Contraction of range, declines in abundance and site-based threats to Velvet Scoter *Melanitta fusca* breeding in the Caucasus

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Abstract

The geographically discrete Caucasus breeding population of the Velvet Scoter *Melanitta fusca* has shown significant range contraction to its one last existing colony in Georgia. Despite active conservation efforts at this site, where numbers currently appear to be stable, there is an evident need to understand past and present pressures that have driven the species to the verge of extinction in the region. An assessment of the potential for recreating suitable conditions for restoring the species to its former range and abundance is also required. Here, we review historical information to determine potential factors (some of which may still be in place) that contributed to the decline and range contraction of the Velvet Scoter in Armenia, Georgia and Türkiye. Breeding surveys conducted in all three countries since 2013 confirmed the species' absence from all sites except for the breeding colony at Lake Tabatskuri in Georgia, which supported 45–50 pairs in 2024. Of 13 lakes with documented observations of Velvet Scoters, seven were confirmed as former breeding sites, with < 150 pairs in the last 60 years. The remainder were either spring/autumn staging areas, or unconfirmed breeding sites. For some sites, reasons for the loss of breeding Velvet Scoter locally were evident; for instance, at Lake Sevan in Armenia, reductions in the water levels in the lake rendered nesting islands accessible to terrestrial predators. Elsewhere, it was not possible to identify the causes of declines and extinctions, but by using the IUCN-CMP classification of threats and stresses we identified interactions with native species, recreational activity, hunting/egg collecting and fishing as critical threats to the viability of Velvet Scoters in the Caucasus. Several sites are suffering water quality issues, which require management interventions to

restore turbid water to clear aquatic systems before the sites would become suitable for the return of the species. More site-based research and management will be necessary to restore the Velvet Scoter to its former levels of abundance and distribution.

Key words: Armenia, conservation, Georgia, population decline, sea duck, threat analysis, Türkiye.

Within the Anatidae family, the Mergini tribe consists primarily of diving ducks adapted to high-latitude ecosystems, predominantly exploiting marine environments during the non-breeding season (Kear 2005). The 20 extant northern hemisphere Mergini species typically breed in tundra habitats or northern boreal forests and mainly overwinter in coastal waters (Johnsgard 2010; Savard *et al.* 2015). Velvet Scoter *Melanitta fusca* (in the western Palearctic), Stejneger's Scoter *Melanitta stejnegeri* (in the eastern Palearctic) and White-winged Scoter *Melanitta deglandi* (in the Nearctic), three closely related species, form a "super-species" primarily breeding in boreal regions of the Northern Hemisphere and wintering in maritime habitats generally to the south (Collinson *et al.* 2006).

The Velvet Scoters' breeding distribution extends from Baltic Sea (particularly Scandinavia and Estonia), through Asia, east of the Yenisei River to Central Siberia and south to northeastern Kazakhstan (Carboneras *et al.* 2020; Cramp & Simmons 1977; Keller *et al.* 2020; Rogacheva 1992). The discrete breeding population in the Caucasus region, which formerly occurred in Georgia, Türkiye and Armenia, has been considered isolated from the main breeding range and was thought likely to winter in the Caspian and Black Seas (Carboneras *et al.* 2020; Dagys 2016; Kear 2005). This population represents not only the only sea duck species breeding in the Caucasus but also the only one to breed in Türkiye, despite its vast territory and diversity of biotopes (Cramp & Simmons 1977; Kirwan *et al.* 2008). Additionally, these birds are thought to be connected to those breeding in Turkmenistan (Kear 2005). Recent genetic studies suggest that the Northern (*i.e.* boreal forest) and Caucasian Velvet Scoter populations may represent a single panmictic population, implying recent isolation and/or continued genetic exchange (Paposhvili *et al.* 2023).

The past two decades have witnessed significant declines in numerous sea duck species, including the Velvet Scoter (Kilpi *et al.* 2015; Skov *et al.* 2011). The current global population is estimated at between 210,000 and 400,000 individuals (BirdLife International 2024) and, with an estimated 30–46% decline over the last three generations, the species has been listed as Vulnerable on the IUCN Red List (BirdLife International 2024). Reflecting this broader trend, the Caucasian population has also declined rapidly, bringing this tiny and geographically restricted population to the brink of extinction. Over the past six decades, the Caucasian population has declined and contracted its range, such that

(as far as is known) it is now restricted to a single breeding site in Georgia (Keller *et al.* 2020; Paposhvili 2018; Wetlands International 2024).

Historical information about the breeding population in the Caucasus is limited, making the causes of this rapid decline unclear. Recent studies suggest that hunting, egg collection, bycatch (entanglement/drowning) in fishing nets, predation and habitat degradation contribute to reductions in juvenile and adult survival rates and breeding success, potentially driving the population's decline (Paposhvili 2021). Climate change however is considered the most significant threat to the species, both currently and into the future (Drever *et al.* 2012).

The primary objective of this study is to analyse the past and current threats and their impact on the population, which have driven it toward extinction in the Caucasus region over the past six decades. Additionally, this study aims to establish the potential for currently abandoned sites to be restored to a suitable ecological status, to support the Velvet Scoters' recolonisation of formerly occupied breeding sites. In doing so, this lays the foundation for the assessment of the potential for a reintroduction programme in the Caucasus, informed by recent research and conservation efforts. Clearly, reintroduction programmes can only be successful if the original causes of local extinction have been identified, quantified and rectified. Therefore, it is essential to examine the local causes of decline at previously occupied sites in order to facilitate recovery strategies that are critical to preventing the species' extinction in the region. In conservation biology, understanding the influence of both historical and current factors on populations is crucial for developing effective strategies. By addressing these factors, this study aims to develop practical conservation strategies to halt further decline and support efforts to conserve and restore this charismatic duck to its former abundance and distribution in the Caucasus.

Methods

Geographical scope of the study

The Caucasus Ecoregion, covering approximately 586,800 km^2, encompasses diverse territories across Armenia, Azerbaijan, Georgia, the north Caucasian region of northeastern Türkiye and northwestern Iran. Renowned for its exceptional biodiversity, this region is classified as one of the world's biodiversity hotspots (Zazanashvili 2009). This study focused on both historical and current breeding sites of the Velvet Scoter, specifically within Georgia, Armenia and the Caucasian region of Türkiye, where the species is known to have bred in the recent past. Study sites were selected based on historical records and the known breeding distribution of the Velvet Scoter; the lakes and their habitat characteristics are summarised in Table 1. The transparency of the water column was recorded during site visits, and changes in trophic status were assessed subjectively based on ecological indicators, such as the abundance of submerged vegetation. In total, 13 former breeding sites were revisited, including six in Georgia, four in Türkiye, one transboundary lake partly in

Table 1. Summary table of the habitat characteristics of the study sites (TR = Türkiye; AM = Armenia; GE = Georgia). Coordinates for the study sites are provided in the Supporting Materials (Table S1).

Site no.	Site name (Country)	Altitude (m)	Surface area (km²)	Average (max.) depth (m)	No. of islets	Habitat on the islets	Transparency, year	Trophic state
1	Çıldır (TR)	1,963	123	42.0 (30.0)	4	Human-planted woodland, grassland, shrubs, rocky, stony, ancient ruins	Transparent, 2020	Mesotrophic
2	Aktaş (TR)/ Kartsakhi (GE)	1,800	14.0 (TR)	1.0 (0.70) 13.0 (GE)	12	Scattered trees and shrubs, stony, rocky, grassland	Turbid, 2023	Eutrophic
3	Aygır (TR)	2,131	3.7	30.0 (?)	0	–	Transparent, 2022	Mesotrophic
4	Balık (TR)	2,254	34	37.0 (7.0)	2	Rocky, stony, grassland	Transparent, 2022	Oligotrophic
5	Nemrut Caldera (TR)	2,252	34	155.0 (100.0)	2	Rocky, stony, woodland, shrubs	Transparent, 2023	Oligotrophic
6	Arpi (AM)	2,025	20	8.0 (4.2)	2	Grassland, shrubs, stony	Turbid, 2023	Oligotrophic
7	Sevan (AM)	1,900	1,242	79.0 (26.0)	1	Grassland, shrubs, stony	Transparent, 2023	Oligotrophic
8	Khanchali (GE)	1,931	6.9	1.0 (0.5)	0	No island	Severe algal growth, 2023	Eutrophic

Table 1 (*continued*).

Site no.	Site name (Country)	Altitude (m)	Surface area (km²)	Average (max.) depth (m)	No. of islets	Habitat on the islets	Transparency, year	Trophic state
9	Bughdasheni (GE)	2,045	0.4	1.5 (0.8)	1	Grass, two half-dried small trees	Turbid, 2023	Mesotrophic
10	Madatapa (GE)	2,112	8.8	1.7 (0.7)	2	The first, large island is grassy; the second is stony	Severe algal growth, 2023	Eutrophic
11	Saghamo (GE)	1,999	4.8	2.2 (1.6)	1	Grassy, with three or four small trees	Turbid, 2023	Mesotrophic
12	Paravani (GE)	2,079	37.5	3.3 (2.2)	4	All four islands are grassy with a few shrubs	Turbid, 2023	Mesotrophic
13	Tabatskuri (GE)	1,993	14.2	45.0 (15.0)	3	The island: grassy, with shrubs and trees; the islets: grassy and stony	Transparent, 2023	Oligotrophic

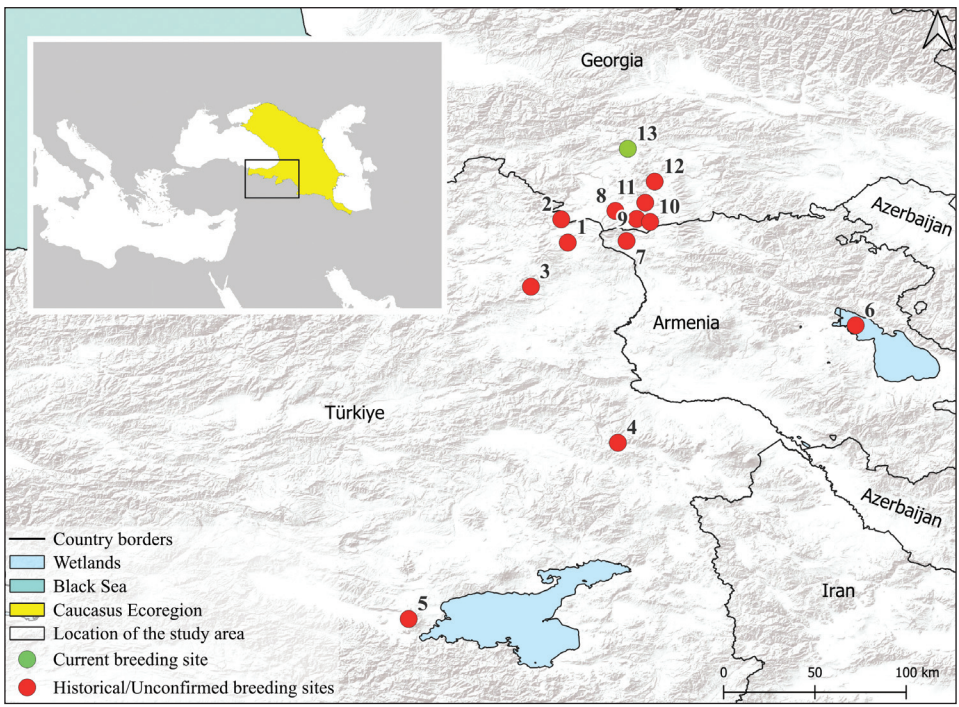

Figure 1. Historical and current breeding sites for Velvet Scoters in the Caucasus and the location of the Caucasus Ecoregion. Site codes (numbers) are listed in Table 1.

Georgia and Türkiye, and two lakes in Armenia (Fig. 1). Azerbaijan, and the territories of Russia and Iran within the Caucasus region, have been omitted from the study due to the absence of Velvet Scoter during the breeding season.

Compiling historical data

Historical data were collected from literature sources dating back to 1896, by making keyword-based searches (*e.g.* for Velvet Scoter, *Melanitta fusca*, Caucasus/Caucasia, Armenia, Georgia, Russia and Türkiye) within books and databases such as Google Scholar and national academic repositories, in English, Armenian, Georgian, Russian and Turkish. These were supplemented by observational data obtained from the two popular, most frequently used citizen science avian databases in the region: eBird (2024) and Observation.org (2024), and also from a Turkish web-based ornitho-photo platform, TRAKUŞ (2024). The regional scale of the data collection spanned three countries, and the data were consolidated into a summary table (Table 1). Historical breeding records were identified using the highest of the 16 breeding behaviour codes suggested by Keller *et al.* (2020) – grouped as "A" (codes 1–2; possible breeding), "B" (3–9; probable breeding) or "C" (10–16; confirmed breeding) – where C16 sites were those where a nest was found and young were seen or heard.

Current breeding survey

The breeding surveys made during our study were conducted at former breeding sites and also at the last known existing breeding site. Observations were performed using the "point count" method described by Bibby *et al.* (2000). Surveys in Georgia were conducted between 2017 and 2023, in Türkiye during 2016–2018 and 2021–2023, and in Armenia between 2013 and 2024. Where several behaviours indicative of breeding were recorded in an area, we assigned the highest breeding code (*i.e.* one of the 16 standardised codes listed by Keller *et al.* 2020), as the definitive breeding status for birds at that site.

Threats analysis

Threats to the Velvet Scoter and its breeding habitat, as well as the stresses caused by these threats, were identified through observations made during visits to all target sites and from the literature listed in Table 2. Threats were classified using the *IUCN-CMP Unified Classification of Direct Threats (Version 4.0) and Stresses (Version 1.0)* (Salafsky *et al.* 2024). "Threat ranking methodology" was employed for threat analysis (Ministry of Agriculture and Forestry 2023; developed for implementation in Türkiye). Each threat was assessed based on three criteria: (1) Scope = the proportion of the population or habitat affected; (2) Severity = the intensity of the impact on the species or its habitat; and (3) Urgency = the immediacy of required action. All threats were ranked individually for each of the three criteria and assessed across all areas covered in the study without distinguishing between countries. Each criterion was scored on a numerical scale of 1–16, where 1 represents the broadest/highest impact, and 16 represents the narrowest/lowest impact. This range reflects the total number of threats included in the assessment. The same approach was applied separately to each of the other criteria. After ranking for all three criteria, the scores for each threat were summed, and the threat with the lowest total score was identified as the most critical. Threats were then categorised as "critical", "high", "medium" or "low", based on their assessed impact levels on the Velvet Scoter and its ecosystem. Boundaries of the four different categories were settled by the authors' experience of the region and, although not strictly delineated, were established by consensus. Relationships between the threats identified and resultant stresses on the birds were visualised in a problem tree schema developed for Velvet Scoter breeding in the Caucasus.

Results

Historical and current breeding distributions

During the surveys, no Velvet Scoter were observed in Türkiye (2016–2023) and Armenia (2013–2024). The only confirmed breeding site, with 45–50 pairs, was at Lake Tabatskuri, Georgia. The last remaining Caucasian Velvet Scoter continue to breed on the largest of the three islets in the lake. Of the 13 sites evaluated, associated with the species in the recent past, seven were confirmed as having been breeding areas, while the remainder comprised historical sites which were pre- or post-nuptial stopover sites or unconfirmed breeding sites (Table 2).

Table 2. Overview of historical and current data. ? = lack of data. Breeding codes indicate the increasing probability of birds breeding, based on the *European Breeding Bird Atlas 2* categories (Keller *et al.* 2020): A1 = species observed in the breeding season, in possible nesting habitat; B3 = pair observed in the breeding season, in possible nesting habitat; B4 = territorial behaviour; C12 = recently fledged or downy young observed; C13 = adults entering/leaving nest site; C15 = nest containing eggs; and C16 = nests with young seen/heard.

Site name (country code)	Status of the site	Year of			Number of pairs	Max. number of ♂ – ♀	Max. number of ducklings	Breeding code	References
		Max. count	Latest observation	Latest breeding attempt					
Çıldır (TR)	Unconfirmed breeding	14 (2005)	2005	?	?	?	?	A1	1, 2
Aktaş (TR)/ Kartsakhi (GE)	Former breeding	725 (1980)	2005	1980	20–50	?	?	C12	1, 3, 4, 5, 6, 7, 8
Aygır (TR)	Unconfirmed breeding	32 (2001)	2008	1967	?	?	?	A1	1, 2, 6
Balık (TR)	Former breeding	18 (1967)	2008	1985	3	3	15	C12	1, 2, 9
Nemrut/ Caldera (TR)	Former breeding	21 (1967)	1992	1998	3–5	5–5	18	C12	1, 2, 9
Arpi (AM)	Unconfirmed breeding	?	1998	1969	0–1	2–1	0	B4	10

Table 2 (*continued*).

Site name (country code)	Status of the site	Year of: Max. count	Year of: Latest observation	Year of: Latest breeding attempt	Number of pairs	Max. number of ♂ – ♀	Max. number of ducklings	Breeding code	References
Sevan (AM)	Former breeding	~50 (1968)	1969	2004	?	?	?	C15	11, 12, 13
Khanchali (GE)	Former breeding	?	2004	?	10–20	?	1	C12	4, 5, 14, 15
Bughdasheni (GE)	Unconfirmed breeding	?	2nd half of 20th century	?	?	?	?	B3	4, 5
Madatapa (GE)	Unconfirmed breeding	?	2nd half of 20th century	?	?	?	?	B3	4, 5, 16
Saghamo (GE)	Unconfirmed breeding	21 (2002)	2004	?	4	5–4	?	C13	4, 5, 15, 17
Paravani (GE)	Unconfirmed breeding	?	2nd half of 20th century	?	?	?	?	B3	4, 5
Tabatskuri (GE)	Current breeding	106 (2023)	2023	2024	45–50	56–50	39	C16	18, 19, 20

References: 1 = Kirwan *et al.* 2008; 2 = eBird 2024; 3 = BirdLife International 2024; 4 = Janashvili *et al.* 1960; 5 = Kutubidze 1985; 6 = TRAKUŞ 2024; 7 = van der Ven & Gheyselinck 1982; 8 = Magnin & Yarar 1997; 9 = Vielliard 1968; 10 = Adamian & Klem 1999; 11 Lyayster & Sosnin 1942; 12 = Dahl 1954; 13 = Margaryan 1975; 14 = Matcharashvili, pers. comm.; 15 = BirdLife International 2025; 16 = Matcharashvili *et al.* 2004; 17 = G. Darchiashvili, pers. obs.; 18 = Paposhvili 2018; 19 = Paposhvili 2021; 20 = Paposhvili *et al.* 2023.

Breeding codes used to assess the status of each site revealed the following: two sites were classified as "possible breeding" (code A1), four sites as "probable breeding" (codes B3 and B4), and seven sites as "confirmed breeding" (codes C12, C13, C15 and C16) (Table 2). The estimated maximum number of pairs recorded at Aktaş/Kartsakhi (TR/GE) and Tabatskuri Lakes (GE) was 50. Based on historical data, the regional maximum population of Velvet Scoter in the Caucasus was likely fewer than 150 pairs in 1942–2025.

Historical data indicate that the earliest recorded breeding occurrence of the Velvet Scoter in the Caucasus dates back to 1896, relating to observations made at Lake Tabatskuri (Satunin 1907). In Türkiye, the most recent record of a bird seen during the breeding season was from 2008, when a male was observed at Lake Aygır, while the last confirmed breeding occurred at the Nemrut Caldera in 1998 (Table 2). In Armenia, the last breeding attempt was recorded in 2004 at Lake Sevan, where two males exhibited territorial behaviours. Following the rediscovery in 2014 of Velvet Scoter breeding at Lake Tabatskuri in Georgia (Toriashvili 2023), the species' breeding population was believed to have disappeared from the rest of the region.

Classification and analysis of threats

A total of 18 direct threats to Velvet Scoter and its habitats were identified (Table 3), causing six different types of stress (Fig. 2). The distribution of threats was as follows: 16 in Georgia, 13 in Türkiye and 12 in Armenia, with 10 threats common across all three countries. The most frequently recorded threats at all sites were "native species interactions" (n = 13), recreational activity (n = 12) and "hunting & collecting eggs" (n = 11). Paravani and Tabatskuri had the highest number of threats (n = 12), while Lake Balık and the Nemrut Caldera had the fewest (n = 4). The threats of "viral diseases" and "climate change" were classified as non-site specific.

Grazing & ranching. In Türkiye and Armenia, cattle grazing on breeding islands has led to habitat degradation and the destruction of nests and eggs. On Lake Çıldır, cattle and horses graze on the islands. Until 2016, the islands at Aktaş/Kartsakhi Lake were also used for grazing by Turkish farmers. However, grazing was banned after the establishment of a Turkish military border post and the designation of the area as a protected zone for the Dalmatian Pelican *Pelecanus crispus* and Great White Pelican *P. onocrotalus* colonies.

Hunting & egg collecting. Poaching of waterfowl occurs at all breeding sites in Türkiye and Georgia. At Lake Aktaş/Kartsakhi, eggs of the Greylag Goose *Anser anser* and Mallard *Anas platyrhynchos* were collected for food, and Greylag eggs were also used for incubation under domestic geese. Likely Velvet Scoter eggs were also taken during these activities. As a result of restrictions at Lake Aktaş/Kartsakhi, this threat has been mitigated and is no longer present at the lake. Such threats increase direct mortality and reduce reproductive success. Egg collection, once a major issue at Lake Tabatskuri, has also been resolved through local conservation initiatives and the cooperation of local communities.

Table 3. Threats to Velvet Scooter and its habitats, recorded for each of the study sites. Shading = threat identified.

Classification of threats	Study sites												
	Khanchali (GE)	Bughdasheni (GE)	Madatapa (GE)	Saghamo (GE)	Paravani (GE)	Tabatskuri (GE)	Aktaş (TR)/Kartsakhi (GE)	Çıldır (TR)	Aygır (TR)	Balık (TR)	Nemrut Caldera (TR)	Sevan (AM)	Arpi (AM)
Grazing & ranching			■				■	■	■				■
Hunting & collecting eggs	■	■	■	■	■	■	■	■	■	■	■		
Cutting & collecting terrestrial plants			■				■	■					
Fishing				■	■	■	■	■		■		■	■
Recreational activities	■	■	■	■	■	■		■	■	■	■	■	■
Scientific research						■							
Abstraction of surface water	■		■	■	■							■	■
Dams	■												■
Native species interactions	■	■	■	■	■	■	■	■	■	■	■	■	■
Invasive non-native species				■	■	■	■	■					
Sewage					■	■		■				■	
Nutrient loads	■	■	■	■	■	■	■	■				■	■
Herbicides & pesticides	■	■	■	■	■	■	■	■				■	■
Garbage & solid waste	■	■	■	■	■	■		■			■	■	■
Agricultural disturbance	■	■	■	■	■	■	■	■	■				■
Drought	■	■	■	■	■	■	■					■	■
*Viral diseases *Climate change	*Since both are considered hypothetical for the entire geographical scope, they were classified as non-site specific.												

Cutting and collecting terrestrial plants. Vegetation on breeding islands was cut and baled for livestock feed. During the mowing process, females might have been killed, and the nesting habitat irreversibly damaged for the breeding season. This threat, previously documented at Lake Aktaş/Kartsakhi, is no longer an issue at this site due to access

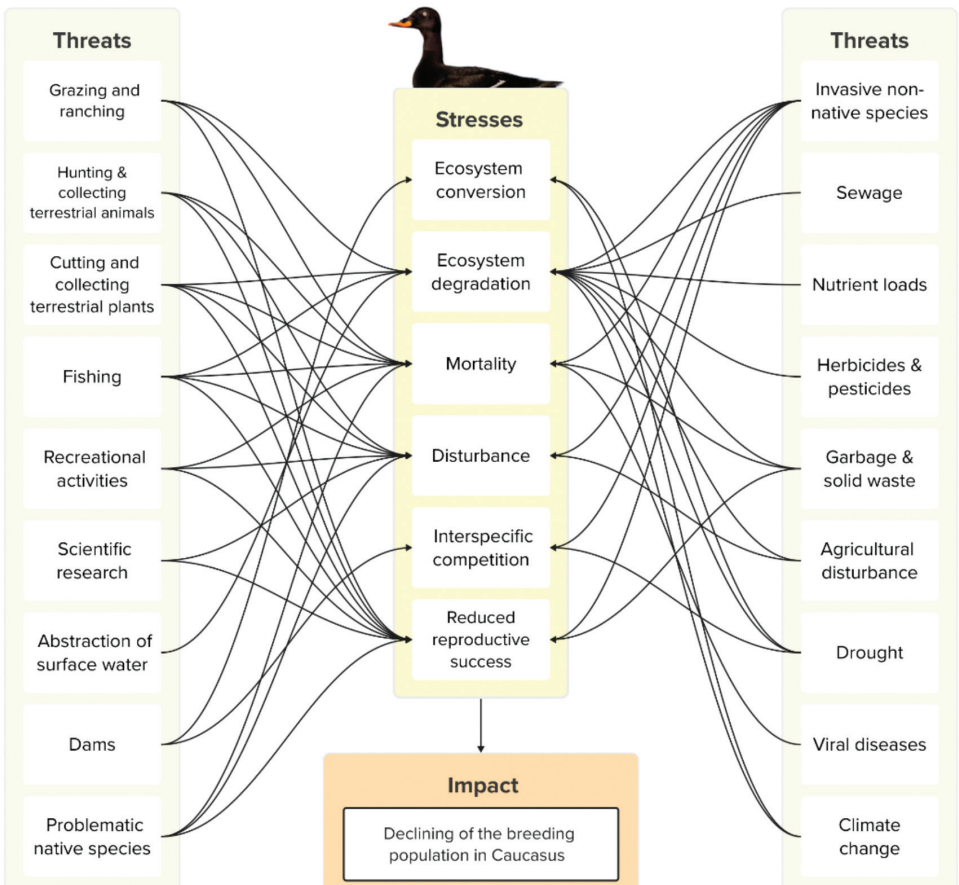

Figure 2. Problem tree for the declining Velvet Scoter breeding population in the Caucasus.

restrictions, which have also stopped egg collection.

Fishing. Fishing-related boat activity and human presence cause disturbances during the breeding season. At Tabatskuri, this has been a particular problem that causes the dispersal of broods from females, which facilitates Armenian Gull *Larus armenicus* predation of very small ducklings. Additionally, being a diving duck, the species is vulnerable to entanglement and bycatch in set gillnets and lost "ghost" nets, which result in drowning mortality and injuries (Fig. 3).

Recreational activities. Human presence on breeding islands disrupts nesting females, leading to nest abandonment, and poses a potential risk of crushing eggs underfoot. Off-road vehicles, motorboats and tourists also increase disturbance to nesting birds during incubation and while feeding and raising ducklings, making the ducklings and eggs vulnerable to predation.

Figure 3. Two juveniles entangled in a fishing net at Lake Tabatskuri in August 2021, by H. Muradyan.

Scientific research. Scientific research has only been conducted at lakes in Georgia. The length of stay on the islands, size of research teams, and the methods used all have the potential to cause disturbance, although researchers make every effort to minimise their disturbance activities, including by covering the eggs with down and camouflaging the nests after visits. On considering the number of nests recorded and Velvet Scoter ducklings counted in recent surveys, however, there was no evidence to suggest that these activities have a significant effect on Velvet Scoter.

Abstraction of surface water. Excessive abstraction of surface water for domestic, agricultural and industrial purposes has altered the natural water levels and their fluctuations at some Armenian wetlands, causing dramatic drops in water levels. A direct consequence of reducing water levels at Lake Sevan in the 1970s was the transformation of the breeding island into a peninsula, accessible to terrestrial predators (see Table 4). A situation worsened by the development of a historical monastery on the peninsula (*i.e.* the former island) for tourism, causing far greater disturbance.

Dams. At the end of the 20th century, a dam divided Lake Khanchali into two parts. One section is now mostly dry, to the extent that it is now used by locals for grazing. Before the dam's construction, the lake covered 13.1 km^2, but its surface area has since decreased to 6.9 km^2, leading to significant ecosystem changes.

Native species interactions. Overall, six mammal and five bird species were identified as confirmed (n = 5) or potential (n = 6) predators for Velvet Scoter across the study

Table 4. Native predators and their effects on Velvet Scoters. Evidence codes: d = documented by cameras; do = direct observation; p = potential predator.

Predator	Stage of Predation					
	Location	Egg	Duckling	Adult	Nesting competition	Level of evidence
Dalmatian Pelican *Pelecanus crispus*	Aktaş/Kartsahki	–	+	+	+	p
White Pelican *Pelecanus onocrotalus*	Aktaş/Kartsahki	–	+	+	+	p
Armenian Gull *Larus armenicus*	All lakes (except Aygır)	+	+	+	+	d & do
Marsh Harrier *Circus aeruginosus*	All lakes	+	+	+	+	d & do
Northern Goshawk *Accipiter gentilis*	Sevan & Arpi	–	+	+	–	do
Brown Rat *Rattus norvegicus*	Çıldır & Nemrut Caldera	+	+	–	–	p
Least Weasel *Mustela nivalis*	Sevan	+	+	–	–	do
Eurasian Otter *Lutra lutra*	Tabatskuri & Çıldır	+	+	–	–	p
Caucasian Badger *Meles canesens*	Madatapa	+	+	–	–	p
Red Fox *Vulpes vulpes*	Madatapa, Sevan & Arpi	+	+	–	–	do
Brown Bear *Ursus arctos*	Nemrut Caldera	+	–	–	–	p

area (Table 4), and these are illustrated in the Supporting Materials (Fig. S1). At Lake Tabatskuri, Armenian Gulls are known to breed and to compete with Velvet Scoters for breeding habitat, as well as to prey upon their eggs and ducklings. Whilst Marsh Harriers *Circus aeruginosus* also occur at all lakes included in the study, the Armenian Gull was identified as the most frequently observed predator at Lake Tabatskuri, where Velvet Scoters still breed and are monitored (see Fig. 4). Although predation on nests was considered to be of lesser concern (accounting for only 15–25% of nest

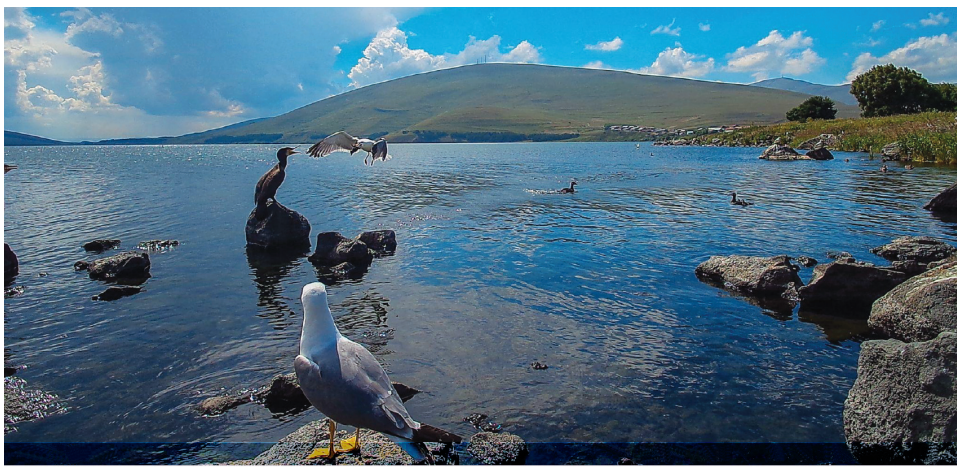

Figure 4. An Armenian Gull that has preyed on a duckling, by N. Paposhvili.

losses), it was observed that 65–75% of the ducklings that hatched and entered the water died on their first day due to gull predation (N. Paposhvili, pers. obs.). Based on these observations, it was assumed that similar predation pressure would have been faced at most historic breeding lakes where large colonies of Armenian Gulls are known to occur.

Invasive non-native species. Crucian Carp *Carassius carassius* and Danube Crayfish *Pontastacus leptodactylus* in Lakes Aygır, Çıldır, Aktaş/Kartsahki and Tabatskuri, and Vendace *Coregonus albula* in Lake Tabatskuri, all may contribute to ecosystem degradation by altering ecosystem function as well as the water's physicochemical properties and transparency. The Black Rat *Rattus rattus* is the only invasive nest predator of ground-nesting species recorded at breeding sites in Türkiye.

Sewage. Wastewater discharge has been recorded at four wetlands. The flow of pollutants from these discharges will lead to enhanced nutrient availability that results in ecosystem degradation, which can adversely affect food sources and the overall health of Velvet Scoter. However, in the absence of knowledge on the amount and frequency of discharges at these sites, it is not possible to judge their ultimate effects on water quality and the food supply for Velvet Scoter.

Nutrient loads. In addition to sewage discharge, nutrient loading from fertiliser runoff and livestock manure has been observed in many wetlands, contributing to ecosystem degradation through excessive nutrient input, which causes ecosystem degradation.

Herbicides & pesticides. Most wetlands are surrounded by agricultural land, and the widespread use of herbicides and pesticides in all three countries leads to chemical runoff from farmlands These pollutants, which may seep into groundwater feeding into lakes, degrade wetland ecosystems and reduce populations of specific invertebrates

with low toxicity tolerance, reducing food availability for the Velvet Scoter.

Garbage & solid waste. Pollution from garbage and solid waste in lakes and on breeding islands poses risks of injury and mortality, as the material can entangle the legs, necks and wings of the birds. Additionally, some waste may be mistaken for food and ingested by the ducks, potentially causing internal harm.

Agricultural disturbance. Agricultural machinery and farming activities can disturb Velvet Scoter at Tabatskuri. Newly hatched Velvet Scoters require shallow, crustaceans-rich shoreline habitats for feeding. Disturbance near such feeding grounds can hinder their ability to feed effectively, potentially leading to reduced breeding success.

Drought. More frequent periods of drought, exceeding normal variations, can lead to ecosystem degradation. As was evident in the case of Lake Sevan, where excess water abstraction led to water levels so low that Velvet Scoter breeding and feeding habitats were lost, this could potentially occur under increasingly arid conditions at other sites. However, as long as breeding and feeding habitats do not completely dry up, the overall impact may remain minimal.

Viral diseases. Highly pathogenic H5N1 avian influenza virus infections and associated mortality have been reported in the global literature for the Velvet Scoter (actually involving the kindred species Stejneger's Scoter, Melville & Shortridge 2006). No cases of Velvet Scoter mortality attributable to avian influenza have been reported in the Caucasus region to date, but it remains a potential risk for the species.

Climate change. Reduced snow accumulation and shorter durations of snow cover compared to earlier times affects the snowmelt that feeds into the lakes, altering the physicochemical properties of the water. Climate change can also impact biodiversity within the food chain, posing a long-term threat that has been classified as a potential risk.

Ranking of the 16 threats identified for Velvet Scoter and its habitats in the Caucasus region, and assessment of the impact levels for these threats (see Methods), classed four as critical, three as high, four as medium and five as low (Table 5). The most significant threat (with the lowest rank score) – interactions with native species (specifically predation) – was recorded at all 13 sites, whilst the other critical threats – fishing, hunting/egg collection and recreational disturbance – were evident for 8, 11 and 12 of the sites, respectively (Table 3). The impact of climate change on Velvet Scoter could not be fully predicted, and there was insufficient evidence regarding the occurrence of viral diseases in the region, so these two threats were not included in the threat analysis.

Discussion

This analysis of current surveys, observations, and results of the literature search confirm that the small disjunct Caucasus population of Velvet Scoter has declined severely from *c.* 150 nesting pairs at 13 suspected breeding sites in the mid-1960s to just 50 pairs at one remaining lake in Georgia, where the species survives as a result of intensive conservation effort. Although 13 lakes in the Caucasus

Table 5. Ranking of threats to the Caucasus Velvet Scoter population. Red = critical; orange = high; yellow = medium, green = low, determined by a combination of raw score calculated for each threat and the authors' knowledge of the region (see Methods).

Threats	Ranking criteria			Raw score	Ranking score
	Scope	Severity	Urgency		
Grazing & ranching	12	5	8	25	6
Hunting & collecting eggs	3	1	4	8	3
Cutting & collecting terrestrial plants	16	6	6	28	11
Fishing	8	4	3	15	4
Recreational activities	2	3	2	7	2
Scientific research	14	15	15	44	15
Abstraction of surface water	9	13	13	35	12
Dams	15	16	16	47	16
Native species interactions	1	2	1	4	1
Invasive non-native species	11	8	7	26	7
Sewage	13	12	10	35	13
Nutrient loads	4	11	12	27	9
Herbicides & pesticides	5	10	11	26	8
Garbage & solid waste	6	7	5	18	5
Agricultural disturbance	10	9	9	28	10
Drought	7	14	14	35	14

were identified as potential breeding sites, based on the literature and previous observation notes (Adamian & Klem 1999; Dahl 1954; Eken *et al.* 2006; Janashvili *et al.* 1960; Kirwan *et al.* 2008; Kutubidze 1985; Lyaister & Sosnin 1942; Magnin & Yarar 1997; Matcharashvili *et al.* 2004; Paposhvili 2018, 2021; van der Ven & Gheyselinck 1982; Vielliard 1968; Yarar 1995), further investigation confirmed that breeding has occurred at only seven of these sites in the recent past, at: Aktaş/Kartsakhi, Balık, Nemrut Caldera, Sevan, Khanchali, Saghamo and Tabatskuri.

Historical records indicate that the breeding range for the species in Georgia included Lakes Saghamo, Paravani, Khanchali, Bughdasheni, Madatapa, Aktaş/Kartsakhi and Tabatskuri on the Javakheti Plateau during the second half of the 20th century (Gavashelishvili 2005; Kutubidze 1985; Matcharashvili *et al.* 2004). Breeding pairs were reported at Lakes Khanchali, Bughdasheni and Madatapa as recently as

the 2000s (Matcharashvili *et al.* 2004), with estimates of 10–20 pairs at Lake Khanchali and smaller numbers at the other two, but no concrete evidence for nesting has ever been found at Lakes Bughdasheni and Madatapa. Given the lack of sufficient reliable evidence, these two sites therefore have been classed as unconfirmed breeding areas. By the 2010s, the Georgian population was considered extinct until investigations in 2014 found some still to be present at Lake Tabatskuri (Toriashvili 2023). Currently, Lake Tabatskuri continues to host the last breeding pairs in Georgia and the entire Caucasus region (Paposhvili 2018, 2021; Paposhvili *et al.* 2023).

In Türkiye, breeding activity by Velvet Scoter has been reported at five alpine lakes (Aktaş, Çıldır, Aygır, Balık and Nemrut Caldera) in northeastern and eastern Anatolia (Boyla *et al.* 2025; Eken *et al.* 2006; Kirwan *et al.* 2010). At Lake Akta , which straddles the Türkiye-Georgia border, all breeding islands are located on the Turkish side. Lake Aygır, identified as a breeding site by Eken *et al.* (2006), lacks conclusive evidence of Velvet Scoter breeding behaviour and was most likely only a stopover site supporting pre- and post-nuptial activity before they dispersed elsewhere. The absence of any islands on this lake provides weak support for the idea that it was not a regular breeding site. However, ducklings have been observed on Lake Khanchali (G. Darchiashvili, pers. obs.) despite the lack of an island there, where it is thought that nests were established in the rocky shoreline vegetation. Such breeding behaviour, although based on limited information, would be unique for the Caucasus population.

Çıldır Lake is only 11 km from Lake Aktaş (a confirmed historical breeding site) and also appears to have islands suitable for breeding. However, the limited number of historical observations makes reliable assessment of whether Lake Çıldır was ever used as a breeding site quite challenging. Assessing the information from other wetlands, such as Şenkaya Pond and Lake Nazik (in eastern Anatolia) (eBird 2024), produced no evidence of Velvet Scoter using these areas as breeding sites, either historically or currently. Therefore, these sites have been excluded from the assessment. Considering all available data for Türkiye, it is evident that the Turkish breeding population did not survive into the 21st century (current study; Boyla *et al.* 2025). Nevertheless, the species continues to winter regularly along Türkiye's Black Sea coast (Boyla *et al.* 2025; eBird 2024; Furtun *et al.* 2021).

In Armenia, breeding pairs were documented with certainty only on Lakes Sevan (confirmed breeding) and Arpi (unconfirmed breeding, Adamian & Klem 1999). As was the case in Türkiye, it seems that the Armenian population did not survive into the 21st century. The breeding population of Lake Sevan apparently disappeared in the 1970s, when the 19 m reduction in water levels (Vardanian 2009) created a series of problems for the species at the lake. Firstly, it is suspected that the lower water levels may have affected the dissolution of oxygen in some parts of the lake, which may have affected zooplankton species. More importantly, it allowed terrestrial predators access to former islands and resulted in greater accessibility by

tourists to a local attraction, the Sevanavank Monastery. The Velvet Scoter occurring at Lake Arpi also disappeared during the last decade of the 20th century.

Although various sources describe the very small population across the entire Caucasus and its rapid decline (BirdLife 2024; Paposhvili 2018, 2021), the causes of this decline have not been comprehensively assessed across the entire region. This study aimed to fill this gap in our knowledge, not only to understand the causes of the decline in the Caucasus but to propose potential solutions. The analysis identified 16 different direct threats affecting the species and its habitat at different sites in the Caucasus, both historically and currently. Some of these threats are based on direct evidence; others remain hypothetical. Four of these threats (interactions with native species, recreational activities, hunting and collecting eggs, and fishing) are classed as critical and have been identified as causing significant pressure on Velvet Scoters in the Caucasus. This may however have been influenced by shortcomings of the ranking method, because the effects of threats and pressures can be extremely site-specific. For example, there is no doubt that excessive reduction of the water table caused the loss of birds at Lake Sevan, Armenia, as described above. Yet since 2022–2023 the water level at Lake Tabatskuri has fallen, by 1 m, but here these changes saw a positive outcome for the Velvet Scoter, with 1–2 pairs nesting successfully on one of the small newly-created islands in 2022 and 2023, respectively, which again became unsuitable for nesting with the rise in the water level in 2024 (N. Paposhvili, pers. obs.).

All predators of Velvet Scoter, both potential and confirmed, are listed in Table 4, but the Armenian Gull stands out as being the most significant. This "predator" typically breeds on lake islands (in colonies of 200–250 nests), potentially limiting the nesting area for scoters, and causes intense predation pressure on both unattended eggs and newly hatched ducklings, thereby reducing their breeding success significantly (Kiknavelidze *et al.* 2024). It is however important to stress that, at the same time, nesting gulls likely play a crucial role in protecting incubating females from predation by locally nesting Marsh Harriers, which not only take eggs but are also known to kill sitting females on their nests (Paposhvili 2021; Paposhvili *et al.* 2023). The loss of a breeding adult female (taken by Marsh Harrier) is significantly greater than the loss of eggs and young ducklings (which have high initial mortality and poor first-winter survival). Therefore, local elimination of Armenian Gulls may not provide a total solution to predation, but it may be the case that some level of gull presence might be tolerable if they provide aerial protection from Marsh Harrier attacks. In this context it is important to consider the fact that, in the 1980s and 1990s, the number of Armenian Gulls was at least 10–15 times smaller than it is now, not only at Tabatskuri but throughout southern Georgia (A. Abuladze, pers. obs.).

Local fisheries activities can have profound multiple effects on Velvet Scoter breeding on a lake. Drowning mortality and injuries can result from birds becoming entangled in lost or static fishing nets, while active fishing from boats cause disturbance

to nesting and brood feeding routines. For example, fishing boats frequently fragment broods, challenging brood females to protect ducklings from aerial predation by Armenian Gulls. Despite these actions being unintentional, such activities have a significant impact on breeding success. Although landing by fishermen and egg collection on the islands at Lake Tabatskuri has been considerably reduced as a result of local conservation efforts, bycatch-related mortality remains a major persistent threat (Paposhvili 2021). Recreational activities on the islands during the breeding season have also decreased significantly, which, as for the fishing-related activities, is thanks to successful engagement with local communities. These remain ongoing threats, however, due to a lack of local enforcement. Defining no fishing/recreational boating zones on the lake, setting restrictions on boat movements during appropriate periods (*i.e.* the scoters' breeding season), and imposing strict control of these measures, are necessary for ensuring that the conservation of Velvet Scoter at Lake Tabatskuri is maintained.

Between the late 20th–early 21st centuries, freshwater crustaceans and fish (Danube Crayfish and Crucian Carp) were introduced into the breeding sites of the Velvet Scoter in Lakes Aygır, Çıldır, Aktaş/Kartshaki and Tabatskuri. During the same period, another species of fish, Vendace, was introduced to Tabatskuri. These aquatic alien species may have two potential impacts on Velvet Scoter, through competition for food resources and by contributing to decreased water quality. They increase turbidity, damage macrophytes, and elevate nitrogen and phosphorus concentrations, all of which contribute to a decline in water quality. This can have a negative effect on the distribution and abundance of macroinvertebrates, which constitute a major part of the Velvet Scoter's diet (*e.g.* Nummi *et al.* 2016; Maceda-Veiga *et al.* 2017). The introduction of these species may also have had a positive effect for adult scoters, which have regularly been seen taking crayfish or food at Lake Tabatskuri (N. Paposhvili, pers. obs.). Pending more detailed scientific evidence (which is currently lacking), these introduced alien species may be considered competitors, as they may all feed on amphipods *Gammarus* sp., which are an important food source for ducklings (N. Paposhvili, pers. obs.). Albeit at the same time some of the lakes have now been colonised by species such as White Pelican, Dalmatian Pelican and Great Cormorant *Phalacrocorax carbo*, which prey upon these introduced species and are likely reducing or limiting their populations. In addition to the pelicans and cormorants, the fishermen further contribute to the reduction of the introduced fish and crayfish in the lakes.

The extent to which non-native fish and crayfish compete with scoters for their food resources therefore is quite complex and unclear but during recent years, for unknown reasons, introduced crayfish have disappeared from Lakes Tabatskuri and Kartshaki, and numbers of fish have also generally been decreasing due to overfishing. Without appropriate research and monitoring, it is impossible to determine the influence of introduced and native species, and also the past and current effects of fisheries, on the local abundance and reproductive success

of Velvet Scoters in the Caucasus. A study of the scoters' diet, and of the aquatic invertebrates/vertebrates existing in all the lakes (species, diversity and abundance) that potentially could support Velvet Scoter in the future, clearly is necessary to shed light on the interactions of these species. This may also help to determine one of the important reasons why the species survives and is restricted only to Lake Tabatskuri within the entire Caucasus region.

Many formerly occupied sites were suffering from problems with water quality issues during site visits and showed signs of increasing eutrophication over time. Rönkä *et al.* (2005) reveal that Velvet Scoter populations dropped as eutrophication increased. Reducing or controlling water use, nutrient load, herbicide and pesticide runoff related to local livelihoods such as agriculture and farming, as well as water extraction, sewage, garbage and solid waste from rural settlements, will help prevent the loss and degradation of critical habitats, but this requires considerable local community engagement. However, even if the factors causing adverse water quality are mitigated or completely eliminated, rapid returns to improved water quality and previous trophic status will not necessarily follow, especially in closed inland water basin systems, where recovery may be slower and more complex. The presence of invasive species also influences the process of water quality degradation. In such cases, biomanipulation techniques should be considered as part of conservation measures, with several case studies from Türkiye highlighting their effectiveness (Beklioğlu *et al.* 2003; Beklioğlu & Tan 2008). In parallel to biomanipulation, systematic monitoring studies remain crucial for evaluating the effectiveness of conservation efforts.

This study suggested that a combination of anthropogenic factors and interspecific interactions led to the decline at the various sites reviewed here and contributed to its disappearance from all historical sites except Lake Tabatskuri in the Caucasus. It is undeniable that all threats addressed in this analysis are likely to have contributed to the decline to some extent; however, the most significant factors adversely affecting the species at most of the sites seem to have been native species interactions, recreational activities, hunting and collecting eggs and fishing. Ironically, some of these pressures continue to be active at Tabatskuri Lake where the species has survived. More puzzling, out of the 16 major threats analysed here, Tabatskuri is subject to the most (13) ongoing threats. This suggests that the real reasons for the declines and losses at other sites may be linked to factors that we failed to include in the analysis due to lack of data. Such factors may not be currently obvious, but they were historically fatal to the species and their effects have not been fully examined here. Moreover, existing threats such as poaching, or destruction of breeding habitat (*e.g.* on the last breeding island), may also cause progressive local breeding extinctions that erode the resilience of the entire breeding populations. For each former breeding site, we need more data collection and in-depth analysis of locally critical elements such as nesting habitat and the food resources available during brood-rearing, to provide a clearer picture of the potential of each site to support Velvet

Scoter again as a breeding species, based on the limited knowledge available from the Lake Tabatskuri site. Only after eliminating the factors that led to the previous extinction will it be possible to consider recolonisation. At the same time, it is clear that now, more than ever, that it is vitally important to maintain and conserve the remaining population at Lake Tabatskuri and protect its habitat, not only on the breeding grounds but also in the wintering areas, which will potentially increase the Caucasus population and perhaps contribute to its natural recolonisation if any historical sites still meet the species' specific requirements.

It has been claimed that the Caucasian population must be isolated from the main population (Carboneras *et al.* 2020; Paposhvili 2021), yet despite the long distance to the nearest other breeding stock, Paposhvili *et al.* (2023) showed that these two populations (Baltic & Caucasus) are genetically likely to be geographically separate parts of a single panmictic population. Since it is hypothesised that these two breeding populations may share the Black Sea wintering areas, this provides an enabling mechanism for the pairing of individuals from the two breeding areas and the exchange of genetic material through migration to either region, to the Baltic or to the Caucasus (Paposhvili *et al.* 2023). The apparent lack of genetic differentiation of Caucasus birds from the Baltic wintering stock suggests that there is little reason: (i) to doubt that natural recolonisation remains a possibility, and (ii) not to initiate a reintroduction programme from existing local stocks. Despite this optimism, some breeding habitats currently cannot meet the fundamental ecological requirements of Velvet Scoter (*e.g.* the absence of breeding islands on Lake Sevan). Whether through natural recolonisation or artificial reintroduction, the same question remains: what features need to be in place at a site to facilitate the species' recolonisation? This, in turn, highlights the need for more detailed research to understand the key factors enabling their continued success at Tabatskuri, in order to address the many uncertainties surrounding the future of the species at other potential sites in the Caucasus. To be truly successful, a programme like this must take into account the Velvet Scoter's migratory nature and the fact that it overwinters at sea. Given the limited resources available for nature conservation in the study's geographic area, it is critical for the success of a reintroduction programme that threats in the wintering areas are clearly documented and that effective conservation measures to address these threats are identified and implemented. Although it is known that bycatch and poaching have a direct effect on the Velvet Scoter in its wintering range, the impact of ecosystem degradation in the Black Sea on the Velvet Scoter is unclear and requires further research to guide successful conservation efforts.

Conclusions

Conservation planning is now required throughout the former breeding distribution, which should focus on research at each current, former or potential breeding site, to determine the true threats to re-establishment of Velvet Scoter, for targeted management interventions to mitigate these

threats and improve conditions for the species' reintroduction or natural recolonisation. Potential or former breeding sites that need to be supported by conservation efforts should also be evaluated in terms of how well they meet the species' habitat preferences, such as a safe island for successful breeding and the potential for effective management of human activities. A critical knowledge gap in the Caucasus region remains our poor understanding of diet, prey abundance and access to food resources, where the species still exists, to guide actions elsewhere. The process must also address the conservation at stopover and wintering sites to understand relationships between the Caucasus breeding birds and those wintering in the Black and Caspian Seas, to support full annual cycle conservation efforts. As the Velvet Scoter is fully migratory, this helps not only in addressing challenges to breeding but also in understanding the threats and stresses faced during stopover and wintering periods, thus improving a comprehensive approach towards its conservation.

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Photograph: A pair of Velvet Scoters flying along the Black Sea coast of Türkiye, by Engin Bıyıkoğlu.