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Reconstructing the Global Spread of African Terrestrial Snails: Phylogenomic and Ecological Evidence

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Abstract African terrestrial snails, especially the invasive species of the genus *Achatina*, have brought significant ecological and agricultural problems to the world. This study presents some new advancements in phylogenetic genomics, population genetics, and niche modeling, reconstructs the evolutionary process and diffusion pathways of African terrestrial snails, summarizes their origin in Africa, the differentiation trends of their populations, and also explains how they spread to Asia, Europe, and America through natural diffusion and human activities. This study combined genomic data and climate information to analyze the adaptability and invasion mechanism of this type of snail. This study hopes to provide theoretical support and research ideas for understanding the evolutionary background and environmental influencing factors of African terrestrial snails, as well as how to prevent and control their spread.
Keywords African terrestrial snails; Phylogenomics; Global dispersal; Invasion biology; Ecological niche modeling

1 Introduction

The African terrestrial snail is a kind of invertebrate with a wide variety of species and strong ecological significance. In southeastern Africa, in biodiversity hotspots such as Maputaland-Pondoland-Albany, many of these snails are endemic genera to the region and make significant contributions to the local biodiversity. These terrestrial snails are very important in the native ecosystem, especially in terms of soil nutrient cycling. Their activities can affect some key elements in the soil. The quantity and distribution of terrestrial snails can also serve as an indicator of ecological health status. They are helpful for understanding the changes in the natural environment, such as whether it is a natural succession process or influenced by human activities, as well as for the assessment of biodiversity and soil functions (Perera et al., 2021; Horsák et al., 2024; Wu et al., 2024).

With the global spread of African terrestrial snails, especially the giant African snail (*Lissachatina fulica*), it has attracted attention in many aspects. It is not only an agricultural pest, but also an ecological invasive species and may pose public health risks. The giant African snail has become one of the most invasive species in the world and has currently invaded more than 50 countries. Its spread has led to problems such as the reduction or extinction of local species, intensified competition for ecological niches, and the destruction of crops, causing ecological and economic losses. The invasion of such snails will also make the biodiversity in the soil monotonous, disrupt ecological processes and change the original ecological community structure. It has strong adaptability and a wide ecological range. The impact of climate change on its distribution also makes its diffusion path more complex. Combining phylogenetic genomics and ecological methods, it becomes necessary to conduct in-depth research on how it invades, thereby providing a scientific basis for formulating more effective management countermeasures and policy measures (Sarma et al., 2015; Liu et al., 2020; Teles et al., 2022; Wu et al., 2023; Wu et al., 2024).

This study introduces the evolutionary process and geographical distribution history of key African terrestrial snail groups, analyzes their roles and influences in the native and invasive ecosystems, and also explores the main reasons why these snails were able to successfully invade and how they continuously expand their distribution range. This study hopes to provide some theoretical basis and practical references for the formulation of protection strategies and the control of their global spread risks.

2 Native Distribution and Taxonomic Diversity

2.1 Phylogenetic lineages in Africa

The genus *Gittenedouardia* in South Africa is the one with the most species in the Cerastidae family. This genus is divided into three main phylogenetic branches, and there are obvious deep genetic differentiations among species in different regions. Raphalo et al. (2021) found through molecular analysis that the diversification of this genus mainly occurred from the Miocene to the Pliocene, which might be related to the climate change at that time and the fragmentation of its habitat. Some phylogenetic independent units were also discovered using the species delving method, indicating that there are still many undescribed species in this group and that this group needs to be reclassified and reorganized. Similar studies have also been conducted in the biodiversity hotspot of Maputaland-Pondoland-Albany. Raphalo et al. (2023) conducted a systematic geographic analysis of *Gittenedouardia spadicea* and *Maizania wahlbergi* and discovered clear phylogenetic branches and genetic isolates, which were related to past climate events. In West Africa, there are at least 20 species in the Philinidae family. Malaquias et al. discovered hidden species diversity in their molecular research in 2017, and there are obvious biogeographic fractures near the Cape Verde Islands and the Sahel upwelling system.

2.2 Biogeographic patterns in native ranges

The research by Raphalo et al. (2021) and Raphalo et al. (2023) found that Gittenedouardia in South Africa mainly lives in fragmented areas of some African temperate forests and Indian Ocean coastal woodlands, and their diverse patterns reflect the history of past climate change and the shrinking of forest areas. The Nyungwe Forest in Rwanda is a forest "refuge" that has existed since the Pleistocene epoch. Here, the species richness of terrestrial snails is extremely high, with 102 recorded species. It is currently one of the most diverse terrestrial snail communities known in Africa. The high diversity of this area lies in its proximity to historical forest remains, significant changes in terrain and altitude, and rich habitat differences. High β -diversity indicates that there are significant species differences in different regions and the species turnover among communities is obvious (Boxnick et al., 2015). There are not many species of terrestrial snails on the tropical continents of Africa, and they are even rarer in desert and semi-desert areas. However, on islands like Madagascar, there are more species and larger sizes of terrestrial snails, which may be related to the lower hunting pressure, less competition and biogeographical isolation on the islands. Malaquias et al. 's research in 2017 indicated that in West Africa, some geographical faults and environmental barriers also affected the distribution patterns of these snails.

2.3 Morphological and behavioral traits of note

On the mainland, many operculated terrestrial snails are relatively small in size. On some islands, these snails are actually larger in size, possibly because the pressure of predation and competition on the islands is smaller and the ecological space is more free. In the Nyongwe Forest, different species respond differently to environmental conditions. Most snails are distributed in clusters, but only a few species have obvious ecological groups, indicating that they have different preferences for the microenvironment and there is an ecological specialization phenomenon (Boxnick et al., 2015). Raphalo et al. (2023) found that terrestrial snails living in forests usually have weak diffusion ability and limited gene exchange, which can easily lead to genetic isolation and the formation of local endemic species. Adaptive characteristics and historical climate change have jointly influenced the current diversity and distribution pattern of African terrestrial snails.

3 Phylogenomics of African Terrestrial Snails

3.1 Mitochondrial and Nuclear Genome Studies

Guo et al. (2019) and Liu et al. (2020) have successfully assembled the chromosome-level genomes of several important African terrestrial snail species, such as the giant African snail (*Achatina fulica*) and *Achatina immaculata*, providing basic resources for phylogenetic research. The commonly used genes in the research include mitochondrial genes (such as COI and 16S rRNA) and nuclear gene markers (such as ITS2 and 28S rRNA), which are used to analyze the genetic diversity, population structure and evolutionary history of different populations (Moussalli and Herbert, 2016; Cole et al., 2019; Raphalo et al., 2021; Vijayan et al., 2022; Raphalo et al., 2023). Vijayan et al. (2022) demonstrated in their study that mitochondrial DNA analysis of the invasive populations of giant African snail in Asia showed very low genetic diversity, and their haplotypes were very similar to those of the populations on Indian Ocean islands, indicating that these snails were the result of recent rapid spread. In terms of nuclear genomics, the whole-genome sequencing and annotation work conducted by Guo et al. (2019) and Liu et al. (2020) on *A. fulica* identified more than 23 000 protein-coding genes. The genome was highly complete and the functional annotations were also comprehensive, laying a foundation for future comparative genomic studies and adaptive evolution analyses.

3.2 Phylogenetic relationships and species delimitation

Cole et al. (2019) and Raphalo et al. (2021) found in their research on Gittenedouardia and Chondrocyclus that they have deep genetic structures, including multiple monophyletic lineations, which often correspond to distinct physical features or ecological habits. Researchers have also discovered many hidden diversifications by using species delisting methods like PTP and STACEY, proving that there are a large number of undescribed evolutionary units in this group and indicating that this group urgently needs to be reclassified and reorganized (Moussalli and Herbert, 2016; Cole et al., 2019; Raphalo et al., 2021). Molecular data have even prompted the redivision of certain genera or the proposal of new genera and subfamilies. In the studies of Moussalli and Herbert (2016) and Salvador (2022), the genus *Nata* was redefined, and the Trachycystinae subfamily was elevated to an independent taxonomic rank within the Charopidae family.

3.3 Divergence dating and evolutionary origins

The giant African snail (*Achatina fulica*) and its closest related species diverted approximately 182 million years ago, while the evolutionary lineage to which it belongs from *A. immaculata* underwent a whole-genome replication event approximately 70 million years ago. This time point coincides exactly with the Cretaceous-Tertiary extinction event (Guo et al., 2019; Liu et al., 2020). Raphalo et al. 's research in 2021 suggests that species diversification in the genus Gittenedouardia occurred between the Miocene and Pliocene, mainly influenced by climate fluctuations and ecological environment changes at that time.

The formation times of multiple branches coincided with these periods of change. Salvador (2022) discovered that in the Charopidae family, some groups of African terrestrial snails are located at the base of the phylogenetic tree, suggesting that they may have a very ancient origin, even dating back to the disintegration of Gondwana.

4 Mechanisms and Routes of Global Spread

4.1 Natural dispersal barriers and limits

The African terrestrial snail, especially the giant African snail (*Lissachatina fulica*), has a strong climate adaptability and can expand its ecological niche and enter areas outside its native habitat. However, its natural diffusion is still restricted by some environmental factors, such as high temperatures and less rainfall. In the central region of India, its invasion risk is relatively low due to unsuitable climatic conditions (Sarma et al., 2015; Wu et al., 2023). Wu et al. 's research in 2023 indicates that this type of snail lives on land and has limited mobility. It is very difficult for them to spread over long distances on their own. Without human intervention, the possibility of large-scale spread is very small.

4.2 Human-mediated introduction pathways

African terrestrial snails have been introduced to some countries for breeding as edible snails (escargot). In Brazil, due to the promotion of commercial breeding projects, some snails escaped into the natural environment and established populations in the wild. International trade has also provided opportunities for their proliferation. Trade activities such as timber transportation have opened up channels for their repeated invasions into new regions. In Asia and the United Arab Emirates, Vijayan et al. (2020) and Vijayan et al. (2022) also found evidence related to these transmission routes in genetic diversity.

In Cuba, the spread of the giant African snail (*L. fulica*) is also related to the religious rituals of the Uruba religion, indicating that cultural behaviors can also promote their diffusion in local areas (Vázquez et al., 2016). Some people keep them as pets and later abandon them, or release the snails back into the wild due to commercial failures, which also accelerates their establishment and spread in new areas.

4.3 Historical case examples of introduction

Sarma et al. (2015) and Vijayan et al. (2022) found that the earliest record of the introduction of the giant African snail (*L. fulica*) can be traced back to 1847, and it has since spread in multiple regions through some human operations or accidental events. In the Andaman and Nicobar Islands, due to the suitable climate and frequent trade ties, this species can easily settle and spread. In the 1980s, the giant African snail was used for commercial breeding of edible snails, and as a result, it established populations in at least 23 states (including some cities and nature reserves). It was first discovered in Havana, Cuba in 2014.

A study by Vázquez et al. in 2016 indicated that its spread was related to the religious rituals of the Uruba religion, once again demonstrating the crucial role of human activities in its invasion process. The genetic studies of Vijayan et al. (2020) and Vijayan et al. (2022) also found that there were multiple independent invasion events in Asia, and they had a relatively high haplotype diversity, which might be related to the frequent local trade and commodity flows.

5 Invasive Potential and Ecological Impact

5.1 Host ecosystem disruption

The African terrestrial snail, especially the giant African snail (*Lissachatina fulica*), has a strong ability to adapt to the climate and a fast reproduction rate. It can live in various environments and is regarded as a species that is prone to invasion (Sarma et al., 2015; Rasal et al., 2022; Wu et al., 2023). Its introduction and rapid spread will cause many problems to the local ecology. It will compete with local mollusks for resources, damage horticultural plants and crops, and also change the structure of plant communities (Figure 1) (Cazarin-Oliveira et al., 2022; Gabetti et al., 2023; Abdulla, 2024). In some severely affected areas, its population density can be as high as over 500 per square meter, causing serious ecological imbalance and posing a threat to local biodiversity (Sarma et al., 2015; Cazarin-Oliveira et al., 2022; Makherana et al., 2022).

Figure 1 Giant African snail (*Achanita fulica*) infestation observed in Laamu Atoll (Adopted from Abdulla, 2024)

5.2 Disease transmission and human health

The African terrestrial snail is an important vector for a variety of zoonotic parasites, especially *Angiostrongylus cantonensis* and *A. costaricensis*, which respectively cause eosinophilic meningoencephalitis and abdominal angiostrongylasis. These snails can also serve as intermediate hosts for many fluke parasites, posing a higher risk to human and animal health in the invaded areas. As the population of African terrestrial snails continues to spread to cities and urban-rural fringe areas, the opportunities for human contact with them are also increasing, posing a threat to public health. It becomes very necessary to conduct continuous monitoring and take necessary public health intervention measures (Cazarin-Oliveira et al., 2022; Gabetti et al., 2023; Outa et al., 2024).

5.3 Impact on biodiversity and soil function

The research conducted by Cazarin-Oliveira et al. in 2022 and by Gabetti et al. and Wu et al. in the same year, that is, in 2023, indicates that the invasion of African terrestrial snails has exerted competitive pressure on native mollusks, leading to a reduction in the number of native species and even their replacement. Their diet is very diverse. They can consume more than 500 kinds of plants, causing severe damage to local vegetation and crops and accelerating the decline of biodiversity (Cazarin-Oliveira et al., 2022; Wu et al., 2023; Abdulla, 2024). These snails may also alter the physical and chemical properties of the soil and nutrient cycling, interfering with ecological processes in the soil by affecting organic matter input and microbial activities. Existing data indicate that they may have a profound impact on the functions of soil ecosystems (Sarma et al., 2015; Makherana et al., 2022).

6 Environmental Niche Modeling and Climate Suitability

6.1 Habitat preferences and environmental limits

African terrestrial snails have a strong ability to adapt to the environment, which is helpful for their successful transition from an aquatic lifestyle to a terrestrial one. The genomic research by Guo et al. (2019) and Liu et al. (2020) found that they have obvious adaptive evolution in some gene families related to respiration, summer sleep and immune defense, enabling them to survive in the changeable terrestrial environment. The systematic geographic analysis of terrestrial snails in the forest areas of South Africa conducted by Raphalo et al. in 2021 and Raphalo et al. in 2023 revealed that habitat fragmentation and climate fluctuations from the Miocene to the Pliocene, such as rainfall changes and forest shrinkage, jointly affected their genetic structure and species differentiation. Many species of snails show a strong dependence on microhabitats and have limited diffusion capabilities, and are highly sensitive to environmental changes and habitat loss (Cole et al., 2019; Horsák et al., 2024).

6.2 Predictive models for spread under climate change

Horsák et al. (2024) found in their study of the *Vertigo* genus snails that soil moisture is a key ecological factor, and their niche conservation limits the expansion of their distribution range and phylogenetic differentiation (Figure 2). Historically, the reduction events of forest biota have prompted the evolutionary differentiation of some snail lineage (Raphalo et al., 2021). Ecological models predict that species with little change in ecological niches or weak diffusion capabilities are more likely to be affected in the context of future climate change. While snails like *A. fulica*, which have a wide range of adaptability, are more likely to expand their distribution range in climate change (Liu et al., 2020; Horsák et al., 2024).

6.3 Anthropogenic drivers in expansion

The expansion of the giant African snail (*A. fulica*) and other invasive species largely depends on international trade, especially the transportation of agricultural products and timber. Vijayan et al. (2020) and Vijayan et al. (2022) found that these activities caused multiple introduction events and also led to the emergence of new haplotypes in the invaded areas. Outa et al. demonstrated in their 2024 study that some artificially disturbed environments, such as reservoirs and fragmented habitats, also provide conditions for their settlement and spread, often at the cost of the loss of native species. Snails in invasive areas often exhibit high genetic diversity, which is generally related to multiple introductions and continuous artificial dissemination.

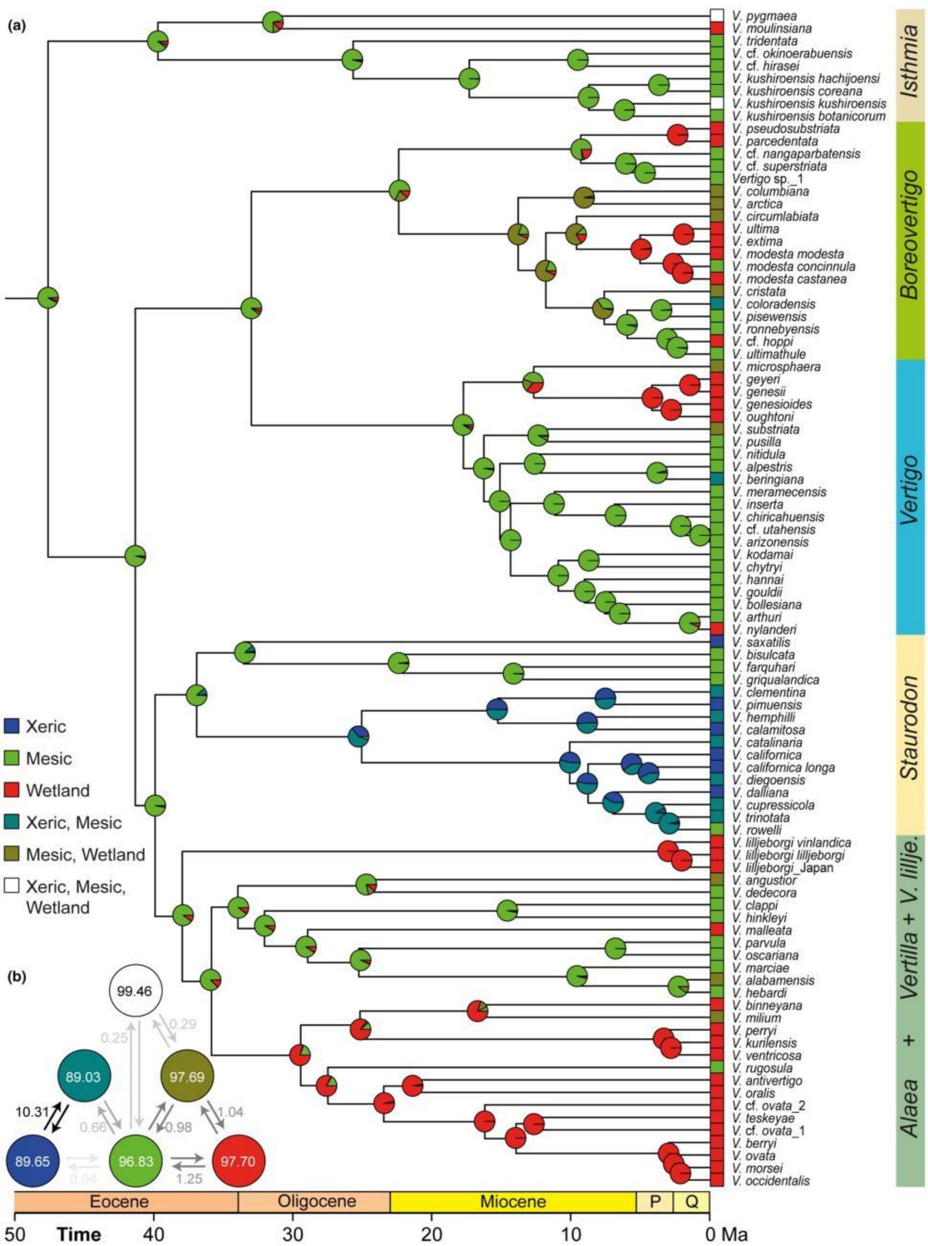

Figure 2 (a) Estimation of ancestral moisture-related ecological niches along the *Vertigo* phylogeny with a six-state discrete character using the best-fit symmetric transition model. (b) Graphical representation of the moisture niche transition matrix. Transition frequencies are indicated with greyscale arrows (the darker the more frequent), illustrating that only 4 out of 15 possible transition types are regularly observed (Adopted from Horsák et al., 2024)

7 Case Study: Global Dispersal of *Achatina fulica*

7.1 Introduction history and routes

The giant African snail (*Achatina fulica*), native to East Africa, has now become one of the most invasive terrestrial mollusks in the world and is currently present in at least 52 countries in Asia, the Pacific region, the Caribbean Sea and the Americas. Global diffusion began in the 19th century and experienced many significant introduction events in the 20th century. Vijayan et al. (2022) found that most of these spreads were caused by trade, accidental transportation, and human activities such as the failure of edible snail farming in Brazil. Both genetic and historical data indicate that several islands in the Indian Ocean were the earliest sources of most non-native populations, which later spread to regions such as Asia and the Americas (Ayyagari and Sreerama, 2017). Countries like India and the United Arab Emirates have been confirmed from trade data and multiple different haplotypes emerging in these regions, and multiple introduction events have been confirmed (Vijayan et al., 2022).

7.2 Genomic tracing of populations

Genetic studies conducted by Guo et al. (2019), Dumidae et al. (2021), and Castillo et al. (2025) using mitochondrial markers have shown that the genetic diversity of most invasive populations is very low, and they are usually dominated by only a few major haplotypes (such as type C), which have been widely distributed in Asia, the Pacific, and the Americas. In India, the research by Ayyagari and Sreerama (2017) and Vijayan et al. (2022) identified eight haplotypes, some of which were newly identified but all closely related to the populations of Indian Ocean islands. In Thailand and Colombia, only one or a few haplotypes were dominant, indicating that the populations in these regions experienced the primal effect, and it might also be due to fewer introduction events (Guo et al., 2019; Castillo et al., 2025). The chromosome-level genomic assembly of giant African snail (*A. fulica*) has been completed at present, providing important data resources for in-depth research on population genetics and adaptive characteristics (Guo et al., 2019; Toma et al., 2023). The genomic data in Toma et al. 's 2023 study also revealed that *A. fulica* has evolutionary advantages in rapid growth and environmental adaptation, such as stronger metabolic pathways, which are helpful for its survival in different environments.

7.3 Ecological consequences and control measures

Silva et al. (2022) and Castillo et al. (2025) hold that the invasion of the giant African snail (*A. fulica*) would lead to the replacement of local mollusk populations, damage crops and gardens, and spread parasites like *A. cantonensis*, posing a threat to public health. In urban and agricultural areas, the population density of this kind of snail is very high, which will make these problems more serious (Silva et al., 2022). The prevention and control measures in different regions are not uniform at present. Common methods include national management plans, public education, and targeted clearance actions, etc. The new genomic study by Toma et al. (2023) provides some information about its metabolic and adaptive mechanisms. These data are helpful for formulating more effective prevention and control strategies, especially for intervening in its growth and reproductive pathways (Figure 3). Guo et al. (2019) and Castillo et al. (2025) proposed that most invasive populations have only a few haplotypes, and conducting genetic monitoring is beneficial for tracking their transmission paths and strengthening invasion management.

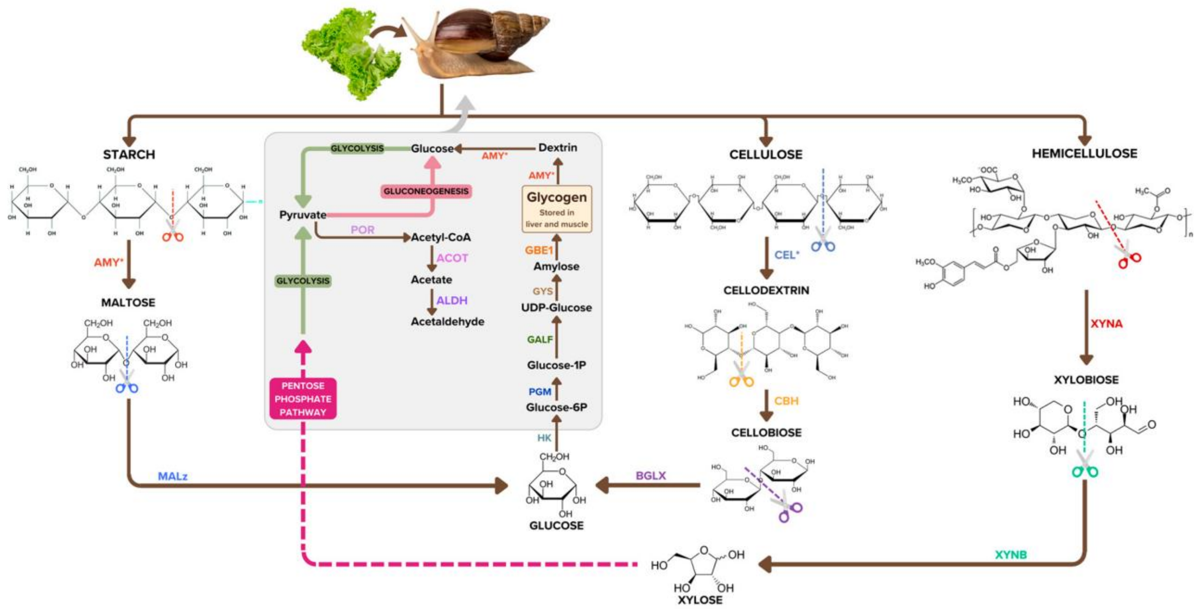

Figure 3 Starch, cellulose, hemicellulose, and glycogen degradation pathways of *Achatina fulica* were reconstructed from our bioinformatic analysis to perform metabolic pathway prediction on the basis of the giant snail genome (Adopted from Toma et al., 2023)

Image caption: The pathways include enzyme names in abbreviation, metabolite intermediates with some structural representation, and arrows determining the reaction direction. Polysaccharide degradation, glycolysis, gluconeogenesis, and pentose phosphate pathways were represented by brown, green, pale pink, and bright pink arrows. Asterisks (*) indicate the enzymes with high copy numbers (Adopted from Toma et al., 2023)

8 Genomic Adaptation and Local Evolution

8.1 Signatures of selection in invasive populations

The genomic study of African terrestrial snails (particularly *Achatina immaculata* and *Achatina fulica*) conducted by Liu et al. in 2020 found that genome-wide replication (WGD) was very important in their adaptive evolution and the formation of invasion capabilities. The WGD event occurred approximately 70 million years ago. It provides a basis for the expansion of some key gene families. These genes are related to respiration, summer sleep and immune defense, and are very important for snails to adapt to various terrestrial environments. Some gene families related to mucus secretion, gas exchange and antioxidant stress have undergone significant expansion or repetition, indicating that these functions are strongly influenced by natural selection during the invasion process. Toma et al. (2023) hold that the copy numbers of digestive enzyme genes such as amylase, cellulase, and chitinase have also significantly increased, which is helpful for them to obtain nutrients more effectively and grow rapidly, thereby enhancing their invasion success rate.

8.2 Local adaptation in introduced ranges

In the newly introduced regions, the giant African snail (*A. fulica*) and its close relatives may have undergone locally adaptive evolution. Guo et al. (2019) and Nyu (2024) demonstrated in their research that the existing chromosome-level genomic data provide a more accurate tool for studying population genetic differences and are helpful in identifying which genetic variations are related to environmental adaptation. Aristide and Fernandez (2023) discovered that some gene families related to metabolism, regulation of water balance and defense systems have expanded, suggesting that snails may have undergone a similar gene amplification process in adapting to life on land. This is considered a convergence or parallel evolution mechanism. Genes related to pathways such as carbohydrate metabolism have also changed. This genomic "innovation" is beneficial for their successful population establishment in different environments and may have also promoted their rapid adaptation in new places (Aristide and Fernandez, 2023; Toma et al., 2023).

8.3 Hybridization and genetic introgression

Direct evidence of hybridization or genetic infiltration among African terrestrial snails is still scarce at present, but studies from other terrestrial snails have provided some clues. Chueca et al. found in their 2021 study on the genus *Candidula* that gene flow has been constantly occurring during the species differentiation process of these snails. Some genes that have been positively selected have promoted the differentiation of reproductive isolation and ecological adaptation among species. African terrestrial snails may also have a similar situation. This genetic exchange may be helpful for them to adapt to new environments more quickly, generate new genotypes in invasive populations, and improve their adaptability.

9 Conservation and Biosecurity Implications

9.1 Threats to native mollusk diversity

African terrestrial snails, especially invasive species like the giant African snail (*Lissachatina fulica*) and the *Archachatina marginata*, have strong adaptability, can tolerate different climatic conditions, and they can self-fertilize and reproduce without finding a mate. This enables them to establish populations quickly in new places and spread rapidly (Gabetti et al., 2023; Wu et al., 2023). Perera et al. (2021) found that in new environments, they often compete with local snails for resources and even replace local populations. For instance, in the MPA hotspots of South Africa, many mollusks there are endemic species. The arrival of invasive snails may cause the partial extinction of some local species. Studies by Gabetti et al. in 2023 and Outa et al. in 2024 have shown that these snails can also spread parasites that are harmful to humans and animals, increasing health risks. Outa et al. (2024) also found that in some places, there was even a situation of "parasite spillover - reflux" (the repeated spread of parasites between snails and native animals), which affected the health of the ecosystem.

9.2 Policy frameworks for prevention and response

Gabetti et al. (2023) demonstrated in their research that both wild and farmed snail populations need to be monitored over the long term and undergo health checks to identify problems early and prevent them from taking root in new areas. Perera et al. (2021) suggested that the priority of local conservation be set based on the actual species distribution data and the areas where endemic species are concentrated. In places like the MPA area in South Africa where there are many rare species, special management measures can be arranged. Global trade is an important way for the spread of these snails, and cooperation among countries is also very important. The research by Vijayan et al. (2022) and Outa et al. (2024) found that their invasion was not a single route but had multiple transmission paths. Panisi et al. (2024) hold that policies should also take into account the actual lives of local people. Some communities use these snails as food or an economic source. When formulating management measures, a balance should be struck between ecological protection and social and economic benefits.

9.3 Public engagement and education strategies

Making the public aware of the possible ecological and health risks brought by invasive snails is helpful for establishing broader social support and promoting the smooth progress of monitoring and prevention and control efforts (Gabetti et al., 2023; Panisi et al., 2024). Invasive snails have economic value in places like São Tomé, where many people rely on them for a living. Intervention measures in these areas require the joint participation of environmental protection departments and multiple social sectors, with special attention given to vulnerable groups who make a living by collecting and selling snails (Panisi et al., 2024). Responsible pet-keeping behavior can be promoted through educational publicity to reduce the release of invasive snails into the wild. It can also encourage the public to actively report the discovery of snails, making it easier to achieve early warning and rapid response (Gabetti et al., 2023).

10 Concluding Remarks

The African terrestrial snail has spread rapidly around the world and has now settled in more than 50 countries. The genetic diversity of these invasive snails is not high. Many genotypes (haplotypes) found in Asia and West Africa have the same ancestor, suggesting that they may be the result of multiple introductions and are mostly related to human activities and trade. *L. fulica* has a strong environmental adaptability and can survive in places with more complex climates than its native habitat. This is also an important reason for its rapid expansion. This snail has undergone a whole-genome replication during its evolution, which may make it easier to survive in terrestrial environments. Some other African snails of the genus *Cornu aspersum* and *Bellamya* also have a similar history of transcontinental spread, which is related to climate change and geological events.

At present, there are still quite a few problems unsolved. Genetic sampling of them in their original distribution area in East Africa is not comprehensive enough, which makes it difficult to figure out how they spread and where they originally came from. Research on the real ecological impact of these invasive snails in the new environment, including whether they spread parasites and whether they threaten local animals, has not been in-depth enough and may have been underestimated. The fundamental mechanisms of why they can adapt to different places so quickly and why they have such strong adaptability are also unclear, and there are not enough studies in terms of genes and physiology. It is necessary to conduct comparative studies among different continents and snail species to solve these problems, so as to clarify how climate change and environmental change affect the spread and evolution of these snails, and also better explain why they have successfully invaded on a global scale.

To effectively deal with the global spread of African terrestrial snails, it is necessary to establish a unified international monitoring system. This system should be able to combine genetic monitoring with ecological risk assessment. Especially in their places of origin and newly invaded areas, more genetic sampling should be carried out in order to track their transmission routes and discover new genetic types (haplotypes) earlier. The monitoring content should also include the possible ecological impacts they may bring, such as whether some parasites will turn around to infect local animals (backflow), or cause more disease transmission. An efficient management system should focus on strengthening aspects such as early problem detection, rapid response, and enhanced public publicity and education. Making full use of the research results of genomics and ecology can also control the spread and harm of these snails on a global scale to the greatest extent.

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Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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