25th MEETING OF THE

ALPINE IBEX EUROPEAN SPECIALIST GROUP

GSE – AIESG

Zernez, 23rd – 25th October 2024

ABSTRACT BOOK

Index

Session: Behaviour

Environmental and individual drivers of seasonal migration in Alpine ibex

Chauveau V.1, Garel M.2, Toïgo C.2, Anderwald P.3, Apollonio M.4, Bassano B.5, Beurier M.2, Bouche M.6, Brambilla A.5,7, Brivio F.4, Bunz Y.6, Cagnacci F.8,9, Canut M.10, Cavailhes J.11, Champly I.12, Filli F.3, Frey-Roos A.13, Gressmann G.14, Grignolio S.4,15, Herfindal I.16, Jurgeit F.14, Martinelli L.17, Maurino L.18, Papet R.6, Petit E.2, Ramanzin M.20, Semenzato P.20,21, Vannard E.6, Coulon A.22,23, Loison A.1, Marchand P.2

1 University Grenoble Alpes, University Savoie Mont-Blanc, Centre National de la Recherche Scientifique (CNRS), 2 Office Français de la Biodiversité, 3 Swiss National Park, 4 University of Sassari, 5 Gran Paradiso National Park, 6 Écrins National Park, 7 University of Zurich, 8 Fondazione Edmund Mach, 9 National Biodiversity Future Center Palermo, 10 Mercantour National Park, 11 Vanoise National Park, 12 Asters, 13 University of Natural Resources and Life Sciences Vienna, 14 Tyrol National Park Authority, 15 University of Ferrara, 16 Norwegian University of Science and Technology, 17 Ente di gestione Aree Protette delle Alpi Marittime, 18 Ente di gestione Aree Protette delle Alpi Cozie, 20 University of Padova, 21 DREAM-Italia, 22 Sorbonne University, 23 University of Montpellier

Understanding how variation in the phenological patterns of resources can modify migratory behaviour of species in space and time, is crucial for determining how species face the pervasive consequences of global changes. Here, we investigated the environmental and individual drivers of migration propensity as well as behavioural plasticity of migration timing in an emblematic mountain ungulate, the Alpine ibex *Capra ibex*. Using 20 years of GPS data from 327 Alpine ibex *Capra ibex* across 17 populations, we found that males have a higher propensity to migrate than females, whose migration is more influenced by environmental differences among populations than by year-to-year variation as in males. Fast and spatially heterogeneous spring green-up resulted in a better exposure and prolonged access to high quality vegetation for migrants, correlating with an increased propensity to migrate under these conditions. However, when spring conditions favoured migration, residents ibex compensated for their foraging deficit by increasing fine-scale tracking of peaks of green-up. In addition, vegetation phenology also

affected migration timing as we found the timing of spring and autumn migration was mainly related to peak green-up, snowmelt/snowfall timing and length of spring and senescence seasons. Those global responses were predominantly driven by phenotypic plasticity at the individual scale, although with a magnitude lower than that of interannual environmental variations. Ibex migration phenology was also related to sex, males timed spring migration to coincide with peak green-up more closely than less plastic females. Together, these results highlight how the spatio-temporal dynamics of vegetation drives migratory movements in Alpine ibex. Differences in individual plasticity related to sex-specific constraints exemplify the complexity of foraging responses to environmental changes among individuals.

Massive sport events in natural areas exacerbate the corridor of fear in a protected species, the Alpine ibex *Capra ibex*

Marchand P.1, Risser N.1, Petit E.1,2, Garel, M.1

1 Office Français de la Biodiversité, 2) University of Lyon

The ongoing development of recreational activities in natural areas raise concerns on the impacts on the environment, and in particular in the mountains. Despite recent advances in recreational ecology, little is still known about the impacts of nature-based massive sport events which number recently explosed. We focused on the impact of two types of massive sport events (MSE) that occurred between 2014 and 2023 in the Bargy massif (northern French Alps), i.e. a trail running event divided in 4 races and occuring nearly each year (n=8 years) and stages of emblematic cycling races (n=8). We compared several behavioral metrics recorded by GPS collars (total=139 individuals) during daytime when the MSE occurred, and the following night, with references data recorded on the same dates from other years. We revealed trail running events, that occurred in early June and crossed ibex distribution range, enhance the corridor of fear for Alpine ibex. They triggered a redistribution of ibex further from the routes (i.e. > 500m), with changes in movements and activity levels during both daytime and nightime in individuals located in the 500m of the route the night before. By contrast, the redistribution of ibex further from the route and the behavioural consequences were more limited when cycling events occurred, mostly during summer when ibex were already far from roads. We will discuss about the developement of such MSE in mountain areas, the period relative to ibex biological cycle and the consequences for this species already facing major changes during this crucial spring-summer period.

High and steep: comparing anti-predatory response in reproductive and non reproductive female ibex at multiple temporal scales

Semenzato P.1,2, Ramanzin M.1§, Ossi F.2,3, Morellet B.4, Cagnacci§ F.2,3

1 University of Padua, 2 Fondazione Edmund Mach, 3 National Biodiversity Future Centre, Palermo, 4 University of Toulouse
§ Cagnacci F. and Ramanzin M. are co-senior authors

Predation represents a major selective force for animal populations, with direct consequences on their dynamics and evolution. In most mammal species, anti-predatory tactics are expected to be exacerbated in reproductive females, due to parental care and direct link to fitness. Several studies on mountain ungulates have identified steep rocks as elective anti-predatory refuges. We used GPS-determined movement behavior to test such anti-predatory tactic in Alpine ibex from a colony in Eastern Italian Alps (Marmolada massif). We compared movements of reproductive and non reproductive female ibex along the altitudinal gradient and with respect to refuge areas throughout the spring-summer phases of the reproductive cycle, and between daytime and nighttime. Regardless of their reproductive state, females moved towards higher elevation during the peak of the summer, and to lower elevation at night at the diel scale. However, reproductive females exhibited a lower altitudinal shift between day and night and stayed closer to the refuge areas, both at day and night, but only with kids at heels. We argue that this behavior is related to the need for protection of kids from predators, and conditional to their lower mobility, especially in the first phases after birth.
In this work we provide some evidence that the use of specific refuge sites by female ibex could be mediated by a trade-off between safety and other needs, such as thermoregulation and resource acquisition, in direct relation to potential fitness costs.

Session: Conservation and management

Management recommendations to reduce inbreeding and their implementation in four ibex populations

Biebach I.1, Keller L.1

1 University of Zurich

Due to their reintroduction history, many ibex populations in the Alps have low genetic diversity and a high degree of inbreeding. Both may negatively affect population viability through inbreeding depression and reduced adaptive potential. Therefore, ibex populations with high levels of inbreeding would likely benefit from reinforcements. To inform management decisions from a genetic perspective on how best to conduct such reinforcements or establish a new population, we used a detailed genomic data set and combined it with life history data in individual-based simulations. The recommendations were the basis for implementation of several reinforcements and a new established population. Here we show the outcome of the implementations for four populations. For two populations we estimate the extent of successful gene flow one generation (ca. 8 years) after the reinforcement. For one reinforced population and an establishment of a new population we summarize monitoring data one year after implementation.

Hybridization in Alpine ibex: evidence and perspectives

Brambilla A.1,2, Moroni B.3, Bassano B.2, Zehnder N.2, Meneguz P.4, Rossi L.4, Tizzani P.4, Grossen C.5

1 Gran Paradiso National Park, 2 University of Zurich, 3 Istituto Zooprofilattico Sperimentale di Piemonte Liguria e Valle d'Aosta, 4 University of Turin, 5 Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Hybridization between wild species and their domestic relatives can be detrimental for conservation. Knowledge on this issue is nevertheless often missing also because of a lack of appropriate tools for hybrid identification. By means of a multi-disciplinary approach, we studied the phenomenon of hybridization between Alpine ibex and domestic goats. First, using an online survey and reports we gathered and mapped evidence of the presence of suspected hybrids (based on phenotypic characteristics) covering most of the areas of ibex presence in the Alps. Suspected hybrids were reported in most of the Alpine countries with some swarms including 4-20 probable hybrids. Secondly, we focused on two of the hybrid swarms identified (Valli di Lanzo (TO) and Valsavarenche (AO), both in Italy) and conducted genomic analysis to estimate the hybridization level of the suspected individuals and to test for correlations between phenotypic appearance and hybridization level. Our method, based on amplicon sequencing of 63 diagnostic SNPs specifically developed for this purpose, allowed us to identify hybrids and backcrosses up to the fourth-fifth generations. All the suspected individuals were confirmed as hybrids based on genetic analysis. Despite some precautions have to be taken, phenotypic appearance can serve as a first tool for a reliable identification of hybrids in the field. Genetic analysis remains however necessary for uncertain cases. Non-invasive genetic samples can be used for this purpose.

Alpine ibex habitat suitability and connectivity in Slovenia

Černe R.1, Prostor M.1, Javornik J.1, Krofel M.2

1 Slovenia Forest Service, 2 University of Ljubljana

The Alpine ibex (*Capra ibex*) is currently recognised as a native species in all Alpine countries except Slovenia. Its historic presence of the species was until recently unresolved in Slovenia, therefore the ibex is still considered as a species with an undefined status, which makes its management difficult. Three colonies are currently present in Slovenia: in the Julian Alps, in the Kamnik-Savinja Alps and in Mt. Kanin, the latter originating from and being shared with Italy. Lately, due to the desire to clarify the status of the species, we have been working on its recognition as an indigenous species in Slovenia. One of the activities was to investigate the suitability of ibex habitat in the country and its spatial connectivity. Habitat modelling was studied based on MAXENT models which included various spatial and environmental variables in combination with species presence data from all three colonies. The habitat modelling results indicated suitable habitat in Slovenia within five habitat patches covering approximately 282 km2. Spatial connectivity between habitat patches was analysed using the Least-Cost-Path methods, through which we have identified five potential corridors with a total area of approximately 7 km2. Habitat patches in the Karavanke and Kamnik-Savinja Alps are isolated from the rest of suitable ibex habitat in the Julian Alps. Habitat patches in the Julian Alps and neighbouring areas in Italy seem to be sufficiently connected, although some important barriers including roads and touristic infrastructure are evident. Guidelines for managing connectivity within identified corridors will be presented.

How can the conservation and sustainable management of Alpine ibex ensure its favourable conservation status in the cross-border Julian Alps area?

Nève Repe A.1, Arih A.2, Favalli M.3, Santi S.4, Poljanec A.1

1 Slovenia Forest Service, 2 Triglav National Park, 3 NaturaForYou di Favalli Marco, 4 Julian Prealps Nature Park

The Alpine ibex (*Capra ibex*) was presumed extinct in the Julian Alps by end of the Middle Ages. However, successful reintroduction efforts began in the mid-20th century, with initiatives in Slovenia starting in 1964 and in Italy's Friuli-Venezia Giulia region in 1978. These efforts aimed to restore the Alpine ibex population within the Julian Alps biosphere reserve. Recent work including AlpBioNet2030 and DINALPCONNECT projects, have focused on crossborder management of the Alpine ibex. The methodology involved participatory workshops, stakeholder consultations, and the development of cross-border management documents to enhance collaboration. Since 2017, four transboundary workshops have been conducted with Italian and Slovenian stakeholders, including hunters, landowners, protected area managers, foresters, national and regional decision-makers, and conservationists. Our work examined various aspects of Alpine ibex management and proposed adaptations to improve population conditions and ensure ecological connectivity across different colonies on a transboundary scale. The significant question that arose repeatedly during our work and discussions with stakeholders pertained to the harmonisation of legislation of Alpine ibex status on both side of the border. The participatory process has led to a comprehensive cross-border management concept for the Alpine ibex. The expert group developed a wildlife vision and a strategy ensuring long-term conservation. It outlined goals, objectives, measures, and indicators regarding legislation, monitoring, habitat enhancement, communication, education. Stakeholders endorsed an action plan, prioritizing proposals for transboundary wildlife management. Some of the concrete actions from the action plan have already been completed, including work on the Alpine ibex status on the Slovenian side border.

Session: Ecology

Alpine ibex and climate change: can we reliably predict the future?

Bollmann K.1

1 Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Understanding the specific impacts of climate change on mountain ungulates is crucial for developing effective conservation and management strategies. Climate change can affect a species' distribution or survival and alter entire ecosystems by changing interactions between plants and animals. Warming may alter exposure to snow and influence the energy demands of endothermic organisms. Similarly, earlier snowmelt may have cascading effects on plant growth, resource availability, and the optimal provisioning of herbivores during periods of growth and reproduction. However, the evidence on this topic is still scattered, and conclusions regarding the impact of climate change on the Alpine ibex are contradictory. Therefore, a better understanding of how climate change affects the viability of Alpine ibex populations is needed. In this talk, I will compile the available evidence and discuss it in the context of the species' life cycle and ecology. I will pay special attention to recent population trends and explore why the threats related to climate change are assessed differently. The aim of this talk is to increase our understanding of how climate change alters interactions between the Alpine ibex and its environment, and how this feeds back into population dynamics and management.

Temporal variation of diet quality in male and female Alpine ibex

Cortinovis S.1,2, Isotton A.3, Brambilla A.2,4

1 University of Pavia, 2 Gran Paradiso National Park, 3 University of Parma, 4 University of Zurich

The study of diet quality plays a key role to understand numerous aspects of the life of wild species because it can provide information on the nutritional status not only of an individual, but of the entire population. Alpine ungulates live in habitats that exhibit extreme seasonal variations in forage availability. Therefore, having access to resources of high nutritional value may be crucial for their overwinter survival and reproductive success.
Due to its remarkable seasonal changes in body mass the Alpine ibex (*Capra ibex*) is a good model species to study this dynamic. On this species, same environmental conditions seem to have different effects on different age and sex classes. However, there is no detailed information on resource availability or on differences in diet quality between male and female ibex. Our study analyzes the differences in seasonal variations in diet quality between male and female Alpine ibex, the environmental variables influencing it, and the effects on individuals' body condition (i.e., seasonal weight variations).
This study focused on the population of Gran Paradiso National Park and collected data over three years (2022 – 2024). Diet quality was assessed through NIRS analysis of faecal and vegetation samples. The results of this study provide an initial overview of the diet of male and female Alpine ibex, showing how diet quality differs in relation to the season, the individual characteristics and the different habitat occupied. Moreover, the NIRS technology proves to be an excellent technique to investigate diet quality of herbivores in long-term monitoring.

Environmental drivers of annual horn growth in ibex across three distinct populations"

Reiner R.1, Gressmann G.2, Senf C.3, Filli F.4, Anderwald P.4

1 Berchtesgaden Nationalpark, 2 Hohe Tauern Nationalpark, 3 Technical University of Munich, 4 Swiss National Park

We measured and examined 996 ibex horns (78 from Berchtesgaden National Park - Germany, 729 from Hohe Tauern National Park - Austria, and 189 from Swiss National Park - Swiss) with a total of 7125 annual rings from 1924 to 2021. These horns were obtained from hunting and natural mortality. Additionally, annual population development data has been available for each area since the populations were established. It is already known that horn growth synchronizes in nearby populations of the Eastern Swiss Alps (Büntgen et al., 2013). We investigate whether this is also the case for populations that are far apart and what explains differences in horn growth.
We found that population density affects horn growth differently between populations. Age also has a varying impact depending on the population. Spring precipitation negatively affects all areas, while winter precipitation only has a negative effect in Berchtesgaden National Park and Swiss National Park. These differences could be due to the distinct habitats, and hunting, which does not occur in Swiss National Park, could also explain the variations.
Our study provides valuable insights into the environmental drivers of annual horn growth in ibex, demonstrating that different ecological and climatic conditions in separate populations can lead to varying growth rates.

Alpine ibex resource selection under the pressure of livestock and rising temperatures

Sganzerla F.1, Ciuti S.2, Bassano B.3, Grignolio S.1

1 University of Ferrara, 2 University College Dublin, 3 Gran Paradiso National Park

Global warming represents a major challenge for mountain-dwelling species, often experiencing a reduction of suitable habitat due to rising temperatures. To mitigate these effects, it is often suggested to minimise other stress factors such as tourism or livestock husbandry.
Livestock poses threats to many mountain-dwelling species by increasing disease transmission risk and competing for resources. Morover, livestock are often guarded by humans and their dogs, therefore causing disturbance and eliciting antipredatory responses. Whereas the negative effects of livestock husbandry across several ungulate species have been documented, its effects on resource selection have never been investigated in the Alpine Ibex (*Capra ibex*), a cold-adapted species which is already suffering foraging limitations due to rising temperatures.
We built a resource selection function to study the potential interference by free-ranging sheep on Alpine ibex in the Gran Paradiso National Park, Italy. We showed that on warmer days, and when the livestock was in close proximity, Alpine ibex selected pastures at higher elevations with lower food quality. We found that both high temperature and closeness to livestock interacted negatively in affecting resource selection, forcing ibex to select for suboptimal habitats. Our results imply that summer husbandry in alpine pastures can cause shifts in resource allocation by ibex, potentially affecting species fitness under climate change scenarios. In alpine areas where husbandry is practiced, the reduction in available optimal grazing areas due to the dual pressures of climate change and livestock competition is likely to represent a further challenge for the Alpine ibex.

Session: Demography

From crisis to recovery: demographic changes in female ibex following pneumonia outbreak

Bonsacquet L.1, Garel M.2, Cavailhes J.1, Besnard A.3,4

1 Vanoise National Park, 2 Office Français de la Biodiversité, 3 University of Montpellier, 4 EPHE-PSL

Epizootics can profoundly impact population dynamics by affecting both individuals survival and reproduction over relatively short periods. However, the long-term impacts of epizootics on population dynamics and the mechanisms behind these impacts are less understood. To assess these potential long-term effects, we compared the demographic parameters of a female ibex population before (10 years) and after (14 years) a severe pneumonia outbreak in the Vanoise National Park. We used an integrated population model, combining capture-mark-recapture and census data, and accounting for individual heterogeneity, to estimate age-specific reproduction, survival, and population growth rate. On average, we observed an increase in breeding probability after the epizootic. This finding was consistent with a release from density-dependent processes following the population crash (-62% in abundance), which affected most age categories. However, this higher reproductive involvement may have come at the cost of survival, which was on average 7.3% lower in most adult females during post-outbreak periods. Adverse environmental conditions, such as warmer springs and summers, which occurred during post-outbreak periods, may have also contributed to or exacerbated this pattern. Whatever its cause, this low adult survival resulted in a weak post-epizootic recovery of the population (+2%/yr), driven only by high quality females, who represent 75% of the female population. Monitoring populations under adverse environmental conditions, such as disease outbreaks, provides valuable insights into how long-lived iteroparous females navigate trade-offs between survival and reproduction in response to rapid shifts in the cost of immunity and access to resources.

First insights into birth detection and neonatal period monitoring in ibex at Vanoise National Park

Caillot Y.1, Bonsacquet L.1, Garel M.2, Habermacher L.1, Marchand P.2, Cavailhes J.1

1 Vanoise National Park, 2 Office Français de la Biodiversité

For nearly 30 years, the Vanoise National Park has been studying the dynamics of ibex populations within its territory. According to previous studies, none had yet focused on the juvenile phase, particularly the neonatal period. Identifying the occurrence and precise timing of births is crucial in animal ecology due to their central role in female reproductive performance and, consequently, in population dynamics. This fact motivated a significant research effort that began in the spring of 2024. Studying juvenile ibex during the post-natal period is very challenging. Unlike other ungulates, such as roe deer, it is impossible to capture newborns. To overcome this difficulty and study this still largely unknown biological period in ibex, we employed tracking methods that do not require capturing very young animals. We used GPS collars equipped with accelerometers on females detected as pregnant via ultrasound, combined with intense monitoring pressure, to detect timing of births and accurately track the development of their young. Although few animals were equipped this first spring (n = 6), our initial results are very promising and demonstrate the value of this project.

Key drivers in Alpine ibex population dynamics: new insights from Gran Paradiso National Park

Panaccio M.1,2, Brambilla A.1,3, Smith, T.2, Bassano B,1, von Hardenberg A.4

1 Gran Paradiso National Park, 2 University of Chester, 3 University of Zurich, 4 University of Pavia

Understanding the key drivers that shape the population dynamics of the Alpine ibex is crucial for the species' conservation. The ibex population in Gran Paradiso National Park (GPNP) has exhibited an unexplained pattern over the past years, with an initial increase in abundance followed by a significant decline of more than 50% between the 1990s and 2010, and a seemingly stable phase in the last decade. Previous studies identified snow cover and density dependence as key factors influencing the GPNP ibex population but were unable to determine the causes of the decline.

We analyzed the ibex population dynamics in GPNP using a new statistical approach based on Integrated Population Models (IPMs), which combine total counts with capture-mark-resight, kid survival and fecundity data collected over the last 25 years from individually tagged Alpine ibex. The IPMs were run using a Bayesian approach, that allows to estimate population parameters during periods with missing data and also infer unobserved parameters.

Our initial results suggest that females and juveniles are more affected than males by density dependence and environmental factors (primarily snow cover, but also maximum summer temperatures). We also found evidence supporting the hypothesis that population ageing played a critical role in the decline that began in the 1990s.

If these results are confirmed by further analyses, they would provide significant insights into the risks posed by climate change to the Alpine ibex, particularly regarding the impact of heat waves on females and kids.

Session: Genetics

Depleted genetic diversity of Alpine ibex populations in Slovenia

Buzan E.1,2, Kolenčik S.1, Pokorny B.2,3, Toškan B.4, Nève Repe A.5

1 University of Primorska, 2 Environmental Protection College Velenje, 3 Slovenian Forestry Institute, 4 Research Centre of the Slovenian Academy of Sciences and Arts, 5 Slovenia Forest Service

Alpine ibex is the least common wild ungulate in Slovenia, with a population size estimated at about 300 individuals. The species has been present in Slovenia since 1890 when it was reintroduced in the Karavanke Mountains, northern Slovenia. Additional reintroductions after World War II resulted in established populations of Alpine ibex in two Slovene areas: the Kamnik–Savinja Alps and the Julian Alps. In Slovenia, Alpine ibex was till recently considered a non-native species. However, our current study on ancient DNA confirmed that four bone remains from the Julian Alps, dated to the 5th/6th century, were part of an Alpine ibex skeleton. This supports the appeal for reconsidering the formal status of the species, i.e., to classify and manage it as a native species. Analysis of mitochondrial and immunogenetic diversity from recent samples revealed limited haplotype variation, with only one predominant mitochondrial haplotype present in both the Julian Alps and the Kamnik–Savinja Alps populations. The MHC genetic diversity in the same populations showed only one functional allele (Caib-DRB*01) present.
In this study, we analysed recent Alpine ibex samples collected from different locations (subpopulations) in the Julian Alps using a whole genome sequencing approach with a high coverage to study signatures of inbreeding depression linked to founder events and populations isolation in the past. We showed that despite the rapid recovery of the Slovenian populations and increase of abundance in the 1960s, Alpine ibex carry a persistent genomic signature of historical bottlenecks, reintroduction history, and recent population decline. Not clear status of the species in Slovenia in the past was hampering conservation efforts of the Alpine ibex habitat and the improvement of its genetic diversity, which is crucial for increasing population viability and disease resistance.

A highly contiguous reference genome for the Alpine ibex

Çilingir F.G.1,2, Landuzzi F.3, Brambilla A.2,4, Charrance D.3, Furia F.3, Trova S.3, Peracino A.4, Camenisch G.2, Waldvogel D.2, Howard-McCombe J.5, Castillo De Spelorzi Y.C.7, Henzen E.6, Bernagozzi A.7, Coppe A.3, Christille J.M.7, Vecchi M.5, Vozzi D.6, Cavalli A.3,8, Bassano B.4, Gustincich S.3,6, Croll D.9, Pandolfini L.3,6, Grossen C.1

1 Swiss Federal Institute for Forest, Snow and Landscape Research WSL, 2 University of Zurich, 3 Italian Institute of Technology IIT CMP3VdA, 4 Gran Paradiso National Park, 5 Royal Zoological Society of Scotland, 6 Italian Institute of Technology IIT Genova, 7 Astronomical Observatory of Autonomous Region of Aosta Valley, 8 CECAM-EPFL Lausanne, 9 University of Neuchâtel

Anthropogenic hybridization is a major concern for species conservation and a challenge for conservation management decisions. Genetically depleted species are expected to be vulnerable to hybridization and introgression, since hybridization can restore or introduce new adaptive genetic variation that alleviate the effects of inbreeding. However, defining the sets of deleterious or beneficial mutations resulting from anthropogenic hybridization is complex and limited by the quality of genomic resources.

The Alpine ibex faced near-extinction two centuries ago, but conservation programs have successfully restored its populations. Alpine ibex are knowns to hybridize with the domestic goat, occasionally leading to hybrid swarm formation. Past introgression has been observed at immune-related genes and was suggested to have had an adaptive effect. Alpine ibex also carry deleterious mutation load from the reintroduction bottlenecks, which could be alleviated through admixture.

Here, we produced a chromosome-level reference genome for Alpine ibex based on ONT sequencing coupled with high-throughput chromosome conformation capture. The highly contiguous assembly reveals 30 chromosomes and a 98.8% gene completeness. Overall, the Alpine ibex genome presents a high degree of synteny compared to the domestic goat that likely facilitates haplotypes recombination. This finding is in accordance with the observation of hybrid swarms. To determine the precise impact of recent admixture, we resequenced eight hybrid from two swarms in Northern Italy. Swarm individuals carried between 18-80% goat genome representing up to 3rd generation hybrids, including one F1 hybrid. The reference genome will facilitate quantifying maladaptive variation introduced from domestic goats and guide management efforts.

Wildlife population assignment using low-coverage whole-genome sequencing (lcWGS)

Vasiljevic N.1, Biebach I.1, Kratzer A.1, Keller L.1, Ogden R.2

1 University of Zurich, 2 University of Edinburgh

One of the most serious threats to the survival of animal and plant populations is the illegal wildlife trade. Identification of geographic origin of poached animals could facilitate the detection of poaching "hotspots" and trade routes and is thereby an important means of informing law enforcement related to wildlife crime. Geographic origin assignment tests often rely on moderate- to high-coverage sequence data to genotype SNP panels, and require large numbers of geo-referenced samples per locality. These can be difficult to obtain for fields such as ancient DNA and wildlife DNA forensics, where DNA sample quality and number are limited. Here, we use low-coverage whole-genome sequence (lcWGS) data to investigate our ability to simultaneously assign a sample to a particular population, while excluding it from others, when we have different levels of background population structure. We re-sequenced the genome of 80 Alpine ibex individuals from six populations with different levels of pairwise Fst (0.02-0.14) across Switzerland. To examine the use of lcWGS to characterise assignment power we want to answer three questions: (1) how many population reference samples do we need? (2) what read depth is required? (3) how many markers do we need? The development of this method will address the pressing need for affordable and validated methods for identification of geographic origin in the wildlife DNA forensic and conservation genetic communities.

Session: Methods

An automated identification system for Alpine ibex

Bohlens L.1, Brambilla A.1,2

1 University of Zurich, 2 Gran Paradiso National Park

Long term individual-based data are crucial for monitoring and studying wild species. However, capturing and marking animals is time-consuming, limited to a small number of individuals, costly and potentially harmful. Automated photo-identification is a cheap, fast, and non-invasive option for identification of individuals but needs to be customised for new species. Bovids' horns show inter-individual variability and can therefore be used as a unique feature to allow individual identification in several species. We tested end-to-end deep metric learning to identify individual male Alpine ibex (*Capra ibex*) and implemented it in a web-based application for in field use. To test the models we used images of 82 known male Alpine ibex over the span of 11 years of the marked population of Gran Paradiso National Park (Italy). To minimise image-to-image variability we cropped and aligned each horn based on two landmarks and mirrored the images showing the right horn to match the shape of the left horn. This resulted in a dataset of more than 7300 homogeneously aligned left facing crops from 161 individual horns. We deployed the triplet loss to embed single-horn images in Euclidean space for identification based on their similarity in that space. We trained metric embedding with 5-fold cross validation and evaluated reidentification experiments in an image retrieval setting. We show that the method reliably matches images of unseen animals. However, we find that the identity clusters are not defined distinct enough to leverage the embedding space for accurate classification in a fully open setting. The web-based application allow o identify unseen animals and to build a catalogue of non marked individuals. However, the models need to be further refined to allow a more reliable identification in the field.

Non-invasive DNA sampling of Alpine ibex using faecal swabs

Grob D.1, Brambilla A.1,2, Biebach I.1, Waldvogel D.1, Grossen C.3

1 University of Zurich, 2 Gran Paradiso National Park, 3 Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Genetic studies of Alpine ibex (*Capra ibex*) often rely on invasive sampling techniques to obtain genetic material (e.g., captures or biopsy darting), which can lead to ethical and logistical challenges. This project aims to develop a non-invasive genetic sampling method for herbivores, using the Alpine ibex as a model species. We adapted a previously proposed faecal swab sampling technique for use in Alpine ibex. The method involves swabbing the surface of fresh faces in the field and placing the swab in a lysis buffer. This allows for the transportation and storage of samples at room temperature until extraction. By swabbing the surface layer of the faeces, it might be possible to collect the cells sloughed from the intestinal walls of the animals while minimising the amount of actual stool material, which can contain more non-target DNA and PCR inhibitors. To test the effectiveness and usability of this method, we collected faecal swab samples from individuals with known identities, performed Amplicon sequencing of approximately 1,000 SNPs, following the method developed for Alpine ibex by Kessler et al. (2022) and compared the DNA quality obtained to that of tissue samples. In this way, we determined the potential and limitations of this method for the genomic analysis of Alpine ibex. Faecal swab sampling could become an effective genetic monitoring strategy for Alpine ibex and could potentially also be applied in other ungulates.

Double observer methods for accurate abundance estimates considering detectability

Improta R.1, Panaccio M.2,3, Brambilla A.2,4

1 University of Roma La Sapienza, 2 Gran Paradiso National Park, 3 University of Chester, 4 University of Zurich

Abundance estimates are essential for wildlife monitoring and conservation. However, imperfect detection often impedes accurate estimates. Understanding the key factors that affect the possibility of observing individuals (i.e. detectability) is therefore essential for the management of the Alpine ibex and other mountain ungulates. At the same time, the use of alternative counting methods that take detectability into account seems crucial.
In this study, the Double Observer (DO) method was used to investigate the detectability of Alpine ibex in Gran Paradiso National Park (GPNP) and to obtain population abundance estimates. DO is based on two observers independently counting groups of animals at the same time and the count data is subsequently compared with a mark-resight approach.
We found an high variability in detection probability across the different DO repeats, with detectability influenced mostly by sex and the temperature recorded during the sampling. Specifically, an higher detectability was observed with intermediate temperatures, corresponding to those already identified as optimal for the species..
This study highlights the critical influence of detectability and its variability on accurate abundance estimates. Therefore, the DO method could improve conservation efforts for mountain ungulates. However, this method could be too costly in terms of sampling effort. Therefore, we also propose an alternative survey method with reduced field effort, the Double Observer Adjusted Survey (DOAS). This new technique is based on total block counts adjusted with a only a few DO surveys conducted in a small proportion of the total area. The DOAS method could improve abundance estimates of the Alpine ibex, taking detectability into account and requiring a reduced effort compared to the DO in the entire area.

Ibex in a changing climate: the response of a large ungulate to severe weather conditions

Bonaglia A.1, Gehr B.2, Filli F.1, Anderwald P.1

1 Swiss National Park, 2 University of Zurich

Climate change is predicted to strongly impact alpine environments, with increased temperatures and altered precipitation patterns. These changes are expected to lead to more frequent and extreme weather events, such as summer heatwaves and strong rainfalls. The Alpine ibex (*Capra ibex*) is highly sensitive to heat stress, and variability in weather as well as climate may severely influence survival and reproduction. Understanding how ibex respond to different weather conditions is essential for predicting its long-term persistence under climate change.

In this study, we investigated the fine-scale behavioral responses of Alpine ibex to severe weather conditions. We used integrated step selection analysis (iSSA) to analyze summer habitat selection for 22 GPS-collared adult ibex in the Swiss National Park. Our findings reveal that ibex respond to changing weather conditions by performing altitudinal shifts and adjusting their position with respect to the aspect of the slopes.

The results indicate that ibex exhibit the potential to behaviourally adapt to changing climatic conditions by fine-scale adjustments in habitat selection. As extreme weather events will increase in frequency and severity, it is yet unclear if ibex are able to further adapt to the increasing pace of climate change. To better understand the impact of climate change on fine-scale habitat selection, further research will be necessary, encompassing larger sample sizes and multiple study areas.

Posters

Second outbreak of sarcoptic mange in ibex population of the Friulan Dolomites Regional Nature Park

Frega B.1, Favalli M.2, Galuppi R.1, Danelin G.2, Granziera E.2

1 University of Bologna, 2 Parco Naturale Regionale delle Dolomiti Friulane

The establishment of the ibex (*Capra ibex*) colony within the Friulian Dolomites Nature Park dates back to 1985-87 and it started with the release of 26 specimens sourced from the surviving population of the western Alps. The colony experienced steady growth until 2011, when the onset of sarcoptic mange led to a progressive decline in population numbers.
Starting from the analysis of historical data collected from 2012, this study aimed to understand the current size of the population and the trend of the mange epidemic, with particular attention to the Salta-Borgà area.
This survey is the result of the monthly monitoring of ibex through direct observation, aided by optical instruments along established paths. Each observation session included photographic documentation for subsequent health analysis, resulting in classification into four degrees of mange severity based on skin lesions.
During the survey, biological samples were collected from the environment and from carcasses exhibiting mange-related lesions. Laboratory analysis revealed S. scabiei presence in both kind of samples, indicating potential indirect transmission.
The findings confirmed the presence of a second sarcoptic mange outbreak, commencing in 2019 within the Salta-Borgà area. Despite a reduced demographic decline and milder cutaneous lesions, this recovery failed to facilitate a positive population trend. Moreover, due to the natural evolution of the disease, future cyclical waves with low incidence are expected.
Hence, this study recommends to enhance genetic variability through reintroducing individuals from colonies with prolonged exposure to sarcoptic mange, which potentially exhibit an efficient coevolutionary response to the parasite.

Alpine ibex *Capra ibex* winter monitoring in the Monviso Natural Park (Cuneo, Piedmont, Italy)

Giordano O.1, Ficetto G.1, Bertinat C.1, Garabello D.1, Gaggino A.1, Molinari V.M.1, Rastelli M.1

1 Ente di gestione Aree Protette del Monviso

In the past, the species lived in the Po and Varaita valleys until the mid-1700s, but already from the early 19th century, official accounts no longer report ibex among the animals that lived in the territories in the former province of Saluzzo that included the Italian side of Monviso.
Between 1978 and the early 2000s, thanks to a number of reintroduction operations carried out in neighboring Italian and French valleys (Pellice, Varaita, Guil and Ubaye), ibex completely recolonized, by natural expansion, the Monviso massif after more than 150 years of absence.
Since December 2016, the Monviso Natural Park Authority has started the winter monitoring of ibex in its territory giving continuity to what has already been carried out in neighboring valleys by other managing authorities (PN Queyras, PN Alpi Cozie, C.A.CN2, C.A.TO1) with the same method.
Counts are carried out by direct observation during the breeding season, in fact during this period the monitoring effort needed is less as observers can focus on wintering and mating areas only, with more accurate and reliable results.
The areas monitored are in the territory under the jurisdiction of the Monviso Natural Park Authority - or in the immediate vicinity because of the continuity of the areas used by ibex - in the municipalities of Crissolo, Oncino and Pontechianale.
During the last census (December 2023), 148 animals were observed (sex-ratio= 1:0,9; KK/100FF= 42,1) with an average density of 30.8 animals/100 ha. The short historical series does not allow in-depth analysis and the population trend appears at least stable (S-Spearman 0,29, p= 0.01, rho= 0.85).

Fly or freeze? Movement and space use response of Alpine ibex to hunting pressure

Heurman M.1,2, Ossi F.2,3 Semenzato P.4, Corradini A.2,3, Just M.5, Cagnacci F.2,3

1 Wageningen University and Research, 2 Fondazione Edmund Mach, 3 National Biodiversity Future Centre, 4 DREAm Italia, 5 Tiroler Jägerverband

The combination of successful reintroduction projects and its protected status has brought back the Alpine ibex (*Capra ibex*) from the brink of extinction. Its protected status prevents the ibex from being hunted. However, exceptions can be found such as in the northeastern corner of Italy, in South Tyrol, where selective hunting is allowed, and on the northern side of the Alps, particularly in Switzerland and Austria with which South Tyrol shares a border. The hunting season generally lasts from August to early December, with hunting pressure varying throughout the season and Countries. In this transboundary area, two ibex colonies (Sesvenna and Palla Bianca/Weißkugel) are exposed to different hunting regimes and pressures during the hunting season, whilst being exposed to similar biotic and abiotic conditions. Some individuals in these two colonies have been GPS-tracked in recent years (2018 – 2023), allowing the investigation of the effect of lethal pressure on their movement patterns and habitat selection. We expect to find differences in the movement patterns of ibex between hunting and non-hunting seasons. During the hunting season, ibex, especially males, may increase their step length and prefer refuge areas such as banning areas, steeper slopes and rugged terrain, or may cross the border where hunting pressure is lower or absent in order to escape such lethal pressure. Investigating the movement ecology of ibex under different hunting regimes can help us to better understand the impact of such lethal pressure on the spatial behaviour of this iconic high-mountain ungulate.

Winter census of Alpine ibex in the Cottian Alps

Maurino L.1, Giovo M.2

1 Ente di gestione Aree Protette delle Alpi Cozie, 2 Comprensorio Alpino TO1

A series of reintroductions carried out between 1978 and 1995 in the Pellice and Chisone Valleys and the neighbouring French region of Queyras have allowed the return of the Alpine ibex (*Capra ibex* L. 1758) in the Pinerolo Valleys, a sector of the Cottian Alps. This species is currently protected and is widely distributed in an area that includes Hunting Districts, Game Reserves, Regional Parks and Natura 2000 Sites. In order to monitor the distribution and abundance of the Alpine ibex in the area between Val Pellice and Val Chisone from 2005 the hunting district "Comprensorio Alpino TO1" with the collaboration of the "Albergian" and "Valloncrò" Game Reserves, carried out standardized counts on wintering areas. This census method was also applied in the Protected Areas of the Cottian Alps, first in the Val Troncea Regional Park (2006) and subsequently in the Orsiera Rocciavrè Regional Park (2017). In December, the Alpine ibex concentration and the reduced mobility of the animals allows to a reduced number of operators to define the population size (MNA minimum number alive) and structure, and to estimate the related demographic parameters. At the moment, 20 wintering areas are monitored, (n =3 in Chisone Valley, n= 9 in Germanasca Valley, n= 7 in Pellice Valley = 7, n= 1 in Sangone Valley) extended over a surface of 4.174,7 ha (range: 74.2 - 485 ha, mean = 208.74 ha) that seems to include the main wintering areas located in the mountains around Pinerolo city (NO 336587 - 4984244, SE 348030 – 4954167, UTM 32 N, WGS 84). The overall data show a strong increase in the population, growth from 182 heads (2004) to 679 in 2024, with some differences in different areas. The district with the largest number of ibexes corresponds to Val Germanasca (n= 353 in 2023), where however the population appears to be decreasing from 2021, perhaps due to a greater dispersion of the animals favoured by the absence of snow cover in the first part of the winter. In Val Chisone and Val Pellice the population presents similar growth characteristics and seems to be constantly increasing (VP n= 36 in 2004, n= 164 in 2023; VCH n= 55 in 2006, n= 162 in 2024). Results show a substantial population stability in Val Troncea Regional Park (n= 55 in 2006, n= 58 in 2023), while the increasing in Orsiera Rocciavrè Regional Park (n= 31 in 2017, N= 73 in 2023) it could be due in part to more effective monitoring of wintering areas.

The situation of the ibex in South Tyrol: a positive evolution between conservation and management

Righetti D.1, Schober L.1, Trenkwalder D.1

1 Bozen Autonomous Province

In recent decades, the ibex population in South Tyrol has increased not only in number but also in distribution. However, the situation remains sensitive regarding the number of independent colonies. Since 2015, thanks to a series of translocations, some colonies that had suffered serious losses due to sarcoptic mange (Croda del Becco-Seekofel; Ponte di ghiaccio-Eisbrugg; Sella; Val d'Ultimo-Ulten) have been restocked. In other cases, new colonies have been created from scratch, such as in Val Sarentino-Sarntal.
This progress was made possible by the five-year management plan for ibex in South Tyrol (2022-2026), agreed upon by provincial and state authorities. In recent years, the balance of ibex management has been characterized by the success of the strategy for maintaining the population, which has reached a total of 2250 animals, while also responding to the demands of the hunting community. The synergy has enabled both the reinforcement and/or creation of new colonies, as well as moderate hunting compatible population conservation.
In general terms, a hunting harvest of 5-8% of the population has been observed (2022-2024 data), which can only be carried out under certain conditions (age and sex class limits, positive colony trend) and only in certain colonies (i.e., those in a good state of conservation). Additionally, the simultaneous translocation of a quota of 20% of the ibex hunted for the above-mentioned purposes has been observed. Trapping for translocation is entrusted to the hunting reserves under the coordination and supervision of the forestry staff of the Game Management Office.

Spatial and temporal dynamic of horn growth of Alpine ibex (*Capra ibex*) in Gran Paradiso National Park

Fobelli M.1, Sauro M.1, Brambilla A.2,3

1 University of Pavia, 2 University of Zurich, 3 Gran Paradiso National Park

Climate changes are one of the most significant challenges for the conservation of biodiversity. The Alpine regions are particularly influenced by climate changes due to strong seasonality and altitudinal gradients. The most affected species are those at their physiological-altitudinal limit; one of these is the Alpine ibex (*Capra ibex*), today present on the entire Alpine chain. In order to study the correlation between this species and the variation in past and present ecological conditions, one of the best indicators is represented by the annual horn growth rings (annuli). Indeed, they can be assimilated to a database of the ecological conditions that affected each individual during the period and the place in which he was alive. We measured annual horn growth of 61 male Alpine ibex that lived in three different valleys of Gran Paradiso National Park (North-Western Italian Alps) between 1984 and 2017 and for which the year of death and the valley of provenience was known. We conducted two different analyses: 1) We compared two time periods of 13 years each (period 1: 1984-1997; period 2: 2004-2017) and tested for variations in the average annuli length and volume. Separate analyses were conducted for rings of each age. A total of 244 annual rings (from 4 to 8 years of age) were included in this analysis. We also tested for the presence of trends in weather-climatic variables during the same periods to look for possible correspondence with horn growth. 2) We tested for variations in the annuli average length in the three different valleys in the time period 1989-1998. A total of 108 annual rings (from 3 to 10 years of age) were included in this analysis. We did not find consistent differences in the length of the annuli in the two periods. We found instead differences horn length between the valleys. Despite we can't exclude genetic basis for such differences, this results partly support the hypothesis that different environmental conditions (i.e., those experienced by the animals in the three valleys and in the different periods) can affect horn growth.

ORGANIZED BY

Swiss National Park

Gran Paradiso National Park

WSL- Swiss Federal Institute for Forest, Snow and Landscape Research

SUPPORTED BY

COST - European Cooperation in Science and Technology

SNSF - Swiss National Science Foundation

UNDER THE ENDORSEMENT OF

IUCN Caprinae Specialist Group

ALPARC Alpine Network of Protected Areas

Gruppo Stambecco Italia

ORGANIZING COMMITTEE

Alice Brambilla - University of Zurich, Gran Paradiso National Park
Christine Grossen - Swiss Federal Institute for Forest, Snow and Landscape Research
Flurin Filli - Swiss National Park
Bruno Bassano - Gran Paradiso National Park

CONFERENCE SECRETARIAT

Ente Parco Nazionale Gran Paradiso,
servizio biodiversità e ricerca scientifica
Via Pio VII, 9 - 10123 – Torino (Italy) tel. +39-11-8606211
e-mail: gse@pngp.it www.pngp.it/gse