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# Biology, Ecology, and Significance of Terrestrial Snails: A Comprehensive Review

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## ABSTRACT

Snails belonging to the Phylum Mollusca, class Gastropoda, are the Pulmonates that form the second most successful phylum across the world. They constitute simple structures with a fully developed head and a foot that performs all the essential functions for their survival. The shells serve a variety of purposes, including the identification, classification, and aging of species. Although they are distributed globally, several environmental factors, such as climate, season, vegetation, and soil, affect their distribution. They have adapted themselves to these environmental changes by allowing alterations at the physical, behavioral, and cellular levels. Snails serve as herbivores, fungivores, detritivores, predators, prey, and intermediate hosts. They cause a huge economic loss by threatening agricultural and horticultural crops. They possess significant medical importance because they are valued for their antioxidant, anti-inflammatory, and anti-cancer properties. They serve an important role in the transmission of parasitic diseases, where some countries use them as an important food source. Extensive research has been done on the identification and investigation of the abundance, diversity, and distribution in different ecosystems. This review provides an overview of their characteristics, distribution, feeding habits, behavior, and significance of terrestrial snails.

## INTRODUCTION

After the phylum Arthropoda, the phylum Mollusca consists of the largest taxon among the other taxa in the kingdom Animalia containing over 1,00,000 species known today (Biessy *et al.,* 2019 & Rafiq *et al.,* 2021). Eight classes encompass the phylum Mollusca (Ab Hamid *et al.,* 2021), of which the class Gastropoda and Bivalvia comprise 95% of the molluscs found today (Biessy *et al.,* 2019). Class Gastropoda is the largest class of phylum Mollusca (Sundalian *et al.,* 2021) which comprises approximately 80,000 species residing on the earth today (Hollyman *et al.,* 2018). They have been further classified into two major groups i.e., Pulmonates and Caenogastropoda (Ab Hamid *et al.,* 2021), divided into marine water snails, freshwater snails, land snails, slugs (Biessy *et al.,* 2019) and limpets (Sundalian *et al.,* 2021). About 25,000 defined species of known gastropods belong to the Pulmonates including the snails and slugs (Teasdale 2017), as they can breathe through their lungs. The Caenogastropoda usually includes marine snails, as they can breathe through their gills (Ab Hamid *et al.,* 2021).

Snails are a diverse group of invertebrates inhabiting the earth, being the second largest group with successful existence throughout the world (Altaf and Qureshi 2017 & Kakar *et al.,* 2023) except in Antarctica (Proios *et al.,* 2021). A survey on the snail population showed a total of 1,222 terrestrial and 708 freshwater molluscs found around the globe (Zinab *et al.,* 2023 & Altaf and Qureshi 2017). They are facing a sudden decline in their number at a global level (Amr *et al.,* 2018). Some of the factors that may cause the endangerment of gastropods include loss of habitat, habitat degradation, climatic fluctuations, and the introduction of invasive species (Kakar *et al.,* 2023). There is a lack of documentation on the extinction of snails and any practice for their conservation (Zinab *et al.,* 2023).

Being invertebrates, the body of snails is not very complex instead consists of a simpler head-foot portion. This portion serves many distinct functions like feeding, locomotion, and sensory purposes (Pissia *et al.,* 2021). They contain a single shell with striking banding patterns and shapes (Pissia *et al.,* 2021 & Ab Hamid *et al.,* 2021).

Shells are intensely variable in size, shape, and color. The morphology of the shell is interlinked with genetic adaptation and phenotypic plasticity as well (Verhaegen *et al.,* 2018).

The snails are found in a diverse range of habitats inhabiting marine, freshwater, and terrestrial regions across the world. They tend to inhabit areas with high humidity and hence are called nocturnal in nature (Zinab *et al.,* 2023). Several factors have been known that could affect its distribution and diversity including temperature, climate, vegetation, soil, rainfall, and anthropogenic activities (Murtaza *et al.,* 2020; Kakar *et al.,* 2023). The reason for the vast distribution of snails is due to their high adaptability to a variety of ecosystems (Kakar *et al.,* 2023). The snails feed on a variety of agricultural and horticultural crops relying on the bark of trees, green vegetation, seedlings, herbaceous plants, and fruit trees as they are herbivorous in nature. They have also been reported to consume other live organisms like nematodes, other snails etc., portraying themselves as a predator (Murtaza *et al.,* 2020; Zinab *et al.,* 2023; Kakar *et al.,* 2023). They exhibit a variety of behaviors like physiological, behavioral, morphological, and cellular adaptations (Schweizer *et al.,* 2019). They do not exhibit active dispersal because they have a sedentary nature (De Roma *et al.,* 2017, Proios *et al.,* 2021). Due to their high adaptability, they tend to shift themselves from one place to another where they grow in larger numbers (Gabr *et al.,* 2023).

Snails, the tiny creatures inhabiting different ecosystems, play a very crucial role in the well-being of human beings. These species are agriculturally important as they are known to be pests of many crops and cultivation (Murtaza *et al.,* 2020; Rafiq *et al.,* 2021; Gabr *et al.,* 2023; Altaf *et al.,* 2017). The medicinal importance of snails is exhibited by a variety of features, like their healing property, their anti-cancerous nature, their antioxidant properties, and their role in providing well-being to humans (Radwan *et al.,* 2020; Greistorfer *et al.,* 2020; Pissia *et al.,* 2021). Due to its high proteinaceous nature, low-fat content, presence of different minerals, and minimum amount of lipids, many countries are using snail meat as a delicacy in their regular diet (Pissia *et al.,* 2021; Rafiq *et al.,* 2021). They also have a role in the transmission of a variety of diseases by acting as the intermediate hosts of several parasites (Gabr *et al.,* 2023; Gondal *et al.,* 2020; Zinab *et al.,* 2023).

The methodology of morphological identification of snails has a limitation. There may arise some kind of intraspecific complications in identifying the closely related species within the snails. So, the malacologists are focusing on other methods to provide ease in the identification of related species and remove all these gaps for better identification, even if the snails exhibit phenotypic plasticity or divergence. To resolve all these gaps, a variety of new approaches are being applied. Biochemical and molecular analysis has emerged as an exciting approach that serves to identify closely related species with more precision and clarity (Borland and Kading 2021, Ab Hamid *et al.,* 2021).This review focuses on a general overview of all major aspects of gastropods, particularly terrestrial snails.

**DESCRIPTION**

Snails exhibit a diverse range of colors, shapes, and sizes. Their size ranges fall between less than 1mm to 1m in length (Ab Hamid *et al.,* 2021). One of the biggest snail species is the Giant African Land Snail, commonly known as the Tiger Snail can grow up to 30 cm in length (Onyishi *et al.,* 2018). They possess a single heavy shell with a variety of shapes, coloration, and banding patterns (Ab Hamid *et al.,* 2021). They consist of a muscular foot that assists in the crawling of the snails, a fully developed head with two pairs of tentacles (Ng *et al.,* 2013), and a pair of eyes (Kakar *et al.,* 2023). Their body parts are adapted for various functions including feeding, sensory, and locomotion. They have several systems including the respiratory, digestive, circulatory, and reproductive organs encompassing the visceral mass part (Pissia *et al.,* 2021). The snail has another portion of its body called the periostracum, which outlines the surface of the shell (Hirano *et al.,* 2019). The foot portion is used as an edible consisting of the collar and a fraction of the mantle. The internal organs are associated with the mid gut joining the digestive part (Pissia *et al.,* 2021).

**SHELLS**

The shell of gastropods is made up of calcium carbonate which is also a main constituent of most of the shells (Hollyman *et al.,* 2018). The shell surface is covered by a thin layer of chitin called periostracum (Hirano *et al.,* 2019). The size of the shell can be impacted by the temperature (Altaf and Qureshi 2017). The shells of the snails have growth rings over them which serve to determine the age of the snail. The measurement of the shell's lip also provides insight into the age of the snail (Hollyman *et al.,* 2018). The tremendous variations in the shell morphology are due to genetic adaptation and phenotypic plasticity. It is concerned with many of the biotic and abiotic factors like rate of flow, water depth, risk of predation, and parasitism (Verhaegen *et al.,* 2018).

**IDENTIFICATION CHARACTERS**

The classification and identification of gastropods, especially snails have been carried out for the last two decades mostly on morphological and conchological bases (Altaf and Qureshi 2017, Aksenova *et al.,* 2018). Afterward, the anatomical studies of genitalia, characteristics of the shell, and the color of the mantle have also served as an important aspect in the identification of snails (Aksenova *et al.,* 2018; Bashê and Al-Qassab, 2024). However, due to the phenotypic plasticity shown by freshwater molluscs, the researchers now do not solely rely on the morphological or conchological basis. The molecular and biochemical characteristics also play a significant role in the identification and classification (Altaf and Qureshi 2017). Several studies have been made for the identification of land snails based on their conchological characteristics including the texture of the shell, the number of whorls, the coiling of the shell either clockwise or anticlockwise, the shape of the shell, the color of the shell, shape of the aperture, position of aperture, tentacles and its numbers and shape, eye position, presence or absence of operculum, height, and diameter of the snails (Altaf *et al.,* 2017, Murtaza *et al.,* 2020, Kakar *et al.,* 2023, Rafiq *et al.,* 2021, Zinab *et al.,* 2023). Recently, the

identification and classification of snails have been brought about by molecular analysis, as it has cleared the ambiguities relating to the variations in interspecific and intraspecific levels (Aksenova *et al.,* 2018).

## DISTRIBUTION AND HABITAT

Snails are widely distributed in a variety of habitats throughout the world and hence are known as cosmopolitan (Gondal *et al.,* 2020). These species have not been reported from Antarctica (Proios *et al.,* 2021). These habitats include freshwater, marine water, land (Murtaza *et al.,* 2020), and brackish water (Ab Hamid *et al.,* 2021). Several species of snails have been observed in arid regions, semi-arid regions, and Mediterranean regions (Schweizer *et al.,* 2019). Most of the land snails are known to reside on land dispersed in a variety of ecosystems including deserts (Amr *et al.,* 2018), grasslands, wetlands, forests (Kakar *et al.,* 2023), marshes, swamps, and mountainous regions (Gondal *et al.,* 2020). They are known to be found in those places which have relatively high humidity, dwelling towards the damp and shady areas of a region (Murtaza *et al.,* 2020 & Onyishi *et al.,* 2018). They have also been seen in many anthropogenic sites like urban parks and garbage (Faiz *et al.,* 2020). Snails have also been reported from fields of chalk and limestone at higher altitudes, and gardens and humid parks living in alkaline and calcareous soils. They have not been reported in deciduous or coniferous forests (Faiz *et al.,* 2020). Most of the snails live under the rocks, in the crevices, ditches, and on the plants (Gondal *et al.,* 2020). Some of the snail species have been found in areas near human sites including parks, garbage, cemeteries, and meadows (Faiz *et al.,* 2020).

## FACTORS AFFECTING THEIR DIVERSITY AND DISTRIBUTION

The diversity of snails is largely influenced by changes in climate and variations in season. Some of the climatic factors that cause excessive changes in the diversity and distribution of snails are temperature, humidity (Murtaza *et al.,* 2020), pattern of precipitation (Kakar *et al.,* 2023), topography, hydrography, and biological factors (Gondal *et al.,* 2020). There are a few more factors that are responsible for the distribution and diversity of land snails including soil, type of vegetation, and anthropogenic activities (Kakar *et al.,* 2023). The rainy season is considered the most favorable season for the abundance and diversity of snails (Gondal *et al.,* 2020).

## FEEDING HABITS

Land snails are usually classified based on their feeding habits as herbivores, fungivores, detrivores (Zinab *et al.,* 2023), and predators as well (Kakar *et al.,* 2023). Land snails have been known to cause severe damage to a variety of agricultural and horticultural crops (Murtaza *et al.,* 2020). They have been reported to attack soft vegetables, fruits, flowers (Kakar *et al.,* 2023), green vegetation, and young seeds directly. They tend to live on plants by eating the bark of a tree (Murtaza *et al.,* 2020), fungi, and algae (Altaf and Qureshi, 2017). They not only rely on plants for food but also help in the growth of plants. During the growing or sowing season, they had also been related to ingesting the roots, seeds, and tubers of the growing plant (Kakar *et al.,* 2023). They have been reported to feed on various fruit plantations like avocado, citrus (Murtaza *et al.,* 2020), and herbaceous living plants (Altaf and Qureshi, 2017). As they are detrivores in nature, they rely on both living and non-living plants (Murtaza *et al.,* 2020) and dead and decaying organic matter (Altaf and Qureshi, 2017). They also live a predatory lifestyle by feeding on live or dead snails, empty shells of snails, nematodes, animal manure, remains of animals, and even scraping and scratching the cement or rocks (Murtaza *et al.,* 2020).

## BEHAVIORS

They exhibit extrinsically unique behaviors. They are usually sessile, displaying extremely little movement (De Roma *et al.,* 2017), and are not considered to show active dispersion (Proios *et al.,* 2021). Land snails can move from one place to another as they can withstand environmental transitions and can grow and reproduce in larger numbers (Gabr *et al.,* 2023). They show various adaptations during the daytime. They tend to climb up or live in a burrow (Kakar *et al.,* 2023) or live in the form of clusters (Schweizer *et al.,* 2019). It has been noticed that about 90% of the snails live above the soil, especially in topsoil (Altaf and Qureshi 2017). They not only act as predators but also as prey to many animals like small mammals, amphibians, birds, and reptiles including snakes, arthropods, rodents, and humans (Rosales *et al.,* 2020). The diversity of snails can be found in the rainy season. They have a shorter life span (Kakar *et al.,* 2023) and they may face a major risk of extinction due to their smaller size (Salvador, 2019). Snails have a gland present on the foot that secretes mucus. This mucus serves a lot of purposes including locomotion, feeding, reproduction, and as a defense against predators (Greistorfer *et al.,* 2020 & Pissia *et al.,* 2021). The snails usually use the air-borne or water-borne chemicals released from the tail mucus to locate their true mates and for communication as well. It has also been observed that the tail mucus plays a vital role as a chemical cue in tracking and detecting prey and as an important energy source for other predatory organisms too (Ng *et al.,* 2013). To deal with the heat stress during the daytime, the snails enter a period of dormancy called estivation (Schweizer *et al.,* 2019).

## IMPORTANCE

The snails have been playing a significant role in various domains. They exhibit agricultural importance, medicinal importance, ecological importance, economic importance, and nutritional importance. They also act as biofilters, bioindicators, and indicators of prey. They have been used as biomarkers to indicate any sort of contamination or pollution. They also take part, acting as vectors, in the transmission of various diseases, particularly parasitic infections.

### 1. Agricultural and Horticultural Importance

The snails have shown great importance in the agricultural sector as well as in the horticultural sector. They damage agricultural production by infesting several crops like green vegetation, rice fields (Murtaza *et al.,* 2020), cereals, maize (Faiz *et al.,* 2020), wheat, sugarcane (Rafiq *et al.,*

2021), clover, broad bean, cabbage, lettuce, and potato (Gabr *et al.,* 2023). They also pose a serious threat and damage to the horticultural sector by growing in larger numbers (Bashê and Al-Qassab 2024). They pose a destructive impact on various fruit trees and ornamental trees. They attack fruit trees like bananas, citrus, grapes (Gabr *et al.,* 2023), avocado, herbaceous plants (Murtaza *et al.,* 2020), and ripening plants like tomatoes and strawberries (Altaf *et al.,* 2017).

2. **Medicinal Importance**

The shells of snails are medically very important. The shell contains certain active substances like chitin, chitosan, calcium carbonate, and several minerals that are medically very important. The shells show various properties including antibacterial, antimicrobial, antioxidant, and anticancer (Radwan *et al.,* 2020). Other beneficial elements may include the presence of hydroxyapatite, biomaterials, and collagen. It is also used as a stabilizer and emulsifier in the pharmaceutical industry, an absorbent of various metals, and a thickening agent for various food products in the food industry (Sundalian *et al.,* 2021). The snails are also being used to treat several diseases. For oral rehydration therapy and oral treatment of vomiting and diarrhea, the snails' hemolymph is being used efficiently (Onyishi *et al.,* 2018). They have been extensively used in the pharmaceutical industry to heal wounds faster as healing is their distinct characteristic. They have been excessively used in the cosmetic industry as well due to their antiaging property (Greistorfer *et al.,* 2020 & Pissia *et al.,* 2021). Numerous land snails have been used as biomarkers to identify the presence of various contaminants. Biomarkers are the components that can identify various problems in the field of medicine as well environment. As snails have antioxidant properties, they can be used to detect any change in the levels of reactive oxygen and oxidative stress due to heavy metals. Due to their anticancer properties, they can detect changes in the DNA caused by the contaminants (Radwan *et al.,* 2020).

3. **Ecological Importance**

The snails play a very important role in maintaining the ecological balance. Due to their ability to break down dead organic matter and recycle nutrients, they are regarded as a chief element of the ecosystem (Kakar *et al.,* 2023). They can transfer the energy to other trophic levels including the crustaceans, fish, and birds, improving the health of the soil and enhancing the aeration of soil by promoting decomposition (Gondal *et al.,* 2020). They also transfer calcium to the higher trophic levels by recycling (Rosales *et al.,* 2020). Another important characteristic exhibited by snails is that they eat algae, zooplankton, and diatoms, thus maintaining the ecosystem through biofiltering (Kakar *et al.,* 2023). Several types of snails are being used as biomarkers extensively for a variety of purposes. But mostly they have been used to identify the contaminants (Radwan *et al.,* 2020).

4. **Economic Importance**

These tiny creatures have economic importance too. Several species have served as a delicacy to various countries like France, China (Rafiq *et al.,* 2021), Nigeria, some parts of Africa, Greece, Spain, Morocco, Italy (Pissia *et al.,* 2021), Portugal, and Sardinia while some countries in Asia including Hongkong, Japan, Thailand, Taiwan, and Indonesia also use snail meat in their food (Sundalian *et al.,* 2021). The economies of many countries are dependent on the consumption of snails to some extent. The great exporters of snails include countries like Morrocco, Romania, Bulgaria, Greece, Latvia, Hungary, and Germany while the great importers include France, Portugal, Bosnia, Spain, Italy, and Turkey (Pissia *et al.,* 2021). Many people rely on culturing the snails for their livelihood (Gondal *et al.,* 2020). Heliciculture, also known as snail farming, is now an emerging field for the sustainable production of snails (Pissia *et al.,* 2021) and has proven to be a valuable and profitable industry in some regions (Kakar *et al.,* 2023). The shells of the snails are being used for ornamental purposes, i.e., in the manufacture of bracelets, necklaces, wall hangings, and other accessories (Sundalian *et al.,* 2021). Besides the economic benefits of snails, they are also economically damaging. As they feed on other living organisms like plants, contaminating and reducing the importance of products ultimately leads to financial loss (Heiba *et al.,* 2018).

5. **Nutritional Importance**

The snails have been used as a delicacy. Many of the snails have been regarded as edible as they are being eaten in numerous countries. In France, the snails are served as *Escargots* while in Nigeria and African regions, they are served as *Congo meat.* The locals of Greece used the land snails as a part of their regular diet. *Hohlioi* is regarded as the regional diet of the Greek people. They are rich in protein content, essential amino acids like leucine and lysine, important vitamins, and some minerals. They are considered a healthy, beneficial meat as they contain lower fat content. The main component of marine snails is moisture, which consists of about 67-78%. Marine snails possess a higher protein content varying between 16.2-19.2 % w.b., a low-fat content consisting of polyunsaturated, saturated, and unsaturated fatty acids of up to 1-8.5% w.b. only along with various types of essential and non-essential amino acids. Iron, zinc, sulfur, calcium, chloride, and potassium are the main minerals found in marine snails. Similarly, freshwater snails also contain moisture as an important and major factor. Their protein content ranges between 10.67-25.6% w.b., with the lowest fat content constituting saturated and unsaturated fatty acids with less than 1% w.b. They also contain varying amounts of essential and non-essential amino acids. Calcium, potassium, magnesium, and phosphorus have been reported from different freshwater species. Land snails also consist of moisture as a major component. They show a varying amount of protein content of about 5.8-20% w.b. They compose different fat content including saturated and both monounsaturated and polyunsaturated fatty acids, with varying degrees among various species. They also exhibit different compositions of amino acids. They predominate with a high number of calcium, potassium, and phosphorus (Pissia *et al.,* 2021).

6. **Bioindicators**

The snails have been significantly used as effective bioindicators to indicate the contamination level present in the environment. Due to their ability to accumulate heavy metals in a preferred amount than the other species (Salih *et al.,* 2021), they proved to be an efficient indicator in aquatic as well as terrestrial environments. As the adults

lack a proper exoskeleton, they can sense even a minor change in their surrounding environment (De Roma *et al.,* 2017). Land snails can be considered an important indicator of any changes in the climate as well i.e. global warming (Amr *et al.,* 2018). They also behave as good indicators of rainforest biodiversity due to their adaptation to the moist and nutrient-rich environment (Rosales *et al.,* 2020). Land snails are well adapted to accumulate large amounts of heavy and trace elements and indicate soil health (Salih *et al.,* 2021).

7. **Transmission of Diseases**

The snails are considered the key aspect of transmitting diseases to human beings and animals (Murtaza *et al.,* 2020). They act as intermediate host of some helminthic parasites, the worms that affect the host on which they rely (Zinab *et al.,* 2023). It has been recently reported that they may act as a reservoir host of various parasites, i.e., trematodes and nematodes (Gabr *et al.,* 2023), favoring them to harbor on their bodies (Ab Hamid *et al.,* 2021). Some of the most important parasitic infections that have been reported across the globe are caused by *Schistosoma spp.* (Murtaza *et al.,* 2020), *Fasciola spp.*, *Paragonimus spp.* (Ab Hamid *et al.,* 2021), and *Dicrocoelium spp.* (Onyishi *et al.,* 2018). Many species of snails have been known to be pests to many agricultural crops and animals including domestic animals i.e., cows, sheep, buffalo, and dogs (Faiz *et al.,* 2020).

## CONCLUSION

Snails are one of the most successful and diverse groups of invertebrates inhabiting the Earth and may serve as a serious pest of several parasitic infections and might prove to be a beneficial organism. Directing a major impact on human health as well as the health of other domesticated and non-domesticated animals, they may be considered an important entity for ecosystem maintenance and balance through recycling the nutrients from the soil and maintaining the soil health.

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