snail species in The main and secondary water bodies of the Tigris river passing through the governorate during the study period that extended from March 2022 to February 28, 2023. 5,109 shells were collected from the four stations belonging to nine species: *Radix auricularia* (Linnaeus, 1758) [44], *Physa acuta* (Draparnaud, 1801) [45], *Gyraulus huwaizahensis* (Gloer and Naser, 2007) [23], *Melanoides tuberculate* (Muller, 1774) [51], *Melanopsis buccinodea* (Olivier, 1801) [29], *M. costata* (Olivier, 1804) [29], *M. nodosa* (Russac, 1804) *Bellamya bengalensis* (Lamarck, 1822) [46]. And *Thedoxus jordani* (Sowerby, 1836) [47] the highest presence of *Melanopsis* spp. snails was recorded. It amounted to 2166 individuals, and the minimum presence of *G. huwaizahensis* snails amounted to 12 individuals during the study period.

Keywords: Freshwater snails, Tigris River, southern Iraq

Introduction
The phylum Gastropods is the second largest animal phylum after the Arthropods phylum in terms of diversity and abundance. It includes several taxa, led by the Gastropods, which includes snails and slugs (Taylor and Lewis, 2007) [40]. Gastropods live in marine and freshwater environments, and some of them live in wet terrestrial environments (Ponder and Lindberg, 2008) [34]. Gastropods are usually inactive animals associated with the bottom, because most of them have heavy shells and slow movement, although some of them specialize in attachment, swimming, or Holes and shells are the main means of defense for animals, although they also obtain protection through their colors and secretory habits. Many of them have a cover or horny plate (Operculum) that covers the mouth of the shell when the shell withdraws into it, even if some do not have a shell at all (Hickman *et al*., 1988) [25]. Some appear Snail populations have a wide range of phenotypic variations that are formed as a result of internal genetic factors or the influence of prevailing external environmental factors or interactions between them (Ofoezie, 1999) [31]. The study of classification and diagnosis of aquatic snails in Misan Governorate, southern Iraq, did not attract the attention of researchers. This is why the idea of the current study came, which is the first of its kind at the governorate level, which mainly targeted the knowledge and classification of snails found in the water bodies of the Tigris River passing through Misan Governorate.

Materials and Methods
Sample collection
Snail samples were collected randomly monthly from four stations in Misan Governorate. Southern Iraq (Figure 1) during the period from March 2022 to February 28, 2023. The first site S1 is located at the beginning of the river's entry north of Misan Governorate in the Kimit district (3539805.31 north, 67909.1 east). The second site S2 is a branch connected to the Tigris River east of Misan governorate in the Al Musharrah district (3526383.87 north, 723877.86 east) The third site S3 is in Al-Salam district, west of Misan Governorate (3485463.07 north, 689886.61 east). The fourth site S4 is located in the south of Misan governorate in the Qalaat Saleh district (3488891.37 north, 719793.07 east). The shell dimensions of the snails were taken using digital calipers according to Riedel method (1995) [36] and diagnosed according to Cuzzo *et al*. (2020) [50].

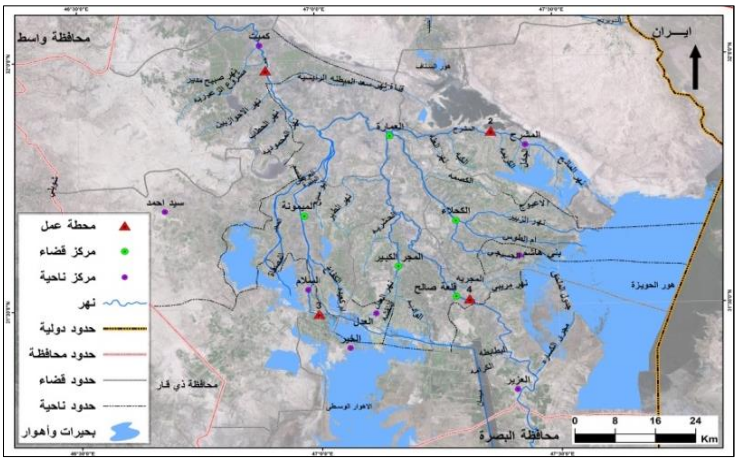

Fig 1: Map of study sites in Misan Governorate, southern Iraq

Results

Nine species of freshwater snails were recorded from the four study stations (Kmit, Al-Musharrah, Al-Salam, and Qalat Saleh) during the study period. The number of individuals collected reached 5109 individuals, including 339 individuals of *R. auricularia*, 118 individuals of *P. acuta*, 12 individuals of *G. huwaizahensis*, and 2030 individuals. One individual from *M. tuberculata*, 2166 individuals from *Melanopsis*, which included three species: *M. nodosa*, *M. buccinoides*, and *M. costata*, 231 individuals from *B. bengalensis*, and 213 individuals from *T. jordani*. The results of the study showed that the distribution and spread of snails differed according to the months of the study and according to the type of snail. The species *R. auricularia* was most present during the months of April and May and disappeared during August, September, October, 2nd and January. The species *P. acuta* was present during the months of March, April and May and its presence disappeared during August, September, October, October, second and January, and the species *G. huwaizahensis*, which was found during the month of May and disappeared in most of the remaining months and was the least widespread species in all stations. As for the species *M. tuberculata* and the genus *Melanopsis*, they were found during all months of the year and were the most widespread in all stations, and type The presence of *B. bengalensis* fluctuated during the months of the year and disappeared during the months of May and October, and finally the species *T. jordani* was present throughout the month of May and disappeared during the months of November, December and the second. It is noted that all species disappeared during the months of January and February from the first station, Table (1).

Table 1: Distribution of snail species at the study stations during the sampling period.

Snail	St	March	April	May	June	July	August	September	T1	T2	K1	K2	February	Total
R. auricularia	1	*	*	*								*		
	2	*	*	*								*		
	3	*		*									*	339
	4	*	*									*		
P. acuta	1	*	*		*									
	2	*		*								*		
	3	*	*											
	4			*								*		118
G. huwaizahensis	1	*	*											
	2		*											
	3													
	4													12
M. tuberculata	1	*	*	*	*	*	*	*						
	2	*	*	*	*	*	*	*						
	3	*	*	*	*	*	*	*						
	4	*	*	*	*	*	*	*						2030
M. nodosa *M. buccinoides* *M. costata*	1	*	*	*	*	*	*	*						
	2	*	*	*	*	*	*	*						
	3	*	*	*	*	*	*	*						
	4	*	*	*	*	*	*	*						2166
B. bengalensis	1	*	*	*	*	*	*							
	2	*	*	*	*	*	*							
	3	*	*	*	*	*	*							
	4	*	*	*	*	*	*							231
T. jordani	1	*	*	*	*	*	*							
	2	*	*	*	*	*	*							
	3	*	*	*	*	*	*							
	4	*	*	*	*	*	*							213

Presence of snails
Subclass Pulmonata
Family: Lymnaeidae
***Radix auricularia* (Linnaeus, 1758)** [44]
The shell is transparent, conical in shape, and has a large opening located on the right side, meaning that the rotation of the shell turns in a clockwise direction to the right and is therefore called right-wing rotation. It has 4-5 convex coils. The last coil is large, while the first coil is small, giving it the shape of an ear. The snail has a pair of flat, triangular tentacles and a pair of basal eyes located at the base of each tentacle. These snails lack an operculum, and the ventral foot is the edge is rounded, and these snails lay their transparent eggs in the form of elongated gelatinous masses. The length of the shell is 9-14 (11) while its width is 6-9 (7). The opening of the shell is oval, elongated, its length is 7-10 (8) and its width is 7-9 (8)), (Panel 1A)

Family: Physidae
***Physa acuta* (Draparnaud, 1801)** [45]
The shell is conical in shape, transparent, thin to medium thickness, with a smooth surface. It has 3-4 turns and has a speckled shell of a coffee or dark brown color that can be observed through the transparent shell. The shell has an elongated, oval opening located on the left side. It is of the sinistral type, meaning that the rotation is counterclockwise. It has a pair of filamentous tentacles and a pair of basal eyes at the base of the tentacles. It lacks a cover, and its ventral foot has a rounded front end and a pointed back end. It lays its transparent eggs in kidney-shaped gelatinous masses attached to rocks, aquatic plants, or anybody in the water. External Sculpture The shell has an outline. The length of the shell is 5-11 (7) while its width is 3-8 (5.6). The opening of the shell is oval, 3-6 (4.6) and its width is 2.5-4.5 (3) (Plate 1-B)

Family: Planorbidae
***Gyaulus huwaizahensis* (Gloer & Naser, 2007)** [23]
The shell is small, transparent, disc-shaped, keratinized, with growth lines prominently visible on it, and it twists towards the right. The coils are convex, reaching about 3 and a quarter of a coil. The coils increase in size towards the oval shell opening, which is crescent-shaped and has no cover. The length of the shell is 4-10 (9) while its width is 3 8- (5) the shell opening is oval in shape and very large, about 3.5-2.5 (3) long and 6.5-3.5 (5) wide (Plate 1-C)

Subclass: Prosobranchiata
Family: Thiaridae
***Melanoides tuberculata* (Muller, 1774)** [51]
The shell is conical in shape, elongated with vertical ribs. The coils contain a very fine spiral groove and wide ribs that are more prominent near the last coils. The coils are round and convex and gradually increase in size towards the right-hand shell opening. The number of coils in an adult shell is 8-11 coils. The surface of the shell is characterized by vertical lines of rusty brown spots that are more evident in juveniles than adults. It contains an irregular paucispiral cap to close the shell opening located at the end of the ventral foot with a lobed edge. And a pair of filamentous tentacles and a pair of eyes at the base of the tentacles. The length of the shell is 38-25 (31.6) and its width is 11-8 (9). The opening of the shell is small, oval in shape, its length is 12-8 (10) while its width is 7-4 (5). (Plate 1- D)

***Melanopsis* spp.**
These snails are characterized by the large size of their conical shells, which vary in size and external sculpting within the same population group and are small to medium in size. The crest is thick and solid and has a cover at the end of the ventral foot, which is irregular in shape with a lobed edge identical to the specifications of its hosts. It has single eggs. Milky in color, it has a pair of filamentous tentacles and a pair of basal eyes located at the base of the tentacles. Three species were found in the current study. The first type, M. nodosa, can be easily distinguished by its large size, as its shell reaches 10-14 (11.5) in length, conical in shape, and rough in texture. This shell has different colors, dark or light (coffee, green, yellowish pink), and is rarely light black. The shell has a pointed end that may disappear due to erosion. The shell also has 4-5 turns clockwise, meaning it is right-handed. The shell has many solid knots, its width is 6.5-4.5 (5), and the opening of the shell is small, oval in shape, with a length of 5.5-3.5 (4). Its width is 4-5-2.5 (3). The second type is M. costata, whose shell is characterized by the presence of ribs on the outer surface of the shell. The length of the shell is 16-14 (15) and its width is 7.5-5.5 (6). As for the third type, M. buccinoides, its shell is characterized by being smooth. The shell is 17-16 (16) long and 5.5-8.5 wide (7), (Plate 1-E)

Family: Viviparidae
***Bellamya bengalensis* (Lamarck, 1822)** [46]
The shell is medium to large in size, conical in shape, green or brown in colour, with reddish-brown bands. The shell is twisted towards the right and has 5 convex coils. The outer sculpture is precisely vertically striped. It is considered a reproductive snail. The opening of the shell is almost round and has an oval cover. The length of the shell is 24-32 (28)) and its width is 22-17 ((19.6) and the shell opening is small, oval in shape, its length is 12.5-8.5 (10) while its width is 8.5-5.5 (6.6) (Plate 1-F)

Family: Neritidae
***Theodoxus jordani* (Sowerby, 1836)** [47]
These snails are characterized by being disc-shaped, resembling a drop of water and not conical. They are small in size. The shell is very hard and has a soft texture. They have 2-3 turns clockwise, meaning they are right-handed, as the shell's opening is located on the right side. The shell has bright and attractive colors (light coffee, green, yellowish pink, grey, black) and is striped with transverse green lines. It has an oval-shaped paucispiral cover. The shell has a pair of filamentous tentacles and a pair of dark eyes located at the base of the tentacles. Its ventral foot has a rounded edge and the shell has a rounded cover. It is a thin, flexible sheet of protein with a teardrop-shaped disc shape, which acts as a door that closes the opening of the shell. Albi Small, single, milky or cream-colored shell. The snails lay their eggs on rocks or any other body of water. The length of the shell is 6.5-4.5 (5) and its width is 5.5-3.5 (4). The opening of the shell is small and oval in shape, with a length of 3 (3.5-2.5). Its width was 5.5-3.5 (3), plate (1-G)

Plate (1) External shells of the snail species recorded in the current study
A- *R. auricularia* B- *P. acuta* C- *G. huwaizahensis* D- *M. tuberculata* E- *Melanopsis* spp. F- *B. bengalensis* G- *T. jordani*

Discussion

Subclass Pulmonata

Family: Lymnaeidae

R. auricularia

The Lamnaidae family contains more than 1,200 species (Burch, 1980) [12]. Species may vary in the shapes of their shells, which is a class of taxonomic value (paraense, 2004) [32]. The main geographical origin of these shells is America, Eurasia, and the Indian and Pacific Oceans, and the genera of this family may not reflect phylogenetic relationships with the exception of the genus *Radix* (Correa *et al*., 2010) [14]. Brown and Wright (1980) [11] found the snail *L. auricularia* in the Arabian Peninsula, and it was also recorded in the Mediterranean basin and its presence was recorded in Jordan (El-karmi and Ismail, 2006) [17]. This snail is widespread even in polluted environments. Adam and Lewis (1992) [2] mentioned that this conch lives in heavy water in Britain, as it has the ability to withstand pollution, as well as high concentrations of organic materials and sulfates (Matuskova, 1985) [28] The results of the current study, based on the phenotypic characteristics of the shell, revealed that all the study samples from the Lymnaeidae family belong to the genus *Radix*, which can be easily identified by its broad, triangular tentacles and right-rotating shell. It was recorded on a small scale and at specific stations and specific times during the months of the study. As indicated by Yakhchali *et al*. (2014) [44]. The appropriate temperatures for the growth of snails are between 15-30 °C, and this leads to the conclusion that their spread is low in the current study due to the high temperatures and salinity values during the study period due to the lack of rainfall and the increase in the rate of water evaporation during the study period. The results of the current study showed that there is no real presence of the species. *L. auricularia* in the study area, and the results were in agreement with Al-Waeli (2014) [4], who conducted a survey of freshwater snails in the central and southern governorates, including Misan Governorate, but this species was not recorded, and the Al-Asadi (2021) [5] study in which he investigated genetically the presence of *R.auricularia* in the south Iraq**.**

Family: Physidae

P. acuta

The *P. acuta* snail is considered one of the lung snails that belong to the Physidaea family. It is one of the most important types. It is found on all continents except Antarctica. Its presence has been recorded on the Asian continent in Iran, Japan, India and Iraq. Its presence has also been recorded in the countries of the African continent. It is also common in regions Many from Australia (Madsen and Frandsen, 1989) [26] Aditya and Raut, 2002; (Appleton, 2003) [3, 9]. Molecular studies have shown that the total number of species belonging to the genus *Physa* is between 15 and 20 species (Wethington and Lydeard, 2007) [43], 65% of which suffer from low fertility because self-fertilization occurs at a late age (Wethington, 2003) [42]. Avoid this preys on snails in part by leaving the water (Mower and Turner, 2004) [30]. Snails that follow escape behavior to avoid predators may experience morphological change compared to snails that cannot escape by leaving the water (Ross *et al*., 2014) [37]. The results of the study showed The current study indicates that all the specimens collected from the current study stations of the genus *Physa* belong to the species *P. acuta*, and the most important feature of the individuals of this species was the sharp end of the shell, the left side of its rotation, and the tentacles with a filamentous structure. The description of the current model agrees with what was presented by Cuezzo *et al*. (2020) [15] This colonizes The freshwater species is characterized by its attachment to plants and other solid bodies, and it has been found in a few areas and in very small numbers, as it was not found in month August, September, October and November 2022, and January 2023. A sharp decline in its distribution was also observed in the month of June, and this is consistent with the results of a study Rabba (1986) [35]. And is contrary to the study Vayrynen *et al*. (2000) [49]. The reason may be due to the environmental conditions that are not suitable for its growth and the lack of abundance of aquatic plants such as reeds and sedges, which decreased in presence in the area in the years preceding their burning by the people, and which constitute a suitable habitat for snails to provide protection and protection from the rapid water current

on the one hand and from excessive sunlight on the other hand. It also provides a supportive material for snails to lay egg masses, and it works to reserve algae that constitute food for snails, and this is what Ali and Rabba (1994) [6] indicated that the type of food has a significant effect on the distribution and spread of snails.

Family: Planorbidae

G. huwaizahensis

The results of the study showed that the phenotypic characteristics of the shell of the species that is characterized by the number of turns between 3 and 3 and a quarter belong to the genus *Gyraulus* and the species *G. huwaizahensis*, which was found in a very small percentage among the other snail species in the study. Gloer and Naser (2007) [23] described this snail for the first time in Iraq as a new species to science from the Al-Hawizeh Horus in Misan Governorate. The small number of its individuals in the study stations may be attributed to the increase in water salinity during the study period due to the lack of water releases from internal dams, as it is a freshwater snail and prefers fresher water. Its usual habitat is the semi-aquatic part of the vegetation of lakes and swamps**.**

Prosobranchiataa Subclass

Family: Thiaridae

M. tuberculata

It is a widely distributed benthic freshwater snail, native to the continents of Africa and Asia. It is widespread on both continents (Clench, 1969) [13]. It has moderate resistance to drought, good tolerance to low levels of dissolved oxygen (DO), and has a low mortality rate. The shells of snails of this genus differ in their shapes, colors of pigment, and even in size, and therefore many shapes can be distinguished (Samadi *et al*., 1999) [38] The results of the current study revealed that the samples collected from the genus *Melanoides* belong to the species *M. tuberculata*, which can be identified by its phenotypic characteristics and its characteristic elongated shell with a regular increase in the size of the coils towards the shell opening. This description was in agreement with Duggan and Al-Waeli (2002). 2014) [4] and he found it It is found at all study stations and in almost all months. The reason for its successful presence is due to the strength of its shell, its tolerance to erosion factors, and its feeding on algae. This result is consistent with (2022) Al-Yacoub *et al*. [7]. Who studied the density of gastropods of the Euphrates River passing through Nasiriyah Governorate in southern Iraq, where the snail *M. tuberculata* recorded the highest density among the other species studied during the collection period. And the study (2022) by Al-Maliky *et al*. [2]. In which the snail *M.turbuclata* recorded a higher density than *M.preaemorsa* recorded in their study of the Euphrates River passing through Basra Governorate**.**

Melanopsis spp.

Species of the genus *Melnopsis*, with shells decorated with various nodular shapes, are widespread in North Africa and the Middle East. They inhabit most water bodies around the world. Most of these species crawl through the mud in search of food and are found associated with *Theodoxus* species in stagnant water containing algae that is one meter deep (Brown, 1994) [10]. Also, species of this genus are widespread in ponds and streams in Iran (Farahnak and Massoud 1996) [19]. A study was conducted in the Levant by Heller *et al*. (2005) [24]. It relied on conchometric shell measurements and specifications for freshwater snails of the genus *Melanopsis* and distinguished 10 species of this genus, five of which were smooth-shelled, including *M. buccinoidea*, *M. ammonis*, *M. dircaena*, *M. khabourensis*, and *M. meiostoma*, and four polygonal-shelled species, which included *M. costata* and *M. germaini*, *M. pachya*, and *M. infracincta*. The fifth type is a hybrid between *M. buccinoidea* and *M. costata*, which is *M.saulcyi*, which has a narrow shell and shorter, more protruding ribs**.**The current study recorded three common species in one environment: *M. nodosa*, *M. buccinodes*, and *M. costata*, and thus it agrees with what was recorded by Mohammad (2014) [29] and Al-Waeli (2014) [4] that these are species belonging to this genus. These types of snails were found prevalent in all study stations, and the reason for their spread and dominance may be due to the hardness and thickness of the shell and its possession of a cover that closes its mouth, thus providing good protection for the snails from drought and predation by other predators such as fish and waterfowl that are unable to crush the strong shell**.**

Family: Viviparidae

B. bengalensis

This species belongs to the Vivparidae family. It prefers calm, fresh waters and is considered a recent immigrant, as it lives in the bottom mud of ponds, swamps, sediments, and the shores of river mouths, and when the water level rises, empty shells float (Plaziat and Younus, 2005) [33]. It is considered one of the largest freshwater snails. Its shell is oval in shape with irregular, variable dark bands on it. The study agrees in description with Al-Waeli (2014) [4]. It is one of the most widespread snails in freshwater and on a large scale in Southeast Asia, as it is found in both stagnant and fast-flowing ecosystems and is used as food by some peoples. It was found in all study stations, but in somewhat small percentages, and this is contrary to what was found by (2021) *et al*. Al-Maliky [1], which recorded the highest density of this conch among the other species recorded in the three stations chosen for their study along the Shatt al-Arab River. It was also recorded as widespread in Mazandaran Province, northeastern Iran, by Mansoorian (2000) [27].

Family: Neritidae

T. jordani

The genus *Theodoxus* includes more than 35 described species. Species are found throughout Europe, western Asia, and northern Africa. Record (2020) Sand *et al*. Fourteen species belonging to the genus *Theodoxus* were previously described, in addition to the registration of three new species to science: *T.gurur*, *T. wesselingji*, and *T. wilkei***.** *T. Jordani* is exceptionally widespread in lakes, canals and estuaries. It was recorded in the Levant, Iraq, parts of the Middle East, and southern Iran (Sands *et al*., 2019) [39] *T. jordani* overlaps with Neritina michonii (Bourguignat, 1852) due to the phenotypic similarity of its shell and their distribution range. It is sometimes difficult for researchers to separate them, so Sands *et al*. (2019) [39] By separating the phenotypic overlap between the two genus using molecular analysis using PCR technology**.**It also overlaps with *T. octagonus* due to the color of their shell and the similar structure of their gill cover, but *T. octagonus*, in its distinctive characteristic, prefers to be present under sediments. It was recorded in the waters of

Basra Governorate by Plaziat and Younis (2005) [33]. It was found in the study stations in somewhat high abundance, as it was found attached to rocks and solid objects. This explains its abundance compared to other species, because most areas are characterized by the presence of stone substrates after a process of drying and filling. Rivers and the spread of stones on the river cliff. The distinctive characteristic of this species is that it has a shell that differs in color and external sculpture. These phenotypic characteristics of the *T. jordani* shell are identical to what was described by Zettle *et al* (2004) [48]. (2004) Amr ans Baker, (2020) Sands *et al*. [39]. In the current study, a companion to the *Melanopsis* snail was found in the same environment, which may indicate the similarity of their environmental requirements, and as a result of their presence in areas far from aquatic plants, it made them prefer to feed on algae instead of aquatic plants**.**There are many biotic and abiotic factors that affected the distribution and environment of snails in the current study in terms of increases and decreases in abundance and fluctuations in appearance between stations and during the months of the study, including water current, temperature, turbidity, transparency, distribution of suspended solids, concentration of ions and gases dissolved in the water, in addition to the biological factors that It is represented by the availability of food, competition, and interaction between predator and prey, as snails are exposed to predation by birds, fish, and rodents (El-Zeiny *et al*., 2021) [18].

Conclusions

1. The biodiversity of snails in the water bodies of Misan Governorate does not differ from what was recorded in previous studies in the rest of the water bodies in southern Iraq**.**
2. The phenotypic characteristics of the complete outer shell can be relied upon to diagnose most types of freshwater snails**.**
3. Some species of snails were widespread as they were found in all stations, including species of the genus *Melanopsis* and species *M. tuberculata*, and species with limited distribution, such as the snail *G. huwaizahensis***.**
4. The disappearance of some important species from a public health standpoint, such as the snail *Bulinus trucatus*, which is an intermediate host for the urinary schistosoma worm**.**

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