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Mollusk fauna and regional distribution of the Kelkit Basin, Türkiye

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This study was conducted between October 2023 and October 2024 at a total of 85 stations covering the provinces of Gümüşhane, Giresun, Erzincan, Ordu, Tokat, and Sivas, with the aim of determining the freshwater mollusk fauna of the Kelkit Basin. The taxonomic identifications and habitat characteristics of the species recorded during the research were determined. From the study area, seven families belonging to the class Gastropoda were identified, including the species *Oxyloma elegans*, *Peregriana labiata*, *Gyraulus piscinarum*, *Physella acuta*, *Potamopyrgus antipodarum*, *Valvata macrostoma*, and *Theodoxus fluviatilis*. From the class Bivalvia, *Dreissena polymorpha gallandi* and *Dreissena caputlacus* were identified. In the Kelkit Basin, the alien invasive mollusks *D. caputlacus*, *D. p. gallandi*, *P. acuta*, and *P. antipodarum* were recorded from Kılıçkaya Reservoir, Çamlıgöze Reservoir, and Tepekışa Reservoir, but not from Sadak Reservoir and Gölova Reservoir. *Potamopyrgus antipodarum*, which has previously been reported to spread across many regions of Türkiye, was recorded from this basin for the first time. The potential impacts of this occurrence on the Kelkit Basin were also discussed.

INTRODUCTION

Phylum Mollusca successfully inhabits marine, terrestrial and freshwater biotopes. They can withstand even the harshest climatic conditions, especially in both terrestrial and freshwater environments. This success in withstanding is due to their ability to aestivation and hibernation. They have adapted to all types of environments, from deserts to arctic tundra, from temporary forest pools to steppes (Boss, 1974). Freshwater gastropods, on the other hand, successfully live in almost all aquatic habitats, including streams, lakes, rivers,

puddles, marshes, and drainage canals, on all continents except Antarctica (Strong et al., 2008). Some species prefer oxygen-rich waters (Prosobranch), while others do not seek oxygen-rich waters much (Pulmonate). Again, some Prosobranch species prefer cold waters (Cantrell, 1981; Aldridge, 1983; McMahon, 1983). Determining systematic and faunal information is essential for uncovering the medical, physiological, chemical, and economic aspects of these diverse groups. While numerous studies have been conducted in this area outside the Black Sea Region of Türkiye, there is no detailed study of the malacofauna in the



basin. This study aimed to determine the mollusc fauna of the Kelkit Basin and their distribution within the basin. The Kelkit Basin is one of Türkiye's important basins due to its soil and water resources, rich biodiversity, and agricultural potential (Doğan, 2009; Karadağ et al., 2021). This basin is located in the Central Black Sea Region of Anatolia and covers the cities of Tokat, Amasya, Gümüşhane, Giresun, and Sivas, as well as 17 districts. Covering a total area of 16244 hectares, the basin is surrounded by plains and high mountains with altitudes ranging from 200 meters to 2400 meters (Karadağ et al., 2021). Although located in the Black Sea Region, the Kelkit Basin is under the influence of a continental climate. The most important stream of this basin is the Kelkit Stream.

Although located in the Black Sea region, the Kelkit basin is under the influence of a continental climate. The most important stream in this basin is the Kelkit Stream. The Stream is formed by the confluence of small streams originating from Spikör Mountain, Pülür Mountain, Otlukbeli Mountain, Sarhan Mountain, and Balaban Mountain North of Erzincan near the Kelkit district. The most important tributaries forming the upstream section of the Upper Kelkit Stream Basin are Çömlecik Stream, Köse Stream, Balahor Stream, and Koşmasat Stream. The total length of the Kelkit stream is 320 kilometers (Karaca et al., 2016). The Kelkit Stream reaches the Suşehri Plain in a south easterly direction. After passing through the Suşehri and Niksar plains, it joins the Yeşilirmak River north of the Erbaa plain (Figure 1). There are some malacological studies near the research area. There are also some malacological studies carried out in the western Black Sea region, mostly in the provinces of Sinop and Tokat, as well as in Samsun, Bolu and Zonguldak (Retowski, 1889; Croockewit, 1953; Boettger, 1957; Bat et al., 2000; Duran et al., 2003; Öktener, 2004; Özbek et al., 2004; Duran, 2006; Duran and Suiçmez, 2007; Kazancı et al., 2008; Akbulut et al., 2009). The molluscan fauna of the Çoruh river and its tributaries was reported by Gözler et al. (2020), preliminary research on gastropod species in some freshwaters of the Black Sea region was conducted by Yıldırım et al. (2022), and studies on molluscan species and their distribution in streams and creeks of Trabzon were conducted (Kara et al., 2024).

Reported from approximately 33 different localities in Türkiye to date, *Potamopyrgus antipodarum* exhibits an increasing spread particularly in eutrophic and polluted stream ecosystems, carrying the potential to exert competitive pressure on native benthic fauna and alter ecosystem processes. Nevertheless, the species' distribution across the country is still not monitored through a comprehensive surveillance program; this represents a significant gap both for controlling existing populations and

for the early detection of new invasion fronts. The species displays broad ecological tolerance; it can adapt well to variations in temperature, water quality, and nutrient levels, and is capable of successfully establishing colonies even in aquatic environments where stress factors such as pollution, organic load, and habitat degradation are pronounced. This tolerance allows the species to spread rapidly not only in clean and stable ecosystems but also in habitats that are disturbed or ecologically weakened as a result of human impact (Gürlek, 2015; 2025). This study aims to fill the gap in the literature by determining the freshwater mollusc fauna of the Kelkit Basin, systematically classifying the species, and revealing their distribution patterns within the basin while also considering their invasion status.

This study aims to fill the gap in the literature by determining the freshwater mollusc fauna of the Kelkit Basin, systematically classifying the species, and revealing their distribution patterns within the basin. Furthermore, the obtained data are intended to form the basis for future biological monitoring and conservation studies.

MATERIALS AND METHODS

This study was conducted in the Kelkit Basin, located in the Central Black Sea Region of Türkiye. The study area covers the provinces of Tokat, Gümüşhane, Giresun, Erzincan, Sivas, and Ordu. The basin covers an area of approximately 16244 hectares and has elevations ranging from 200 m to 2400 m (Figure 1). Its terrain is characterized by mountainous areas, alluvial plains, and river valleys. The Kelkit stream, the main stream of the Kelkit basin, is formed by the confluence of streams originating in the Spikör, Pülür, Otlukbeli, Sarhan, and Balaban mountains north of Erzincan. It flows from west to east to join the Yeşilirmak River. The basin also contains important reservoirs Kılıçkaya, Çamlığöze, Tepekışla, Sadak, and Gölova. These aquatic systems represent different habitat types for mollusc species. The regional climate is generally continental, characterized by low temperatures in winter and high temperatures in summer. Average annual temperature ranges from 9-12°C, and average annual precipitation ranges from 400-600 mm (Karadağ et al. 2021). The basin has a high biodiversity potential due to its location at the intersection of different ecological zones. Agricultural areas, forested areas, pastures, and aquatic habitats are intertwined. This environmental diversity provides highly favorable habitats for the distribution of molluscan fauna.

The Kelkit Basin is one of Türkiye's most important basins due to its water resources and biodiversity (Figure 1). The living snails were collected by 65x65 cm in size (200 µm mesh size) aquatic hand-scoop (kick-net) and sieve. In springs samples were collected on stones and aquatic plants

by hand. Mollusc samples in question were taken into containers containing 96% ethyl alcohol, and the necessary notes were written on them. Later, they were brought to Karadeniz Technical University, Department of Biology, Hydrobiology Research Laboratory. Molluscs samples are kept as museum material in the Hydrobiology Research Laboratory of the Faculty of Sciences of Karadeniz Technical University. The samples were identified according to Zhadin (1965), Bilgin (1980), Glöer and Meier-Brook (1998) and Yıldırım (1999), Glöer (2002), Yıldırım (2006), Kebapçı et al. (2012).

Descriptive geographic maps showing features such as elevation, slope and bedrock in the research area were produced using DEM raster data. In addition, the altitudes and coordinates of the sampling stations in the research area were determined in the field, and the maps were made using the ArcGIS 10.5 program (Figure 1).

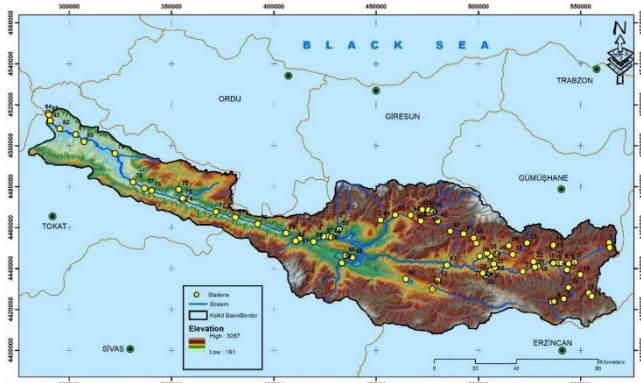


Figure 1. Map of the study area, sampling stations and identified species

RESULTS AND DISCUSSION

In this study conducted in the Kelkit Basin, the following species were identified from the Gastropoda class: *Oxyloma elegans*, *Peregriana labiata*, *Gyraulus piscinarum*, *Physella acuta*, *Potamopyrgus antipodarum*, *Valvata macrostoma*, *Theodoxus fluviatilis*, and from the Bivalvia class: *Dreissena polymorpha gallandi* and *Dreissena caputlacus*. The identified species and their localities are shown in Figure 1. In the Kelkit basin, *O. elegans* has been detected at eight stations and has a wide distribution between altitudes of 941-1358 m. The habitats where *O. elegans* is found are rich in aquatic plants. It prefers to live on moist stones and aquatic plants. *O. elegans* individuals have been identified from the littoral zone of the Kelkit Stream, Bağırsak Creek, and Zinav Lake. *G. piscinarum* has also been identified in the same basin at altitudes between 212-1657 m and from habitats rich in aquatic plants. *V. macrostoma* was identified only from the Çamlığöze Reservoir. *G. piscinarum* was identified from the Kelkit stream, the Gökçeköy vicinity and Kuşmasat Creek. It was

determined that *O. elegans*, *G. piscinarum* and *V. macrostoma* did not form strong populations in the habitats where they are found (Table 1).

The distribution of *P. acuta* is thought to be limited to countries bordering the Mediterranean, Central Asia, and the Black Sea basin (Zhadin, 1965). *P. acuta* is one of the most widespread invasive species, a cosmopolitan invasive species that has established itself in various parts of the world, particularly in Eurasia and Africa, as well as in Türkiye (Vinarski, 2017; Ebbs et al., 2018). Research has determined that *P. acuta* is more common in areas with abundant vegetation and slow-flowing or stagnant waters. *P. acuta* has also been identified in streams flowing into the Black Sea (Kara et al., 2024), and this research marks the first recorded occurrence of *P. acuta* in the Kelkit region. *P. acuta* has been identified at six stations in the Kelkit Basin, from aquatic plant-rich stream habitats ranging from 187 to 941 m elevation, as well as from the littoral zone of Tepekışla Reservoir and Zinav Lake. Members of the Basommatophora are of parasitological importance because they serve as intermediate hosts for parasitic trematodes. The passive dispersal of this alien invasive species in the Kelkit Basin is unknown, as it is known to expand its distribution through human activities such as the aquarium trade (Ng et al., 2015).

P. labiata inhabits a variety of habitats, ranging from small stagnant or slowly flowing freshwater bodies of water to marshes, floodplains, and the shallow areas of high-altitude lakes (Angelov, 2000; Glöer, 2002; Khokhutkin et al., 2009; Glöer and Diercking, 2010). This species is common in habitats rich in aquatic plants and algae in the Kelkit Basin. *P. labiata* has been distributed between altitudes of 367 and 1657 m in the Kelkit Basin. This species has been identified in habitats rich in aquatic plants and algae in the Kelkit Basin. This species has been identified in habitats rich in aquatic plants in the Kelkit Stream (main stream), Kuşmasat and Bağırsak streams, Aluçra Stream, Zinav Lake, and the littoral zone of the Çamlığöze Reservoir. *P. labiata* has also established very strong populations in the littoral zone of the Çamlığöze Reservoir.

T. fluviatilis, commonly known as the "River Nerite" is a freshwater and brackish water snail with gills and an operculum (Neubauer, 2014). This widespread "nerite snail" is widely distributed from Europe to Central Asia (Kebapçı et al., 2012; Şahin and Yıldırım, 2007). The shell exhibits considerable polymorphism, varying in color and pattern. This species readily attaches to rocks, allowing it to inhabit fast-flowing waters and wavy areas of lakes (Kirkegaard, 2006). In the Kelkit Basin, *T. fluviatilis*, known as the "River Nerite", has been found in very strong populations at altitudes of 184-194 m around Erbaa.

Table 1. Sampling localities and identified species in the study area

Stations	X (Longitude)	Y (Latitude)	Location	Altitude (m)	Species				
1	563897	4452638	Gökçeköy	1657	<i>G. piscinarum</i>	<i>P. labiata</i>			
2	564135	4450269	Kuşmasat Creek	1607					
3	547064	4443027	Kuşmasat Deresi	1450					
4	539357	4442814	Kuşmasat Creek	1407	<i>G. piscinarum</i>	<i>P. labiata</i>			
5	540629	4442726	Kuşmasat Creek	1418					
6	544114	4442356	Kuşmasat Creek	1436					
7	535821	4423578	Değirmendere	1671					
8	537119	4423875	Değirmendere	1664					
9	541704	4425084	Değirmendere	1622					
10	544087	4430680	Değirmendere	1548					
11	543248	4439284	Çömlecik Creek	1460					
12	553958	4428036	Çömlecik Creek	1630					
13	555367	4426349	Çömlecik Creek	1656					
14	549822	4436928	Çömlecik Creek	1524					
15	536474	4443050	Kelkit Stream	1393					
16	536650	4442608	Değirmendere	1394					
17	536714	4450587	Özen Creek	1608					
18	536630	4451433	Özen Creek	1634					
19	529075	4440925	Kelkit Creek	1358	<i>G. piscinarum</i>	<i>O. elegans</i>			
20	527548	4440623	Kelkit Creek	1350	<i>O. elegans</i>				
21	521733	4438547	Kelkit Stream	1326	<i>O. elegans</i>				
22	526905	4443381	Elmalı Creek	1387					
23	523703	4452479	Dilekyolu village	1592					
24	514842	4451165	Çağıl village	1463					
25	503724	4436710	Tomarza waterfall	1308					
26	503974	4437889	Kelkit Stream	1212					
27	503200	4438120	Kelkit Stream	1208	<i>O. elegans</i>				
28	502070	4437804	Kelkit Stream	1196	<i>O. elegans</i>				
29	505426	4437901	Kelkit Stream	1223					
30	506014	4438803	Kelkit Stream	1233					
31	507637	4440962	Çakırkaya village	1266					
32	507918	4440458	Kelkit Stream	1252	<i>O. elegans</i>				
33	507502	4442286	DSİ Reservoir	1314					
34	505954	4445879	Şıran Stream	1322					
35	504206	4447464	Şıran Stream	1372					
36	508886	4447010	Şıran Stream	1359					
37	516787	4446784	Şıran Stream	1430					
38	500642	4446036	Alancık Creek	1292					
39	498934	4452313	Yeşilbük location	1401					
40	497688	4454901	Kızlar Kalesi Reservoir	1478					
41	492773	4456905	Bağırsak Creek	1662					
42	486331	4458276	Bağırsak Creek	1581					
43	480263	4463120	Bağırsak Creek	1469	<i>P. labiata</i>	<i>O. elegans</i>			
44	475831	4467103	Bağırsak Creek	1380	<i>P. labiata</i>				
45	475528	4468710	Alucra Stream	1369	<i>P. labiata</i>				
46	474465	4468717	Alucra Stream	1349	<i>P. labiata</i>				
47	472561	4468785	Alucra Stream	1324					
48	475626	4468648	Bağırsak Creek	1369	<i>P. labiata</i>				
49	477771	4468404	Elmacık Creek	1392					
50	477796	4467712	Moran Creek	1391					
51	471904	4463271	Aktepe	1453					
52	466872	4466069	Alucra Stream	1254					
53	459376	4466226	Alucra Stream	1103					
54	452112	4463692	Çatak Creek						
55	432095	4459017	Elma Creek	860					
56	426670	4455814	Çamlığöze Reservoir	748					
57	424471	4455477	Çamlığöze Reservoir	751	<i>V. macrostoma</i>	<i>P. antipodarum</i>	<i>D. caputlucis</i>	<i>D. p. gallandi</i>	
58	419405	4453100	Kelkit Stream	728					
59	433309	4442685	Akşar Creek	866					
60	464503	4434918	Gölova Reservoir	1294					
61	477572	4429871	Çobanlı Creek	1205					
62	480199	4434425	Çobanlı Creek	1167					
63	484645	4441611	Kelkit Stream	1076					
64	428218	4455320	Çamlığöze Reservoir	752	<i>V. macrostoma</i>	<i>P. antipodarum</i>	<i>D. caputlucis</i>	<i>D. p. gallandi</i>	<i>P. labiata</i>
65	438553	4445287	Kılıçkaya Reservoir	844	<i>D. caputlucis</i>	<i>D. p. gallandi</i>			
66	435121	4446235	Kılıçkaya Reservoir	837	<i>D. caputlucis</i>	<i>D. p. gallandi</i>			
67	412664	4454592	Kelkit Stream	700	<i>P. antipodarum</i>	<i>G. piscinarum</i>	<i>P. labiata</i>		
68	410630	4453409	Alman Creek	775					
69	405994	4457197	Kelkit Stream	671	<i>P. antipodarum</i>	<i>G. piscinarum</i>			
70	392199	4461793	Kelkit Stream	610	<i>D. caputlucis</i>	<i>D. p. gallandi</i>			
71	381337	4464798	Kelkit Stream	566	<i>D. caputlucis</i>	<i>D. p. gallandi</i>			
72	371828	4467691	Kelkit Stream	528					
73	353644	4478643	Zinav Lake	941	<i>O. elegans</i>	<i>P. labiata</i>	<i>P. acuta</i>		
74	355695	4473338	Kelkit Stream	460					
75	355478	4474298	Delice Creek	485	<i>P. acuta</i>				
76	340338	4478064	Kelkit Stream	367	<i>P. labiata</i>				
77	336848	4479227	Kelkit Stream	347					
78	331280	4482237	Kelkit Stream	315					
79	322468	4496262	Kelkit Stream	267					
80	307362	4501976	Kelkit Stream	252	<i>P. acuta</i>	<i>D. caputlucis</i>	<i>D. p. gallandi</i>		
81	303312	4505499	Kelkit Stream	212	<i>P. acuta</i>	<i>D. caputlucis</i>	<i>D. p. gallandi</i>	<i>G. piscinarum</i>	
82	295476	4508305	Kelkit Stream	194	<i>P. acuta</i>	<i>T. fluviatilis</i>			
83	290795	4512229	Kelkit Stream	187	<i>P. acuta</i>	<i>T. fluviatilis</i>			
84	289896	4515890	Yeşilirmak and Kelkit Stream	182	<i>T. fluviatilis</i>				
85	290129	4515069	Kelkit Stream	184	<i>T. fluviatilis</i>				

x,y coordinate: WGS_1984_UTM_Zone_37N (6°)

P. antipodarum is an invasive species and has spread to North America, Europe, Asia and Australia, except Africa and Antarctica (Ponder, 1988). Again, *P. antipodarum* is

considered one of the most successful and widespread invasive freshwater molluscs worldwide (Nentwig et al., 2018; Dias et al., 2024). The first record of *P. antipodarum* in

Türkiye was reported by Bilgin (1980). Later, the species was recorded by different researchers from the Aegean, Western Mediterranean, Marmara Region and Southeastern Anatolia Region (Ustaoğlu et al., 2001; Özbek et al., 2004; Kebapçı and Yıldırım, 2010; Gürlek, 2015). This is a species that causes numerous ecological and economic problems (Alonso and Castro-Díez, 2012; Alexandre et al., 2019;). The most important factor that makes this species an effective invader in a new habitat is its reproduction by parthenogenesis (Jacobsen and Forbes, 1997). The success of *P. antipodarum* in living in local non-native areas is associated with its broad tolerance to different physicochemical conditions (e.g. pH, water temperature, dissolved oxygen), as well as its shell morphological adaptations and the absence of local enemies. For example, thanks to the operculum and strong shell, these snails can survive in the digestive system of fish and can be carriers of *P. antipodarum* (Alonso and Castro-Díez, 2008). Freshwater invasions are of particular concern as they are among the most endangered ecosystems (Dudgeon and Strayer, 2025). *P. antipodarum* was detected in this research in Çamlığöze Reservoir, Kılıçkaya Reservoir and Tepekışla Reservoirs in the Kelkit Basin and they form dense populations. Thus, while *P. antipodarum* is distributed from the west to the east and south of Türkiye (Gürlek, 2015), this study revealed its spread into the Black Sea Region as well. Gürlek (2025) mentioned in his study that, in the event of a south-to-north expansion from the Malatya and Elazığ line toward the Kelkit Basin, the species could first spread into the Kelkit Basin and subsequently into the Eastern Black Sea Region. Alonso and Castro-Díez (2008) state that the spread of this species is carried by ship ballast water (ship hull), aquatic plants, fish and birds. It is thought that *P. antipodarum* individuals were carried to these dam lakes by fishing nets and water birds. Pyšek et al. (2020) state that alien invasive species are an important factor behind the extinction of native species. Again, Higgins and Zanden (2010) state that alien invasive species are a major threat to biodiversity and genetic diversity of native species. This situation may cause the invasive *P. antipodarum* to form dense populations in the Kelkit Basin before its malacofauna is known, causing the extinction of native species in the basin.

D. caputlacus in the Central Anatolia and Eastern Anatolia regions of Türkiye; *D. p. anatolica* taxa are found especially in the lentic systems of the Aegean, Mediterranean and Southeastern Anatolia, and *D. p. gallandi* taxa are found in the aquatic habitats of the Marmara and western Black Sea regions (Gelembiuk et al., 2006). In studies conducted in Türkiye to date, *D. caputlacus*, *D. p. anatolica* and *D. p. gallandi* taxa have been reported to be widespread (Gürlek et al., 2019). The presence of *D. caputlacus* and *D. p. gallandi* individuals was detected from 7 different stations in the

Kelkit Basin. Fishing is done in Çamlığöze Reservoir, Kılıçkaya Reservoir and Tepekışla Reservoirs. Yıldırım et al. (2023); species belonging to the genus *Dreissena* state that reasons such as fishing activities and lack of adequate controls cause them to easily invade new areas. *D. caputlacus* and *D. p. gallandi* individuals form dense populations in both lentic and leutic systems in the lower Kelkit Basin, at altitudes of 184-610 m. It is thought that *D. p. gallandi* individuals were transported to the lower Kelkit basin as a result of fishing activities.

When the general molluscan fauna of the Kelkit Basin is examined, alien invasive molluscan species (*D. p. gallandi*, *D. caputlacus*, *P. acuta* and *P. antipodarum*) are present in Zinav Lake, Kılıçkaya Reservoir, Çamlığöze Reservoir and Tepekışa Reservoir, especially in the middle and lower Kelkit Basin. Individuals of *D. p. gallandi*, *D. caputlacus*, and *P. antipodarum* from very dense populations in Çamlığöze Reservoir, Kılıçkaya Reservoir, and Tepekışa Reservoir. These alien invasive species are thought to have been transported to the reservoir by fishing nets and waterfowl. This situation may pose a threat to biodiversity and native species, as invasive species can compete with native species and cause extinction (Dudgeon and Strayer, 2025). Freshwater invasions are particularly worrying because they are among the endangered ecosystems (Dudgeon and Strayer, 2025) and are an important driving force behind the extinction of native species (Pyšek et al., 2020). This poses a major threat to biodiversity and genetic diversity of local species (Higgins and Zanden, 2010). These alien invasive species were not encountered in Sadak Reservoir and Gölova Reservoir during the study. Local residents indicate that aquaculture activities have only recently begun in Sadak Reservoir, while Gölova Reservoir is not suitable for aquaculture, and fishing is not currently taking place. Therefore, these invasive species may not have yet been introduced to Sadak Reservoir and Gölova Reservoir. In conclusion, the invasive alien species *D. p. gallandi*, *D. caputlacus*, *P. acuta*, and *P. antipodarum* are found in a significant portion of the Kelkit Basin. Therefore, detailed ecological and monitoring studies are needed for the Kelkit Basin in the future.

CONCLUSION

This study provides the first comprehensive assessment of the freshwater mollusc fauna of the Kelkit Basin and reveals a heterogeneous assemblage shaped by habitat type, altitude, and biological invasions. Native species such as *Oxyloma elegans*, *Gyraulus piscinarum*, *Valvata macrostoma*, *Peregriana labiata*, and *Theodoxus fluviatilis* show distinct ecological preferences and generally form weak to moderate populations, with the exception of *T. fluviatilis* and *P. labiata*,

which establish strong local populations in suitable habitats. In contrast, invasive species (*Physella acuta*, *Potamopyrgus antipodarum*, *Dreissena caputlacus*, and *D. p. gallandi*) are widely distributed and form dense populations, particularly in reservoirs and lower basin systems. The occurrence of *P. acuta* and the expansion of *P. antipodarum* into the Black Sea Region represent new and significant records for the basin. These findings indicate that biological invasions, likely facilitated by human activities and waterbirds, pose a serious threat to the native malacofauna and ecosystem integrity of the Kelkit Basin. Continued monitoring and management measures are therefore essential to prevent further spread and potential loss of native biodiversity.

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COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

CK: Conceptualization, Methodology, Supervision, Resources, Data curation, Formal analysis, Investigation, Literature review, Writing - original draft, Writing - review & editing.

NB: Data curation, Formal analysis, Investigation, Writing - original draft.

FKK: Data curation, Formal analysis, Investigation, Writing - original draft.

MK: Data curation, Formal analysis, Investigation, Writing - original draft.

MEG: Formal analysis, Literature review, Writing - original draft.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

Since the species included in the study is an invertebrate, approval from the Local Animal Research Ethics Committee is not required.

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Data Availability

The data supporting the findings of this study are available from the corresponding author upon request.

AI Disclosure

The authors confirm that Generative AI was not used in this research paper.

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