

22nd Meeting of the
Alpine Ibex
European Specialist Group

GSE-AIESG

Zernez (CH)
Parc Naziunal Svizzer
26-28 October 2012

Abstract book

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Overview on Status of European Populations

Distribution and management of Alpine Ibex in Switzerland

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The Swiss hunting statistics for 2011 recorded the presence of around 17,000 animals throughout the country, of which around 7,500 were males, 7,400 females and 2,200 kids. This represents an all-time high for Switzerland. At the beginning of this century, the situation was very different. After decades of continuous population growth and stabilisation, around the turn of the century the populations in many Alpine ibex colonies declined. The cause of the decline was largely unknown. For this reason, from 2003 to 2012, the Federal Office for the Environment (FOEN) carried out a research programme on the Alpine ibex in cooperation with the cantons and universities. The aim was to investigate the factors that influenced population development in the colonies with a view to enabling the optimisation of ibex management in Switzerland. The research programme dealt with a wide variety of topics including genetics, diseases, and reproductive and winter ecology. The influence of hunting on the population was also examined. In accordance with the Federal Act on Hunting and the Protection of Wild Mammals and Birds (Bundesgesetz zur Jagd und zum Schutz der wildlebenden Säugetiere und Vögel) the Alpine ibex is a protected species. The species is also listed among the protected fauna species in Appendix 3 of the Bern Convention. Despite this status, the federal authorities allow the regulation of Alpine ibex populations. In 1990, damage caused in the areas of agriculture and forestry prompted the federal authorities to authorise the hunting of the Alpine ibex, however only under certain conditions and under the control of the federal authorities. The federal authorities receive annual data from the cantons on shooting plans and population figures. The implementation of these instruments is intended to ensure that hunting is sustainable and that Alpine ibex populations are not over-hunted. The ten-year research programme has enabled the definition of direct management optimisation measures. For example, in future, older males (11+), mainly responsible for successful reproduction, shall receive increased protection, resettlement is discussed for the purpose of genetic renewal and the Federal Ibex Ordinance shall be updated correspondingly in 2014.

Ibex in Austria, an Overview

Greßmann G.

Hohe Tauern national park

In Austria ibex populations can be found regularly in five provinces (Vorarlberg, Tyrol, Carinthia, Salzburg and Styria). The total number of ibex in these provinces is estimated to at least 6.800 animals at the moment. In two other provinces ibex are present from time to time in small numbers, but not all over the year (Upper and Lower Austria). In the western and southern parts of Austria numerous populations are more or less connected, while a lot of populations are isolated on segregated mountains in the eastern part of the Austrian Alps. In these isolated areas the small numbered ibex populations are often subject to fluctuations and in the single small population (about 65 individuals) in Lower Austria hybridization with goats is known. Some early releases (first release in Austria in 1924) did not respect the habitat requirements of ibex. Due to this fact, a slow shift (which lasts much more than one generation) to more suitable habitats can be observed and is still going on in some regions. In the parts eastward of the "Brenner-line" scabies is also playing a role and probably paratuberculosis may lead to problems in some populations in the future. The kind of hunting, which is regulated by every province for itself, has still great effects on the population structure of ibex populations in Austria. In many areas the hunting pressure on 5 to 9 years old males is too high and leads to too little old male individuals in the populations. Also the environmental conditions like precipitation in winter (great snow depth), especially in the eastern and northern parts of the Austrian Alps, can also lead to heavy losses in populations.

Status of the french populations of *Capra ibex* in 2012

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Parc national de la Vanoise

In 2012 the population of *Capra ibex* in france is estimated at 9500-10000 individuals spread in 40 colonies. Reintroductions projects are still occurring in the northern Alps but projects are also emerging in the southern Alps.

Overview of the status of Alpine Ibex (*Capra ibex*) population in Slovenia

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In Slovenia, the Alpine Ibex (*Capra ibex*) species populates only Alps and its area of distribution presents only 1% of the Slovenian territory. It is considered as the rarest species of mountain ungulate in the country. All Slovenian Alpine Ibexes originate from Gran Paradiso National Park where the only indigenous Alpine Ibex population survived up to 19th century. Although there's no firm evidence about the existence of indigenous Alpine Ibex population in Slovenia after the last ice age, the experts assume that in Slovenian territory, the Alpine Ibexes were exterminated in 16th century. For this reason, the species now populating Julian and Kamnik-Savinja Alps is not considered as an alien species in Slovenia. In 1989, the size of Alpine Ibex population was estimated to 237 animals, in 1994 to more than 400 animals and recent population counts around 200 specimens. The first re-introduction of Alpine Ibexes in Slovenia was carried out at the end of 19th and at the beginning of 20th century in the area of Karavanke (EN: Karawanks, DE: Karawanken) where first 20 animals have been released on western slopes of Košuta, Korošica and Begunjščica. To that colony, some specimens were also added in the period between 1897 and 1912. Population size reduced significantly during the First and Second World War and as a consequence, only 10 animals were populating that area in 1945. In the years 1953, 1956 and 1970, altogether 14 animals originating from Switzerland and Germany were released. In 1975, the Begunjščica colony counted about 60 animals but the whole population died out due to the eruption of sarcoptic mange in 1980s. The re-introduction of Alpine Ibex to Kamnik-Savinja Alps took place in 1953 in Kamniška Bistrica

where 3 animals obtained from Switzerland were released into the wild. In 1961 and 1964, 4 additional ibexes were released. The population size of 35 animals was estimated in 1975. The colony size reached its maximum at the end of 1980s, when approximately 90 ibexes inhabited the area. A sarcoptic mange was the reason that the population dropped to only 20 animals. Today, the Alpine Ibex population in Kamnik-Savinja Alps is presented with 30 animals and it is limited to the "State hunting reserve with special purpose Kozorog Kamnik". In Julian Alps territory, the re-introduction happened in 1965 in the Zadnjica valley. The first 16 animals originated from Italy and in the same year, 5 animals from Switzerland were released as well. Within the period between 1966 and 1975, 54 additional ibexes were released into the wild. The population was estimated to 160 Alpine Ibexes in 1976 and it grew to more than 200 animals in 1980s when their number significantly decreased to less than 100 in 1986 due to the eruption of sarcoptic mange. In 1996, 330 animals were counted in the "State hunting reserve with special purpose Triglav" and that was the largest population of Alpine Ibex ever observed. In present time, about 150 Alpine Ibexes are populating the area managed by the "State Hunting Reserve with special purpose Triglav". The abovementioned estimation is quite reliable due to the fact that animals populate open alpine habitats above the tree line therefore the spatial distribution and population size of the colonies are well known. In 1975, a pair of Alpine Ibexes was also introduced in the Bavšica valley followed by the release of another 3 pairs in 1978. The sarcoptic mange caused the reduction of the population to only 8 animals. Today's population is presented with 60 ibexes that are spatially separated from the population in the area of the "State hunting reserve with special purpose Triglav". We can therefore conclude that about 200 Alpine Ibexes inhabit the Julian Alps in the present time. We're of opinion that the current habitats for Alpine Ibex are suitable for its long-term survival and that species concerned is mostly threatened by the sarcoptic mange. The management of Alpine Ibex as a game species is regulated by the game and hunting legislation in Slovenia. In the Kamnik-Savinja Alps, 18 animals, mostly sick and old individuals, were harvested within the period of 1996-2005. In the Julian Alps, 129 animals were taken from the wild within the same period. It should be pointed out that in the area of the "State hunting reserve with special purpose Triglav" that is managed by the Triglav National Park authority, Alpine Ibex is treated as a protected species. As a consequence, only exceptional harvesting of sick (sarcoptic mange) individuals outside the park's First Protection Zone is allowed.

Status and distribution of Alpine ibex in the Italian Alps

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In the Italian Alps the Alpine ibex populations originate in part from multi-annual programs of reintroduction, in part from natural dispersion. Since all the founders came from the only remaining population in the Alps and because of the many bottlenecks that occurred over time, the genetic variability of this species is among the lowest described in mammals. This should be the main challenge for the future conservation strategies of the Alpine ibex: conservation and improvement of the average genetic diversity. In 1993 the estimated Alpine ibex population size in the Alps was about 31,000 animals, of which 9,100 were present in Italy, split into about 36 colonies. About 55% of these animals belonged to the Gran Paradiso National Park (GPNP). At present, the Italian population of Alpine ibex amounts to about 15,300 animals, split into about 65 colonies. Only 17% of these ibexes belongs to GPNP. The distribution of the species is almost continuous in the Western Alps, where the population densities range from 1 to 5 individuals/100 hectares. The distribution is less continuous in the Central and Eastern Alps, with density values locally comparable to those of Western populations. The main conservation concerns are related to: 1) fragmented distribution of many populations, especially in Central and Eastern Alps; 2) outbreak of infective diseases that cause local extinctions (especially sarcoptic mange which caused the extinction of 4 colonies in the Veneto region); 3) competition with other herbivores (Red deer in Stelvio National Park). For a better conservation of the species we suggest for the future: *i*) to carry out periodic censuses for better estimating the size and the dynamic of all populations; *ii*) to restart the reintroduction programs, particularly in the Central and Eastern Alps, taking into account the problems related to the genetic variability of the founders and the expansion of sarcoptic mange.

Genetics, Physiology
and Ecopathology

Inbreeding effects on population dynamics in Alpine ibex

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Inbreeding depression is a concern in conservation biology, because the negative effects of inbreeding are well known from captive and wild populations. However, inbreeding depression is usually measured in individuals, and effects on the individual level are only of immediate importance to conservation biology if they translate into effects at the population level. For example, inbreeding depression in individual fitness may not result in a reduced population growth rate if selection is density-and frequency-dependent. Thus, studies of inbreeding effects should also ask whether inbreeding effects are apparent at the population level, e.g. in population growth rate. Here we study the effects of inbreeding on population growth rate among 25 Swiss Alpine ibex populations. We quantified the level of inbreeding for each population using genetic data from 37 neutral microsatellites. Population growth rate for each population was estimated with a state-space model applied to yearly census data of the ibex populations. Using statistical analyses which account for the uncertainties in the inbreeding estimates, we show that inbreeding significantly reduces population growth rates of Swiss Alpine ibex populations. The relatively low levels of density-dependence among these populations may in part explain why inbreeding effects are apparent also at the population level. These findings show that inbreeding depression can have strong effects on population dynamics, and that it is therefore important for evolution and conservation biology.

Genome-wide analysis of introgression in Alpine ibex

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Introgression (the gene flow between species, also known as introgressive hybridization) is frequent in nature and has wide-ranging effects on organisms, with implications both for evolutionary biology and conservation efforts. Introgression from domesticated animals to related wild species is of particular concern for species conservation. However, introgression may act both as a constraining and a creative force in the evolution of populations. Using a combination of sequencing and microsatellite analysis, we had previously found evidence for introgression from domestic goats into Alpine ibex at the Major histocompatibility complex (MHC), a gene complex important for immune resistance. I will present recent data from high-density SNP chip genotyping assays, which strongly support introgression into Alpine ibex. This new analysis furthermore shows, that gene flow from domestic goats to Alpine ibex has been restricted to only a small portion of the genome, including but not limited to the MHC. No evidence for ongoing introgression has been found. Alpine ibex have low genetic diversity due to their reintroduction history; hence gene flow from domestic goats may have had positive effects at both the individual and the population level. Importantly, increased genetic diversity at the MHC gene complex has been shown to be beneficial in other species, while low diversity has been related to decreased disease resistance. I will discuss possible positive and negative effects of introgression in Alpine ibex.

Seasonal acclimatisation and over-wintering at the extremes: the Alpine ibex

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The extent to which ungulates seasonally adjust their energetic expenses under truly natural conditions is unknown. Our field study, conducted between June 2007 and June 2009 with 20 Alpine ibex (*Capra ibex*) from the population of Albris, Switzerland, delivers the first long-term measurements of physiological data collected from completely free-ranging ungulates. Using a self-constructed telemetry system attached to these animals, we simultaneously recorded heart rate (HR) as a proxy for metabolic rate, rumen temperature (Tr) as a correlate of core body temperature and locomotor activity (LA). We found pronounced seasonal changes in daily mean HR with a winter nadir about 60% below the summer peak. Tr and LA were also reduced during winter. As tested by a generalized additive mixed model, Tr, LA, wind chill, body size as well as snowfall significantly contributed to changes in daily mean HR. The unexplained residual variation in daily mean HR still showed a strong seasonal pattern and hence required further explanation. We therefore analysed daily rhythms of physiological parameters with regard to their seasonal changes and found that the daily amplitude in Tr was twice as high during winter compared to summer. This was predominantly due to a stronger reduction of daily minimum Tr during winter nights. Subsequent rewarming from low Tr during the morning was independent of HR and, during winter, occurred phase-delayed to the increase in environmental temperature, i.e. rewarming began after local sunrise. This indicates that the process of rewarming caused no measurable energetic costs for Alpine ibex, but rather occurred passively by basking in the sun.

Effects of Alpine Ibex life history on parasite infections: are old males the most infected and affected individuals?

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Ecological studies of parasite infections may provide fruitful insights on the life history of the host species as sex and age effects on infection status may disclose differences in strategies of resource allocation. Alpine ibex have a strong sexual dimorphism and peculiar survival profile; males have high survival rates until 11 years afterwards they show a drastic senescence, while females show a more constant and progressive survival decline. Such a pattern is interpreted as a life-history strategy where male allocate most of their energy to survival until reaching the definitive body size which allows reproduction while females optimize their fitness modulating reproduction. In this system we hypothesized sexes differs in their strategies to control infections along with age; males control parasites until 11 years old at which point infections rise uncontrolled, whilst females constantly control lower infections burdens. As such, the old male individuals being the most infected will be the most infectious and most affected by the parasites effects. We tested this hypothesis modelling the age effects of each sex on gastrointestinal parasite infections from 94 abomasal counts and 314 faecal egg counts of individually tagged ibex. The model best describing our data confirmed our hypothesis identifying the highest infections in old males whilst females were more constant and less infected.

Population Dynamic and History

Climate change drives horns shrinkage trend in Alpine ibex in Gran Paradiso National Park

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Environmental changes such as global warming can cause reductions in the availability of high-quality grassland feeding resources. This can lead to phenological and phenotypic changes in wild animal populations. Secondary sexual traits, such as ungulate horns and antlers, are costly to develop and are dependent to body condition. These traits should therefore be sensitive indicators of environmental changes affecting resource availability. In this study we tested if yearly age-specific horn growth segments (annuli) in Alpine ibex (*Capra ibex*) reflect climate change trends recorded over the last 25 years in the Gran Paradiso National Park (North-Western Italian Alps). We measured yearly horn growth segments in 734 male Alpine ibex (5972 annuli) that died for natural causes from 1980 to 2005 and for which cohort and year of death is known. We show strong declining trends between 1980 and 2005 in the size of annuli grown between 3 and 8 years of age. The shrinkage in annulus size appears to be negatively influenced by density, snow precipitation in the previous winter, rainfall and temperature in spring. Even accounting for these variables, there is a strong relationship between the decline in annulus size and Maximum Increase in NDVI (normalized difference vegetation index), a measurement obtained from IR satellite images, that correlates strongly with net primary productivity. Rapid changes in NDVI, reflected by Maximum Increase in NDVI, are an index of high plant productivity but also can lead to a shorter period of availability of the best quality forage that is associated with earlier phenological stages of vegetation. The recorded decline in horn annuli size over time coincides with climatic and vegetational changes consistent with a climate change scenario.

Integrated model of temporal variability in demographic parameters of Alpine ibex in Gran Paradiso National Park

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Recent studies suggest that temporal variability in demographic parameters of juvenile age classes (before the age of primiparity) is responsible for most of the variability in the growth rate of wild ungulate populations. The total counts of Alpine ibex (*Capra ibex*), conducted for more than 50 years in the Gran Paradiso National Park (GPNP) provide a unique opportunity to analyze in detail the population dynamics of a wild free-ranging large herbivore in the absence of harvesting and to test the impact of variability in vital rates. Since 1993, when the Gran Paradiso Alpine ibex population reached its peak (4990 ibex counted), it declined by 53% over the following 16 years. In previous work we showed that adult survival and, to a lesser extent, fertility are determined by density dependence and winter snow cover. Despite milder winters since the mid eighties, possibly due to climate change, while the survival probability of adults increased, survival of kids declined dramatically, passing from an average value of 58% (% of kids which reach the yearling stage in 1981-1990) to an average of 36% in the last 10 years. Furthermore, female productivity (kids/females) declined although not as strongly (43% in 1981-1990 vs 36% in 1999-2008). We analyze the sensitivity of the total population to these changes in juvenile vital rates showing how the strong decline in kid survival can explain, to a great extent, the declining population trend recorded since 1993. We further explore the temporal variability in demographic parameters and modifications in the age structure in this population using a state-space modeling approach integrating site specific census data with Capture-Mark-Resight data collected over the last 20 years on individually tagged Alpine ibex.

The Extinction of the Ibex in the Eastern Alps

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During the Middle Age ibexes were still wide-spread all over the Alps. But hunting, poaching, harsh climate conditions and the reduction of their ancestral habitat through humans and their domestic animals nearly led to the total extinction of this species of goat. At the beginning of the 18. century the last ibex has disappeared in the Eastern Alps, in the 19. century this animal was also gone in the Western Alps, except to one small population in the Gran Paradiso valley in northern Italy. Based on historical records, a dissertation project at the University of Salzburg now tries to resolve the question why the last provable ibex colony in the Eastern Alps, which can be situated in the Zillertal Alps in Austria, has disappeared. Here at the end of the 17. century about 180 individuals can be proved, but 15 years later they were all gone. Historical records suggest that the colony probably collapsed because the Arch Bishop of Salzburg wanted to found a new population in Tennengebirge in the south of the City of Salzburg. Nearly half of the ibex in Zillertal were caught alive in the following years, which lead to a reduction of the initial population. One of the harshest winters in the 18. century during the years 1708/09 might have killed the last ibexes in the Zillertal mountains, which according to evolutionary biologists probably were the last exemplars of a today extinct Eastern Alpine subspecies of the ibex.

Not by bread alone – Stone Age hunters in the Engadin

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For many hundreds thousands years, hunting and gathering was the ancestral subsistence mode of *Homo*, and all modern humans were hunter-gatherers until around 10,000 years ago. Consequently, hunting and fishing techniques, complex weapons and tools as well as instinct were perfected quite early to survive, especially in times of economic or climatic crises. Some 12 to 10 000 years ago, the sudden rewarming and the rapid retreat of alpine glaciers opened wide areas for the spreading flora and fauna, which attracted new people to the Inner Alps. During summer they used the ice-free, high alpine zones for hunting, to collect plants and to provide themselves with raw material. Although the material traces of these activities are sparse and hardly visible, systematic field surveys in the Silvretta mountains were able to uncover several base camps of these prehistoric Alpine hunters. This presentation provides a fresh insight into the world of alpine ibex hunters over the last 11 millennia.

Management

Is there life after hunting, or how sustainable is the management of swiss Alpine ibex?

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Human exploitation can be a major threat for many plant and animal species. As such, good management practices are central for conservation. In particular managing protected species raises great challenges and requires careful monitoring and sound demographic data. Only hundred years ago the Alpine ibex (*Capra ibex*) was nearly exterminated by overexploitation and only a remnant population survived in northern Italy. However, subsequent reintroductions across the Alps were successful and newly established populations rapidly increased throughout Switzerland. This resulted in growing impact on the vegetation and in 1977 hunting started in many Swiss populations. Here we present a cohort analysis for three populations in the canton of Grison with roughly 30 years of hunting data. We used age-structured harvest data to reconstruct cohorts, and long term data sets of animals found dead to get an independent estimate of survival. We compared the reconstructed populations to yearly census counts and applied time series and multiple regression analysis to assess the relative importance of hunting on population parameters such as age structure and population growth. In addition we contrasted different harvesting strategies and assessed their potential impact on population dynamics. As expected, hunting was a major driver of population dynamics and affected both population dynamic parameters and age structure. However, hunting was sustainable and only very rarely led to unexpected declines in population size. We discuss our findings and their implications for the future management of Alpine ibex populations.

Research on Alpine ibex (*Capra ibex*): an overview of contributions and management adaptions in the Swiss National Park

Campell Andri S., Filli F., Anderwald P., Haller R.

Swiss National Park

According to early contracts between the park authorities and the home municipality Zernez and, the reintroduction of Alpine ibex (*Capra ibex*) was a declared goal from the beginning of the Swiss National Park's (SNP) existence (Kupper 2012). After releases in the 1920s and 1930s, a first census started and has been continued until present. These data have been the baseline for extensive studies on the population dynamics of alpine ibex under natural conditions (Filli 2002; Saether, Engen et al. 2002) and have been further developed to predict future scenarios in the Swiss population (Saether and Filli 2007; Grotan, Saether et al. 2008). However, it was not until the 1960s that the former president of the SNP scientific commission published the first study on the habitat use of ibex (Nievergelt 1966) and initiated a series of projects to improve the knowledge on their behaviour (Wirz 1991; Catania 1995), and their ecology (Hofmann and Nievergelt 1972; Stauffer 1988; Bollmann 1989; Zimmermann 1990; Hemmi 1991; Brandt 1992; Schatanek 1992; Hegglin 1996). Management issues were also investigated (Niederberger 1992; Wüst 1996; Filli 2002). Conflicts due to forest damage in the Upper Engadine led to a larger project focused on the SNP/Albris colony. This resulted in contributions on the effects of ibex presence on forests (Feuerstein 1996; Abderhalden 2005; Theus 2006), their habitat use (Rochat 1996) and sexual segregation, which was also a major topic in other regions, extended further in Bon, Rideau et al. (2001) and Ruckstuhl & Neuhaus (2001). A series of studies has recently been published on the diet and food resources of ibex (Ruckstuhl and Neuhaus 2001; Grignolio et al. 2003), which was also locally adapted for the SNP (Zingg 2009) and compared with Alpine chamois (*Rupicapra rupicapra*, (Trutmann 2009)). Social dominance is a fundamental aspect of evolutionary ecology in polygynous mammals (Bergeron, Grignolio et al. 2010; Willisch and Neuhaus 2010; Tettamanti 2011). Currently, the hot topics in ibex research are focused upon population genetics (Keller, Biebach et al. 2012), climate impacts (Grotan, Saether et al. 2008) interaction with the vegetation and predation (Grignolio, Rossi et al. 2007). These are also topics of current and future research in the SNP.

Behaviour and Space Use

Companion preferences and social behaviour on Alpine ibex (*Capra ibex*) during the rut

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In this article we investigated the social organization in Alpine ibex analysing association between different age/sex classes and the effect of this aggregation on the group behaviour during the rut. Alpine ibex (*Capra ibex*) form similar age and sex groups throughout the year, except during the rut due to the decrease of sexual segregation. Groups social organization and association index were analysed using data from 14 years of censuses (1997-2010), and group time budget using data recorded during the rut in 2009-2010. Association index represent the time spent of two different age/sex classes together. The main social organization unit found during the rut was mixed groups. Where females accepted association from each males classes. However females spent more time preferably with males of 7-10 years old. During the rut both initiator and recipient of association affected the association index, conversely during the pre rut period only initiator had an influence on the index. Thus during the rut associations were consensual by both initiator and recipient and influenced largely social behaviour of groups. Males increased agonistic behaviour with the increasing of groups size. In addition, the increasing of sex ratio (total number of males/total number of females present in a group) increase the energetic costly behaviour of individuals in group. Thus, these results suggest that association are not random during the mating season and have important effect on social behaviour of individuals and groups.

The effect of wolf recolonisation on ungulate antipredator behaviour in the Gran Paradiso National Park

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The opportunity to monitor the effect of a predator on prey behaviour is a rare event. Indeed, several ecological studies focused on predator-prey relationship, but few of them assessed the behavioural response of prey in face of settlement a variation in predation risk across space and time. The Gran Paradiso National Park was predator free area for ungulates until 2007, when a resident wolf (*Canis lupus*) pack was confirmed. We monitored Alpine ibex (*Capra ibex*) and Alpine chamois (*Rupicapra rupicapra*) using line-transect sampling, recording for each group localisation, size and composition. We compared the antipredator behavioural patterns of ibex before (2003-2004) and after the recolonisation (2008-2010) of the predator. Male group size decreased between the two periods, whereas female group size did not change despite ibex population density was about halved from the first to the second period. Moreover, male groups reduced distance from refuge areas (slope and rocky terrain) whereas female groups did not modify use of safe sites. Presence of wolves was not detected in the Piemont side of the Park, hence we compared chamois antipredator behavioural patterns recorded in the "wolf area" (Aosta valley) and in the "no wolf area" (Piemont). Chamois formed larger groups in areas with than in areas without wolves, particularly in open habitat (alpine meadow). Wolf presence induced females with kids to form larger groups than that of adult and sub-adult male. Our study highlights how a predator recolonisation caused sudden behavioural modifications of the prey species. The variation of predation risk provoked different response between and within the target species, possibly related to their different vulnerability, inducing change in social and spatial behaviour. These adaptations may induce modifications in the resource selection and, consequently, a different ecological trade off between populations of sympatric species.

Effects of body size on foraging decisions in dimorphic males

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Foraging behaviour exerts an important influence on herbivore biology driving population distribution and dynamics, use of ecological niche and impact on the environment. Forage abundance, forage quality, and body mass are key elements of the foraging ecology of wild herbivores. In ungulates, digestive efficiency and, consequently, the feeding niche selected (the minimum quality of food necessary for survival) are strongly related to body mass. We focused on fine-scale foraging behaviour of male Alpine ibex (*Capra ibex*), with two main aims: 1) to assess the effects of vegetation quality and quantity, and 2) to determine if foraging behaviour differs among males of different age and body size. Alpine ibex is characterised by a strong dimorphism among males of different age; hence it is an optimal study case to investigate how differences in body size may affect the foraging behaviour between growing animals and mature animals of the same species and sex. While foraging male ibex increased biting rate as forage biomass decreased and they appeared to graze more selectively when quality of forage in feeding sites became higher. Young and small males seemed to be more selective than older ones, a potential outcome of their different capability in digest plant material and their higher energetic requirements for growth. Higher cropping rates could be a strategy used by male ibex to compensate for reduced bite sizes on short swards, as bite sizes and bite rates are usually inversely related. The strong response of forage selection to the nutritional quality of plants in ibex is possibly a mechanism to maximize their nutrient intake in a highly seasonal and forage-limited environment. These results suggest that male ibex have the behavioural flexibility to adjust their foraging decisions in response to changes in quality of the patches where they feed. These understandings could be helpful to improve the efficiency of the conservation efforts, in view of strong modifications of alpine pastures due to the global environmental changings.

Seasonal distribution and activity patterns of Alpine ibex (*Capra ibex ibex*) in the Hohe Tauern National Park

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From 2005 to 2010 eleven male and one female ibex were equipped with GPS-GSM collars to gain data about the seasonal distribution and the activity patterns to assess the spatial exchange within the national park. Stationary individuals were found as well as wide ranging individuals that cover long distances from summer to winter habitat or rutting season. In two cases the winter habitat was located outside the national park, which can be a problem in establishing a "whole year-management" for a sustainable use of the ibex. On the basis of the collected GPS data a probability model of a possible presence of ibex in the park and its nearest surrounding areas was calculated. The model showed suitable habitat neighbouring the park which might play a role as winter habitat or as a migration/connection corridor. These areas should be considered in the ibex management of the national park. Two sheep were also equipped with GPS Collars. They used the favoured winter habitat of the ibex during summer months. This disturbance and the grazing and removing of biomass during summer might be critical when needed in the late winter months. Furthermore activity data from four male and one female ibex was analysed. The main activity phases were between sunrise and sunset with two peaks during summer (late morning and late afternoon) and one peak during winter (afternoon). The activity data was compared with data from the Swiss National Park where the activity phases start later and stop earlier than in the Hohe Tauern Nationalpark. Reasons might be for example the different management concepts, different habitat conditions or different population structure. An ongoing research on these topics might be needed.

Dynamics of sex-specific utilisation of altitudes in Swiss Ibex

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Sexual habitat segregation is common in ungulates, particularly in sexual size-dimorphic species. Climatic conditions affect the optimal space use patterns by changing the spatial distribution of favourable habitat over the year, and climate change may therefore alter the sex-specific space use patterns. Male and female Ibex differs considerably in size, and are expected to differ in nutritious demands and consequently the foraging niche and habitat use. Female Ibex gives birth in June, which may further add to sexual segregation in habitat use. We used data on Ibex locations based on observations and GPS-collared individuals to describe altitudinal movement patterns over the year during a 19-years period. Males used higher altitudes than females with calf during summer and autumn, whereas females without calf had similar use of altitudes as males in autumn. There were only minor differences in altitudinal use between the three demographic groups during winter and early spring. During the study period, female summer range shifted approximately 250 metres upwards. Such altitudinal shift was not present among males, and at the end of the study period females and males utilised similar altitudes during summer. Upward shift is reported also in plant communities in the study area. The lack of altitudinal shift among males may be because they already utilise the highest areas during summer. As females now have reached the same altitude as males during summer, the Ibex may face a lack of opportunities for further range shift if climate warming continues to alter vegetation distribution in the area.

Poster Session

How to measure yearly horn growth after capture in long term studies

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Secondary sexual characters such as antlers and horns are fundamental for understanding life history strategies and mating systems in ungulates. Ibex horns grow during the whole life of the animal, creating distinct horn rings each year (called annuli) and thus represent a unique tool to investigate individual life history. changing in horn dimensions moreover can also be a signal of changing in environments and resources availability. Annulus length is commonly measured by hand on skulls of dead animals or during live-captures in long term studies. This method is very useful and precise but it has some important limitations: a) dead animals are not always easy to find and to identify; b) animals are often live captured at a young age and thus only the first annuli can be measured. Another method proposed to measure horn length on free-ranging individuals is with parallel lasers providing reference dots on photographs of the horns (Bergeron, 2007 J. Wildl. Manage. 71, 289-292) but we found this method very difficult to apply in field conditions. While the method of Bergeron (2007) has its merits for measuring horns of unmarked individuals, here we propose a simpler method to continue measuring annuli of marked animals in the years following capture. We photographed the horns of marked animal when they were orthogonal to the camera. We then analysed pictures using the 4th annulus measured during capture as a reference unit to estimate the length of the others annuli. We compared annuli length estimated with this method with the length of the same annuli measured by hand. Our results show a very small error and and a high repeatability of the estimate of annulus length. Our method thus permits us to accurately estimate the length of annuli of already tagged individuals simply using photographs of their horns, without the need to recapture the animals or to use other more complicated instruments.

Faecal avoidance in foraging wild Alpine ibex (*Capra ibex*)

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Faeces are crucial vehicles of transmission of various gastrointestinal and pulmonary parasites, mainly Nematodes, among ungulate hosts. Avoiding to forage in proximity of dung piles should therefore be a suitable behavioural strategy to reduce the risk of parasitic infection. While there is evidence of faecal avoidance as an anti-parasitic strategy in experimental settings in domestic and semi-domestic ungulates, only few studies have tested the faecal avoidance hypothesis in wild ungulates. Here we test the faecal avoidance hypothesis in wild, individually tagged male Alpine ibex, by counting the number of faecal pellets found within plots around grazing individuals and comparing them with same sized meadow plots actively avoided by the same individuals. As predicted, we found that grazed plots consistently had a lower density of faecal pellets than the avoided plots. Fresh faeces were more avoided than medium aged and old faeces. We showed consistent differences in the level of faecal avoidance among repeatedly measured individuals but this was not related to the level of gastrointestinal parasite infection, measured as seasonal average faecal counts of parasite eggs, nor to age of the host. Our results suggest that wild Alpine ibex actively avoid foraging in proximity of faeces.

Legal and scientific aspects of the Italian legal battle for the conservation of the Alpine ibex (*Capra ibex ibex*)

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Between 2009 and 2011 a legal battle was fought in Italy between WWF (World Wide Fund for Nature / World Wildlife Fund) and the Italian Provincial Administration of Sondrio. The local hunting/fishery department promoted the creation of a "Conservation, diffusion and management plan of the ibex on the Italian alpine arch", thereby supporting the shooting of the protected species. WWF initiated a legal recourse and the work illustrates the key legal points which led to the NGO's legal victory. The scientific issues that were raised in most cases had little legal weight (for example in the case of biological aspects like genetic diversity) and were thus subjectively used by the counterparts in the debate. Nonetheless, some biological arguments brought by WWF were supported by advice released to the National Ministry by the State Forestry Corps (CFS), which suggested the need of a deeper attention towards those aspects. Moreover, some objective scientific issues remain: the reported example shows a statistical bias contained in the management plan, leading to a map showing uncorrect relative abundance of ibexes at provincial scale, then discussed by WWF's analysis. This leads, in our view, to the need to re-evaluate the role of "unique" scientific advices that are released to public administrations. Democratic and participatory processes become crucial in order to avoid wrong information from being divulged or it potentially being influenced by economic issues and conflicts of interest.

Group composition and kinship in a population of males Alpine ibex

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The aim of this project is to investigate spatio-temporal associations of males Alpine ibex (*Capra ibex*). The study area is in Valsavarenche, Gran Paradiso National Park (Italy). The population is composed of about 65 males, 70% of which is marked and individually recognizable. Data on groups composition have been collected two times a day, in the early morning and in the evening, during 4 summer (from 2008 to 2012).

Males Alpine ibex seems to live in a "fission-fusion" society as group composition varies often during the day and the season. The question this project would like to answer is if there is a pattern in association between individuals (e.g. if some of them tend to stay together more often than others) and which are the factors that influence these association (e.g. age class, season..). We would then test whether closely related individuals tend to stay more associated as it happens in other ungulates where kinship is a factor influencing associations. Data on genetic relatedness will be provided by a parallel project that is studying pedigree in the same population.

Evolution of the Alpe Veglia and Devero colony and firsts counts in Alta Valle Antrona natural park

Bionda R.

Ente di gestione delle aree protette dell'Ossola

From 2009, the former Alpe Veglia and Devero natural park manage a new alpine regional park, the Alta valle Antrona natural park. In this poster I will provide some data about the ibex population living in this park, as well on the numerical evolution of the Alpe Veglia and Devero colony. The Alpe Veglia and Devero colony is censused in winter, and now counts 315 heads whereas the Alta valle Antrona colony is censused in march-april and the population is estimated in at least 182 heads. In both colony some 30% of the ibexes overwinter outside the park boundaries.

Population status and dynamics of Alpine Ibex in an area of Western Italian Alps, study data from hunting districts CN2 “Varaita Valley” and CN3 “Maira Valley”

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Hunting districts are local institutions that on behalf of the Piedmont Region, manage and oversee all hunting activities. Hunting districts monitor wildlife and game resources, in order to plan the specific culling of wild ungulates. In the last years, during the routine chamois monitoring activities, it has become always more frequent to encounter the Alpine Ibex. Ibex has been successfully reintroduced in the Southern Cottian Alps since 1999, by the Cuneo provincial administration. In collaboration with the Regional Wildlife Observatory, the hunting districts began to specifically monitor the Ibex population. In the present work we describe the results of the summer monitoring activities for Alpine Ibex, within the two hunting districts of the Varaita Valley (hunting district CN2) and Maira Valley (hunting district CN3). These hunting districts are crucial for Ibex reintroduction since is where most of the reintroduced ibex were released. Here we will present and discuss data on Ibex population status during summer months, population dynamics and future perspectives.

Results of Alpine ibex winter countings in Varaita Valley (Cuneo, Italy)

Giordano O., Ficetto G.

Comprensorio Alpino CN2 "Valle Varaita"

The latest records of ibex presence in Varaita valley date from the second half of XVIII century. In 1999 the Cuneo Province started a project to reintroduce the species in the Cozie Alps. The project affected directly the Varaita valley, releasing 13 animals: 10 in 1999 and 3 in 2003. In 2006 as part of the project "100 years of ibex in Switzerland / Steinbock 2006" other 11 ibex coming from Swiss Alps were released in this area. Since 2002 the "Comprensorio Alpino CN2" organizes annual counts of this species in conjunction with the census of chamois in early summer. To increase the quality of the monitoring activity, since December 2009 the census is carried out during the ibex breeding season. In this way the observation effort is focused on the wintering areas used for breeding activity with results that are considered more reliable. The study area is represented by the territorial jurisdiction the "Comprensorio Alpino CN2" and in particular by the municipalities of Bellino and Pontechianale (Cuneo province, Piedmont, Italy). The census areas are represented by five wintering areas with an extension of about 830 ha. During last census operation (December 2011) 185 ibex were observed (sex-ratio 1:1.2, KK/100FF 56.3; % Indet. 3.8) with a mean density of 22.4 animals/100 ha.

Summer and winter Ibex censuses in the Varaita Valley (Cuneo, Italy): comparison of two monitoring techniques

Giordano O., Ficetto G., Giovo M.
Comprensorio Alpino CN2 "Valle Varaita"

From 2002 to 2009, Ibex censuses in Comprensorio alpino CN2, have been organized in early summer (mid-June). Beginning from 2009 instead, the summer census was integrated with a winter census on the mating areas. The two different methods have since then been compared in order to evaluate which is the most suitable for an accurate monitoring of the Alpine Ibex. The two methods were compared by evaluating the following parameters: number of counted animals; reliability of demographic parameters, relationship between demographic parameters and population dynamics, cost/benefit ratio. Data show that the winter census returns better results than the summer count. The demographic parameters recorded during the winter census better agree with those reported in the literature. The summer census gives more variable results, that are highly affected by annual seasonal conditions. It also accounts for a lower number of animals than the winter census, which is instead more reliable over time. Winter counts have shown a constant increasing of population in the surveyed area during the study period. Is important to remember that the number of animals estimated on wintering areas reflects the real carrying capacity of the area. A further advantage of the winter census is represented by the lower number of operators required. Animals concentrating on defined wintering areas, allow for a census that targets only those limited parts of their habitat. On the other hand, a disadvantage with this type of census is represented by the very difficult environmental condition. The results from the two techniques regarding the year 2011 are compared in table below.

Date	S.U.S. cens	Operators	TO T	KK	Y Y	MM 2-4 years	MM 5+ years	FF	IND	FF/MM	KK/100F F	%Y Y	%IND
Jun.	8482,7	68	96	6	10	17	27	35	1	0,8	17,1	10,4	1,0
Dec.	826,8	2	185	40	8	29	30	71	7	1,2	56,3	4,3	3,8

Winter census of Alpine ibex, *Capra ibex* in Chisone, Germanasca e Pellice Valleys (Piedmont, Italy)

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A series of reintroductions carried out between 1978 and 1995 in the Pellice and Chisone Valleys and the neighboring French region of Queyras have allowed the return of the Alpine ibex in the Pinerolo Valleys. In order to monitor the distribution and abundance of this species in the area, from 2005 the hunting district "Comprensorio Alpino To1" and, since 2006, the "Val Troncea Regional Park", with the collaboration of the "Albergian" and "Valloncrò" Game Reserves, carried out standardized counts on wintering areas. 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. The monitored sites (n = 16, Chisone Valley = 2, Germanasca Valley = 9, Pellice Valley = 5) include the main wintering areas located in the mountains around Pinerolo city (NO 336587 - 4984244, SE 348030 - 4954167, UTM 32 N, WGS 84), for a total area surveyed of 3218 ha (range: 74.2 - 485 ha, mean = 214.6 ha). Results show a substantial population stability in Troncea Valley (range: 28-55, mean = 44.8, standard deviation = 10.3) and Pellice Valley (range = 46-64, mean = 56, standard deviation = 8.4), while Germanasca Valley MNA seems still to be increasing (range = 203-304, mean = 247,9, standard deviation = 32,6).

Sustainable anthropic activity for Ibex safeguard in Alpine environment

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The aim of this work is to promote pastoral activities for safeguarding ibex (*Capra ibex*) in the Vallone Massello (Germanasca Valley, Western Alps, Italy), by improving vegetation quality. The ibex population in the studied area originates from the expansion of 12 animals, reintroduced in the neighboring Val Troncea Natural Park in 1987/88, and now represents one of the most important groups of the Turin Cozie Alp (262 animals). Individuals showed a different level of presence in different wintering areas, with equivalent geomorphological parameters, so it has been hypothesized a direct relationship between the ibex presence and the distribution of various vegetation types. In wintering areas, identified through regular monitoring, the flora was examined through Cluster analysis; the Pastoral Values were calculated according to Daget & Poissonet method, the spatial distribution was analyzed with the χ^2 test. The results confirm a significant role of vegetation in determining the Ibex presence in certain areas, with equivalent geomorphological parameters: the ibex prefers areas used by domestic herbivores during the summer season for the greater variety of vegetation, which is essential to the nutritional needs during the adverse season. To support the further expansion of the population in the surrounding areas it is necessary to promote proper grazing practices, distinguished in: rational grazing, transfer of fertility, extensive grazing of sheep, daytime rest paddocks, manual operations. Proper grazing management so can effectively contribute to the improvement of the alpine environment, increasing its carrying capacity in favour of the ibex population growth and being fully sustainable.

Variations in nutritional content of grasslands and population dynamics of Alpine ibex: a spatio-temporal approach using remotely-sensed imagery

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Population dynamic of alpine large herbivores is strictly related to seasonality, since plant availability is mainly limited to a short summer season: as a consequence, life history strategies of these species have been selected to fit the best environmental conditions in their most sensitive phases (e.g. kid birth). In the case of the Alpine ibex (*Capra ibex*) females give birth in early summer when grasslands are greening-up: in this way, they can benefit of the entire growing season during lactation and kids can gain enough mass in order to survive to their first winter. Global warming and consequent shifting of plant phenology is thus expected to alter this equilibrium, especially in species with a low genetic variability as Alpine ibex is.

The goal of this work is to analyse the changes in grassland seasonal patterns in the last decades and between different morphological conditions in Gran Paradiso National Park. In particular, we are investigating if the strong decrease of ibex populations during the last 20 years is linked to alterations in seasonal trend of grassland nutritional content. We will use remotely sensed imagery since there are no other way to obtain data of the quality of grass in the past.

The first step is to test the suitability of remote sensing as estimators of the nutritional content of grasslands by collecting field samples and linking their nutritional properties with values of remotely sensed indexes. Afterwards, images will be analysed to model phenological variations over environmental covariates. Finally, these models will be applied to population dynamics of alpine herbivores. This work started in 2012: for now, field data collection has been carried out (May-September 2012).