Caprinae news

Newsletter of the IUCN/SSC Caprinae Specialist Group

IN THIS ISSUE (1/2021)

Editorial

Dear CSG members,

This first year of the IUCN quadrennium 2021-24 has represented a transition in many senses. After our former co-chair Sandro Lovari last year stepped down and left the CSG, the co-authors of this Editorial continued with pending assignments and started new ones.

A huge effort was required to reassess the Caprinae Red List, with twenty-one out of thirty-seven species completed in 2020. The reassessment continued in 2021 with four additional species, including aoudad *Ammotragus lervia*, red serow *Capricornis rubidus*, long tailed goral *Naemorhedus caudatus*, red goral *Naemorhedus baileyi* and Northern chamois *Rupicapra rupicapra*, which are now available online.

Work is ongoing on the takin *Budorcas taxicolor*, Himalayan goral *Naemorhedus goral*, Nilgiri tahr *Nilgiritragus hylocrius*, snow sheep *Ovis nivicola* and Formosan serow *Capricornis swinhoei*. We expect these reassessments to be completed in 2022-24. We are on the lookout for experts who can confidently reassess the snow sheep and Formosan serow. Muskox *Ovibos moschatus* was reassessed in 2020 and will soon we available online.

We had initiated the process of inviting members for the new quadrennium keeping in mind representativeness of regions, gender, themes, and age. We have already confirmed 40 members and will invite a few more in early 2022.

Two important international meetings on mountain ungulates were endorsed by our specialist group: the *Rupicapra* meeting in Croatia and the Cantabrian and Pyrenean chamois II Meeting in Spain (see both contributions in this issue). The 8th World Conference on Mountain Ungulates was also endorsed by our group, and will be held in September 2022 in Cogne, Gran Paradiso National Park, Italy (information available in this issue of Caprinae News). We would be glad to meet there with as many of you as possible.

Probably the most challenging contribution has been the start of our advice to the Tajik government on markhor *Capra falconeri* conservation and monitoring. The Tajik counterpart was represented by the Commission for Environment Protection (CEP), who organized the mission, and by the Academy of Sciences, an important partner in the monitoring of the species. Participating members included Yash Veer Bhatnagar and Munib Khanyari (India), Arash Ghoddousi (Iran and Germany), Juan Herrero (Spain) and Zalmai Moheb (Afghanistan), all with experience in ungulate monitoring in similar landscapes. The results of this work will be presented in following issues of the Caprinae News.

After a long period of silence, Caprinae News is consolidating as an annual worldwide publication on mountain ungulate research, conservation and management and receives increasing attention and contributions in each new issue. We invite you to provide manuscripts.

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Headline News

Valerius Geist Obituary

It is impossible to think of mountain ungulate research without thinking of Val Geist, who passed away on July 6, 2021, aged 83. His 1960's studies of Stone's sheep, bighorn sheep and mountain goats were widely acclaimed and paved the way for most subsequent research on wild sheep and goats. His work on taxonomy of argali contributed substantially to our understanding of a subject that continues to intrigue taxonomists, fascinate hunters and baffle conservation biologists. He played a major role in identifying the North American Model of Wildlife Management and was an extremely effective advocate for conservation. The many popular books he wrote on most species of North American ungulates, on hunting and on conservation, introduced key concepts of ecology, evolution and conservation to the general public. His superb artistry helped him communicate with other scientists and with a wider audience.

It has been 50 years since Val published his "Mountain sheep" book, which remains essential reading for anyone interested in mountain ungulates. It was well ahead of its times because it examined behavior and ecology by looking at sheep as individuals, and proposed a range of innovative hypotheses from evolution to mate choice to life-history strategies. Developing new ideas was Val's trademark, on topics ranging from sexual segregation in ungulates to human evolution and latitudinal gradients in body size. He had a remarkable ability to draw ideas and concepts from disparate fields to develop his theories. He also read widely in several languages, an increasingly rare example of a scientist not confined to literature in English.

Professor Geist was an exceptional communicator. Whatever he talked or wrote about, he projected an aura of knowledge and authority. One argued with Val at one's peril. He used those skills effectively in presenting his views of conservation and wildlife management to general audiences, developing a strong following within the North American hunting public and often raising the ires of other scientists and wildlife management professionals who may disagree with him. Events in the last few decades have confirmed that he was right in opposing game ranching in a North American context. He correctly predicted increased disease outbreaks among wild species and the commercialization of wildlife, leading to catalogues of 'trophy' animals for sale and a deteriorating view of hunting in the public eye.

Val was a generous and kind person. His enthusiasm for science and for natural history was contagious, and he always showed the deepest respect for people with different views. After retiring from the University of Calgary he moved to a farm in Port Alberni on Vancouver Island, where I had the pleasure of visiting him a couple of times, sampling his various local products and listening to his latest stories about dominance interactions with black bears, marauding wolves and shy black-tailed deer. He continued to vigorously contribute to wildlife debates until his death, publishing scientific and popular books, writing articles for journals and magazines and being interviewed about topics from wolf parasites to giant extinct bears. The community of students of mountain ungulates owes him a great debt.

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8th World Conference on Mountain Ungulates: towards an integrated approach to species conservation

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We are pleased to inform you that the 8th World Conference on Mountain Ungulates will be held on the 27th-30th of September 2022 in Cogne, Aosta Valley (Italy). Registrations are now open. The deadline for early registration is 28th February 2022, the deadline for abstract submission is 15th May 2022. More info on the conference and on registration and abstract submission are available at https://8wcmu.grand-paradis.it/ and on twitter https://twitter.com/8wcmu.

Conference presentation: Scientific research is indispensable for effective management and to foster species and ecosystem conservation. The recent history of some mountain ungulates gives examples on how this can be achieved. In the last decades, however, as research and technology progresses and knowledge accumulates, new questions present exciting and urgent challenges both for researchers and managers. Answering those questions will require an inclusive approach that integrates different perspectives. It is with this aim, that we are delighted to invite you to the 8th Conference on Mountain Ungulates (Cogne, Italy, 27-30 Sept. 2022). As in the spirit of past editions, the goal of the conference is to share the most recent and interesting results of research on mountain ungulates as well as to provide networking opportunities for researchers and wildlife managers. We will cover several topics (see the list below), with the ambitious aim of facilitating the integration of different research fields and connecting them with management and conservation.

Planned sessions

Ecology, Behaviour and Evolution: The interactions between mountain ungulate species, the environment and other species inhabiting it, including humans and livestock, are particularly relevant both for evolutionary biology and for conservation. Rapid changes currently occurring in the mountain environments around the world offer a unique opportunity to investigate the response of wild species to environmental changes, including the return of large predators to many areas of the world, and to shed light on possible changes in selective pressures. Moreover, despite the ecology of some mountain ungulates being relatively well-known, for many others we still lack basic information essential for their conservation. This session aims to share new discoveries on the ecology and behaviour of mountain ungulate species and subspecies. For example, we seek presentations focusing on life history, population dynamics, spatial behaviour, diet, physiology, adaptations to changing environment, within- and between-species interactions, predation and competition.

Genetics: The continuous development of molecular techniques gives new insights on wild species evolution and offers powerful tools to inform conservation. The aim of this section is to present new discoveries on genetics of mountain ungulates. We encourage presentations on the following topics: development of new molecular tools, conservation genetics, hybridisation, immunogenetics and genomics.

Systematics and Palaeontology: Systematics of wild species is constantly revised according to new discoveries on the genetics of mountain ungulates, and we therefore call for talks presenting new knowledge on this subject, obtained through an integration of palaeontological and molecular data. Among others, the intended topics covered by this session are: revised systematics, functional morphology, palaeontological evidence, phylogenetic reconstructions and ancient DNA.

Health and Diseases: Diseases are important drivers of population dynamics and evolution of wild species as they affect the health status of animals and may result in strong selection, drastic reductions of population size, and local extinction. From a conservation perspective, the spread of zoonotic infections may threaten species conservation through indirect effects, such as calls for the extirpation of wild populations to preserve human health or economic activities. This is particularly relevant for mountain ungulates sympatric with livestock and human activities.

The aim of this section is to share knowledge on health and disease of mountain ungulate populations with particular focus on conservation-relevant discoveries. Possible topics are health status of populations, effects of diseases on population dynamics, emergence of new pathogens, immunogenetics, management of zoonotic and major disease outbreaks and macro parasites as markers of climate change.

Conservation and Management: Most mountain ungulate species interact with humans. Those interactions range from simple coexistence to competition for resources (e.g., with livestock), hunting, introduced species and active conservation actions such as translocations or population supplementation. Often, policy makers must make decisions that should be informed by rigorous scientific knowledge. In this section we encourage the presentation of research covering various aspects of mountain ungulate biology and ecology that have potential applications for conservation and management, as well as case studies where management was beneficial or detrimental to populations, as for example in the case of trophy hunting. In addition, we encourage presentations on the role and use of indigenous and local knowledge for the conservation of mountain ungulates.

Monitoring methods: Several methods have been proposed to properly estimate population size of mountain ungulates populations across a variety of habitats. Actually, however, those methods are not yet fully integrated in the monitoring practice. We encourage presentations of methodological studies on mountain ungulates monitoring to promote a thorough discussion between researchers and managers in order to find solutions and trade-offs to incorporate good practices into routine monitoring protocols.

Conservation technologies: Methods in wildlife research have changed dramatically in the last decades due to the advent of new technologies. The spread of tools such as, for example, camera traps, sensors tags, drones, remote sensing, image and video interpretation, acoustic monitoring, coupled with machine learning techniques, allows to collect large amounts of data that can foster conservation. This session aims to share ideas on the applications of technologies to research and conservation of mountain ungulates.

Poster Session: A poster session is planned for the communication of research on all the above-mentioned topic as well as of research of local interest (e.g., results of local population monitoring), work in-progress, methods and new ideas.

Organising institutions
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Abruzzo Lazio and Molise National Park (Italy)
In collaboration with
Fondation Grand-Paradis

Under the Endorsement of
Italian Ministry for Ecological Transition
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CONSERVATION AND MANAGEMENT

Muskox conservation – looking forward

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Muskox *Ovibos moschatus* are large-bodied and stocky with dark wool coats, and are restricted to the Arctic. They are often considered a conservation success story (Barr 1991) but recent information raises questions about their future conservation. During the Pleistocene, climate changes including abrupt warming, rather than early human hunting likely led to a contraction of muskox distribution into the early Holocene and their disappearance from Russia (Campos *et al.* 2010). More recently, human hunting led to muskox having a brush with extinction. By the beginning of the 20th century, muskox numbers collapsed and they were restricted to small pockets in northeastern Greenland and Canada (Barr 1991). Although Icing storms influenced the extirpation of Muskox on the Canadian Arctic Islands, it was unregulated commercial hunting for hides that brought the Canadian muskox to the edge of extinction. By 1930, only 400-500 muskox likely remained on the Canadian mainland tundra and numbers on the Arctic islands were uncertain (Tener 1965). Muskox disappeared from Alaska by the 1890s and from Russia about 2,000 years ago.

Muskox recovery has been encouraged by hunting regulations, introductions and re-introductions. In Canada, a ban on hunting in 1917 led to muskox slowly re-colonizing their historic ranges. By 1999, muskox in Canada numbered 145,000 individuals but by 2019 the population had declined to an estimated 39,200 (Cuyler *et al.* 2019). Muskox were introduced to Russia in 1974, the population increased and were translocated to eight more regions on the Russian mainland tundra and naturally dispersed into two further areas. Russian numbers totaled 15,500 by 2017 (Cuyler *et al.* 2019). Muskox were reintroduced into Alaska in 1935 and translocated to six regions; by 2018, numbers totaled 4,690. Muskox were introduced to West Greenland in 1962/63 and numbered 23,750 by 2018. An introduction to Norway in 1947-53 totaled 234 muskox by 2017 with a few muskox dispersing into Sweden.

In 1996, 2008 and 2020, the IUCN classified muskox globally as Least Concern based on the species wide distribution across the Arctic (Figure 1) and presumed large populations. The 2020 assessment included a low rate of decline (a 14% decrease from approximately 127,000 muskox in 2019 relative to 157,100 in 1998). The 2020 assessment will be the most detailed as it drew on the collaborative work undertaken through the Muskox Expert Network (MOXNET) established through the Arctic Council's Circumpolar Biodiversity Monitoring Program (Cuyler *et al.* 2019). While globally, muskox recovery appears assured based on the widespread circum-arctic distribution, regionally the species still faces threats. Canadian and northeast Alaskan populations have seen declines in abundance and contracted distributions following the periods of recovery (Cuyler *et al.* 2019).

The recent declines of several mainland and large Arctic Island populations may be the initial stages of eruptive oscillations typical of translocated herbivores with a single eruptive peak, decline and then oscillations at a lower abundance (Caughley 1970). Alternatively, regular fluctuations (cycles) are typical of arctic herbivores (e.g., lemmings *Lemmus lemmus* and caribou *Rangifer tarandus*) and the duration of the fluctuations scale to body mass (Gunn 2003). However, for the High Arctic Islands, muskox numbers fluctuate with long recoveries following abrupt declines during severe winters. A similar pattern appears to hold for the endemic muskox in northeast Greenland. For example, the muskox at Zackenberg slowly increased from 1996 to 2007 then declined (Schmidt *et al.* 2019) and recovery may be slow after even 'small' perturbations (Desforges *et al.* 2021). On the large Banks and northwest Victoria islands in Canada, muskox recovered from a handful in the 1920s to peak in the mid-1990s at 87,800 muskox – which was 61% of Canada's muskox (Barr 1991; Cuyler *et al.* 2019) but then declined to 16,500 by 2019. These fluctuations have resulted in uncertainty, as we do not yet have information over long enough to know whether and under what conditions muskox numbers fluctuate.

Lack of information also limits understanding of underlying mechanisms for the declines but disease appears to be a prevalent factor. In northeast Alaska, declines coincided with increased dispersal and grizzly bear *Ursus arctos* predation, as well as a complex interaction between disease, mineral status and physical condition (Reynolds 1998; Afema *et al.* 2017). Likewise, on Banks and Victoria islands in Canada, disease, wolf predation and warmer summers were interacting factors during the declines (Kaffle *et al.* 2020; Tomassini *et al.* 2019; Kutz *et al.* 2015). Disease is not usually considered a leading cause of declines in wildlife population dynamics raising the question of whether muskox are especially susceptible to diseases and whether the susceptibility is the result of or accentuated by low genetic variation. Genetic bottlenecks during the Pleistocene and more recently, have left muskox with markedly low genetic variability especially on the Arctic islands (Prewer *et al*. 2019). Low genetic variability may reduce immune functions although this is not inevitable (Sommer 2005). Additionally, muskox susceptibility to disease is possibly a response to a warmer climate and especially warmer summers. While warmer summers may increase forage biomass, large-bodied, dark animals living on the tundra without shade and exposed to long daylength are likely to be exposed to heat stress.

In summary, the global assessment of muskox as Least Concern should not trigger complacency but should lead to regional assessments to describe muskox responses to the conservation actions. A possible approach is IUCN's Green Status which measures the impact of past conservation and critically, how much muskox will gain from conservation action within the next 10 years, and future recovery potential. A forward-looking approach to muskox conservation will be dependent on using local knowledge and views of the Arctic indigenous people for whom muskox are part of their life and landscape.

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The paradoxical status of the aoudad *Ammotragus lervia* worldwide and the urgent need for a re-evaluation of its subspecific classification through genetic analyses

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The new Red List assessment for the aoudad *Ammotragus lervia* (Fig. 1) has just been published (Cassinello *et al.* 2021). The species will retain its Vulnerable status, which has been maintained since its first inclusion in the Red List in 1986. In relation to a previously published review of the aoudad (Cassinello *et al.* 2008), there have been substantial changes in our understanding of aoudad distribution (see Fig. 2). In particular, a more fragmented distribution than previously thought is known to occur in the northern part of the species range, from the Western Sahara and through the entire ridge of the Atlas Mountains. Since the review of 12 years ago, we have gained information and more precision in determining the distribution of some populations. In reality the global distribution of the aoudad in its native range is going through a worrying metapopulation process, where populations are increasingly fragmented and isolated from one another. In addition, considerable uncertainty is associated with the status of some sub-populations, with numerous populations labeled “possibly extant”, which reaffirms the need to carry out new surveys in these mountainous areas.

Figure 1: Aoudad males at the EEZA-CSIC facilities. Photo: J. Cassinello.

Paradoxically, the aoudad has been introduced as an exotic species in several countries, and in some of them, namely the USA and Spain (Mori *et al.* 2017), its populations have been growing consistently, with no apparent restraint, being considered an invasive by the Spanish authorities (but see Cassinello 2018).

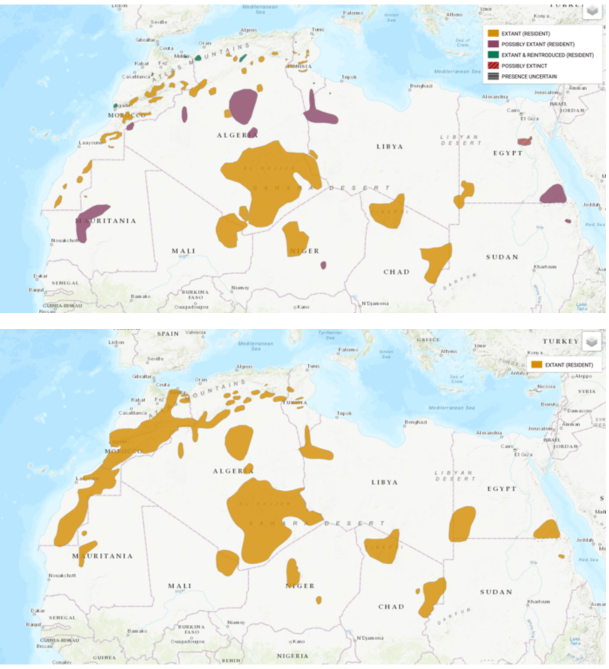

Figure 2: Current (above, Cassinello et al. 2021) and previous (below, Cassinello et al. 2008) estimated distribution of the aoudad in its native range.

The aoudad is a polytypic species, with six subspecies described (Allen 1939, Ansell 1972) based on morphological characteristics (coat colour and horn shape) and based on its distribution (see Cassinello 2013). However, there are serious doubts about the classification of subspecies (Ellerman & Morrison-Scott 1951; Cassinello 2013). Although not included in the new IUCN assessment, I have attempted to depict the distribution of the six subspecies defined for the aoudad (see Fig. 3). This distribution is based on the accepted boundaries for each of the subspecies, although some of them are not clearly defined (Cassinello 2013).

Consequently, and in order to establish more adequate conservation measures, there is an urgent need to carry out a genetic study of the populations associated with the different subspecies, including those that suggest doubts about their attribution, such as the one present in Western Sahara (Cassinello 2013), and in particular those that currently face a high probability of extirpation, such as the population assigned to the subspecies *A. l. blainei* in northeastern Sudan.

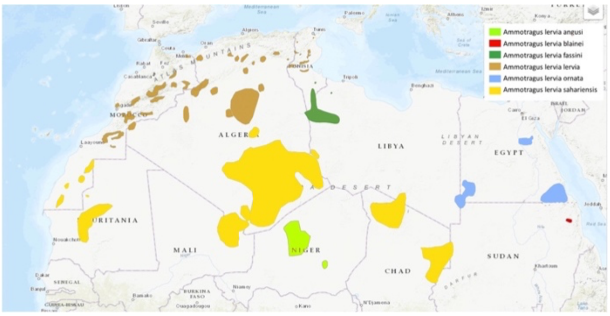

Figure 3: Estimated distribution of the aoudad subspecies.

The paradoxical status of the aoudad worldwide, in decline and characterized by a metapopulation structure in its native lands, whereas in expansion in some exotic locations, advises an urgent revision of its subspecific classification to determine distinct population nuclei of high genetic value and thus of importance to the species future survival.

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Status of the bezoar (wild) goat *Capra aegagrus* Erxleben and Asiatic mouflon *Ovis orientalis gmelini* Blyth 1841 (Mammalia: Cetartiodactyla) – the main prey species of the leopard *Panthera pardus* – in Nakhchivan (Azerbaijan)

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Counts of the bezoar goat *Capra aegagrus* and Asiatic mouflon *Ovis gmelini* populations were carried out in July and December of 2018 in the south-eastern part of the Nakhchivan Autonomous Republic of Azerbaijan, and within the known range of the leopard *Panthera pardus*. Population trends, densities and distribution of both species have shown positive gains since 2006. Our results indicate that effective protection has significantly improved the status of the Bezoar goat and mouflon, even though the area has continued to be used for intensive livestock grazing in the habitats of wild ungulates. However, reproduction and juvenile survival rates for both species were significantly lower than in other parts of their range and lower than found in the same areas in 2012–2013, but the cause of low recruitment could not be established. Our results suggest that the reestablished leopard populations' have not had a negative impact on the recovery of Bezoar goat and mouflon populations in the study area.

Introduction

The aim of our research was to estimate the status of local populations of Bezoar goat (Bezoar) and Asiatic mouflon (mouflon) in the Nakhchivan Autonomous Republic of Azerbaijan. The area is within the range of the leopard which is regularly detected by photo- and video-camera traps. This area (approx. 300 km^2) is situated in the south-eastern Lesser Caucasus, on the southern part of Zangezur Mountain Range (Fig. 1). Bezoar and mouflon are considered the main prey of leopard in the Lesser Caucasus and in the whole of North-West Asia (Lukarevskii 2001; Askerov et al. 2015; Farhadinia *et al*. 2018) and are considered crucial for the survival of the predator.

Material and methods

We conducted two surveys in 2018: (a) during the post-parturition period (18–23 July), and (b) during the rut (9–16 December). Two main survey areas were chosen: (1) the south-eastern end of Zangezur Range (Kotam, Ajinohur and Ganze valleys, 39˚05'N, 46˚05'S, elevation 1000–2520 m a.s.l.), where leopard is commonly detected by photo- and video-camera traps; and (2) Negramdagh Plateau (39˚00'N, 45˚30'S, elevation 900–1620 m a.s.l.) separated from Zangezur by lowland plains (Fig. 1). Two more areas were added in December: the northern half of the separately standing Darydagh massif (39˚02'N, 45˚39'S, elevation 900–1900 m a.s.l.) situated between Zangezur and Negramdagh, and the small Abdel massif (39˚05'N, 45˚50'S, about 1520 m a.s.l.) near Bilav village (Fig. 1). We surveyed these in 2006–2007 (Talibov *et al*. 2009) and in 2012–2013 (Weinberg, Yarovenko 2013). Bezoar prefer precipitous habitat and in general tend to avoid open areas, therefore the main survey areas, Zangezur and Negramdagh, may be considered separate (Fig. 1). Mouflon prefer rolling undulating terrain, none of the habitat within the eastern Nakhchivan could be considered isolated.

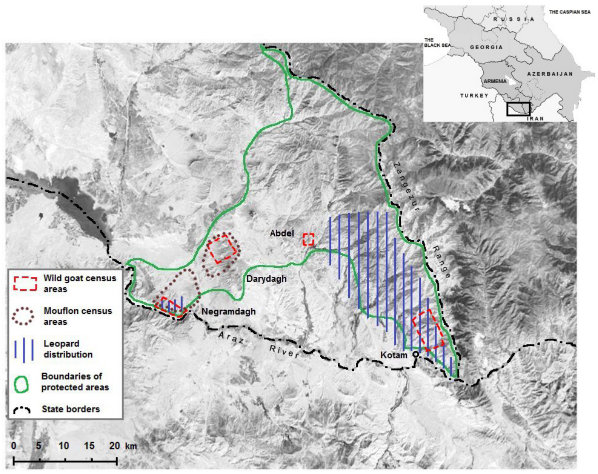

Figure 1. Map of the study area.

For counting, transects were combined with observations from vantage points. In summer, counts were performed in the mornings and evenings, when animals were more active. In December, ungulates are active at daylight, so counts could be carried out the whole day. Binoculars and a spotting scope were used for scanning the area and finding the animals, and to determine age and sex classes.

Five age\sex classes were used for goats, based on body size, horn size and shape, coat coloration and hair appendages (beard, mane etc.): (a) juveniles, <1 year old (juv.); (b) yearlings of both sexes (yr.); (c) females (♀); (d) young males, 2–6 years (young ♂); and (e) adult males, > 6 years (adult ♂) (Schaller 1977; Weinberg 1999). Mouflon mature faster than goats, as displayed by their morphological features, so their young males are 2–4 years old, and adult males are > 4 years (Veynberg 2013).

Because adult males associate with females during the rut in December (Schaller 1977; Weinberg 1999), the probabilities of observing all age and sex classes can be considered similar, and this period is the best for counting and for obtaining data on sex structure of the population. Adult male ungulates are often ecologically and spatially segregated from females with offspring outside of the rutting season. Because of that, proportions (% from the whole number of counted animals) are valid only during the rut, and ratios to females (juv./♀, yrl./♀, etc.) have been chosen to reflect the age structure of the population.

Population densities and numbers

Population densities of bezoar varied between *c.* 10–13 animals/km^2 in Zangezur and Negramdagh (calculated from Table 1), which corresponds to average densities in the other parts of the species' range (Korshunov 1994; Weinberg 1999; Magomedov et al. 2006). Density of Bezoar in the northern part of the leopard's range in Zangezur is supposedly lower than in the survey area, and a conservative estimate of *c*. 500–600 Bezoar has been made for the Nakhchivan side of southern Zangezur Range (area about 300 km^2). Bezoar habitat in Negramdagh is represented by a strip of precipices above the Aras River (about 20 km long) and the adjoining narrow stretch of plateau, so extrapolation may be calculated by the length of these precipices. Our 2013 survey (covering about 3 km) and 2018 surveys (6 km) produced an average estimate of *c*. 24 Bezoar / km in the eastern and central part of the precipices. A conservative estimate of the population size in the area is about 300–350 Bezoar for the whole of Negramdagh. On the northern half of Darydagh massif, the density was half that found in Zangezur (approx. 4.5 anim./km^2, calculated from Table 1). During the rut, total numbers might reach 100 in the entire Darydagh Massif (about 50 km^2).

Abdel did not harbor Bezoar during our first visit in Nov 2000 (Table 1). The existing population is new and has been growing over the past 10–15 years. Several other small cliff areas around also boast newly established small-populations of Bezoar. Re-colonization of such small sites indicates improvement of the species status in the whole area.

In 1972–1974, about 1200 Bezoar were reported for Nakhchivan (Kuliev 1981). In the beginning of the 2000s, numbers declined to about 800 (Guliev 2013). Our data from Kotam indicate that the population grew extensively from 2007 to 2013, but slower afterwards (Table 1). Our survey areas make up just a small fraction of the whole species' range in Nakhchivan (Talibov et al. 2009) but extrapolation of our data to the whole of Nakhchivan would be erroneous, because of differences in topography, vegetation, human presence, among other things.

Table 1. Dynamics of bezoar and mouflon numbers in 2006-2018 in Nakhchivan ($\frac{Jun-Jul}{Nov-Dec}$).

Area (km^2)		Bezoar 2006[a]	Bezoar 2012–2013[b]	Bezoar 2018[c]	Mouflon 2012–2013[b]	Mouflon 2018[c]
Zangezur	Kotam, Genze, Ajinohur (25)			$\frac{317}{279}$		
	Kotam only (15)	$\frac{-}{22}$	$\frac{124}{76}$	$\frac{93}{203}$		
Negramdagh (12 for bezoar, 40 for mouflon)			$\frac{66}{5}$	$\frac{101}{155}$	$\frac{10}{28}$	$\frac{2}{119}$
Darydagh (15 for bezoar, 25 for mouflon)			$\frac{3}{0}$	$\frac{-}{67}$	$\frac{15}{0}$	$\frac{-}{90}$
Abdel (3)				$\frac{-}{43}$		
Total			$\frac{193}{81}$	$\frac{418}{544}$	$\frac{25}{28}$	$\frac{2}{209}$

Notes: sizes of census areas in Negramdagh and Darydagh were different for bezoar and mouflon in 2018; "–" indicates no survey in that season; sources: [a] Talibov *et al*. 2009; [b]Weinberg & Yarovenko 2013; [c] this study.

The density of mouflon in December in the eastern half of Negramdagh Plateau was *c*. 3.0 anim./km^2 (calculated from Table 1). The majority of animals were counted in the eastern corner of the plateau, which has less livestock use and is close to Alinjachay R., the largest natural freshwater source in this area. The western part of the plateau, closer to Negram Village, was so badly over-grazed by livestock that it could hardly be considered actual mouflon habitat. There might be a total of about 150 Mouflon in all Negramdagh (total area about 100 km^2).

On Darydagh Massif itself and its foothills, mouflon density was *c*. 3.6 anim./km^2, very similar to Negramdagh (calculated from Table 1). Mouflon were much more common on the foothills than on the ridge itself, but in both landscapes mouflon and Bezoar usually shared habitat. Total mouflon numbers could be up to 120 (total area *c*. 110 km^2).

The total mouflon population was estimated at about 1200–1500 in 1990s (Guliyev 2000), but this most likely was overestimated. However, a true comparison can be made to figures from our 2012–2013 surveys which show an impressive growth of the mouflon population on Negramdagh Plateau and Darydagh (Table 1).

Numbers of bezoar and mouflon counted in December 2018 were the highest since the beginning of the 21st century, both in total and in separate survey areas (Table 1). The population growth of Bezoar and mouflon in south-eastern Nakhchivan coincided with an intermittent increase of livestock numbers in the autonomous republic: from 425,359 in 2000, to 692,530 in 2018. Zangezur area harbors livestock of local villages all year round, with densities of *c*. 15–20 animals/km^2. Negramdagh (only the eastern and central parts of the plateau) and Darydagh serve as seasonal – winter and spring – pastures mainly for sheep. Livestock densities there are considerably higher than in Zangezur, reaching *c*. 30-60 animals/ km^2 and exceed those of mouflon by up to 20-fold. However, at the time of our survey in the first half of December there had still been almost no livestock in Negramdagh, or in Darydagh. Presumably, livestock impact on mouflon is stronger than on Bezoar, whose habitat is often so precipitous that it can hardly be used for even small cattle pasturing.

It is common to view competition with livestock as one of the main anthropogenic impacts on wild ungulates. However, livestock pasturing involves several different impacts, including (a) competition for forage and space, (b) disturbance from dogs, and (c) poaching by the shepherds - which perhaps has the largest negative impact. If poaching can be minimized, the impact of livestock pasturing, when not excessive, may not always jeopardize the presence of mountain ungulate populations. The situation in south-eastern Nakhchivan shows that even high livestock densities leave enough forage for wild ungulates, as demonstrated by the growth of the populations of bezoar and mouflon in the last decades. The complete ban on hunting, introduced by the Regional Government in 2001, has effectively facilitated wildlife conservation. The effective policing of poaching activities has played a crucial role in allowing the restoration of bezoar and mouflon populations in Nakhchivan.

Age/sex structure of the population

Juvenile and yearling indices (juv./♀ and yr./♀) for Bezoar were low for a species that usually has twins (Weinberg 1999; Magomedov *et al*. 2006), and data obtained in December confirmed summer indices (Table 2). These indices were close in all census areas. In summer 2013, juvenile and yearling indices were 1.0 and 0.53 in Zangezur, and 0.90 and 0.28 in Negramdagh (Weinberg, Yarovenko 2013) and these figures exceed our latest data by 1.5 times (apart from yearling index from Negramdagh).

Summer sex ratio and proportion of adult males was considerably lower in Zangezur (0.41 and 1.6 respectively) than in Negramdagh (0.91 and 9.9). In Negramdagh, adult males stay year-round together with the rest of the local goat population, and all sex and age classes are represented equally in summer, while in Zangezur adult males dwell high up the ridge and can be missed during counts. Sex structure in December during the rut didn't differ much between Zangezur, Negramdagh and Darydagh.

Table 2. Main indices, characterizing age and sex structure of the bezoar and mouflon populations in Zangezur, Negramdagh and Darydagh census areas together in 2018.

Species	Season	Index					Total number of animals (number of females)
		juv./♀	yr./♀	♂/♀	yr., %	adult ♂, %	
Bezoar	July	0.67	0.29	0.52	10.0	3.5	418 (168)
	December	0.50	0.22	0.54	9.9	9.9	501 (218)
Mouflon	December	0.26	0.10	0.27	6.2	9.0	209 (128)

For mouflon, only winter data are available (Table 2). Sex and age structure of the mouflon population in both Negramdagh and Darydagh did not differ substantially. Sex ratio was half of that seen in bezoar, but the proportion of adult males was sufficiently high. Juvenile and yearling indices were very low for a species with common twinning and the yearling proportion was lower than in bezoar (Table 2).

Since reproductive rates and juvenile survival were low for bezoar and mouflon in all survey areas, we speculated that there could be common factor(s) influencing low survival. It was unlikely to be high population density (3–4 times lower in mouflon than in bezoar), or leopard predation, since preliminary analysis of camera and video-trap materials by WWF-Azerbaijan shows that the majority of leopard records come from the areas of bezoar distribution on the Zangezur Range. Similarly, there was no indication that severe weather conditions, such as droughts or harsh winters could have caused reduced survival. Temperature and precipitation data provided by weather stations in Ordubad (closest to Zangezur) and Julfa (closest to Negramdagh and Darydagh) show no drastic deviations for 2017–2018, compared to the whole period of 2010–2019. In Julfa, precipitation was about 70% of average in the first half of 2018, but the indices for mouflon and bezoar from arid Negramdagh were similar to those from humid Zangezur. Data suggest that reproduction and juvenile survival rates are unlikely to be related to weather. Thus, the factors causing low juvenile and yearling indices of both bezoar and mouflon in 2018 remain unclear.

The bezoar goat's role as potential leopard's prey

Data from photo- video-camera traps indicate that the leopard population in this particular area of Zangezur range consisted of at least 5 animals in 2017–2018: an adult male, a female with two cubs, and a young animal, supposedly a female. A leopard male kills on an average 2–3 medium-sized prey monthly (e.g., bezoar, dog; Farhadinia et al. 2018). Consequently, it could be estimated that 3 adult leopards might take up to 100 medium-sized mammals yearly. The bezoar population of the Nakhchivan side of Zangezur Range (estimated 500–600 animals, see Population densities and numbers), within the area inhabited by leopards (about 300 km^2, Fig. 1), is not enough to sustain the number of predators mentioned above. Even with occasional visits to Darydagh and Negramdagh (harboring an additional 650 bezoar and mouflon altogether) Bezoar and mouflon alone would be hardly sufficient to feed 3 adult leopards and cubs without depleting numbers of these ungulates, or at least stopping growth of their populations. Wolf *Canis lupus* and lynx *Lynx lynx* also take their share. Since there is no distinct evidence of Leopard predation affecting the bezoar population in southern Zangezur in Nakhchivan, probably other species like wild boar *Sus scrofa*, porcupine *Hystrix cristata*, hare *Lepus europaeus,* golden jackal *Canis aureus* complement leopards' diet. Also, local leopards, male in particular, would hardly confine themselves with just the rather limited area of Nakhchivan side of southern Zangezur Range, but probably feed on the Armenian side as well, which was not surveyed but accommodate the same fauna.

Lack of villagers' complaints about damage from Leopard is a bit strange, as even with accessible wild prey, Leopards do not restrain themselves from hunting dogs and small cattle (Farhadinia *et al*. 2018).

Conclusions

Our work has shown that the complete hunting ban introduced in 2001 by the Regional Government has facilitated a growth in both bezoar goat and mouflon populations in Nakhchivan. This experience shows that successful anti-poaching policy can improve the status of wild ungulates considerably, despite the existence of extensive livestock pasturing in the area.

Populations of bezoar and mouflon within the leopard range do not appear to be substantially impacted by leopard predation. In addition, reports from local villagers and herders suggest few livestock damages caused by leopards. In combination, both these facts suggest that the leopard may prey on a wide range of wild species, not only bezoar and mouflon.

Low reproduction rates and a low proportion of yearlings in populations of bezoar goat and mouflon are most worrying: a further decline in reproduction and/or juvenile survival could hamper positive population trends of both species in Nakhchivan and might affect the local leopard population.

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A need to facilitate long-term monitoring of Caprinae in India

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India has among the highest diversity of Caprinae species in the world, being home to at least 12 different species from 8 different genera (Groves &

Grubb 2011). For many of these species, India is at the edge of their distribution range, like the Tibetan argali *Ovis ammon hodgsoni* (Namgail *et al.* 2009). It is at range extremities that local populations are often most susceptible to declines (Boakes *et al.* 2017), and for many Caprinae in India this could lead to the extirpation of species from the country. For example, the Ladakh urial *Ovis orientalis vignei* may have less than 1,000 individuals, existing in fragmented populations in the northern Indian region of Ladakh (Khara *et al.* 2021). India is also home to endemic, range limited species like the Nilgiri tahr *Nilgiritragus hylocrius* (Suryawanshi *et al.* 2020). Additionally, various species of Caprinae like the Asiatic ibex *Capra sibirica* feature integrally in various peoples' folklore (Bhatia *et al.* 2021).

Despite such a diversity of Caprinae species, India lacks robust long-term monitoring of Caprinae. Long-term studies following a population through time and space are rare, yet necessary for detecting and responding to population changes in species of conservation concern or management interest (Bull *et al*. 2014). Various long-term monitoring projects for Caprinae species exist in North America and Europe; these monitoring projects help manage populations that undergo selective harvesting like trophy hunting (e.g., Festa-Bianchet & Côté 2012; Granados *et al.* 2020). India has seen a particular paucity in long-term monitoring perhaps because activities like trophy hunting are not permitted. Nevertheless, India has a network of protected areas and several community-based conservation initiatives focusing on the conservation of Caprinae species (e.g., Mishra *et al.* 2017). In addition, monitoring programs exist for several charismatic species such as tiger *Panthera tigris* (Johnsingh & Goyal 2005), snow leopard *Panthera uncia* (Suryawanshi *et al.* 2021) and elephants *Elephas maximus* (Bisht 2002). However, much of our current understanding of Caprinae in India is based on one-time surveys (e.g., Bhatnagar *et al.* 2009; Namgial *et al.* 2009; Bhattacharya *et al.* 2012; Suryawanshi *et al.* 2021). Furthermore, while many of the state forest departments (government body tasked with the conservation of wildlife and its habitat) and protected area administrations organize regular census of species and their populations, these surveys are fraught with methodological issues and the data are rarely of a reliable quality (Milner-Gulland & Singh 2011). For instance, survey of rare species often don't allow for statistical comparison of population change over time, rendering the understanding of population trends precarious (Cunningham & Lindenmayer 2005).

The future of Caprinae in India is far from secure. Traditional conservation issues such as illegal hunting continues to plague many populations (e.g., Aiyadurai *et al.* 2010). Also, as most populations occur outside formal protected areas, both exploitative and interference competition from domestic livestock are issues for many Caprinae in India (e.g., Ghoshal *et al.* 2018). Most Caprinae species in India inhabit mountain habitats which are particularly vulnerable to climate change as this habitat is highly climate dependent (Sony *et al.* 2018). Land-use changes, particularly infrastructural projects like hydro-electric dams provide further causes for habitat destruction and fragmentation to already fragmented populations. Therein lies the need to set-up robust long-term monitoring projects that facilitate understanding of both population status and conservation progress. Conservation status assessments of any species requires rigorous monitoring of their abundance (Lindenmayer *et al.* 2013). Initial baseline studies can aid in framing conservation objectives by helping assess feasibility, concentrate effort, and define the time period within which progress can be evaluated (Bull *et al.* 2014).

There is a need for the different forest departments, NGOs and research institutions in India to work together to initiate long-term monitoring of Caprinae in India. To do so, we need more avenues for stakeholders to collaborate. These could be in the form of national-level workshops that facilitate discussion and knowledge sharing, delimiting priority research, and conservation themes like monitoring methods suitable for mountain ungulates. It is important that the community working on Caprinae science and conservation in India collaborate in setting up a network of long-term studies that bring us into a new paradigm for Caprinae conservation in India – one that can be an example for other countries to follow.

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Present and future of long-tailed goral in South Korea

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The long-tailed goral *Naemorhedus caudatus* is found int South Korea, North Korea, Russia, and China. It is registered as Vulnerable (VU) on the IUCN Red List and is also listed on CITES Appendix I. In South Korea, the long-tailed goral is a legally protected species designated as a Class I Endangered Wildlife and Natural Monument No. 217 (Fig. 1). Despite the government's continued conservation efforts, the population continues to decline due to poaching, habitat destruction and fragmentation, and heavy snowfall, among other causes (Cho 2013).

Taxonomic and genetic studies on long-tailed gorals inhabiting Korea have been conducted steadily since 2000. According to Min et al. (2004), Korean long-tailed gorals have a closer genetic relationship with those in Russia than with those in China. In 2004, 34 cross-specific Bovidae microsatellites were assessed in Caprinae species and showed the genetic diversity within Korean long-tailed gorals was lower than that of other Caprinae species (Kim *et al.* 2004).

Figure 1: A Long-tailed goral in South Korea.

In 2005, another study found the world's first 15 unique genetic markers for Korean long-tailed gorals (An *et al.* 2005). In 2010, the markers developed for Korean long-tailed gorals were tested in species from the subfamily Caprinae including the Japanese serow *Capricornis crispus*, domestic goat *Capra hircus*, Northern chamois *Rupicapra rupicapra*, and brown goral *Naemorhedus goral*. As a result, 11 key genetic markers were determined and their applicability between different species confirmed (An *et al.* 2010). More recently, 12 long-tailed goral-specific genetic markers were selected to identify the genetic diversity and genetic structure between and within long-tailed goral populations in South Korea. From this study it was identified that the populations of the Samcheok and Uljin areas are genetically differentiated from those of other regions (Choi *et al.* 2015). These results highlight the importance of genetic background determination when considering the conservation and movement of long-tailed gorals between differentiated populations. Kim's study in 2008 established the experimental conditions for species identification and sex discrimination from genetic non-invasive samples (bone, feces, and fur) of Korean long-tailed gorals (Kim *et al.* 2008). Recently, non-invasive genetic research has been conducted by Jang *et al*. (2020): they collected fecal samples in Mt. Seorak National Park, one of the main habitats of Korean long-tailed gorals, and analyzed mitochondrial genes and microsatellite markers in the samples to identify individuals, resulting in a population estimate of at least 30 individuals in the area.

Studies investigating the population size of long-tailed gorals inhabiting Korea have also increasingly been conducted. In 2002 the population of long-tailed gorals inhabiting South Korea was estimated to be 690 to 784 (Yang 2002). In addition, it was estimated that more than 100 long-tailed gorals inhabited the areas of Mt. Seorak, the DMZ (demilitarized zone), Yanggu, Hwacheon, Uljin, Samcheok, and Bonghwa, with a small number of long-tailed gorals in other areas. Kim (2020) conducted a study using camera trapping and animal morphology to estimate the population size and sex ratio of long-tailed gorals in the Osaek region of Mt. Seorak, one of the main habitats of long-tailed gorals (Lee et al. 2011; Kim et al. 2020a, 2020b). The study estimated 56 individuals, of which 43 were adults over 2 years of age and 13 were under 2 years of age. A study on population decline related to heavy snow was also recently conducted by Park & Hong (2021). Records show that approximately 6,000 long-tailed gorals died after becoming trapped in the snow due to heavy snowfall from March 1964 to February 1965, and 24 long-tailed gorals died after being trapped in the snow in the Uljin area from March to June 2010. Most of the dead long-tailed gorals were either pregnant females or young. It was postulated that the individuals died due to starvation as they are not a highly mobile species.

In 2006, concerned by the sharp decline in the population of long-tailed gorals on the Korean Peninsula, the Ministry of Environment of the Korean government promoted a long-tailed goral conservation project with the Korea National Park Service. Accordingly, in the same year, the Korea National Park Service established the Northern Conservation Center of the Korea National Park Research Institute, an institution specializing in the conservation of long-tailed gorals and identifying conservation and management strategies for 1) species restoration for stable population formation, 2) habitat stabilization, and 3) promotion of genetic diversity.

1) Species restoration for stable population formation

Through continuous analysis of the population of long-tailed gorals on the Korean Peninsula, it was identified that relatively stable populations of more than 100 individuals were formed in Mt. Seorak, Uljin, Inje, and the DMZ (Cho *et al.* 2014a, 2014b, 2015a, 2015b, 2015c, 2016). In addition, supplementary release of individuals and intensive monitoring (of movement routes, habitat selection, and settlement, etc.) is in progress in the areas where the population of each habitat is significantly smaller than the minimum viable population (MVP) (Mt. Worak, Mt. Odae, Mt. Sobaek, and Mt. Songni). A notable outcome of these efforts is Mt. Worak National Park, in 2019, 13 years after the start of the project the MVP goal of 100 individuals was reached and a stable population was acheied, giving a positive outcome of the restoration project by the Korea National Park Service (Lee *et al.* 2011). According to a recent (2020) estimate of the population of long-tailed gorals in Korea, it is thought that a total of approximately 2,000 individuals inhabit the country, of which 574 are inhabiting national parks (Fig. 2).

2) Habitat stabilization

Habitat stability evaluation and grading of long-tailed goral's food sources, fertility rates, hiding places, and threat factors such as damaged areas, disconnected sections, and disturbance factors is being carried out on an ongoing basis. In the case of hazardous areas that require conservation reinforcement due to disturbance or disconnection, management measures such as habitat restoration (ecological pathways, etc.) or introduction of a rest year are suggested.

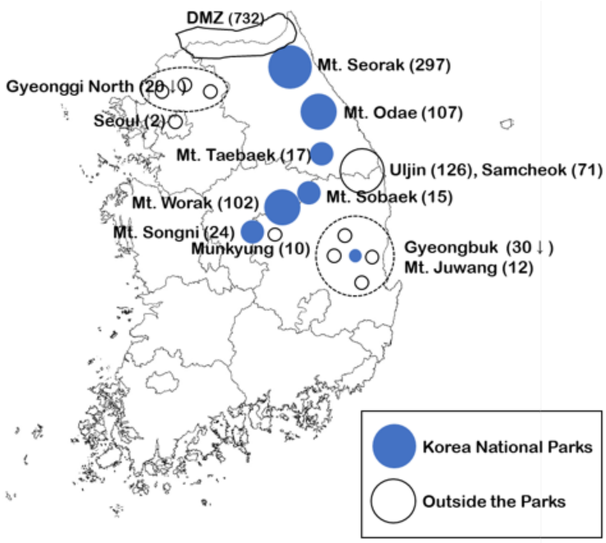

Figure 2: Distribution map of Korea's long-tailed goral population (2020)

Whereas the areas with the best conditions are recommended for designation as specially protected areas through expert meetings. When an area is designated as a specially protected area in a national park, visitor control and long-term monitoring studies (population increase/decrease, fertility rate, competing species, etc.) are conducted. In addition, the long-tailed goral conservation project is removing threat factors (snares, spears, etc.) found in the habitat and striving to improve awareness through publicity campaigns.

3) Promotion of genetic diversity

Securing genetic samples from long-tailed goral' pellets, hair, and blood to build a genetic database is in progress. In particular, to prevent genetic disturbance and promote diversity in each habitat, genotype information of mitochondrial DNA (Cyt-b and D-loop) has been acquired and used to inform the supplementary release of individuals. In addition, microsatellite analysis for the discovery of new individuals and management of newborn individuals is being performed.

There has never been complete loss of long-tailed gorals in Korea. However, we cannot be sure that we will coexist forever. The effort required to restore a species after it has been extirpated is much greater than the cost of actively conserving a threatened species. Therefore, we are doing our best to protect the habitat, promote genetic diversity, promote public campaigns, and collaborate with related organizations to promote the conservation and coexistence of the long-tailed goral population in Korea.

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RESEARCH

A rare phenotype of thinhorn sheep - The dark phased Dall's: New genetic analysis tools help re-map thinhorn sheep subspecies distributions in North America

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Glaciations in North America have shaped not only our geography and vegetative communities, but also our wildlife species distributions. Responding evolutionary processes acting in concurrence with expanded and retracted range recolonizations centered around glacial refugia, and the vegetative-topographic landscape barriers that glaciations produced at times, would have created significant barriers to gene flow. Although today thinhorn sheep *Ovis dalli* still occupy most of their native range and maintain close to ancestral population size (Worley *et al.* 2004), glaciations appear to have been the key agents of change leading to subspecies splits and the resulting taxonomic origins of Dall's sheep *O. d. dalli* and Stone's sheep *O. d. stonei* (Loehr *et al.* 2006; Sim *et al.* 2016) (Fig. 1).

Thinhorn sheep are distributed throughout the mountains of northwestern North America, from Alaska, east to the Mackenzie Mountains of the Northwest Territories and south through the Yukon (YK) into northern British Columbia (BC) (Valdez & Krausman 1999).

Figure 1: Typical pelage colouration, white coloured Dall's sheep *Ovis d. dalli* and dark coloured Stone's sheep *Ovis d. stonei*. Photos (L-R): Bill Jex and Adrian Batho.

There are two subspecies of thinhorn sheep, that have traditionally been classified based on pelage colour: (i) the white coated and more northerly distributed Dall's sheep, and (ii) the dark coated and more southerly distributed Stone's sheep (Valdez & Krausman 1999). While this system of classification works across the majority of thinhorn sheep range, sheep with a wide range of intermediate colouration reside in the contact zone between the subspecies, from southern YK to northern BC (Fig. 2).

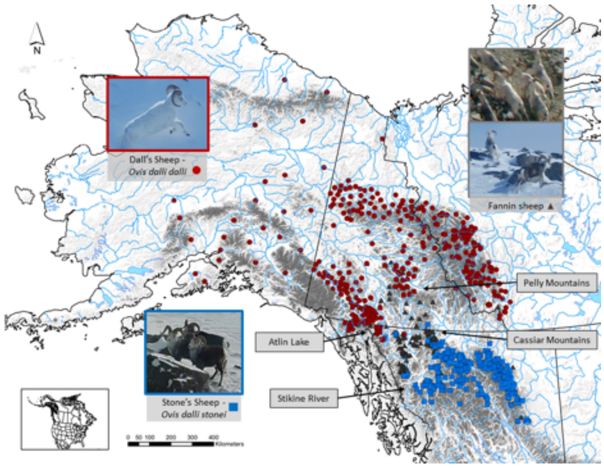

Figure 2: Distributions of Dall's, Stone's and *Fannin* / admixed sheep according to SNP data from Sim *et al.* 2018. Typical pelage colourations for Dall's, Stone's and *Fannin* sheep as shown. [modified from Sim *et al.* 2018].

These sheep, colloquially referred to as *Fannin* sheep, have long been an intriguing taxonomic mystery with most preferring to classify them as Stone's sheep, as a result of their non-white pelage, or the presence of black hairs on the body (B&C 2021).

Over the past two decades however, analyses completed by Worley *et al.* (2004) using microsatellite markers, Loehr *et al.* (2006) using mitochondrial DNA, and Sim *et al.* (2016, 2018) with single-nucleotide polymorphisms (SNPs), have significantly improved our understanding of the *Ovis dalli* population genetic structure and subspecies' range distributions. The combined understandings from this group of researchers has informed our understanding of what we have commonly and collectively referred to as Dall's and Stone's sheep, and *Fannin* sheep: a group of populations and individuals who have admixed genetics and wide ranging colour expressions, but who's family tree roots in Dall's sheep origins (Fig. 3).

Figure 3: The range of pelage colourations of *Fannin* sheep: individuals who are genotyped as admixed Dall's sheep, and includes the dark-phased Dall's phenotype. Photo: Bill Jex.

The body of work to date has shown that previous geographic and pelage-based/phenotypic subspecies classifications are not accurate for taxonomic classifications within the thinhorn sheep species. Prior to work completed by Sim *et al.* (2018), no genetic data existed for sheep in the Pelly / Atlin area; this work was able to show that sheep in this region have mostly admixed genetics with a majority of Dall's sheep ancestry. While it is true that *Fannin* sheep with intermediate colouration and some with grey saddles occur west into Alaska, the most common occurrence of the *Fannin* dark-bodied phenotype (commonly identified as 'Stone's sheep') are predominantly found in the Pelly Mountains of south-central Yukon, and the extreme north-westerly extents of the Cassiar range and eastern Atlin Mountains in British Columbia.

It is in this geography that the *Fannin* dark-phased Dall's phenotype predominantly occurs, and this defines the core geographic range of a truly rare phenotype of Dall's sheep: the dark-phased Dall's (Fig. 4).

Figure 4. The dark-phased Dall's phenotype: Individuals genotyped as admixed Dall's sheep in south central Yukon. Photo: Environment Yukon.

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Camera trap distance sampling: A promising method to monitor mountain ungulates

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A major constraint for conservation and management of mountain ungulates is a lack of knowledge on their status and population trends, particularly for those species that are classified as endangered or vulnerable. Several methods for assessing the abundance of ungulates have been developed (e.g., distance sampling, Buckland *et al.* 2001; track count, Sulkava & Liukko 2007; dung count, Laing *et al.* 2003; Abundance induced heterogeneity model, Royle & Nichols 2003; Repeated count, Royle 2004). However, meeting the key assumptions of these methods for mountain ungulates in the rugged mountainous terrain is often difficult. For example, nonrandom sample point locations, erroneous measurements of animal distance from the observer limits the use of conventional approaches (O'Neill 2008; Singh & Gulland 2013). Further, animal detections (for distance sampling) are likely to be baised by the three-dimensional structure of mountainous terrain. Moreover, the number of observations required for robust density estimation can be limited by rugged and steep terrain, inaccessibility, small population sizes, cryptic and elusive behaviour, and patchy distribution of ungulates (Singh & Gulland 2013). In addition to the above, detecting species with nocturnal activity patterns and forest-dwelling nature makes detection extremely rare during daylight.

For these reasons, mountain ungulate research has generally relied on indirect abundance indices or total counts (e.g., Green 1978; Schaller *et al.* 1988; Oli 1994; Sathyakumar 1994; Bagchi & Mishra 2006; McCarthy *et al.* 2008). Density can be determined via sign production and decay rates, which involve transforming sign density estimations into animal density estimates. However, it is often challenging to obtain precise decay rates (Buckland *et al.* 2001; Walsh & White 2005). Counting animals with aerial methods and infrared imaging can be expensive. The simultaneous point count (Ransom *et al.* 2012; Shrotriya *et al.* 2015) and the double observer approach (Suryawanshi *et al.* 2012) are recent breakthroughs in estimating density in open highland habitats of trans Himalaya (Suryawanshi *et al.* 2012). However, calculating the densities of nocturnal animals (such as musk deer) and species that live in forested habitats still remains a challenge.

Adaptation of conventional distance sampling by camera traps is a recent significant development known as camera trap distance sampling (CTDS) that can estimate the abundance of species that cannot be identified individually (Howe *et al.* 2017). Camera traps are a convenient and widely used tool for detecting elusive and rare species (Burton *et al.* 2015). Extension of the point transect method to include data from camera traps could address some of the issues associated with violations of distance sampling assumptions, allowing this method to be used to estimate species density (Howe *et al.* 2017). Each deployed camera in a survey is treated as a point transect in this method. Camera traps are programmed to record images as long as animals are in the field of view and are placed at random (independent of animal distribution). Animal detection close to the camera should be certain at zero distance, and camera height from the ground should be decided accordingly. The method also requires calculating the distances of the animals in each instantaneous snapshot from the camera. Another key condition is that the proportion of time that animals can be spotted by cameras is quantifiable, as determined by the species' activity patterns (Cappelle *et al.* 2019). For camera-trap point transects, the density is computed using the following equation (Howe *et al.* 2017):

$$\hat{D} = \frac{\sum_{k=1}^{K} n_k}{\pi w^2 \sum_{k=1}^{K} e_k \hat{P}_k} * \frac{1}{A}$$

where $n_k$is the number of observations of animals at a point *k* (camera trap location), e_k is the temporal effort, and $\hat{P}_k$ is the estimated probability of obtaining an image of an animal that is within θ degrees (angle covered by the camera's field of view), *K* is the total number of locations where camera traps were deployed and *w* (truncation distance) in front of the camera at a snapshot of the moment. The effort at a point k is measured as $e_k = \frac{\theta \, T_k}{2\pi t}$ where $\frac{\theta}{2\pi}$ as where describes the fraction of a circle covered by a camera, is the period of camera deployment (in seconds), and t is the unit of time used to determine a finite set of snapshot moments within (also in seconds).

Harris *et al.* (2020) tested the CTDS accuracy on a known population of desert bighorn sheep *Ovis canadensis* in the Chihuahuan desert of New Mexico. The abundance of adult desert bighorn sheep was accurately estimated in this study. On average, the mean abundance estimates were within 4.9 individuals of the census numbers, and bighorn sheep abundance was always within 90 percent confidence boundaries. In our study, 'Using distance sampling with camera traps to estimate the density of group-living and solitary mountain ungulates', we demonstrated the use CTDS for estimating the density of two mountain ungulates species: Himalayan blue sheep or bharal *Pseudois nayaur* and the Alpine musk deer *Moschus leucogaster* (Pal *et al.* 2021). Trans Himalayan alpine habitat and subalpine habitat of Upper Bhagirathi basin, India, were sampled using camera traps for bharal and musk deer respectively. Our density estimates for both the bharal (summer: 0.5 ± SE 0.1 individuals/km^2; winter (0.6 ± SE 0.2 individuals/km^2) and Himalayan musk deer (summer 0.4 ± SE 0.1 individuals/km^2; winter: 0.1 ± SE 0.05 individuals/km^2) were reasonable, but were associated with high variability which can be reduced by increasing the sampling locations.

Other studies have successfully applied CTDS on Maxwell's duiker *Philantomba maxwellii*, in Taï National Park, Côte d'Ivoire (Howe *et al.* 2017), western chimps *Pan troglodytes verus* (Cappelle *et al.* 2019), forest antelopes such as blue duiker *Philantomba monticolain* and sitatunga *Tragelaphus spekii* in Dja forest reserve, Cameroon (Amin *et al.* 2021), Alpine marmots *Marmota marmota* in Stelvio National Park, Italy (Corlatti *et al.* 2020), white-tailed deer *Odocoileus virginianus* in the Duke Forest , United States (Saxton *et al.* 2020) and a diverse vertebrate community in Salonga National Park, Democratic Republic of the Congo (Bessone *et al.* 2020).

In addition to CTDS, there are other potential camera-trap-based methods that can be used for estimating densities: Random Encounter Model (REM) (Rowcliffe *et al*. 2008) and Random Encounter and Staying Time (REST) (Nakashima *et al*. 2018). However, both methods necessitate generating additional information on movement and speed of the species. REM is a frequently used method on range of species (Cusack *et al*., 2015; Enetwild-consortium *et al.* 2019; Pfeffer *et al*. 2018; Zero *et al*. 2013). A comparison of all the three methods showed that CTDS was the most effective method for estimating population size for rare and low abundance species (Palencia *et al*. 2020). REST method is better suited for scenarios of high abundance scenarios, whereas REM is effective when camera trap performance is not optimal (Palencia *et al*. 2020).

Camera traps are ideal for monitoring animal populations since they are non-invasive, unbiased, cost-effective, and efficient, enabling for large-scale surveys to be conducted over longer periods (Rowcliffe & Carbone 2008; Sathyakumar *et al.* 2014). It can overcome some of the logistical challenges that other approaches face due to steep terrain and harsh weather for mountain ungulates. Camera traps offer several advantages over traditional distance sampling methods, including the ability to monitor solitary, forest-dwelling, elusive, and nocturnal species such as musk deer. Additionally, camera trap-based methods can operate in the field for more extended periods, potentially overcoming challenges like low detection rates, low sample size, and observer bias (Cappelle *et al.* 2019). It also enables the simultaneous monitoring of multiple species. CTDS has paved the way for advancing studies on population status, and we recommend the widespread use of this method for developing conservation practices aimed at Caprinae species inhabiting rugged mountainous landscapes.

The cost of using CTDS, on the other hand, is a downside of the method. To obtain precise results, a large number of camera traps would be necessary. Furthermore, CTDS significantly increases the number of desk work hours for photo-video processing. CTDS will also necessitate consideration about the efficacy of camera sensors, which can vary depending on camera type and positioning, temperature, and humidity (Hofmeester *et al.* 2017). Various camera models can be tested at a site to determine their capacity to detect animals. Inconsistencies between the theoretical and actual angle of view (θ) may exist, resulting in skewed estimates (Corlatti *et al.* 2020). Poor camera trap performance will jeopardize population density estimates (McIntyre *et al.* 2020). Field tests can be used to estimate the effective angle, which can subsequently be accounted for in the analysis. A critical requirement is accurate prediction of detection availability. Erroneous estimates can result from imprecise assessments of the target species' availability for detection. Care should thus be taken in selecting the appropriate time period of animal activity and availability for detection (Howe *et al.* 2017). Lastly, it is critical to have a thorough grasp of the target species' habitat use and preferences in order to determine when, where and if sampling coverage is incomplete in the study area (Harris *et al.* 2020).

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SPOTLIGHTS

Pelage color of the Japanese serow shows high variation among and within populations

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The function of pelage coloration in mammals is one of the central issues in ecology and evolutionary biology (Caro & Mallarino 2020). In ungulates, the function of pelage coloration has been studied by interspecific comparison, suggesting that various color patterns exhibited by ungulates have functions such as concealment, communication, and thermoregulation (e.g., Stoner *et al.* 2003; Caro & Stankowich 2009). Although studying intraspecific variation in pelage coloration is one of the most significant methods for elucidating its function (e.g., Singaravelan *et al.* 2010), there are few reports of intraspecific variation in pelage coloration in Caprinae (but see Corlatti & Sivieri 2020).

The Japanese serow *Capricornis crispus* is endemic to Japan, belonging to Caprinae, and retains evolutionarily primal traits, such as small body size (35 kg) and horns (13 cm), sexual monomorphism, solitary behavior, and resource defense territoriality (Geist 1987; Ochiai 2015).

Its distribution is wide, from northern Japan in the cool temperate zone with snow cover to southern Japan in the warm temperate zone without snow cover (Ministry of the Environment of Japan 2019, Fig. 1). The Japanese serow inhabits various vegetation types, such as evergreen broad-leaved forests, deciduous broad-leaved forests, subalpine coniferous forests, alpine meadows, and alpine volcanic deserts (Ochiai 2015; Takada & Minami 2021).

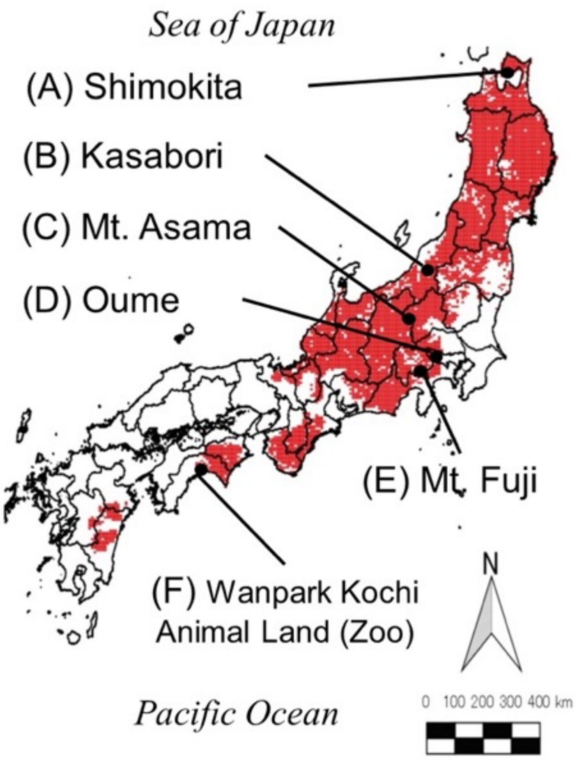

Figure 1: Distribution of the Japanese serow (red area) and the photographed locations of each individual. Distribution was drawn based on data from Ministry of the Environment of Japan (2019).

There is no literature on intraspecific variation in pelage color of the Japanese serow, and most of the photographs in illustrated books depict gray (from blackish to whitish) pelage-colored individuals (e.g., Ochiai 2015; Castello 2016). However, there are remarkable pelage color variations not only among populations but also within populations. Individuals with gray pelage color are most commonly found in cool temperate zones, such as central Japan, to the Pacific Ocean side of northern Japan (Fig. 2A,C; Table 1).

Since these areas are the main distribution of Japanese serows and the population size is relative-

Table 1: Habitat characteristics of photographed locations of Japanese serows. (A) to (E) are wild individuals and (F) is a captive individual derived from a wild individual from Shikoku mountains.

	(A) Shimokita	(B) Kasabori	(C) Mt. Asama
Prefecture (City)	Aomori (Mutsu)	Nigata (Sanjyo)	Nagano (Komoro)
Location	Northern Japan	Central Japan	Central Japan
Altitude zone (m)	Lowland (0-100)	Montane zone (500-1200)	Upper montane zone (1200-1600)
Vegetation	Deciduous broadlea-ved forest	Deciduous broadlea-ved forest	Deciduous and evergreen coniferous forest
Snow cover (cm)	75	200-300	50-100

	(D) Oume	(E) Mt. Fuji	(F) Wanpark Kochi Animal Land (Zoo)
Prefecture (City)	Tokyo (Oume)	Yamanashi (Fujiyoshida)	Kochi (Kochi)
Location	Central Japan	Central Japan	Western Japan
Altitude zone (m)	Lowland (200-500)	Subalpine and alpine zones (2200-3000)	-
Vegetation	Evergreen broad-leaved and coniferous forest	Volcanic desert and evergreen coniferous forest	-
Snow cover (cm)	0-5	100-200	-

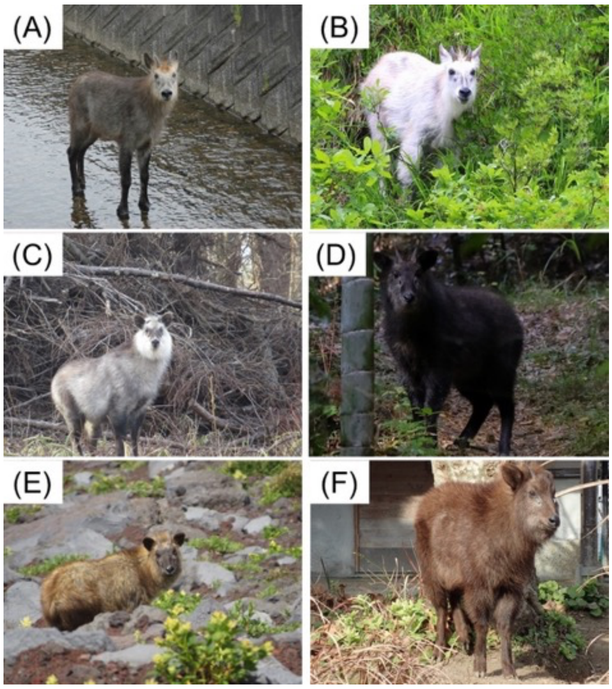

Figure 2: Pelage color variations of Japanese serows among populations; (A) Shimokita, (B) Kasabori, (C) Mt. Asama, (D) Oume, (E) Mt. Fuji, and (F) Wanpark (Zoo). (A) to (E) are wild individuals and (F) is a captive individual derived from a wild individual in Shikoku mountains.

ly large, gray individuals seemed to be most commonly used for illustration.

However, in areas with heavy snowfall (snow depth: 2-5 m) such as the Sea of Japan side of Honshu, individuals that are completely white, like mountain goats *Oreamnos americanus*, can be found (Fig. 2B; Table 1).

Black-colored pelage individuals, like the Sumatran serow *Capricornis sumatraensis*, are frequently found in warm temperate zones with little snowfall (Fig. 2D, Table 1), and even light-brown- or reddish-brown-colored pelage individuals, like the red serow *Capricornis rubidus* or Formosan serow *Capricornis swinhoei*, are found in some areas such as western Japan and Mount Fuji (Fig. 2 E,F; Table 1).

Furthermore, in the alpine meadows of Mount Asama, central Japan (see Takada & Minami 2021), individuals with various pelage colors ranging from black to white and brownish were confirmed within the population (Fig. 3).

Figure 3: Pelage color variations of the Japanese serows within populations from alpine meadows of Mt. Asama, central Japan.

Wide-ranging intraspecific variations in pelage coloration among and within populations, as seen in the Japanese serow, have been reported in small mammals such as rodents (e.g., Krupa & Geluso 2000; Tamura *et al.* 2017), but are relatively rare in ungulates. Japanese serows adopt cryptic anti-predator strategies, such as freezing, to avoid detection by predators (Takada *et al.* 2018).

Furthermore, the background of the habitat is considerably different geographically or seasonally depending on the geology, vegetation, and snow cover. Therefore, the pelage coloration of the Japanese serow may have habitat-dependent variations aimed at background matching. In the future, in order to clarify the function of the pelage color of the Japanese serow, it will be necessary to quantitatively evaluate the relationship between pelage color and habitat characteristics, and seasonal changes in pelage color. In addition, it is necessary to clarify the genetic background that determines pelage color.

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What leucism may reflect in Iberian wild goat *Capra pyrenaica* and in Alpine ibex *Capra ibex*

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White (leucistic) individuals of any animal species have traditionally captured the attention and stimulated the imagination of biologists, artists and the general public. Wild caprines are no exception. While commenting on the deepest reasons for such interest is far beyond the scope of the newsletter, in this note we aim to report on recent episodes relevant to the European representatives of the genus *Capra*, namely the Iberian wild goat *Capra pyrenaica* and the Alpine ibex *Capra ibex*.

Since the eighties of the last century, a herd of Iberian wild goat *Capra pyrenaica* that escaped from an enclosure in the Natural Park of Guara (Northern Spain) started the recolonization of nearby Pyrenees. This expanding population has been the object of long-term monitoring since 2006 (Herrero *et al.* 2013a). The colonized area is shared with a large population of feral goats *Capra hircus* (Herrero *et al.* 2013b). During routine surveys in 2018 and 2019, apparently the same leucistic male was sighted twice in approximately the same location, the first time in a group of 35 individuals, predominantly young males, then alone. His age was estimated to be around 8 years (Fig. 1). Previously, only a single leucistic individual had been observed in the area in 1997, though some uncertainty exists on this record (V. Hernández com. pers).

Figure 1. A leucistic Iberian wild goat male. Photo: Rafel Vidaller.

To our knowledge, these are the first cases of leucism ever reported in the Iberian wild goat (see García-González *et al.* 2020 for a recent review). Interestingly, in 2017 we sighted a female with an overall Iberian wild goat phenotype except for its abnormal horns, feeding a kid of domestic aspect, followed by an Iberian wild goat male (Fig. 2), suggesting a hybridization event. Goat x Iberian wild goat crossbreeds are known to occur in captivity, and apparently quite rarely under natural conditions (Fernández-Arias *et al.* 2001, Alasaad *et al.* 2012). However, Iberian wild goat shows domestic goat genes due to ancient hybridization (Angelone *et al.* 2018), and goat introgression in Iberian wild goat seems common according to a recent genetic analysis of 10 *C. pyrenaica* populations (Cardoso *et al.* 2021).

Similarly, full leucism is rare in the Alpine ibex, with only two documented individuals recorded in the last decades, in Italy and France respectively.

Figure 2. Possible hybrid female with kid of Iberian wild goat. Photo: Alicia García-Serrano.

The first one, a male, was photographed for the first time in spring 2007, as a yearling, in Aosta Valley, Italy, at the edges of the Gran Paradiso Nation Park, which is home of the single Alpine ibex population which survived from extinction in the 19th century. This ibex was observed several times in the Monte Emilius massif (Fig. 3) then disappeared when seven-year-old. No coat anomalies were signalled in other ibexes living in that massif in the following decade.

Figure 3: A leucistic Alpine ibex male. Photo: Luca Rossi.

A second leucistic individual, a female, has been observed in 2019 as a kid in Fiz Massif, near Chamonix Mont-Blanc, France. Open access high quality pictures of this individual, taken in two consecutive years, are available in a regional magazine website (https://www.ledauphine.com/societe/2020/11/26/un-bouquetin-albinos-video-filme-en-haute-savoie-etagne-bouquetin-femelle-albinos-dans-le-massif-des-fiz-passy-mont-blanc). In a famous monographic text on the Alpine ibex (Couturier 1962), the author referred that only two fully and six partially leucistic individuals, all of them males, had been observed during several decades by 58 interviewed Gran Paradiso park wardens, while none was reported by their colleagues operating in the ibex colonies of Mont Plereur and Piz Albris, Switzerland.

Most recently, in fall 2020, interest of local media and their public has been captured by multiple sightings and pictures of a leucistic undefined "goat-like" individual (Fig. 4), well integrated in a herd of a dozen of adult ibex males in Susa Valley, at the border between Italy and France. The exact nature of this hornless and large-sized adult male, that we tentatively identified as a goat x Alpine ibex hybrid following observation end video documentation from short distance, is under investigation by means of not invasive genetic tools. In the meanwhile, interesting pictures have been retrospectively provided by some citizens, showing that an ibex female accompanied by a white "goat-like" kid was roaming in the same zone seven years before. Pictures of a leucistic goat-like young male taken two years later were also made available.

Figure 4: A goat-like leucistic male, possibly a goat x Alpine ibex hybrid. Photo: Luca Rossi.

In turn, this particular case has renovated the interest on the already reported (Couturier 1962; Giacometti *et al.* 2004; Iacolina *et al.* 2018; Alasaad *et al.* 2012; Al-Sheikhly & Ahmed 2020) though poorly investigated and quantified phenomenon of the hybridization between wild Caprinae and feral goats, a more or less hidden reality in the majority of applicable mountain ranges worldwide. In 2021, two parallel on-line questionnaire studies have been launched in Italy and Spain to collect original information and images of putative hybridisation events with the support of a disseminated network of field biologists, rangers and nature photographers, in a Citizen Science perspective. Results will become available within months. It goes without saying that the spread of domestic or non-native genes in native wild ruminant populations is of concern for conservation and should be prevented with the responsiveness that competent conservation agencies are expected to guarantee (Iacolina *et al.* 2018).

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3rd *Rupicapra* Symposium

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It has been eight years since the last, 2nd *Rupicapra* Symposium was held in Bellver de Cerdanya, Catalonia, Spain. The third symposium was finally planned, this time in the beautiful Croatian town of Makarska, under the Biokovo mountain, one of the last natural habitats of the Balkan chamois. Unfortunately, due to COVID-19 restrictions, the 3rd International *Rupicapra* Symposium was postponed twice, and it was eventually held online from 16 to 18 June 2021, in cooperation with the Faculty of Agriculture University of Zagreb and Biokovo Nature Park.

The town of Makarska was purposefully chosen because, although the presence of chamois is often associated with high-elevation mountain environments, Biokovo Nature Park constitutes a deviation from the "traditional" view of chamois habitat. The Biokovo mountain rises directly from the Adriatic Sea and covers an area of 200 km^2, hosting of one of the largest and most stable populations of Balkan chamois. Here, the chamois inhabits limestone peaks, with vegetation and climatic conditions typical of the Mediterranean region.

The aim of the Symposium was to promote exchange of ideas between experts in chamois research and management, and disseminate the most up-to-date information on different species and subspecies of chamois, while promoting research, conservation, and sustainable management. The symposium was open to researchers, experts, managers, and anyone else interested in these species, with the aim of bridging the gap between science and practice.

Despite the conference being held online, the overall interest of the scientific community was massive, with more than 100 participants attending 39 oral presentations and 10 poster sessions. The conference encouraged the participation of early career researchers and aimed at inclusive collaboration, with a good gender balance and wide geographical representation.

The Symposium was opened by Slavo Jakša (Biokovo NP), Juan Herrero (IUCN Caprinae Specialist Group), Luca Corlatti (University of Freiburg) and Nikica Šprem (University of Zagreb) who thanked all the sponsors and highlighted the importance of this symposium for the promotion of chamois research and conservation. Prof. Sandro Lovari gave a plenary speech about the effects of climate change on the global chamois population. The two-day scientific program covered topics related to Genetics and Systematics (keynote speaker: Elena Bužan), Physiology and Disease (keynote speaker: Luca Rossi), Behavior and Ecology (keynote speaker: Marco Apollonio) as well as Management and Conservation (keynote speaker: Marco Festa-Bianchet). One of the main concerns across all disciplines was the scarcity of replicate studies from populations of subspecies and/or geographic areas other than the Alps and the Pyrenees, which still represents a major limit to the advancement of chamois science.

On the last day of the symposium, all participants took part in the final discussion, the main topic being the challenges in chamois conservation and management. One of the main conclusions was that great progress can be made in the conservation of chamois populations through better international scientific cooperation, and by finding adequate, i.e., reliable and sustainable, monitoring tools. The main outcome of this symposium will be presented in a scientific paper that will be submitted to the Journal Wildlife Biology, that saw the contribution of over 30 chamois researchers, and will provide a state-of-the-art overview of research trends and of the most challenging issues in chamois research and conservation.

2nd Meeting on Cantabrian and Pyrenean chamois

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On November 26 and 27, 2021, the 2nd Meeting on the Cantabrian *Rupicapra pyrenaica parva* and Pyrenean chamois *Rupicapra p. pyrenaica* was held at the Benasque Science Centre, in the Aragonese Pyrenees, Spain.

It was organized by the Regional Government of Aragon and the University of Zaragoza. The Benasque City Council, the Aragonese Hunting Federation, the Institute of Alto Aragonese Studies (IEA) and Ega Wildlife Consultants collaborated. It was endorsed by the Conseill International de la Chasse (CIC), the Caprinae Specialist Group of IUCN and the Ungulates Group of the Spanish Society for the Conservation and Study of Mammals (SECEM).

There were 40 attendees, from the Cantabrian Mountains and the Pyrenees, Andorra, France and Spain. The audience was composed of administration personnel, scientists, consultants and hunters, among others.

The sessions, with a total of twelve communications, were dedicated to culture, palaeontology, health status and the evolution of populations and their management. We were also able to attend two workshops on the horns and the chamois trophy, a photographic exhibition related to the Aragón Game Reserves and a round table on the future of management in both subspecies.

Some of the main conclusions of the meeting were:

- the importance of epizootics in both subspecies, since they modulate population dynamics and have immediate consequences for management;
- territorial coordination in population monitoring (interregional and international) is incipient, but it offers interesting forms of collaboration;
- the protected areas, and within them the game reserves, together with the movement of specimens, continue to be important instruments for the conservation of populations;
- the round table on the future of management evidenced the importance of long-term monitoring, the difficulty of establishing them in large territories and the need to affect the entire territory in which these mountain ungulates live, being the basis of the management decisions, such as extraction quotas;

- in some game reserves and hunting territories, there is a lack of qualified technical personnel that could undertake population monitoring in the future;
- a greater quantity and deepening of scientific studies based on data from population monitoring and captures, as well as the effect of hunting or its absence on the dynamics of some populations, would be desirable.

The next meeting will be held in Somiedo, Asturias, Spain during 2025 and will be organized by the Regional Government of the Principality of Asturias. The abstract booklet, in Spanish, is available by request from Juan Herrero. The proceedings will be published in Lucas Mallada journal during 2022.

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Submissions of articles, including research reports, conservation news, recent publications, etc., on wild or feral Caprinae, are always welcome from any professional biologist. A potential author does not have to be a member of the Caprinae Specialist Group.

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