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e-mail: aytzhanovaanel@gmail.com**EXTRAPOLATED DATA-BASED ANALYSIS
OF TERRESTRIAL GASTROPOD DISTRIBUTION
IN THE NORTHERN TIEN SHAN REGION**

A considerable amount of published sources contain incomplete data, as significant knowledge about the diversity of living organisms has been accumulated in museum collections and monographic publications. Nevertheless, the problem of using already published incomplete information remains quite relevant since the monographs covers a significant part of the biological diversity and territories of the planet. In this paper, data on the findings of land mollusks in the Northern Tien Shan were compiled from existing literature. Based on these incomplete data, the distribution of terrestrial mollusks was reconstructed in the whole region. As a result species richness of gastropods in the Northern Tien Shan is not dependent on geographic locality. The study found significant similarities in the fauna of different mountain ridges, with spatial proximity being a significant factor in determining faunal similarity. The difference in the malacofauna between Ile and Kungey Alatau is likely due to the uneven representation of Kungey Alatau in previous studies. The data reconstruction method performed in the study proved to be a simple and quick approach for preliminary estimating faunistic diversity. While this method has some limitations, they can be avoided by incorporating environmental data.

Key words: Northern Tien Shan, gastropods, species distribution, extrapolation.

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e-mail: aytzhanovaanel@gmail.com**Солтүстік Тянь-Шаньдағы жерүсті бауырақты
моллюскалардың таралуын экстраполяцияланған мәліметтер
негізінде талдау**

Жарияланған дереккөздердің едәуір бөлігі толық емес мәліметтерді қамтиды, өйткені тірі организмдердің әртүрлілігі туралы білімнің басым көпшілігі мұражай коллекцияларында және монографиялық басылымдарда жинақталған. Осыған қарамастан, жарияланған толық емес ақпаратты пайдалану мәселесі өте өзекті болып қала береді, өйткені олар планетаның биологиялық әртүрлілігі мен аумақтарының едәуір бөлігін сипаттайды. Осы зерттеуде Солтүстік Тянь-Шань тау жүйесінің жер бетіндегі бауырақты моллюскалардың табылуы туралы жарияланған әдебиет деректері пайдаланылды. Осы толық емес деректерге сүйене отырып, жер бетіндегі моллюскалардың аймақ бойынша таралуын қайта құру жүргізілді. Нәтижелер Солтүстік Тянь-Шань бауырақты моллюскаларының түрлік байлығы географиялық локализацияға байланысты емес екенін көрсетті. Әртүрлі тау жоталарының фаунасында айтарлықтай ұқсастықтар табылды, кеңістіктік жақындық фауна ұқсастығының маңызды анықтаушысы болды. Іле Алатауы мен Күнгей Алатау жоталарының малакофаунасының айырмашылығы бұрынғы зерттеулерде Күнгей Алатауының толық көрсетілмегендігінен болса керек. Зерттеуде фауналық әртүрлілікті алдын ала бағалау кезінде деректердің жетіспеушілігі орын алса қарапайым және жылдам әдісі болып шықты. Қоршаған орта қосымша факторлары туралы деректерді қосу арқылы осы әдістің кейбір шектеулерін болдырмауға болады.

Түйін сөздер: Солтүстік Тянь-Шань, гастроподтар, түрлердің таралуы, экстраполяция.

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Анализ распределения наземных брюхоногих моллюсков в Северном Тянь-Шане на основе экстраполированных данных

Значительное количество знаний о разнообразии живых организмов накоплено в музейных коллекциях и монографиях и представлено неполными, разнородными данными. Тем не менее, проблема использования уже опубликованной неполной информации остается достаточно актуальной, поскольку в них описана значительная часть биологического разнообразия и территорий планеты. В работе были использованы литературные данные о находках наземных моллюсков в Северном Тянь-Шане. На основе этих неполных данных была проведена реконструкция распределения наземных моллюсков во всем регионе. Результаты показали, что видовое богатство брюхоногих моллюсков Северного Тянь-Шаня не зависит от географической локализации. Было выявлено значительное сходство в фауне различных горных хребтов, при этом пространственная близость оказалась важным фактором, определяющим фаунистическое сходство. Разница в малакофауне между хребтами Иле Алатау и Кунгей Алатау, вероятно, связана с неполной репрезентацией Кунгей Алатау в предыдущих исследованиях. Реконструкция данных, использованная в исследовании, показала себя простым и быстрым методом для предварительной оценки фаунистического разнообразия при недостатке данных. Некоторые ограничения метода можно избежать путем включения данных о факторах среды.

Ключевые слова: Северный Тянь-Шань, брюхоногие моллюски, распределение видов, экстраполяция.

Introduction

A significant part of the information about biological diversity has been accumulated in museum collections and faunistic or floristic monographic publications [1, 2]. As a rule, such data are heterogeneous and are represented by numerous series of field collections or single records made by different methods in different seasons and for different purposes. Many of the published sources contain incomplete data on finding localities or circumstances of collection of the studied organisms. This makes it difficult to use these data. As a result, to solve ordinary research or conservation problems, it is necessary to organize new time-consuming and expensive field expeditions. The collection and fixation of new material, especially in the case of rare or protected species, can be associated with harm to the environment.

The need for a detailed description of the preliminary data and depositing them in open repositories has been emphasized many times in the specialized literature [3, 4, 5]. Nevertheless, the problem of using already published incomplete information remains quite relevant since the monographs covers a significant part of the biological diversity and territories of the planet.

In this work, I tried to reconstruct data on the spatial distribution of terrestrial gastropods of the

Northern Tien Shan on the basis of incomplete literary descriptions. Based on the obtained dataset, I presented preliminary analysis of malacofaunistic complexes.

The Tien Shan is a mountain range located in Central Asia, spanning across parts of Kazakhstan, Kyrgyzstan, Uzbekistan, and China, between approximately 40° and 45° N latitude and 67° and 95° E longitude [6]. The boundaries between Tien Shan districts can be difficult to define precisely, as they often pass into each other through the valleys. The northern branch of the Tien Shan is located north of Lake Issyk-Kul and is represented by Ile Alatau (Trans-Ili Alatau, Zailiisky Alatau), Kungey Alatau, Terskey Alatau, Ketmen, and Kirghiz ridges [7]. The predominant elevation in this area is between 4000–4600 meters above sea level, making it a high-altitude mountainous region.

Gastropods are one of the most species-rich groups of animals, ubiquitous on land, in fresh and salt waters. Within the Northern Tien Shan, mollusks inhabit various types of habitats from high mountains to river gorges [8]. High interspecific diversity, dwelling in various biotopes, weak ability of mollusks to overcome geographical barriers make them a convenient model object for ecological research. Many gastropod species serve as intermediate hosts for parasitic helminths of humans and domestic animals [9].

Materials and methods

Data on the species composition and geographical distribution of terrestrial mollusks of Ile Alatau, Kungey Alatau and Terskey Alatau ridges were extracted from monograph by Shileyko and Rymzhanov [10]. The monograph reports on 194 species of terrestrial pulmonate mollusks in Kazakhstan and adjacent territories, and is based on extensive data collected by Shileyko and Rymzhanov between 1972 and 2007. However, the monograph does not provide detailed information on the collection localities of the species including geographic coordinates. Therefore, I reconstructed the missing coordinate data.

I extracted a total of 218 species record from the Northern Tien Shan region. Of these, 166 were from Ile Alatau, 37 were from Kungey Alatau, and 15 were from Terskey Alatau (Figure 1).

To conduct my analysis, I reconstructed geographic coordinates (latitude, longitude). Specimen records ranged from 42.5° to 43.7° latitude and 75.5° to 80.2° longitude.

Since each record contains only data of the presence a single species, I divided the study area into cells with a side of 0.2 degrees (in both latitude and longitude). Thus, each cell represented a quasi-habitat with its own species composition and was considered as a separate unit for analysis.

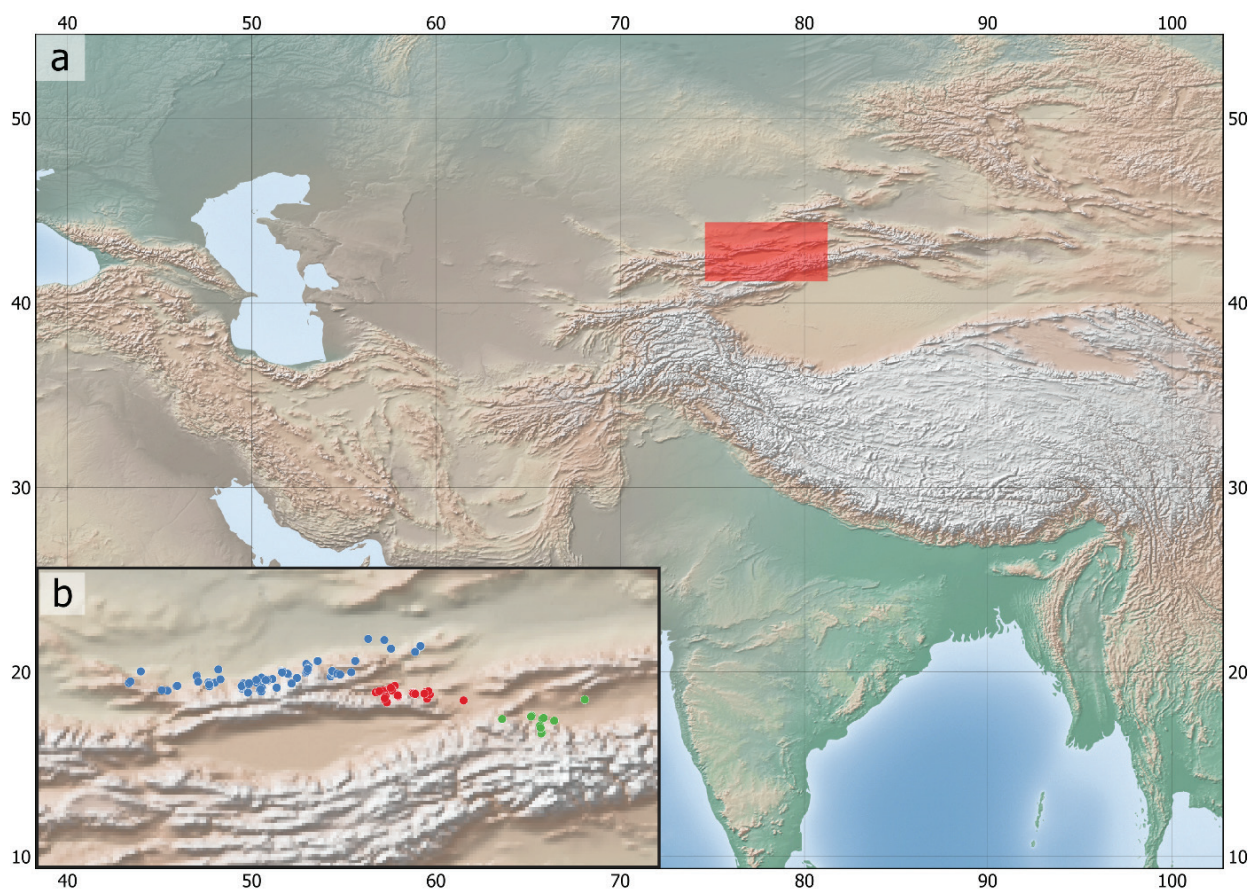


Figure 1 – Localities of reconstructed species records of the Northern Tien Shan. Different ridges are marked by colored dots: blue – Ile Alatau, red – Kungey Alatau, green – Terskey Alatau

To analyze the spatial distribution of mollusks, I used two types of data. First, data on the number of species in each cell; second, data on the species composition in each cell. To reconstruct the species composition, I assumed that the each of the observed species is distributed ubiquitously between

the extreme localities. For example, if a species was only collected at 75° and 80° in longitude, I assumed it could be found at any longitude within that range. Similar reconstruction was applied to latitudinal distribution data. The main drawback of this approach is that the middle range may appear to have the rich-

est fauna. To address this, I excluded one row on each side of the overall analysis. Another flaw of the applied method was that the extrapolation zone included the territory of the adjacent Ketmen range, which was not initially included in the analysis.

I conducted a correlation analysis to examine the potential relationship between species richness and geographic longitude and latitude.

In order to evaluate the similarity of the fauna among the ranges, I employed one-way Analysis of Similarities (ANOSIM) with 100,000 bootstrap replications and constructed a dendrogram with bootstrap support of 10,000 replications using the Bray-Curtis similarity index [11]. The contribution of individual species to differences between range faunas was assessed using the Similarity Percentages Analysis (SIMPER) [12, 13].

Routine data processing was conducted using MS Excel. Classical clustering, ANOSIM and SIMPER analyses were performed in Past ver. 4.11 [14]. Maps were constructed in QGIS 3.28.2.

Results and discussion

The Northern Tien Shan was found to possess a total of 81 species and 16 families of terrestrial mollusks. The families Enidae (20 species) and Camaenidae (17 species) were the most abundant in terms of species number, while the family Pyramidulidae was the least numerous, represented only by a single species.

Out of the three ridges studied, Ile Alatau demonstrated the highest species richness with 72 species, out of which 52 are unique, that is, found within the framework of this study only there. Kungey Alatau contained 23 species, with 5 being unique to the area, whereas Terskey Alatau contained 13 species, of which 4 are unique.

The Northern Tien Shan region contains three species (*Turcomilax turkestanus* (Simroth, 1898), *Turcomilax tzvetkovi* Likharev et Wiktor, 1980, *Pseudonapaeus schnitnikovi* (Lindholm, 1922)) and 21 endemic species belonging to 8 genera (*Columella* Westerlund, 1878, *Deroceras* Rafinesque, 1820, *Pupilla* J. Fleming, 1828, *Leucozonella* Lindholm, 1927, *Macrochlamys* J. E. Gray, 1847, *Ponsadenia* Schileyko, 1978, *Pseudonapaeus* Westerlund, 1887, *Turcomilax* Simroth, 1902) [8]. Notably, some of these species are only known from their type locales.

The number of common species for Ile Alatau and Kungey Alatau ridges was 11, while only 2 species were shared between Ile Alatau and Terskey Alatau. There were no common species observed between Kungey Alatau and Terskey Alatau ridges.

The total number of species presented on all three ridges was 7.

By extrapolating the data, I obtained a total of 122 cells within the study area, which was reduced to 87 after the exclusion of extreme rows (Figure 2). The number of species observed in the studied cells ranged from 1 to 36, as indicated by the varying sizes of the points on the map. The mid-range region turned out to have the highest species richness.

I found significant differences in the species composition between Kungey Alatau and Ile Alatau (ANOSIM, $R=0.0498$, $p=0.0246$), while no significant differences were observed between the Kungey and Terskey Alatau (ANOSIM, $R=0.0498$, $p=0.3466$), Ile and Terskey Alatau (ANOSIM, $R=0.0498$, $p=0.1857$). Further analysis using SIMPER revealed that the greatest contribution to the difference between Kungey and Ile Alatau ridges was made by *Cochlicopa lubricella* (Porro, 1838) – 6.5%, *Pseudonapaeus dissimilis* (E. von Martens, 1882) – 6.2%, *Truncatellina callicratis* (Scacchi, 1833) – 6.1%, *Columella edentula* (Draparnaud, 1805) – 5.4%.

Correlation analysis revealed no significant dependence of the number of species on geographic latitude ($p=0.8444$, $R=0.1159$) and longitude ($p=0.6442$, $R=0.0993$).

The dendrogram (Figure 3) of faunal similarity of the studied cells showed the presence of two groups. The Bray-Curtis similarity index between cells depends on their spatial proximity to each other, so the nearby cells in the dendrogram form clusters with a high bootstrap support.

The data reconstruction method used in the work is a simple and quick approach for estimating faunal diversity. This technique is particularly useful where data are limited, serving as a valuable tool for preliminary analyses. However, it has certain disadvantages. Firstly, the Northern Tien Shan is a mountainous region with a complex landscape, so the extrapolation remains an approximate method, and the gastropods will be distributed only in areas suitable for their ecological niches. For precise identification of mollusk distribution, the availability of environmental data such as temperature, humidity, etc. is necessary [15, 16]. Secondly, the middle ranges exhibit the highest richness of fauna.

Correlation analyses showed that gastropod species richness in Northern Tien Shan is not dependent on geographic location. Dendrogram (Fig.3) indicated that spatial proximity was a significant factor in determining faunal similarity between cells, while the distribution of species between the different ranges appeared to be roughly homogeneous.

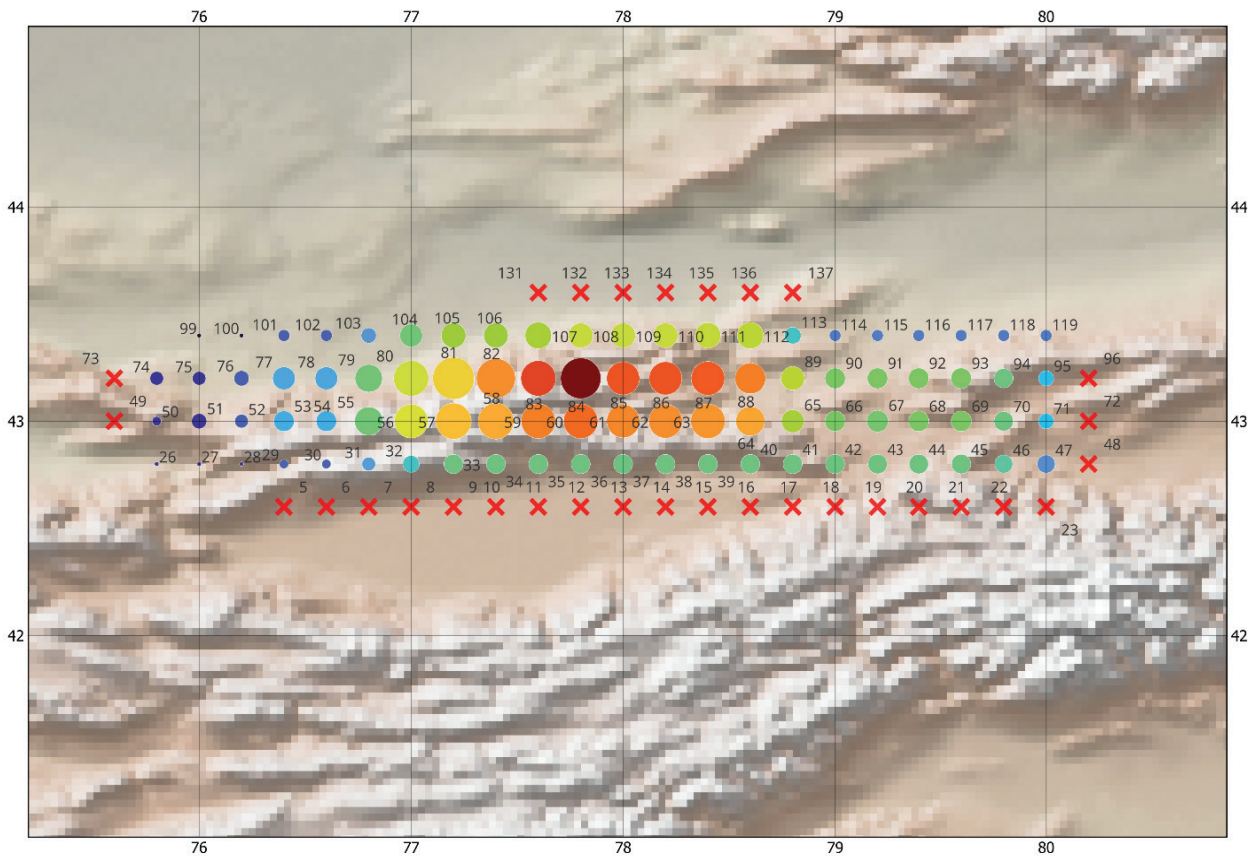


Figure 2 – Reconstructed species composition. The varying sizes of the points on the map indicate the proposed number of species in the studied cells (from 1 to 36). The cell are gradiently colored according to the similarity index to the central cell (brown).

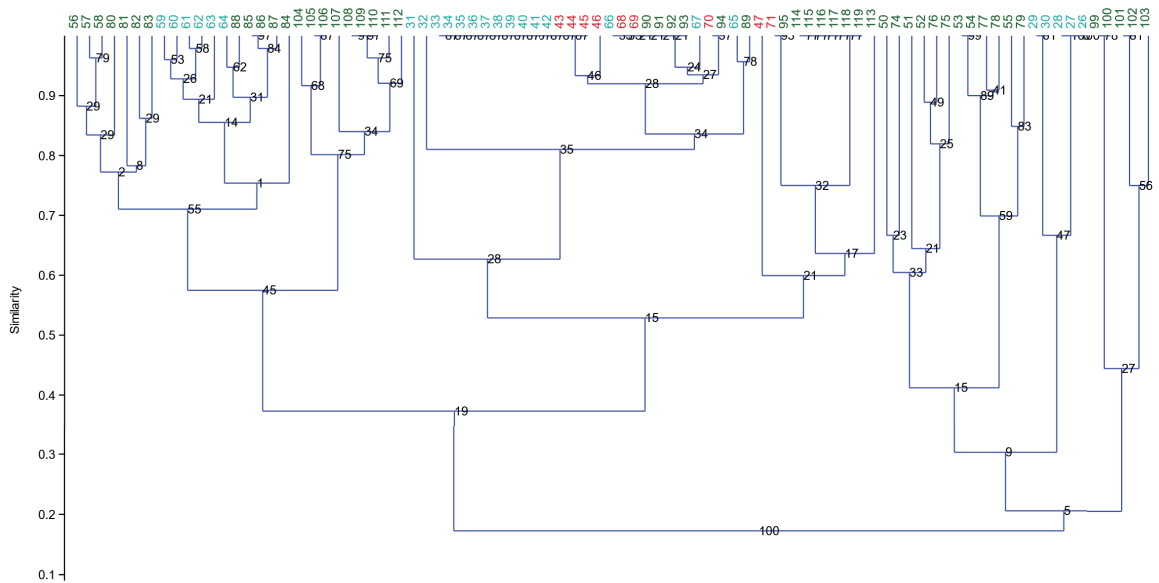


Figure 3 – Cluster dendrogram of faunistic similarity of the studied cells. Colored ordinal number of studied cell signify different ridges: green – Ile Alatau, blue – Kungey Alatau, red – Terskey Alatau. Bootstrap values are located at the nodes.

In the previous works species communities of the ridges was considered as a single entity and was not differentiated between individual ridges [17, 18, 19]. However, Assylbek et al. [20] observed a significant difference in the richness of the species composition of fungi in the Ile and Kungey Alatau. The authors explained this difference by the limited number of studies of the Kungey Alatau. In my study, I also found significant similarities in the fauna of the Kungey and Terskey Alatau, Ile and Terskey Alatau ridges. The difference observed between Ile and Kungey Alatau is likely due to the uneven representation of Kungey Alatau malacofauna in previous studies.

Conclusion

The geographic location does not affect the species richness of gastropods in the Northern Tien Shan. Also, there are significant similarities in the

fauna of different mountain ridges. The difference in malacofauna between Ile and Kungey Alatau is likely due to the Kungey Alatau's uneven representation in previous studies. The performed data reconstruction method is a simple and fast approach for preliminary estimating faunistic diversity, although it has some limitations that can be overcome by incorporating environmental data.

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