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ECOLOGICAL CHARACTERISTICS AND HABITAT DISTRIBUTION OF GASTROPOD MOLLUSKS IN KHOREZM REGION, UZBEKISTAN

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Abstract. Gastropod mollusks are an important component of aquatic and terrestrial ecosystems, participating in the decomposition of organic matter, the formation of food chains and the stability of biogeocenoses. The Khorezm region, located in the lower reaches of the Amu Darya in north-western Uzbekistan, combines an extremely arid continental climate with a dense network of irrigation canals, collector-drainage systems, lakes and irrigated farmland. This study analyses the distribution of gastropods across the main habitat types of the region and the influence of environmental conditions on their life activity. The work is based on the authors' previous research on the regional malacofauna, taxonomic and ecological literature on Central Asian gastropods and long-term climatic data. Six main habitat types were distinguished along a gradient from the Amu Darya floodplain to the desert margins, and the ecological groups of gastropods typical of each were characterised. Moisture was identified as the leading limiting factor: with an annual precipitation of about 135 mm and almost no rainfall from June to September, moist microhabitats created by irrigation serve as the main refuges for terrestrial species. Anthropogenic factors, including agrochemicals, tillage and changes in water quality, may negatively affect sensitive species. Regular monitoring of gastropods is recommended as a tool for assessing biodiversity and ecosystem condition in the region.

Keywords: Khorezm region; Gastropoda; malacofauna; biodiversity; habitat; ecological groups; irrigation.

1. Introduction

Mollusks (Mollusca) are one of the most species-rich groups of the animal kingdom and inhabit marine, freshwater and terrestrial ecosystems. Within this phylum, the class Gastropoda occupies a special place: its morphological and ecological diversity has allowed gastropods to colonise a remarkably wide range of habitats. In freshwater alone, about 4,000 valid gastropod species have been described [11]. At the same time, non-marine mollusks are among the most threatened animal groups and account for a large share of documented animal extinctions, mainly due to habitat loss, pollution and invasive species [5].

Terrestrial gastropods are particularly sensitive to environmental conditions. Their activity, survival and distribution depend on humidity, soil properties, vegetation cover and microclimate, since their soft bodies lose water easily and most species require moist shelters [2]. For this reason, terrestrial snails and slugs are often regarded as good indicators of habitat quality and of environmental change.

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The natural and geographical conditions of Uzbekistan – deserts, foothills, mountains, river valleys, oases and water bodies – have led to the formation of diverse ecological groups of gastropods and to a clear regional differentiation of the malacofauna. The terrestrial mollusks of Uzbekistan and adjacent territories have been comprehensively reviewed by A. Pazilov and D. A. Azimov [7]. The fundamental monographs of A. A. Shileyko on the Helicoidea and Pupillina of the former USSR remain the main taxonomic references for the region [9; 10], and more recent works have studied the conchological variability of endemic species of the Zarafshan range [8]. However, most of these studies focused on mountain and foothill regions, while the lowland oases of the lower Amu Darya have received considerably less attention.

The Khorezm region is located in the north-western part of Uzbekistan, in the lower reaches of the Amu Darya, between the Karakum and Kyzylkum deserts. Its natural conditions are closely linked to the river: the region contains rivers, canals, lakes, collector-drainage networks, irrigated agrocenoses, settlements, and natural and semi-natural areas. Large-scale expansion of irrigation in the Amu Darya basin since the second half of the twentieth century has profoundly changed the water regime of the region and has been accompanied by soil salinisation and the desiccation of the Aral Sea [6]. Such changes in agriculture, irrigation and water regime may directly affect the habitats of mollusks.

In our previous work, the taxonomic composition of the terrestrial mollusks of the Khorezm region was examined [1]. The aim of the present study is to analyse the ecological characteristics of gastropods of the region, namely their distribution across habitat types and the influence of environmental factors on their life activity. The objectives were: (1) to characterise the climatic conditions of the region that limit gastropod activity; (2) to classify the main habitat types; (3) to describe the ecological groups of gastropods typical of each habitat; and (4) to evaluate the ecological and practical significance of this group.

2. Materials and Methods

Study area. The Khorezm region lies on the left bank of the lower Amu Darya at an elevation of about 100 m above sea level. The landscape is a flat alluvial plain, intensively irrigated by a network of canals and drained by collectors. The surrounding territories are occupied by the sandy deserts of the Karakum and Kyzylkum.

Data sources. The study is based on (1) the results of the authors' previous investigations of the terrestrial malacofauna of the Khorezm region [1]; (2) analysis of taxonomic and ecological literature on gastropods of Uzbekistan, Central Asia and other regions [2; 5; 7–11]; and (3) long-term climatic normals of the Urgench meteorological station (WMO 38396; 41.57°N, 60.63°E; 101 m) published by the Japan Meteorological Agency [3].

Analysis. Habitats were classified according to three criteria: water regime, degree of naturalness (natural, semi-natural, anthropogenic) and density of vegetation cover. Following the approaches accepted in malacological literature [2; 9; 10], gastropods were divided into ecological groups according to their relation to moisture: aquatic, hygrophilous, mesophilous and xerophilous species. Climatic data were analysed by month and presented as a climograph. Comparative analysis, systematisation and generalisation methods were applied, and the results were summarised in tables and schematic figures prepared by the authors.

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3. Results

3.1. Climatic conditions limiting gastropod activity

The climate of the Khorezm region is sharply continental and extremely arid (Fig. 1). The mean monthly air temperature ranges from −1.9 °C in January to 28.6 °C in July, and the mean annual temperature is about 13.5 °C. Annual precipitation amounts to only about 135 mm [3].

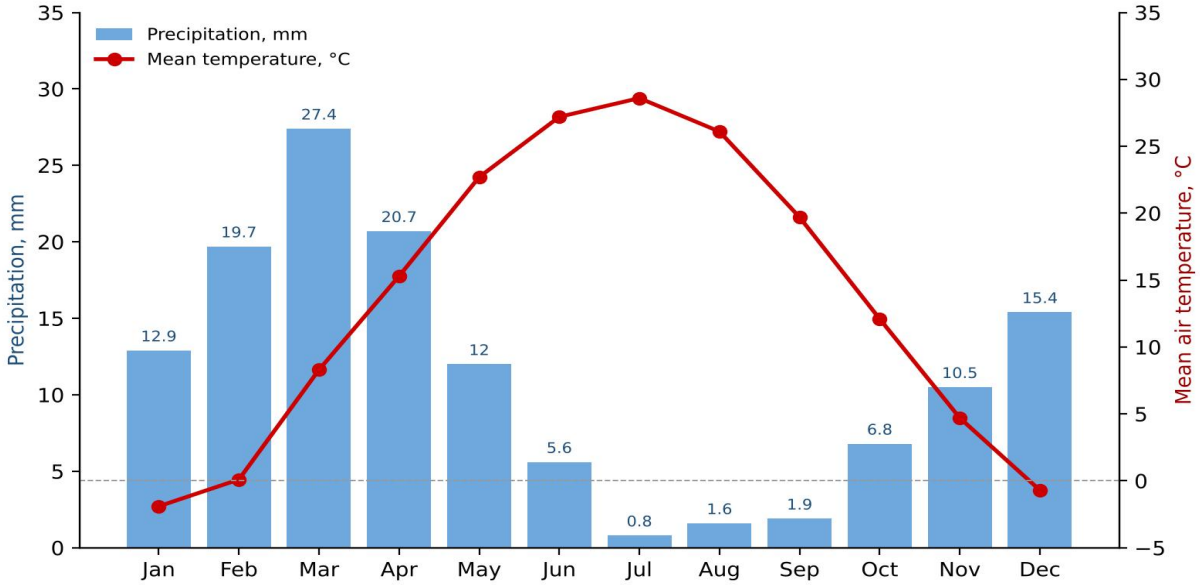


Figure 1. Climograph of Urgench: monthly mean air temperature and precipitation

Precipitation is distributed very unevenly. About 71% of the annual total (96.1 mm) falls from December to April, with a maximum in March (27.4 mm), whereas June–September together receive only 9.9 mm, or about 7% of the annual amount. Thus, the period of highest temperatures coincides with almost complete absence of rainfall. For terrestrial gastropods this means that the favourable periods of activity are limited mainly to spring and autumn, while during the hot summer most species are forced to shelter and enter a state of dormancy (aestivation) [2].

3.2. Habitat types of the Khorezm region

Based on water regime, naturalness and vegetation cover, six main habitat types were distinguished in the region. They form a gradient from permanently wet habitats near the Amu Darya to dry desert margins (Fig. 2). Their main characteristics are summarised in Table 1.

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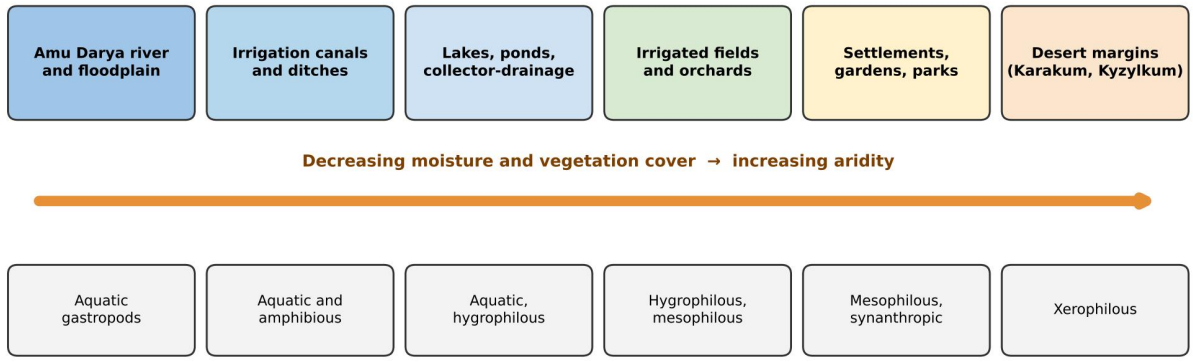


Figure 2. Gradient of the main habitat types of the Khorezm region and the ecological groups of gastropods typical of them

Table 1. Main habitat types of the Khorezm region and their conditions for gastropods

Habitat type	Moisture conditions	Vegetation cover	Main gastropod groups	Main limiting factors
Amu Darya river and floodplain	Permanent water, flooded banks	Tugai forests, reeds, grasses	Aquatic, hygrophilous	Fluctuations of water level, turbidity
Irrigation canals and ditches	Seasonal water flow, wet banks	Grasses, reeds along banks	Aquatic, amphibious	Cleaning of canals, drying out after irrigation season
Lakes, ponds and collector-drainage systems	Permanent or temporary water	Aquatic and coastal plants	Aquatic, hygrophilous	Water salinity, pollution by agricultural runoff
Irrigated fields and orchards	Periodically high soil moisture	Crops, fruit trees, weeds	Hygrophilous, mesophilous	Pesticides, fertilizers, tillage
Settlements, gardens and parks	Watered lawns and gardens	Ornamental plants, trees	Mesophilous, synanthropic	Urbanization, trampling, chemical treatment
Desert margins	Very low, only after rains	Sparse xerophytic shrubs	Xerophilous	Drought, high temperature, salinity

3.3. Ecological groups of gastropods

According to their relation to moisture, the gastropods occurring in the habitats of the region can be divided into four ecological groups (Table 2). The examples of genera given in the table are those widely reported in the terrestrial and freshwater fauna of Uzbekistan and Central Asia [7; 9–11]; the confirmed species composition of the Khorezm region is discussed in our earlier work [1].

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Table 2. Ecological groups of gastropods by their relation to moisture

Ecological group	Relation to moisture	Typical habitats in the region	Examples of genera in the regional fauna
Aquatic	Live permanently in water; breathe with gills or lungs	Amu Darya, canals, lakes, collectors	Lymnaea, Planorbis, Physa
Hygrophilous	Require constantly wet substrate; live near water	Banks of canals and lakes, wet meadows	Succinea, Oxyloma
Mesophilous	Prefer moderate moisture; avoid both flooding and drought	Orchards, gardens, field margins, parks	Cochlicopa, Vallonia, Pupilla
Xerophilous	Tolerate long dry periods; active after rains	Dry slopes, roadsides, desert margins	Xeropicta, Pseudonapaeus

The distribution of these groups closely follows the moisture gradient shown in Fig. 2. Aquatic and hygrophilous species dominate near water bodies, mesophilous species are associated with irrigated and planted areas, and xerophilous species are found mainly on the dry periphery of the region. Notably, irrigated fields, orchards and gardens create moist microhabitats within the arid landscape, which allows mesophilous species to exist in a region whose natural climate would otherwise be unsuitable for them.

3.4. Factors determining gastropod distribution

The analysis showed that the distribution of gastropods in the Khorezm region is determined by the combined effect of four groups of factors: abiotic, hydrological, biotic and anthropogenic (Fig. 3).

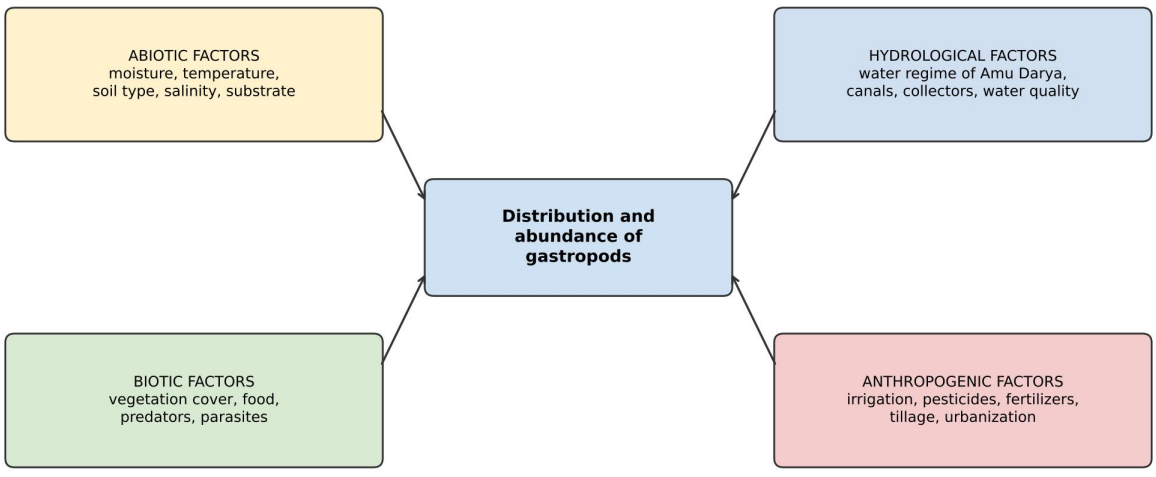


Figure 3. Main groups of factors influencing the distribution of gastropods in the Khorezm region

Among abiotic factors, moisture is the most important. In a dry continental climate, the presence of moist microhabitats is critical for mollusks. Soil moisture is relatively high on irrigated land, along ditches and canals and in the vegetated areas around them, which creates a favourable microclimate for some terrestrial species. Vegetation cover also plays an important role: plants serve as a source of food

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and shelter, retain moisture on the soil surface and reduce sharp temperature fluctuations. Therefore, living conditions for mollusks are more stable in areas with relatively dense vegetation.

Hydrological factors are determined by the Amu Darya and its branches, irrigation canals, collectors and other water bodies. The close proximity of aquatic and terrestrial habitats creates ecotones that are especially favourable for amphibious and hygrophilous species. Anthropogenic factors act in two directions: irrigation partially transforms the naturally dry conditions and creates new moist microhabitats, whereas the use of pesticides and mineral fertilizers, mechanical tillage of the soil and changes in water quality may negatively affect the living conditions of some species.

4. Discussion

The results show that in the Khorezm region the distribution of gastropods is controlled primarily by the availability of water. This is consistent with the general view that moisture is the key limiting factor for terrestrial gastropods [2]. In the extremely arid climate of the lower Amu Darya, where summer rainfall is practically absent (Fig. 1), the irrigation network plays the role of an artificial source of moisture. As a result, the region can be regarded as a system of "moist islands" within the desert, and its malacofauna is largely dependent on human-made water bodies and irrigated landscapes.

At the same time, the dependence on irrigation makes the malacofauna vulnerable. Changes in the water regime of the Amu Darya, reduction of water supply in dry years, and the accumulation of salts in soils and collector waters, which are characteristic problems of the Aral Sea basin [6], may reduce the area of suitable habitats. Agricultural chemicals and regular tillage directly affect soil-dwelling species. Since non-marine mollusks are known to be highly sensitive to habitat degradation and pollution [5], such changes may lead to the disappearance of sensitive species and to the dominance of a few tolerant ones.

Gastropods also perform a number of important functions in the ecosystems of the region (Fig. 4, Table 3). They participate in the decomposition of plant litter and organic matter, serve as food for many animals, and some freshwater species can be used as bioindicators of the ecological state of water bodies [2; 11].

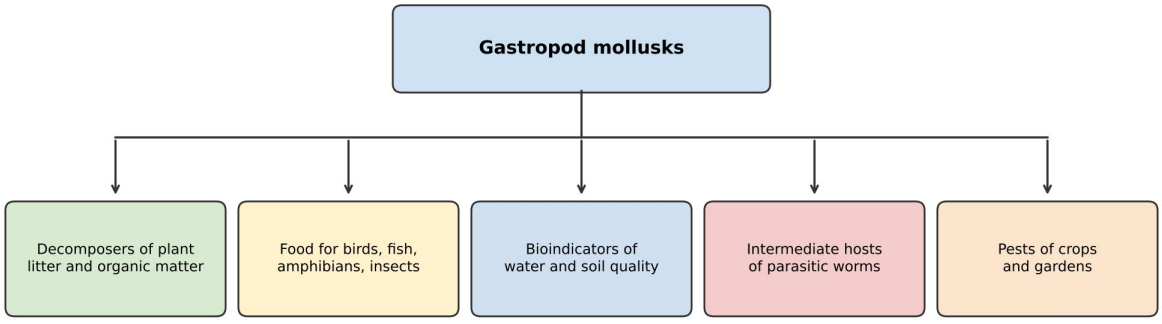


Figure 4. Ecological and practical significance of gastropods in the ecosystems of the Khorezm region

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Table 3. Ecological and practical significance of gastropods

Aspect	Description	Practical importance
Ecological	Decomposition of plant residues; link in food chains between plants and higher consumers	Maintaining soil fertility and stability of biogeocenoses
Bioindication	Sensitivity of species to water and soil quality, salinity and pollution	Monitoring of the state of aquatic and terrestrial ecosystems
Epidemiological and veterinary	Some freshwater snails (e.g., Lymnaeidae) are intermediate hosts of parasitic worms such as liver flukes [4]	Control of helminthic diseases of humans and livestock
Agricultural	Some terrestrial species may damage seedlings, vegetables and garden plants	Planning of plant protection measures

The epidemiological and veterinary aspect deserves special attention. Snail-borne parasitic diseases, including fascioliasis, remain a significant problem in many regions of the world, and their transmission depends on the presence of suitable snail hosts [4]. In an region where livestock is kept near canals and ponds, knowledge of the distribution of freshwater snails is therefore important for the prevention of helminthic diseases. Thus, the study of the malacofauna of the Khorezm region is important not only from a zoological point of view, but also from ecological and applied perspectives.

The present study has limitations. It is based on a synthesis of previous data and literature and does not include new quantitative field measurements. Future research should include seasonal field surveys in each habitat type, assessment of population density, and measurement of soil moisture, salinity and water quality, which would allow the relationships described here to be tested statistically.

5. Conclusion

The natural and anthropogenically transformed habitats of the Khorezm region create conditions for the formation of different ecological groups of gastropod mollusks. Their distribution is closely related to the water regime, moisture, temperature, vegetation cover and substrate properties. Under the extremely arid climate of the region, with an annual precipitation of about 135 mm and an almost rainless summer, the widely developed irrigation network influences the natural moisture regime and leads to the formation of various microhabitats that support aquatic, hygrophilous and mesophilous species. At the same time, agrochemicals, tillage, salinisation and changes in water quality represent potential threats to sensitive species. Regular monitoring of gastropods is of great scientific and practical importance for assessing the biodiversity of the region, detecting ecological changes and observing the condition of aquatic and terrestrial ecosystems. The Khorezm region is one of the important areas for studying the species diversity and ecological distribution of gastropod mollusks in Central Asia.

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