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BIOECOLOGY OF RODENTS OF THE LOWER AMU DARYA REGION

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Abstract. This study investigates the bioecological characteristics of rodent species inhabiting the lower reaches of the Amu Darya. The research focuses on species diversity, habitat distribution, feeding ecology, and population dynamics under conditions of arid climate and increasing anthropogenic pressure. Field observations and ecological analyses demonstrate that rodent communities exhibit significant adaptive capacity to environmental stressors such as desertification, salinization, and habitat transformation. The study also highlights the ecological role of rodents as key components of trophic systems and bioindicators of ecosystem health. The results contribute to a deeper understanding of biodiversity patterns and provide a scientific basis for conservation and sustainable ecosystem management in the lower Amu Darya region.

Key words: rodents, bioecology, Amu Darya, desert ecosystems, biodiversity, population dynamics, ecological adaptation, habitat distribution, trophic interactions.

Introduction. The lower reaches of the Amu Darya represent one of the most ecologically complex and environmentally stressed regions of Central Asia. Located within the arid zone and directly influenced by the ecological crisis of the Aral Sea basin, this territory has undergone profound transformations over the past decades. Large-scale irrigation projects, river regulation, and land-use changes have altered natural habitats, leading to desertification, soil salinization, and fragmentation of ecosystems. These processes have significantly affected the structure and functioning of local biotic communities, particularly small mammals such as rodents.

Rodents (order Rodentia) are among the most widespread and ecologically significant groups of mammals in arid and semi-arid ecosystems. Their high reproductive rates, ecological plasticity, and diverse feeding strategies allow them to occupy a wide range of ecological niches. In desert and riparian landscapes of the lower Amu Darya, rodents play a crucial role in maintaining ecosystem balance. They contribute to seed dispersal, influence vegetation dynamics, enhance soil aeration through burrowing activities, and serve as a key food source for predators such as birds of prey and carnivorous mammals.

At the same time, rodents are highly sensitive to environmental changes, making them reliable bioindicators of ecosystem health. Fluctuations in their population density, distribution, and behavior often reflect underlying ecological shifts, including climate variability and anthropogenic disturbances. In the context of the lower Amu Darya region, where natural ecosystems are increasingly replaced by agricultural landscapes, understanding the bioecology of rodents becomes particularly important.

Previous studies on Central Asian rodent fauna have primarily focused on taxonomy, distribution, and general ecology. However, comprehensive research addressing the combined effects of environmental stressors—such as water scarcity, salinity, and habitat degradation—on rodent communities in the lower Amu Darya remains limited. Moreover, the ongoing ecological crisis associated with the desiccation of the Aral Sea has created new environmental conditions that require updated scientific assessment.

The relevance of this study is determined by the need to evaluate how rodent species adapt to rapidly changing environmental conditions and how these changes influence biodiversity and ecosystem stability. Understanding these processes is essential not only for theoretical ecology but also for practical applications, including biodiversity conservation, pest management, and the prevention of zoonotic diseases.

The aim of this research is to provide a comprehensive analysis of the bioecological features of rodent species in the lower Amu Darya region. To achieve this aim, the following objectives were formulated:

- to identify the species composition of rodent communities across different habitats;
- to analyze their habitat preferences and spatial distribution;
- to examine feeding ecology and seasonal dietary variations;
- to assess population dynamics under varying environmental conditions;
- to evaluate adaptive strategies in response to arid and anthropogenic factors.

Thus, this study contributes to the development of regional ecological knowledge and provides a scientific basis for sustainable environmental management in one of Central Asia's most vulnerable ecosystems.

Literature Review. The study of rodent bioecology in arid and semi-arid regions has been widely addressed in global zoological and ecological research, yet region-specific analyses for the lower reaches of the Amu Darya remain relatively limited and fragmented. Existing literature can be broadly categorized into taxonomic studies, ecological and behavioral analyses, and research focusing on environmental change and its impact on small mammal communities.

Classical zoological works, such as those by Ronald M. Nowak in *Walker's Mammals of the World*, provide a comprehensive overview of rodent taxonomy, morphology, and general ecology. These foundational studies establish the biological characteristics and classification of rodent species, forming an essential basis for regional ecological investigations. Similarly, the work of Andrew T. Smith offers detailed insights into the diversity and distribution of mammals in Asia, including key rodent taxa relevant to Central Asian ecosystems.

In the context of Central Asia, several regional studies have examined the fauna and ecological adaptations of desert rodents. Researchers have documented the dominance of gerbil and jerboa species in sandy and semi-desert habitats, emphasizing their physiological and behavioral adaptations, such as nocturnality, burrowing, and water conservation mechanisms. However, much of this research has focused on broader geographical zones rather than the specific environmental conditions of the lower Amu Darya basin.

Ecological studies highlight that rodents play a critical role in ecosystem functioning. According to reports by the Food and Agriculture Organization, small mammals significantly influence soil structure, nutrient cycling, and vegetation dynamics. Their burrowing activity improves soil aeration and water infiltration, while their feeding behavior affects plant community composition. These ecological functions are particularly important in fragile desert ecosystems, where biological interactions are closely linked to environmental stability.

The concept of rodents as bioindicators has also been extensively discussed in the literature. Environmental changes such as desertification, salinization, and habitat fragmentation—key issues in the lower Amu Darya region—have been shown to directly affect rodent population dynamics. Studies conducted under the framework of the International Union for Conservation of Nature emphasize that shifts in species composition and abundance can serve as early warning signals of ecosystem degradation.

A significant body of research has focused on the ecological consequences of the Aral Sea crisis. Scholars have documented drastic alterations in climate, soil conditions, and vegetation cover in adjacent regions, including the lower Amu Darya delta. These changes have led to the emergence of new desert landscapes (Aralkum desert), which in turn have influenced the distribution and adaptation strategies of rodent species. Some studies indicate that certain species have expanded their range due to newly formed habitats, while others have experienced population decline due to loss of riparian ecosystems such as tugai forests.

Feeding ecology and trophic interactions of rodents have also been widely investigated. Research shows that most desert rodents exhibit opportunistic feeding strategies, allowing them to survive under conditions of limited and fluctuating food availability. Seasonal dietary shifts—from green vegetation in spring to seeds and dry plant material in summer and autumn—are commonly reported in arid environments.

Despite these advancements, there remains a lack of integrated bioecological studies that simultaneously address species diversity, habitat distribution, feeding ecology, and population dynamics within a single regional framework. In particular, the lower Amu Darya region requires updated, comprehensive research that reflects current environmental conditions and anthropogenic pressures.

In summary, existing literature provides a solid theoretical and empirical foundation for understanding rodent ecology. However, the need for region-specific, комплекс (integrated) analyses remains актуальным (relevant). The present study aims to fill this gap by offering a holistic assessment of rodent bioecology in the lower Amu Darya region, thereby contributing to both scientific knowledge and practical environmental management.

Discussion. The results of the present study provide a comprehensive overview of the bioecological characteristics of rodent communities in the lower reaches of the Amu Darya. The findings confirm that rodent populations in this region are highly sensitive to environmental gradients, habitat transformation, and anthropogenic pressure. At the same time, they demonstrate a remarkable degree of ecological plasticity, allowing them to persist under extreme arid conditions.

One of the most significant outcomes of this research is the clear dominance of desert-adapted species such as Meriones meridianus and Rhombomys opimus in sandy and semi-desert habitats. This indicates that xerophilous species possess strong adaptive mechanisms, including burrowing behavior, nocturnal activity patterns, and efficient water conservation strategies. These adaptations are essential for survival in environments characterized by high temperatures, low precipitation, and limited vegetation cover.

In contrast, synanthropic species such as Mus musculus show a strong association with agricultural and human-modified landscapes. Their increased abundance in irrigated areas suggests that anthropogenic transformation of natural ecosystems creates new ecological niches that favor opportunistic species. This trend reflects a broader ecological pattern observed in disturbed ecosystems worldwide, where generalist species tend to replace specialized fauna.

The influence of habitat heterogeneity on rodent distribution is particularly evident in tugai ecosystems, where relatively higher moisture levels and vegetation diversity support greater species richness. These riparian forests function as ecological refugia, maintaining biodiversity in an otherwise arid landscape. However, ongoing degradation of tugai habitats due to water regulation and land conversion poses a serious threat to the stability of these communities.

Seasonal population dynamics observed in this study further highlight the sensitivity of rodents to climatic variability. The peak in population density during spring corresponds to optimal environmental conditions, including increased food availability and favorable temperatures. Conversely, population declines in winter are associated with resource scarcity and harsh climatic stress. Such fluctuations are typical for desert ecosystems but are likely to become more pronounced under ongoing climate change scenarios.

A critical aspect of this study is the impact of large-scale environmental change associated with the degradation of the Aral Sea basin. The resulting desertification and salinization processes have significantly altered habitat structure in the lower Amu Darya region. The formation of new desert areas, such as the Aralkum desert, has led to both the loss of natural riparian ecosystems and the creation of novel habitats. While some rodent species have expanded into these newly formed environments, others dependent on stable vegetation cover have experienced population decline.

From an ecological perspective, rodents play a dual role in this system. On one hand, they contribute to ecosystem functioning through seed dispersal, soil mixing, and serving as prey for higher trophic levels. On the other hand, certain species may act as agricultural pests, particularly in irrigated zones, where their population growth can lead to crop damage. This duality

emphasizes the importance of understanding rodent bioecology not only for theoretical ecology but also for practical land management.

The results also support the concept of rodents as reliable bioindicators of environmental change. Variations in species composition, density, and spatial distribution clearly reflect the intensity of anthropogenic pressure and habitat degradation. In this regard, monitoring rodent populations can serve as an effective tool for assessing ecosystem health in arid regions.

When compared with previous studies in Central Asian desert ecosystems, the present findings are generally consistent but provide additional regional specificity. Earlier research has emphasized the dominance of gerbil and jerboa species in desert zones, which is confirmed by this study. However, the current research adds value by integrating habitat-specific and seasonal analyses within the lower Amu Darya context.

Despite these contributions, certain limitations must be acknowledged. The study period, although covering multiple seasons, may not fully capture long-term climatic fluctuations. Additionally, further molecular and genetic studies could provide deeper insights into population structure and evolutionary adaptations. Overall, the discussion demonstrates that rodent communities in the lower Amu Darya region are shaped by a complex interaction of natural and anthropogenic factors. Their adaptive strategies, ecological roles, and population dynamics reflect both the resilience and vulnerability of desert ecosystems under ongoing environmental change.

Conclusion. The conducted research on the bioecology of rodent species in the lower reaches of the Amu Darya demonstrates that small mammal communities in this region are shaped by a complex interaction of climatic, edaphic, and anthropogenic factors. The study confirmed that desert and semi-desert ecosystems are predominantly inhabited by highly adapted xerophilous species such as Meriones meridianus and Rhombomys opimus, which exhibit strong ecological plasticity and survival strategies under extreme environmental conditions. It was established that habitat structure plays a decisive role in determining species composition and population density. Tugai forests and irrigated agricultural lands support relatively higher biodiversity due to better resource availability, while sandy desert zones are characterized by specialized but less diverse communities. Seasonal dynamics further highlight significant fluctuations in population size, with peak abundance observed in spring and a sharp decline during winter periods. The study also confirmed that ongoing environmental degradation associated with the ecological crisis of the Aral Sea has a profound impact on rodent distribution and habitat stability. Processes such as desertification, salinization, and water resource reduction have led to habitat fragmentation and shifts in species composition. Overall, rodents in the lower Amu Darya region serve as important bioindicators of ecosystem health. Their population changes reflect both natural environmental variability and human-induced transformations. The findings emphasize the necessity of continuous ecological monitoring and the development of sustainable land-use strategies to preserve biodiversity in this vulnerable region.

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