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17-19 June 2014

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DURING THE LIFE09/NAT/IT/000183 COORNATA PROJECT
Development of coordinated protection measures
for Apennine Chamois (*Rupicapra pyrenaica ornata*)

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The 1st international congress on chamois and other mountain ungulates was held in Pescasseroli (Italy), organized by S. Lovari in 1983, and led to the publication of the book "Biology and management of mountain ungulates" (Croom-Helm, London 1985). In fact this was the fourth international meeting on *Rupicapra*, because three previous meetings organized by the Gamswild Treffen in German had been held before, even if they can be considered more local. During 1988, organized by the *Conseill International de la Chasse* (CIC), the Second International Meeting on chamois was held in Ljubljiana, Slovenia. Hunters, managers and scientists from the wide range of distribution of the genus *Rupicapra* gathered together. We managed to know each other, established profitable contacts and shared experiences in a context when research had developed modestly, since the publication of some classic books, like the ones by Marcel Couturier or Wolf Schröder. There were presentations on several subspecies of the genus, which contributed in its proceedings to a better knowledge on this mountain ungulate.

Since then several local meetings were held: Tatra chamois in Slovakia in 2002; Pyrenean chamois also in 2002 (http://www.aragon.es/DepartamentosOrganismosPublicos/Departamentos/AgriculturaGanaderiaMedioAmbiente/Consejo_Proteccion_Naturaleza_Aragon/ci.04_ultimas_publicaciones.detalleDepartamento?channelSelected=0; Cantabrian chamois in 2009 http://www.magrama.gob.es/es/parques-nacionales-oapn/publicaciones/rebeco.aspx); and a meeting on Cantabrian and Pyrenean subspecies (http://pirineos.revistas.csic.es/index.php/pirineos/issue/view/24) in 2011. Following this last meeting chamois specialists renewed their interest in international conferences, and during 2013 the third international meeting occurred in Bellver de Cerdanya (Catalonia, Spain), organized by the Autonomous University of Barcelona. Four sessions were developed and 34 oral and poster communications updated our knowledge on *Rupicapra* genus and its ongoing research and management approaches. Fortunately, many things had changed since the first meeting in Pescasseroli and there was a need to meet again and share experiences.

But it has been in 2014 when the most international meeting was held, in Lama dei Peligni, in the Majella National Park (Abruzzo, Italy). Specialists covering all the species and subspecies of *Rupicapra* in the frame of the LIFE Coornata Project were able to discuss and update the current information on the status of *Rupicapra* in its European and Asian range. In all, 5 sessions and 36 communications were presented during three days, including wonderful pictures and films. Public was diverse, covering rangers, managers, scientists, consultants, demonstrating the existence of a new generation interested in chamois. From all the topics that were discussed, I would like to underline two of them, which I believe have a special value today: first of all, organizers managed to bring specialists covering all the subspecies of *Rupicapra*, from most of the countries were this ungulate lives, including also an important number of specialists with a long track on the subject. This demonstrated dramatic differences between populations and subspecies conservation status. And second, this meeting was the scene in which all the different Protected Areas involved in LIFE Coornata Project showed us that the Apennine chamois *Rupicapra pyrenaica ornata*, one of the most beautiful chamois in the world, had overcome the critical situation that had left it on the verge of extinction. In spite of many difficulties, overall translocations have been successful and the newly released populations tend to increase at a good annual rate. There are few success stories to tell regarding the recovery of large mammals in Italy and Europe, and this is one of them, hopefully. There is still much to do, but the path seems to show the right way to follow. And Protected Areas have played and are playing a key role in the recovery of populations.

Finally I would like to mention the role that global change is producing in chamois habitat worldwide. We will have to focus on this important issue during next years.

I hope that next meeting will continue to show population recoveries, successful management and research progress, and that it will take place in a reasonable time lapse. Any volunteers?

Juan Herrero, University of Zaragoza

LIFE COORNATA PROJECT RESULTS

THE APENNINE CHAMOIS IN THE MAJELLA NATIONAL PARK, FROM A REINTRODUCED POPULATION TO A SOURCE POPULATION: RESULTS OF MONITORING ACTIVITY AND FIRST EXPERIENCES OF WILD CHAMOIS CAPTURE FOR REINTRODUCTIONS

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1 Majella National Park, Italy

INTRODUCTION

The Apennine chamois (*Rupicapra pyrenaica ornata*) is a sub-species endemic of the Central Apennines. It is considered a priority species in the Habitats Directive (92/43/EEC) and it is listed in the Appendix II of the Washington Convention (CITES). In 1996 it has been classified as " Endangered" in the IUCN red list but, thanks to the success of the reintroduction actions that have been carried out, it has recently (2008) been classified as "Vulnerable". The Apennine chamois, at the beginning of the Life Coornata Project, was present in four protected areas: the Abruzzo, Lazio e Molise National Park (PNALM), the Majella National Park (PNM), the Gran Sasso e Monti della Laga National Park (PNGSL) and the Monti Sibillini National Park (PNMS). All but the PNALM population, which is the only Apennine chamois historic population, are the result of reintroduction actions carried out starting from the 1990s. In the Majella massif the reintroduction started in 1992 and since that year the population showed an exponential growth, typical of a colonizing population (Caughley 1977, Loison et al. 2002), reaching a minimum number (MNP) of 839 individuals counted in 2013 (Figure 1).
The released individuals started to explore the territory until establishing themselves in the very core of the Majella Massif. The actual distribution of the chamois in the Park is an area that includes not only the Majella Massif but also part of the

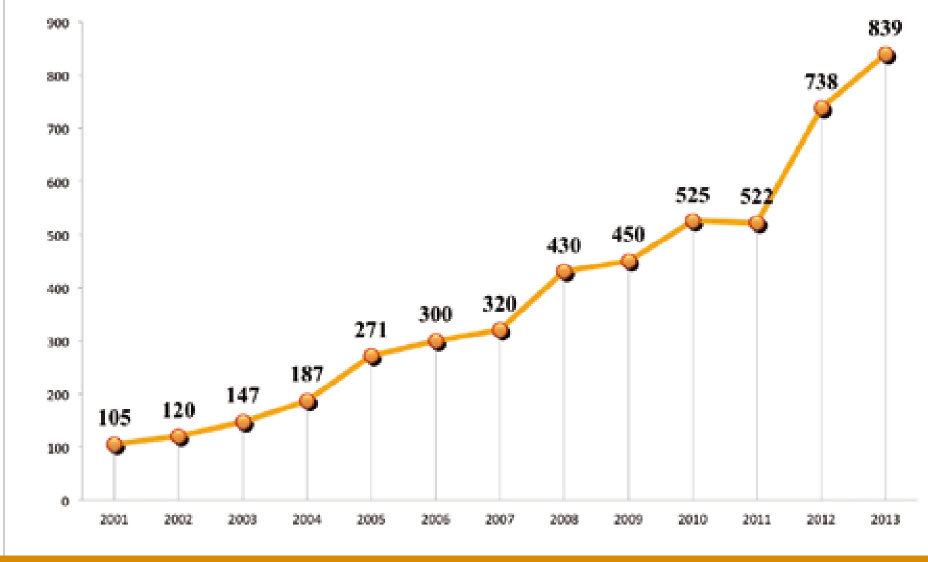
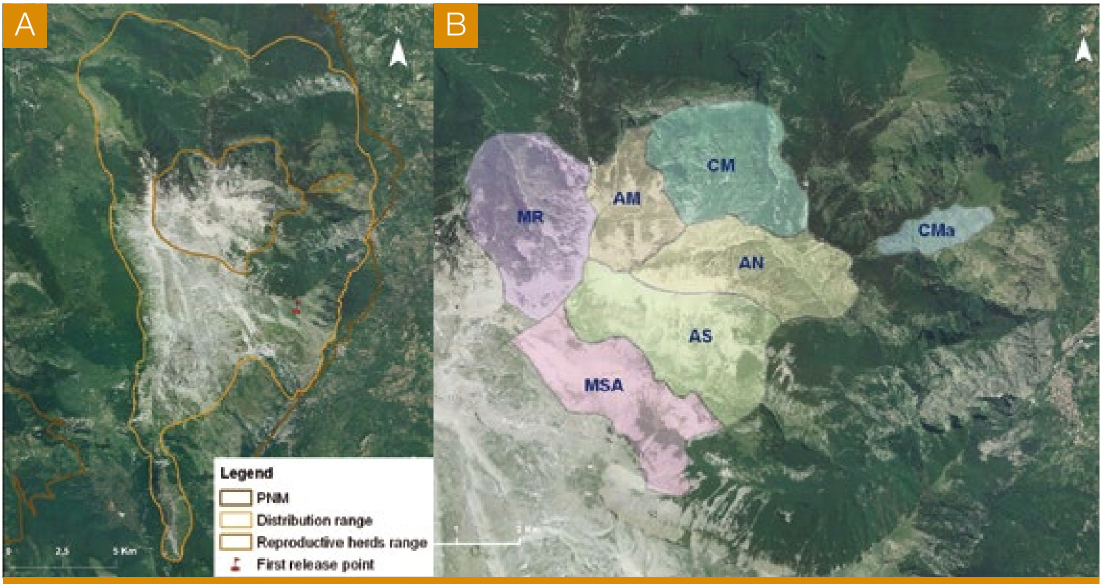
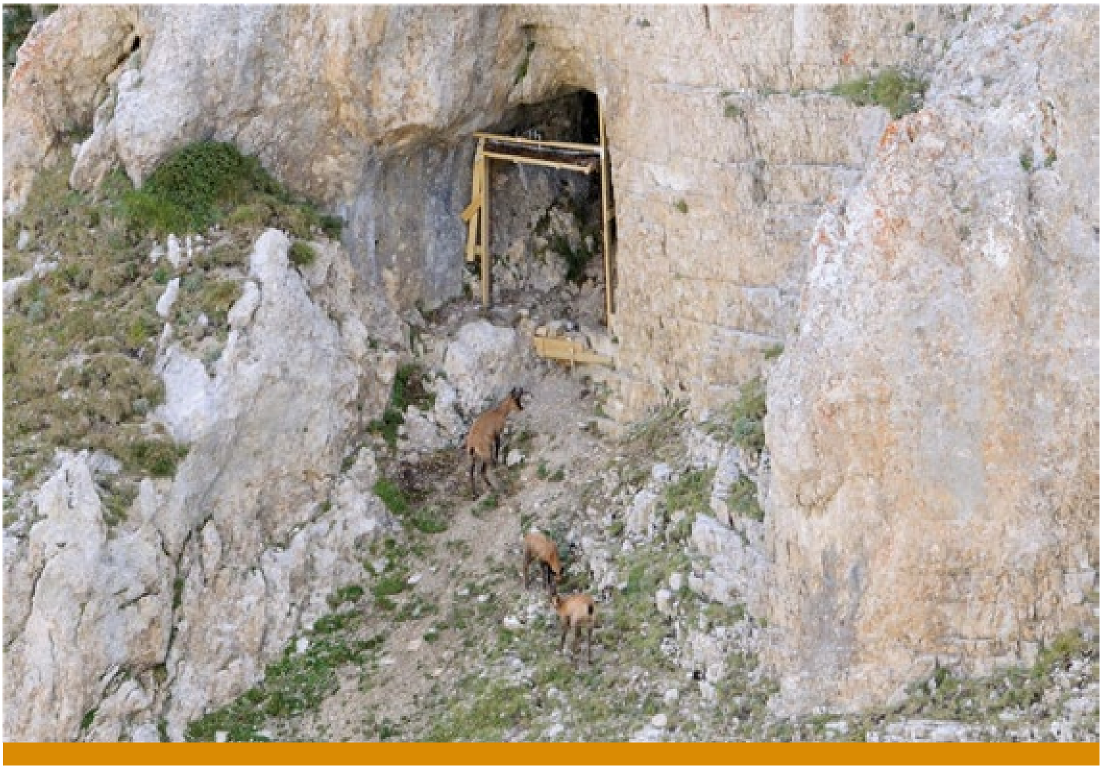


Figure 1. Minimum number of chamois counted with the block census technique from 2001 to 2013 in the Majella National Park and estimated trend line evidencing the exponential growth, typical of colonizing populations.

surrounding areas (Figure 2a). Inside this range 7 main reproductive herds can be individuated: Anfiteatro delle Murelle, Cima delle Murelle, Acquaviva Nord, Acquaviva Sud, Monte Rotondo, Monte S.Angelo and Cima Macirenelle (Figure 2b). The main role of the PNM chamois population in the Life Coornata Project (2010-2014) has been to function as a source to conclude the reintroductions in the PNMS and to start the reintroductions in the Sirente Velino Natural Park (PRSV) to constitute the 5th population. Before the Life Coornata Project, captures of wild Apennine chamois in the PNM had never been attempted and therefore it was necessary to scrupulously plan the activities. The activity has thus been organized in three main phases: the individuation of the herds to be trapped, the capture areas and the best trapping method, which is referred to as the "preliminary phase"; the realization of the captures, referred to as the "operational phase"; the monitoring activity to check for possible negative consequences in regards to the capturing, referred to as the "post-



Figures 2 . Current range of chamois [a] and names and location of the 7 main reproductive herds [b] in the Majella National Park. MR = Monte Rotondo; AM = Anfiteatro delle Murelle; CM = Cima delle Murelle; MSA = Monte S.Angelo; AS = Acquaviva Sud; AN = Acquaviva Nord; CMa = Cima Macirenelle.



Picture 1. Chamois at few centimetres from the entrance of a modified box trap (site AM IV) in the Majella National Park, showing fear against the trap.

The preliminary phase has been the most important part of the capture realization, being an essential phase both considering that the capture of wild chamois was never attempted before in the PNM and that the PNM population is a relatively new chamois population, still increasing in number. At the beginning of the Life Project in the PNM population a minimum of 525 individuals were present (Figure 1) but, despite this population size, it was necessary to individuate specific criteria to choose the herd/s to be object of the trapping activity, in order not to threaten the growing potential of the population. To select the suitable herds we identified five criteria:

1. stability: basing on the monitoring activity carried out in the PNM in the years preceding the Life project, it emerged that when a newborn herd was present in a new area for at least 3 years, it would actually become a new stable herd in that area. Thus we conservatively decided to consider one herd as suitable only if it was at least 4 years old;

2. herd size: the herd must be constituted of at least 10 adult females. We considered unsuitable herds constituted only by young individuals or by less than 10 adult females;

3. presence of target animals: in the herd must be present target animals such as, mainly, young females (with an high reproductive potential) as well as old females. These, in fact, have high experience and herd fidelity so their presence is an important prerequisite to maximize the probability to avoid the herd breaking after the capture of individuals;

4. use of known areas: the use of the areas or at least the pattern of use, in the different phases of the year must be known. This has been considered an issue because the knowledge of the areas used is an essential prerequisite to correctly develop the post-capture monitoring phase;

5. feasibility of monitoring activity: the herds must be easy to contact, which means that it must be possible to observe the herd in all the seasons. Herds that use remote and inaccessible areas during one or more seasons have not been considered suitable. The feasibility of the monitoring activity has been considered an issue because it is essential to guarantee the feasibility of the post-capture monitoring phase.

Herds have been considered suitable only if all 5 of the criteria described above were met.
Once selected the suitable herd, we considered the suitability of the areas frequented as well, in order to evaluate the actual feasibility of the capture and the translocation. We evaluated the suitability of the areas basing on two criteria:

1. accessibility: we considered the accessibility of the areas considering both the orography (possibility to reach the area in a reasonable time) and the feasibility of the capture-translocation management. Particularly we calculated the time to reach the animals and the feasibility of both trapped animals handling and anaesthesia monitoring;

2. suitability for transportation of the animal in terms of the transport of the chamois-boxes and possibility for the helicopter to land. In case of absence of a suitable landing spot near to the traps, we considered an area suitable only if at least one suitable landing site was reachable in no more than an hour's walk.

Basing on the criteria explained, 3 herds were classified as suitable both for the characteristics of the herd and the features of the areas frequented: Acquaviva nord (AN), Anfiteatro delle Murelle (AM) and Cima delle Murelle (CM). These three herds were, thus, the only sources of individuals used for the reintroductions while the other individuals belonging to all the other herds have been trapped only for *in situ* releases.
An almost 40 years of experience in wild Apennine chamois capturing had been developed in the PNALM before the start of Life Coornata but its transfer to the PNM has been only in part possible. This situation is due to the orographic differences between PNALM and PNM, where the area used by chamois are mostly inaccessible except for few grazing areas. One of the toughest parts of the preliminary phase has thus been to decide on the best trapping method, where "best" means the most suitable both for the PNM orographic context and to meet the Life Coornata Project objectives. Since the captures were done to translocate individuals in new areas, one of the most important project objectives was to realize multi-individual captures. This was particularly important for the translocation of individuals in the PRSV, where no chamois were present at the beginning of the project. Based on a bibliographic review, we preliminary selected three trapping methods as potentially usable: the up-net® (Dematteis et al. 2009, Figure 3a), the box traps (Figure 3c) and the box "modified" traps for caves (Figure 3d). Despite the above mentioned differences between PNM and PNALM, we also considered the possibility to apply the Apennine chamois capture technique commonly used in the past in the PNALM, the tele-injection.

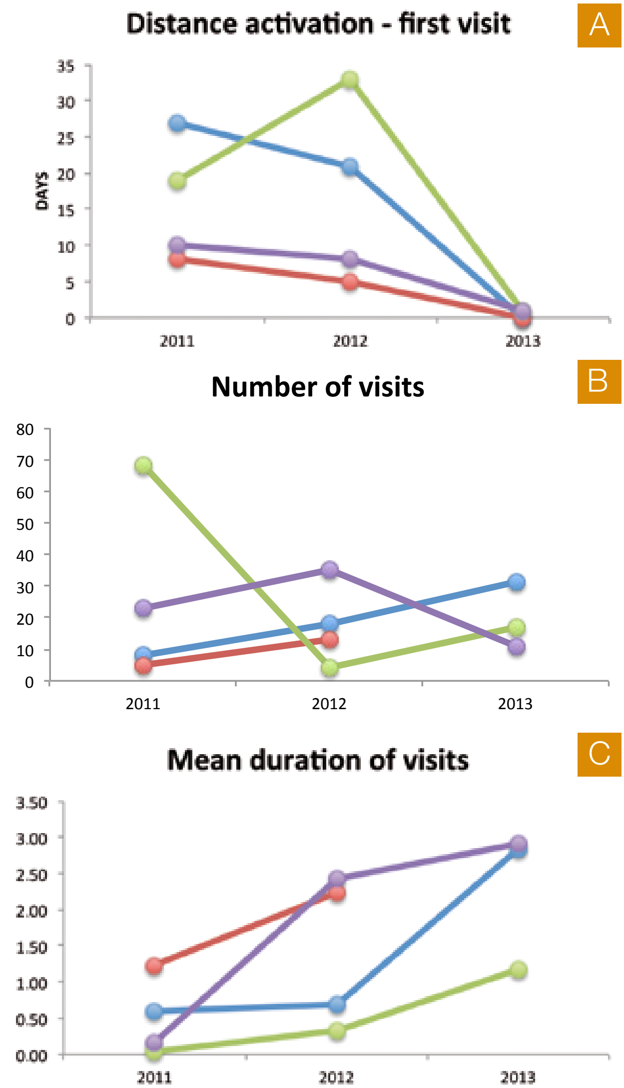
Figures 3. Different traps selected as potentially suitable basing on a bibliographic review, and then used, for wild chamois captures in the Majella National Park (PNM). [a] up-net® ; [b] box trap used in the Alpi Marittime Regional Park, Italy; [c] box trap used in the PNM; [d] modified box trap inspired to the one used in Paneveggio-Pale di San Martino Natural Park.

The up-net® has been selected considering all the advantages of the structure against the other net-based traps (Dematteis et al. 2009) and its high potentiality of being used as a multi-individual trap. The use of the up-net® required specific orographic features not simply found in the PNM. In order to maximize the possibility to put in place several trapping methods, the box traps have been selected as an alternative method of mechanical immobilization, potentially usable in more complex orographic contexts and for the capture of more then one individual.

The box trap model we considered suitable is the one used in the Alpi Marittime Regional Park (Figure 3b) but the model realized for the operational phase has a different kind of door (Figure 3c): the solid yellow panel has been substituted by a remote controlled descending net, the same flexible net used for the up-net®, in order to reduce for trapped chamois the possibility to injure themselves. The modified box traps (Figure 3d) simply consist of a door, identical to a box trap door, put at the entrance of a natural cave that works as the box. All the preliminarily chosen methods are remote controlled, which means that we could select when to close the traps and which animals to trap.

We individuated in the field 16 sites suitable to be bait sites. The choice of the sites used was based both on chamois presence and the possibility to construct there at least one of the selected trapping methods. Sites potentially suitable as bait sites basing on chamois presence but not suitable for any of the trapping methods, including tele-injection, were not chosen. Bait sites were activated before the trap construction in order to verify the actual possibility to attract chamois there and, consequently, to make them enter inside the traps. As the use of baits was experimented for the first time in the PNM, we decided to try different baits (i.e. different kind of salt) in order to individuate the best one.

In 2011, chamois used 62% of the bait sites activated. This result determined that at least one bait site/trapping method was visited which, in turn, allowed us to construct all the trapping methods selected with the bibliographic review (Figure 3). Thanks to the results obtained in 2011, during 2012 and 2013 only the successful bait sites were activated and



Figures 4. Pattern of the three variables used to quantify chamois familiarity with the traps constructed, from 2010 to 2013 in the Majella National Park: distance from activation to the first visit (a); number of visits (b); mean duration of visits (c). Red line: site AM IV; blue line: site AM III; purple line: site CM II; green line: site CM I.

these kept being frequented by chamois for the whole duration of the project determining a 100% success of the bait sites. Based on the literature we expected the use of the bait sites to change and, particularly, we expected the chamois becoming more familiar with them as years went by. To verify the presence of such expected change we considered three variables: the distance activation-first visit; the number of visits; the mean duration of visits. Even if the quantification of the above mentioned three variables has been influenced by problems incurred with the video-trapping (video-trap removed by animals, damages of the traps etc., specially for the site CM II), from 2011 to 2013 can be identified a decrement pattern of the distance from the activation to the first visit and an increase of both the number and the mean duration of visits (Figures 4).

The use of the site AM III is the best example of the familiarization process as the three variables changed as expected from 2011 to 2013 and the use made by chamois has not been affected by the construction of the trap. In fact the site AM III was activated as a bait site in 2011 but the trap (the up-net®) was constructed in 2012. Despite this new element in the site, chamois kept using the bait site without showing any fear. On the contrary the construction of both the box trap (site CM I) and the modified box trap (site AM IV) influenced the behavior of chamois and, thus, the use of the site. The site AM IV is a natural cave in which chamois used to dwell during the summer, as emerged during the monitoring sessions. Being an already-used cave and being suitable to construct a modified box trap, we considered that cave an excellent trapping site. Chamois used the bait site without showing any fear and looking at the pattern of its use it seems that the variables changed from 2011 to 2013 as expected. Nevertheless, the construction of the modified box trap, during the summer of 2012, influenced strongly the use of the cave: chamois have been observed several times stopping at just few centimetres from the entrance, staring at the entrance but not going inside (Picture 1) even if they used the cave before it was a bait site and even if they perfectly knew and used the bait site inside it.

Combining the video-trapping and the observation activity, we could see that chamois started again to use the cave only after 44 days from the construction of the modified box trap. Once the first fear of the structure was passed they started again to use the cave without showing fear or reluctance anymore (see Figures 4). We registered a similar problem in the site CM I where a bait site was activated in 2011 but the box trap was constructed in 2012. The construction of the trap made the bait site not being used for a period of time, determining an unexpected trend of the bait site use (Figures 4). Thanks to the video-trap we could understand that the problem was the presence of the wire netting at the base of the trap: as soon as the hoof touched the wire netting, chamois jumped quickly out of the trap. As soon as we removed the wire netting the chamois started again to use the bait site without showing any fear towards the structure.

Without considering the problems determined by the construction of the trap structures, the expected familiarization with the bait sites is clear and it is particularly underlined by two pieces of data: the distance activation-first visit decreased until reaching time zero, which means that chamois use the bait site as soon as they start to use the area where the traps are, even if there is no bait; the mean duration of the visits increased and varied from few minutes until reaching 3 hours and the visits in 2013 lasted until 10 hours.

The preliminary phase has been the hardest part of the work as at the beginning of the Life Coornata Project wild chamois captures had never been tried and the use of bait had never been experimented. The most important experience we

had from the selection of the bait sites and the success achieved is that, despite the high attractiveness of the bait, it is necessary to put the bait sites in areas normally frequented by chamois without trying to make them go to bait sites far from their grazing/refuge areas. The second important experience we made is related to the impact of the trap structures. We could appreciate the difference between the up-net® and all the other traps. The first is the only one towards which chamois never showed fear or reluctance. One could argue that this could be due to a better choice of the trap location but this is not the case. It is true that the up-net® location was accurately chosen in a grazing area, but also the box trap in the site AM IV was located in a pre-used cave but in that case chamois showed the strongest fear and reluctance behavior.
The work carried out during the preliminary phase has been the most important and it permitted us to reach three fundamental objectives: we individuated the herds suitable to develop wild captures; we individuated the suitable areas and, the most important, we successfully experimented the use of bait and we attracted chamois at least to one bait site/ trapping method. This last point is particularly important as it allowed us to use different kinds of traps and to choose according to the purpose of the capture and to the different situations.

Pictures 2. Field-instruments used during wild chamois captures in the Majella National Park. In order to make the anesthesiological phase the safest possible, this has been monitored using a multi-parametric monitor (left picture) and an emo-gas analyser (right picture).

OPERATIONAL PHASE METHODS, RESULTS, DISCUSSION AND CONCLUSIONS

Using the results of the preliminary phase we started the operational phase, which consisted on the development of wild chamois captures. We did wild captures in all the seasons for the *in situ* releases, while we did wild captures aimed to reintroduce individuals in the PNMS and PRSV (*ex situ* releases) only during the summer (July-September). Captures for *in situ* releases were developed in the areas of four herds, AN, AS, CM, AM (Figure 2), using three trapping methods: tele-injection, up-net® and box traps. Captures for *ex situ* releases were realized in the areas of two herds, CM and AM (Figure 2) using two trapping methods, up-net® and box traps. We considered animals suitable for *in situ* releases as the ones with potentially the highest herd fidelity, like the adult/old females, in order to realize the best possible post – capture herd monitoring (see below). We considered animals suitable for reintroductions as the ones with both the highest reproductive potential, young females and adult males, and the ones with more experience and herd fidelity (i.e. old females) in order to maximize the probability of a success of the reintroduction, especially in the PRSV where no chamois were present.
A special part of the operational phase was represented by the planning of all the phases of the capture management. Before every trapping season and at every trapping day, we realized an accurate logistic organization regarding the PNM team and all the phases that involved other Parks groups and/or external groups. Even if mechanical immobilization has been the main trapping method, once trapped all the individuals have been chemically immobilized. In order to make the anesthesiological phase the safest possible, the trapping team was equipped with field-instruments like a multi-parametric monitor (to measure breath rate, the temperature, the heart rate etc.) and an emo-gas analyser (Pictures 2).
The use of these instruments has been fundamental to prevent the onset of emergencies and to promptly identify and solve any unavoidable emergency situations. As the multiple captures had never been experimented for Apennine chamois before the start of this project, we put a special care in the organization of the team and, particularly we always considered as a necessary condition, the presence of at least two people per animal trapped, in order to realize the best anesthesiological surveillance possible. Once trapped the chamois were equipped with Followit or Vectronic GPS/GSM radio-collars and ear tags or, in some case of *in situ* release, only with ear tags (Table 1). A one year old female chamois

was equipped with a GPS radio-collar modified with a relatively soft foam, covered with medical strip, that allowed an increase of the collar circumference in correspondence to the neck. GPS collars, in case of *in situ* release, have been scheduled to acquire 48 locations/day the first 10 days after the capture. After this period they acquired normally 6 location/day and for one day each 10 days they acquired 48 locations.
From 2011 to 2013 we trapped a total of 23 animals (Table 1), 4 males and 19 females. Seven of the 23 animals were released *in situ*, 14 were released *ex situ* (7 in the PNMS and 7 in PRSV) and two animals died during the capture. In the PNMS we transported 3 two years old females, 1 three years old female, 2 four years old females and 1 five years old female (Table 1). In the PRSV, we transported 1 four years old female, 1 five years old female, 3 six years old females, 1 eight years old female and 1 nine years old female (Table1). As planned, in the PNMS we transported younger females than in the PRSV, where animals with more experience were preferred as no chamois were present before the first translocation from the PNM.

N	Date	Capture method	Herd	ID	Sex	Age (years)	Radio – collar	Destination
1	30/08/11	Teleinjection	AM	M1	M	5	GPS	*in situ*
2	07/09/11	Teleinjection	AM	F1	F	4-5	GPS	*in situ*
3	22/09/11	Teleinjection	AM	M2	M	11	GPS	*in situ*
4	05/10/11	Teleinjection	CM	F2	F	4	GPS	*in situ*
5	01/12/11	Teleinjection	CM	F3	F	3-4	GPS	*in situ*
6	09/08/2012	Up-net	AM	Matilde	F	2	GPS	PNMS
7	09/08/2012	Up-net	AM	Andrea	F	4	GPS	PNMS
8	09/08/2012	Up-net	AM	Nicole	F	2	GPS	PNMS
9	09/08/2012	Up-net	AM	F4	F	5-6	GPS	*in situ*
10	29/08/2012	Modified box-trap	AM	Sabrina	F	2	GPS	PNMS
11	04/10/2012	Teleinjection	-	M3 †	M	6	-	-
12	17/07/2013	Up-net	AM	Lucy	F	9	GPS	PRSV
13	17/07/2013	Up-net	AM	Eva	F	8	GPS	PRSV
14	17/07/2013	Up-net	AM	M4†	M	4-5	-	-
15	18/07/2013	Modified box-trap	CM	Rosa	F	4	GPS	PRSV
16	24/07/2013	Up-net	AM	Assunta	F	6	GPS	PRSV
17	24/07/2013	Up-net	AM	Berardina	F	5-6	GPS	PRSV
18	24/07/2013	Up-net	AM	Giulia	F	6	GPS	PRSV
19	24/07/2013	Up-net	AM	Hely	F	5	GPS	PRSV
20	24/07/2013	Up-net	AM	F5	F	1	GPS	*in situ*
21	29/07/2013	Box-trap	CM	Giovanna	F	4	GPS	PNMS
22	23/08/2013	Up-net	AM	Peppa	F	5	GPS	PNMS
23	23/08/2013	Up-net	AM	Luciana (Lucy)	F	3	GPS	PNMS

Table 1. Wild chamois captured in the Majella National Park from 2010 until 2013. AM = Anfiteatro delle Murelle; CM =Cima delle Murelle; PNMS = Monti Sibillini National Park; PRSV= Sirente Velino Natural Park.

Coinciding with the increase in the use of bait sites (i.e. trapping sites) we had also an increased capture success, both in terms of absolute number of chamois trapped and in term of number of animals trapped/trapping session. In summer 2011 we realized 16 capture attempts and we trapped a total of 5 animals, which correspond to a 0.31 trapped animals/ trapping effort ratio (Figure 5). In summer 2013 we trapped 12 animals during 7 trapping attempts which correspond to a 1.71 trapped animals/trapping effort ratio.
The increase of the capture success, possible only thanks to the success of the preliminary phase, has been the key step that made possible the achievement of the project objectives. Another fact that represented a key part of the capture activity has been the use of the up-net®.
First of all it's been the only trap structure against which chamois have never showed fear or reluctance (see previous section) and second of all it is the only structure that allowed multi-individual captures.

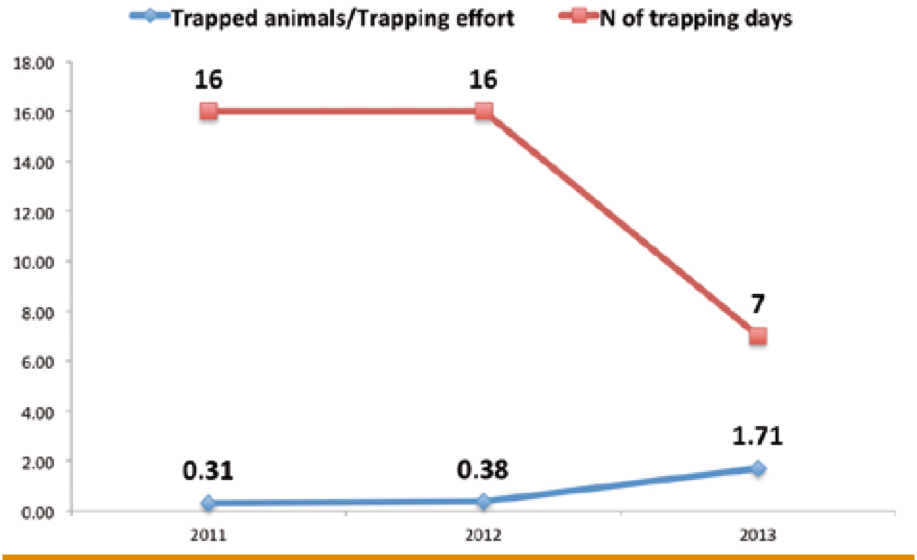


Figure 5. Quantification of wild chamois trapping efficiency in the Majella National Park, comparing the number of trapping days with the number of chamois trapped.

Potentially the box traps too (both the traditional and the modified) are suitable for the captures of at least two individuals but we decided to capture only 1 chamois per box trap as we didn't feel confident about the safety of the traps with two or more individuals inside. We considered the up-net® a safer method and we used it to capture up to 6 animals in the same time. Even if it there were circumstances where we had up to 20 animals inside it at the same time, we decided to trap a maximum of 5-6 animals in order to make the capture management feasible with our personnel. The tele-injection has been also tried, but all the difficulties presumed during the preliminary phase were confirmed during the operational phase. Even if 6 individuals (1 died) have been captured with this technique, it cannot be applied to capture several individuals in a day (as it happened in the PNALM) and is in any case a risky technique to use in the orographic context of the PNM.

The operational phase allowed us to achieve five important objectives. First we successfully experimented, for the first time for Apennine chamois, all the alternative trapping methods we wanted to use, the up-net® and the box traps. Even if the up-net® has been the best trapping method both in term of costs/benefits ratio and in term of possibility to trap individuals suitable for the Life Coornata objectives, we could successfully experiment also the box trap and the modified box traps capturing at least 1 animal per trap. Second we achieved the objective for *in situ* releases, as we released all the 7 animal required by the Project which, in turn, allowed us to adequately develop the post-capture monitoring (see the next session). Third we achieved the objective of animal release in the PNMS as, considering also the work of the PNGSL staff, we closed the reintroduction activity in the PNMS. Fourth we achieved and surpassed the objective of animal release in the PRSV as we released 7 animals, instead of the 4 originally planned. Fifth we successfully realized multi-individual captures of target animals.

POST-CAPTURE MONITORING PHASE METHODS, RESULTS, DISCUSSION AND CONCLUSIONS

Captures of wild chamois in the PNM were performed for the first time during the Life Coornata Project, when the population was still growing and expanding at a spatial level. In order to verify the absence of a possible negative effect of captures on the increasing potential of the population, we conducted a post-capture monitoring on the herds from which individuals were captured and released *ex situ*. Our objective was to verify that the herd remained integer and vital and that the capture event did not represent a disturbance making the herd abandon the area. We thus conducted two kinds of monitoring: short term and long term monitoring. At the short term level we evaluated:

– the possible fragmentation of the herd;
– the possible abandonment of the area.

At the long-term level we evaluated:

– the possible fragmentation of the herd;
– the possible abandonment of the area;

– the possible decrease of herd reproductive capability;
– the possible decrease of kid survival.

To compare the situation before and after the capture and objectively analyze the above-mentioned situations we used specific parameters for the short and long term monitoring (Table 2).

Short term level	Long term level
Number of animals (excluding males)	Reproductive Index (RI): N kids/N adult females
Use of the trapping areas	Kid Survival (KS): N yearling $_{x}$ /N kid $_{x-1}$
	Use of the trapping areas

Table 2. Parameters used to compare the situation before and after the wild chamois capture event both at the short and long term levels, in the Majella National Park.

At the short term level we compared the number of animals before and after the capture events in order to verify the absence of herd fragmentation. Particularly we compared the two numbers excluding males because, given the different behaviour of males in relation to the herd fidelity, the possible absence of males in the post-capture phase would not necessarily be related to the capture event. The use of the trapping areas has been used to verify the absence of abandonment of the areas thus we mainly evaluated if the herd came back to the trapping areas or not. The parameters used for the short term monitoring, are meaningful only if the pre-capture and post-capture phase take place during the same "biological" period during which herds are supposed not to disperse and areas are supposed not to be abandoned. If, for example, the capture event happens at the end of the summer (a transition period), when naturally herds start to break and move to the autumn areas, the possible fragmentation of the herd and abandonment of the areas emerged from the short term monitoring could not be due to a negative consequence of the trapping event. In these cases we did not interpret the short term monitoring results by themselves but we analyzed them taking into account the results of the long term monitoring. The long term monitoring is focused on the verification of herd reproductive capability and vitality. Parameters used are thus the Reproductive Index (RI) and the Kid Survival (KS) (Table 2). We compared the use of the areas also at the long term level for two reasons: first it could be the only use-of-the-areas comparison possible in case of captures during transition periods; second, to further verify the absence of areas abandonment.
Captures for *ex situ* releases took place in 2012 and 2013. In 2012 we made two captures while in 2013 we captured 5 times. The two captures we realized in 2012 took place in the same area, Anfiteatro delle Murelle (see Figure 2), and thus the same herd was involved. During the first capture (09/08/2012) we used the up-net® (site AM III) and we captured 4 females, 3 released in the PNMS and 1 lactating female released *in situ* (F4); during the second capture (29/08/2012) we used the modified box trap of the site AM IV and we captured 1 female released to PNMS. Both the pre-capture and post-capture monitoring were conducted combining the direct observation with the telemetry monitoring. Particularly in the AM herd were present one marked female (F3), one marked and radio-collared female (F1) captured during the preliminary phase and, after the first capture of 2012, a second marked and radio-collared female (F4). The presence of the two marked/radio-collared females and the presence of the new-captured female F4 gave us the possibility to strictly monitor the herd after the first capture event. From the data collected by the F1 and F4 collars we could see that 55 hours after the capture event the two females were associated and, presumably, were associated to the rest of the herd. The association between F4 and the rest of the herd has been confirmed both by direct observation and by the video-trapping activity: the day 15/08/2012, 6 days after the capture, F4 was filmed in the bait site CM II associated with the rest of the herd. During the direct observations, particular attention was paid to the association of F4 with her kid. Even if no data are available for Apennine chamois regarding the effects of mother-kid separation, given the sociality of chamois, we expected the kid running away with the herd and the female F4 recognizing and normally interacting with her kid as soon as come back in the herd. Our expectation was confirmed by several and long-time observations of F4 normally interacting with a kid inside the herd. Given the fact that F4 came back with the herd after 55 hours, spent in a refuge area of the Cima delle Murelle mountain, it can be hypothesized that the separation time between mother and kid has been the same but, unfortunately, this hypothesis cannot be confirmed as the observations during those 55 hours have been impossible due to the roughness of the refuge area in question.
The space use of the AM herd in the post-capture period was not different from the normal (i.e. the known one based on the pre-Coornata monitoring) space use observed in this period: F4 frequented a known refuge area for this herd and, once associated again with the herd, frequented one of the summer areas of the herd. Starting from the 20/08/2012, 11 days after the capture, the AM herd separated into two nuclei: the F1 and F3 nucleus (a) and the F4 nucleus (b), the first coming back in the capture area (Anfiteatro delle Murelle), the second remaining in the Cima delle Murelle area (Table 3).

PRE – CAPTURE PHASE			
	Adult females	**Kids**	**NTOT**
AM herd	51	40	**112**
POST – CAPTURE PHASE			
AM herd – F4 nucleus (a)	34	34	99
AM herd – F1-F3 nucleus (b)	27	12	54
			153

Table 3. Maximum number of females, kids and total number of individuals observed in a single day in the pre-capture and post-capture phase of the first 2012 capture for *ex situ* release (09/08/2012) from the Anfiteatro delle Murelle (AM) herd in the Majella National Park. Particularly in the table are shown data collected in the post-capture period after the separation of the AM herd into two nuclei frequenting two different areas (see the text for details). Majella National Park; NTOT = total number of individuals.

We monitored the two nuclei and we compared the data obtained with the pre-capture phase (Table 3). We found no evidences of herd loss of structure nor evidences of herd destruction: the two nuclei were composed by both adult females and kids, with a kid/adult female ratio consistent with data collected during the pre-capture phase and with data regarding the whole PNM population. We thus concluded that the separation of the herd happened as an event independent from the capture and, considering the data collected during the previous years and the pre-capture phase, we hypothesized that the (a) nucleus is the one with the most attachment to the Anfiteatro delle Murelle area while other nuclei, including the (b) nucleus, frequent the area with less intensity joining the (a) nucleus.
The confirmation of this conclusion arrived with long term monitoring, comparing the data emerged from the observations and the analysis of F4 space use. During the summer 2013 we saw F1 and F3 in the Anfiteatro delle Murelle area every time we saw animals while F4 frequented the area only in 4 occasions. GPS locations confirmed that F4 frequented sporadically the Anfiteatro delle Murelle only for 15 days during the summer 2013 and that the area frequented during the period 10/08/2012-09/09/2012 and the same period of 2013, calculated as the 95% probability of use boundary of a Kernel estimation (fixed Kernel, h_{LSCV}), have an 87% overlap and do not include at all the Anfiteatro delle Murelle in 2013 (Figure 6).

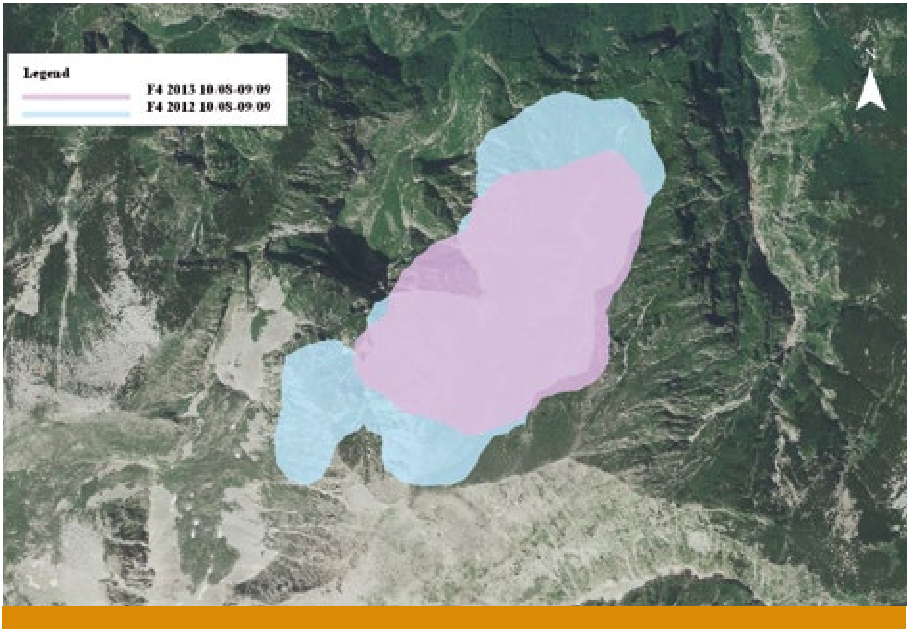


Figure 6. Overlap between the area frequented by F4 during the period 10/08/2012 – 09/09/2012 and the same period of 2013. Majella National Park.

We finally concluded the long term post-capture analysis quantifying the RI and KS of the AM herd, comparing the maximum number of individuals observed in a day in 2012 with the same data of 2013 both in absence and in presence of the F4 nucleus (Table 4).

Year	Kids	Yearlings	Adult females	RI (%)	KS (%)
2012	34	23	58	59	-
2013*	44	19	66	67	56
2013**	78	15	94	83	44

Table 4. Quantification of the Reproductive Index (RI) and the Kid Survival (KS) of the Anfiteatro delle Murelle (AM) herd in 2012 and 2013. Majella National Park.

* F1-F3 nuclus only
** F1-F3 and F4 nuclei

The RI quantified for 2013 is, in both cases, higher than 2012 and the KS is consistent with the value calculated for the whole PNM population in 2013.
The fact that F4 nucleus behaviour in 2012 was due to causes independent from the capture, was also suggested by the behaviour of the F1-F3 nucleus after the second capture of 2012 that took place the day 29/08. When captured, the female released in the PNMS, was associated with F1 and F3 nucleus. After the capture, as emerged by the GPS location and the direct observation, the F1-F3 nucleus continued to frequent the area and, particularly, we saw and video-trapped the nucleus eating at both the bait sites of the Anfiteatro delle Murelle (AM III and AM IV) 9 days after the capture.
In 2013 three captures were realized in the Anfiteatro delle Murelle (9 females released *ex situ* and 1 released *in situ*) and two captures in Cima delle Murelle (2 females released *ex situ*). During the second capture (the day 24/07) the1-year-old female F5 was radio-collared, released *in situ* and monitored to follow the story of the herd. However, being F5 a young female, she showed less herd fidelity than F1, F3 and F4 and we observed her several times but associated to different nuclei or alone. The short term monitoring in 2013 was thus conducted mainly with the direct observation of F3 and F1, whose collar stopped to work in the winter 2012-2013, and the GPS monitoring of F4. The strict monitoring of these three females allowed us to exclude any possible negative consequence on the herds at the short term level (Table 5) and to deepen our knowledge about the dynamics taking place in the Anfiteatro delle Murelle.

Nuclei	Kid	Adult females	Total
F1-F3	–	–	83
FIRST CAPTURE (2 ADULT FEMALES)			
F1-F3 + F4	78	94	187
SECOND CAPTURE (4 ADULT FEMALES)			
F1-F3	44	66	146
F4	27	24	54
Total	**71**	**90**	**200**
THIRD CAPTURE (2 ADULT FEMALES)			
F1-F3	26	37	84

Table 5. Results of Anfiteatro delle Murelle (AM) herd observations realized to carry out the short term post-capture monitoring after the captures realized in 2013 in the Majella National Park.

The short term monitoring and the long term monitoring allowed us to exclude the presence of negative consequences of the captures and, ultimately, to exclude any negative effect of this activity on the herd growing capability at both the numeric and spatial level. The greater evidence of absence of negative effects is, ultimately, the PNM population trend (see Figure 1) and the evidence of a new colonization of an area adjacent to the Anfiteatro delle Murelle by a group of chamois coming, presumably and reasonably, from the nuclei frequenting the Anfiteatro delle Murelle. Beyond all the results and data showed, the post-capture monitoring gave us key information to plan the capture activity and determined the birth of new insights into the PNM population in particular and the Apennine chamois in general.

FINAL CONCLUSIONS

The Life Coornata Project has been one of the most important Projects for the Apennine chamois conservation as it allowed to achieve fundamental results both to have immediate effects and to develop future activities. This last point is mainly related to three factors: first we successfully implemented wild chamois captures in the PNM; second we experimented trapping methods never used before for the Apennine chamois; third we successfully realized multi-individuals captures. All these three factors, beyond allowing the achievement of the Coornata goals, made it possible to consider the PNM population as a good source population to count on for future conservation activities. Thus at 20 years from the reintroduction, the PNM population has shifted from being a reintroduced population to being a source population.

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THE APENNINE CHAMOIS IN THE GRAN SASSO E MONTI DELLA LAGA NATIONAL PARK, FROM A REINTRODUCED POPULATION TO A SOURCE POPULATION: RESULTS OF MONITORING ACTIVITY AND FIRST EXPERIENCES OF WILD CHAMOIS CAPTURES FOR REINTRODUCTIONS

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INTRODUCTION: HISTORY AND EVOLUTION OF THE POPULATION

The Apennine chamois (*Rupicapra pyrenaica ornata*) colony of the Gran Sasso e Monti della Laga National Park (PNGSL) was established in 1992 with the release of 8 animals (2 kids, 3 males and 3 females) coming from the Abruzzo, Lazio e Molise National Park (PNALM). Released individuals came from captures in the wild and captive breeding areas. In 1993 and 1994, other 16 individuals (8 males and 8 females) were added to the neo-colony (Dupré et al. 2011). Further releases were made in 1999-2001, in the frame of the Life Project 97 NAT/IT/4143 "Conservation of *Rupicapra ornata* in Gran Sasso", using 9 individuals coming from the captive breeding areas within the Park (Farindola and Pietracamela; Lovari & Mari 2001). Chamois were counted from 1992 up to nowadays showing a continuous increase in numbers (Figure 1).

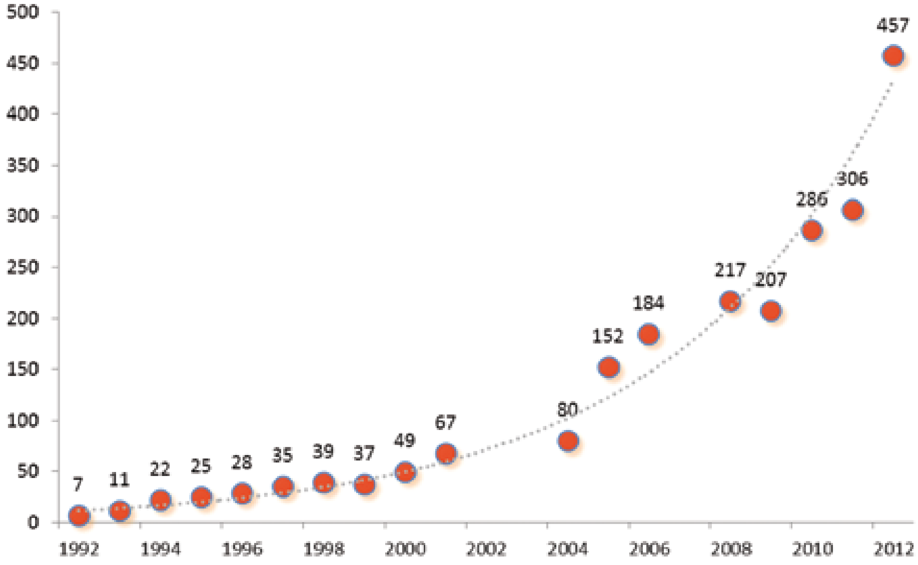


Figure 1. Yearly population counts conducted in the Gran Sasso e Monti della Laga National Park through foot surveys (1992-1998) and block counts (1999 onwards) in Autumn.

In 1992-1999 counts were made using repeated foot surveys; from 1999, counts are performed once in a year in autumn using the ground count method (or block census – Maruyama & Nakama 1983). In the summer transects were regularly performed to count newborn kids. After its fundation, the population exhibited an exponential growth that it is typical for colonizing populations (Caughley 1977, Loison et al. 2002). In 1992-2001 and in 2009-2012 (when annual counts were regularly performed each year) the estimated growth rate was respectively 1.24 when estimated as the mean of the ratio of counts in t_{+1} to counts on t_0 and 1.20 when estimated by regressing the log transformed annual counts against time. This growth rate is high and proximate to the maximum rate of increase described for isard (*Rupicapra pyrenaica*), which is 1.28 (Loison et al. 2002). This observed increase in numbers correspond also to an increase in the distribution range (Figure 2): in 1995 chamois were present in two distinct areas in the surroundings of the release sites (about 1.550 ha) while in 2014 the overall distribution area was of about 24.000 ha. Anyhow, this area includes also areas where single individuals where sighted, probably in dispersal, while groups of females with kids remain concentrated in the central part of the overall range. Groups of females with kids counted in the summer counts showed also an increase in number and in distribution: from 3 groups counted in 1995 to 10 in 2010. The more consistent groups are located in the eastern part of the Gran Sasso chain (Monte Coppe-Camicia, Monte Prena and Santa Colomba).

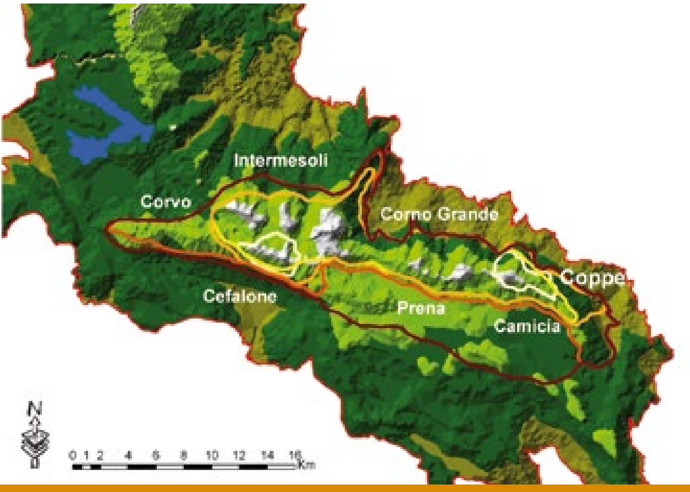


Figure 2. Evolution of the distribution range occupied by Apennine chamois in the Gran Sasso e Monti della Laga National Park. In white the range in 1995, in light yellow 2000, in dark yellow 2005, in orange 2010 and in burgundy 2014.

LIFE COORNATA: DEVELOPING METHODS FOR CAPTURING FREE RANGING CHAMOIS IN PNGSL

In the Gran Sasso e Monti della Laga National Park the Life Coornata Project, started in 2010, aimed to develop and test new methods for capturing free ranging chamois for the first time in Park and to mark individuals to improve chamois monitoring in order to obtain a better understanding of chamois spatial behaviour and group patterns and enhance trap efficiency. The ultimate scope of the project was in fact to translocate free ranging chamois in Monti Sibillini National Park (PNMS) and in Sirente Velino Natural Park (PRSV).

Chamois captures were performed adopting both chemical immobilization, through the employment of a dart rifle for the tele-injection of drugs, and mechanical methods. We employed three different kinds of traps: modified box traps, box traps and multitraps (Figures 3). We baited all traps with salt blocks, salt licks and concentrated vegetable attractants. All traps were remotely controlled by an operator in visual contact with the trap. The modified box trap (Figure 3a) allowed to capture up to 2 chamois simultaneously, was partially built into a natural cave and partially constructed of wood and measured1.5 m x 3.0 m x 2.0 m. The box trap (Figure 3b) allowed captures of single individuals, it was made by a metal frame covered with metal mesh and it measured 1.5 m x 2.0 m x 1.7 m. Both the traps were provided with a radio controlled drop gate at one end with a nylon net in which the animals remain entangled once it tries to escape the trap. Finally, the multitrap (Figure 3c) was a collective capture technique built for the simultaneous capture of several animals belonging to the same social group. The multitrap was a ten-sided (side length 3 m) enclosure (perimeter: 30 m) with metal poles connected by a steel cable and steel trenches in which were folded nylon nets. Also the multitrap was remotely radio – triggered by an operator that observed the trap.

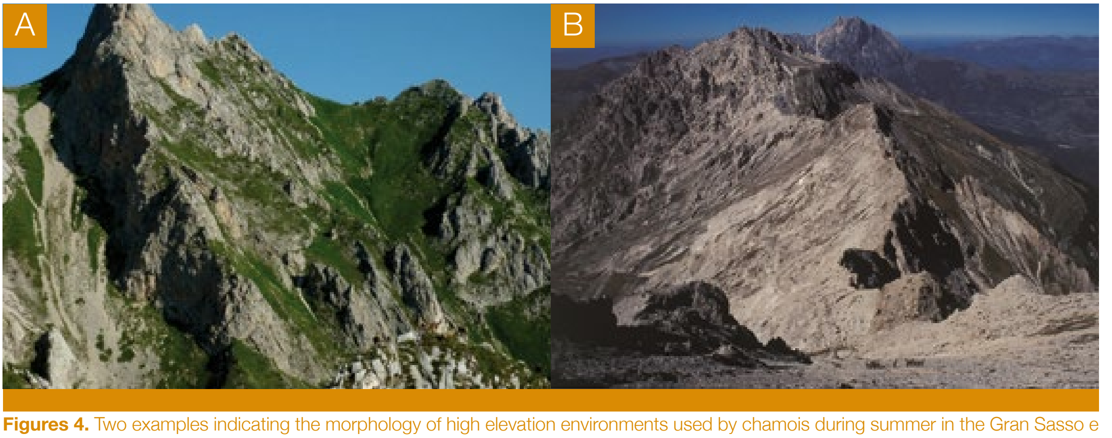
According to the capture protocols developed in the frame of the Life Coornata Project, traps placement had to be based on both biological and logistic criteria. Traps had to be put in areas of observed high chamois use, but it was also important to avoid newly colonized areas and prefer areas used permanently by chamois, since the chamois population of the Gran Sasso e Monti della Laga National Park is still in the phase of range expansion and captures shouldn't affect the colonization of new areas. For the same reason it was important to capture individuals belonging to medium to big – sized groups of females with offspring (i.e. at least 10 adult females in the group). At the same time, to minimize the time interval during which animals remained entangled into the nets, traps had to be set in sites easy to reach quickly and safely by operators. Furthermore the sites had to be easy to reach by the methods of transportation chosen for the translocation to the reintroduction areas (helicopter or car). Regarding the biological criteria, all captures were performed in the eastern portion of the Gran Sasso chain, where chamois groups of female with offspring were regularly sighted in the summer counts since 1995 (this is the case of Monte Coppe-Monte Camicia) or from 2000. Table 1 provide a description of the size and number of adult females present in the areas chosen for captures.

Figures 3. Mechanical methods developed in the Gran Sasso e Monti della Laga National Park for capturing Apennine chamois: a) modified box traps, b) box traps, c) multitrap. (photos by G. Damiani a and c, M. Bonanni b).

AREA		2011	2012	2013
M. Coppe – M. Camicia	Size of the group detected	**39**	**63**	**52**
	Females (F2 + F3)	**20**	**31**	**27**
M. Prena	Size of the group detected	**80**	**53**	**39**
	Females (F2 + F3)	**24**	**20**	**13**
Santa Colomba – Brancastello	Size of the group detected	**45**	**66**	**39**
	Females (F2 + F3)	**10**	**26**	**16**

Table 1. Description of the groups of females with kids present in the areas selected for captures in the Gran Sasso e Monti della Laga National Park.

The solution to logistic problems was instead a complicated issue to be solved in the Park (especially for the summer sessions of captures), since the Gran Sasso is a calcareous chain characterized by steep mountains with a high ridge complexity. The environment is typical alpine, with steep slopes even at lower altitudes (Figures 4) and this caused difficulties in choosing the best position where to place traps, as the safer and easy to reach sites were in some cases located in suboptimal areas as chamois used these sites but not intensively.



Figures 4. Two examples indicating the morphology of high elevation environments used by chamois during summer in the Gran Sasso e Monti della Laga National Park (photos by G. Damiani).

In 2010 – 2011 two modified box traps were built: one in Monte Coppe and one in Monte Prena. Monte Coppe (1992 m a.s.l.) is a wintering area, but it is intensively used by chamois up to mid-June because in this area at lower altitude plant growth starts sooner than in other adjacent areas. Chamois could be captured here therefore in winter and spring, but not in summer as they move in areas where it is not possible to place a trap due to the geomorphology of the area. In the Monte Coppe area was also placed a multitrap, that was simply baited to accustom chamois to the presence of the trap. This multitrap aimed at capturing chamois in late Autumn, when they start to come down to their wintering area, but it was damaged by domestic cattle and horses, attracted by the bait during summer months, therefore it was not possible to keep this structure in that position permanently. In 2012 the multitrap was placed in Pian d'Abruna, a plateau located at about 2200 m a.s.l. in the Monte Prena area. During 2012 we built also 2 box traps: one was located in the Monte Prena (along the trail used to reach the multitrap), the second one was set in November in Monte Coppe (about 200 m downhill in respect to the modified box trap). In 2013, considered the scarce number of visits to the multitrap in Pian d'Abruna, a second multitrap was built. The two multitraps were set in the high altitude meadows of Santa Colomba and Brancastello, where chamois groups of females with offspring were regularly sighted in the summer. The two new sites were easy to be controlled by the same sighting location. We kept the traps active in Monte Coppe, while we did not consider the box traps in Monte Prena as it was not possible to simultaneously check this area for capturing while two other multitraps were triggered in a different site. In 2011-2013, contemporarily, captures using tele-anaesthesia were attempted as well, although the high flight distance of Apennine chamois and the land morphology that posed high risk to the safety of anaesthetized animals made this technique not optimal. Finally, considering the results attained in the previous years (described afterwards) in 2014 captures were performed in spring only in the Monte Coppe area, using both the traps built in the previous year.

RESULTS OBTAINED

As stated above, chemical immobilization through tele-anaesthesia was not the optimal method to capture free ranging chamois in PNGSL, due to high flight distance and the steep environment that pose high risks of falling for anaesthetized chamois. Regarding the traps, we obtained different results in terms of attractiveness to bait sites. The best results were obtained in the Monte Coppe area, where several captures had been performed successfully. In all high elevation capture sites (summer 2012 and summer 2013) we got only sporadic visits to the traps. This was partly expected as the sites where multitraps could be located were a compromise between chamois presence and the logistic possibility to safely capture the animals. In summer chamois groups showed an unpredictable use of high elevation meadows and, as a consequence, of the baiting sites set in the multitraps. Our results indicate also that the use of traps (i.e. of bait) by chamois is a slow process: chamois can take up to 2 years to become aware of the bait location and get accustomed enough to enter the traps and to remain inside for a long period, as shown by data obtained through camera trap in the modified box trap in Monte Coppe (Figure 5). In addition, salt licks do not act as powerful attractants with this species: chamois did not change their habits to reach the bait, but they seemed to use the bait if they are set in sites that chamois already visit. Therefore, it is not sufficient to place the trap in areas steadily occupied by chamois, but it is necessary to find the exact patch within that area, as demonstrated by the box trap installed in M. Coppe in 2012. For these traps unfortunately we did not collect a constant set of camera trapping, therefore we couldn't perform the same detailed analysis done for the modified box trap (Bonanni et al. this volume). In any case, the trap was mounted at the end of

November, damaged by snow in winter 2012/2013, fixed on the 5th of April 2013 and started to be regularly visited by chamois since the 20 April 2013. In the 23rd of April chamois spent already 5 hours going in and out the trap continuously, and a similar trend was observed up to mid-June. The site was as well regularly visited by chamois in the following winter and spring. Although we observed all sex and age classes within the traps, box traps (especially the classical ones) were more frequently visited by yearlings and young individuals (two to three years old), while older animal individuals rarely entered in. In contrasts, the few visits registered to the multitraps showed the predominant presence of adult individuals at the bait site within the traps.

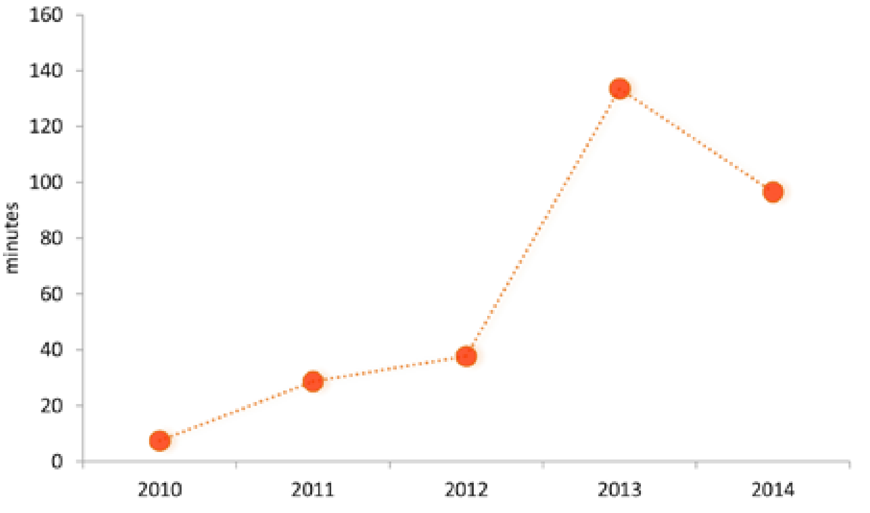


Figure 5. Mean time interval spent by chamois inside (or in the immediate surroundings) of the modified box trap located in Monte Coppe.

A total of 17 chamois were captured. The most efficient method was the box trap (Table 2), and the best site for captures in the Park was Monte Coppe. In agreement with the progressive augmentation in the familiarity of chamois to the traps, capture efficiency increased gradually during the Life Coornata Project development, as indicated by the decrease in the number of man-days needed to capture an animal (Table 3).

Capture method	N of Captured Chamois
Box trap	**9**
Modified box trap	**5**
Chemical Imobilization	**3**
Multitrap	**0**

Table 2. Number of chamois captured by different techniques in the Gran Sasso e Monti della Laga National Park.

Year	Field wordking days	Captures days	N chamois captured
2011	**95**	**40**	**3**
2012	**180**	**95**	**3**
2013	**137**	**59**	**6**
2014	**11**	**16**	**5**

Table 3. Field work efforts required and number of chamois caught in the Gran Sasso e Monti della Laga National Park in 2011-2014.

All captured chamois were aged by horn growth, examined for health status, measured, ear-tagged with a distinctive color combination of tags. GPS radio collar were put on chamois more than two years old, while younger individuals were provided with an extensible VHF collar or simply ear tagged (Table 4). A total of 6 individuals were translocated (3 chamois were transferred to the Monti Sibillini National Park and 3 to the Sirente Velino Natural Park), while 9 animals were released after been marked for monitoring within the PNGSL, and 2 died in the frame of the capture (in both case chemical immobilization). These 9 animals were monitored in order to acquire better information on the possible negative behavioral effects of the capture and to enhance knowledge of spatial patterns of chamois within the PNGSL. As shown in Table 2, the 3 animals caught in 2011 with the modified box trap were yearlings, therefore they were simply provided with ear tags. In 2012 a female was provided with a GPS collar, but it died two days after the capture probably falling from a cliff (the body was partially consumed by an eagle). In 2013, 2 yearlings were ear tagged, while a female was radiocollared with a GPS but it died for traumatism and capture induced stress 6 days after the capture. Finally in 2014 a male and a female were equipped with a GPS collar.

Date	Id	Sex	Age	Capture Method	Right Ear – Tag	Left Ear – Tag	Radiocollar	Translocated
01/06/2011	**M1**	**M**	**1**	modified box trap	red Δ			no
01/06/2011	**F1**	**F**	**1**	modified box trap		yellow n 10		no
20/07/2011	**F2**	**F**	**1**	modified box trap		white n 3		no
27/03/2012	**F3 †**	**F**	**3**	modified box trap		yellowx	GPS	no
03/05/2012	**†**	**F**	**3-4**	teleanaesthesia				no
14/05/2012	**†**	**M**	**2**	teleanaesthesia				no
03/05/2013	**M2**	**M**	**2**	teleanaesthesia	white n 1	light blue		PNMS
04/06/2013	**M3**	**M**	**1**	box trap	red n 5	red		no
06/06/2013	**F4**	**F**	**1**	box trap	white n 7	white n 7		PNMS
10/06/2013	**M4**	**M**	**1**	box trap	green n 9	green n 9		no
11/06/2013	**F5**	**F**	**1**	box trap	orange n 5	orange n 5	VHF	PNMS
04/09/2013	**F6 †**	**F**	**3**	box trap	yellow	light blue	GPS	no
20/05/2014	**F7**	**F**	**3**	modified box trap	yellow	white	GPS	no
21/05/2014	**M5**	**M**	**3**	box trap	light blue	red	GPS	no
27/05/2014	**F8**	**F**	**2**	box trap	green n 9	white n 9	VHF	PRSV
04/06/2014	**M6**	**M**	**4**	box trap	yellow	yellow	GPS	PRSV
05/06/2014	**M7**	**M**	**1**	box trap	yellow	light blue	VHF	PRSV

Table 4. List of free ranging chamois captured in the Gran Sasso e Monti della Laga National Park in the frame of the Life Coornata Project.

Through the Life Coornata Project, chamois groups were monitored regularly, individuals were identified using binoculars and a 60 x magnifier telescope. Each sighting was plotted in a map (1:25,000 scale) and georeferenced in ArcMap© 9.2. For each sighting we noted size and composition (age class and sex of individuals) of chamois group and the main characteristics of the habitat used. Monitoring ear tagged animal individuals was more complex as we could not use the homing technique to sight the animal, as allowed by the VHF collars. Anyway, especially in the first months after release we were able to collect several sightings that indicate that the traps did not affect the spatial and social behaviour. The 3 chamois caught in 2011 continued to use the Monte Coppe area, and two of them were also photographed within the modified trap one year after the capture event, indicating that trapping did not affect displacement of chamois. The two females were observed in groups of variable size (ranging from 3 to 81 chamois – median value 27, mean 30) and composition (only in 24% of all sightings the two females were seen in the same group).
The male caught in 2011 (MI) was seen on Monte Prena (about 6 km far from Monte Coppe) in Autumn 2012 and in 2013, but in Winter 2013/2014 and in the following spring it was sighted again in Monte Coppe and camera-trapped inside the modified box trap. The two yearling males caught in Spring 2013 occupied permanently the Monte Coppe area, within groups of about 10 young male individuals.
A better indication on the lack of negative effects of spatial and social behaviour of traps was given by the two chamois GPS collared in 2014. Both collars were scheduled to obtain a position every half an hour in the 10 days after capture, and every 3 hours afterwards. The female remained less than 1 km far from capture site in the week following the capture, then she moved in an area far 2 km from the trap (Figure 6) where she was seen within a group of 50 individuals. The male instead showed a higher variability in the mean distance to capture site, but as expected it did not belong to the same social individual of the caught female, it was sighted alone or in small groups of males.

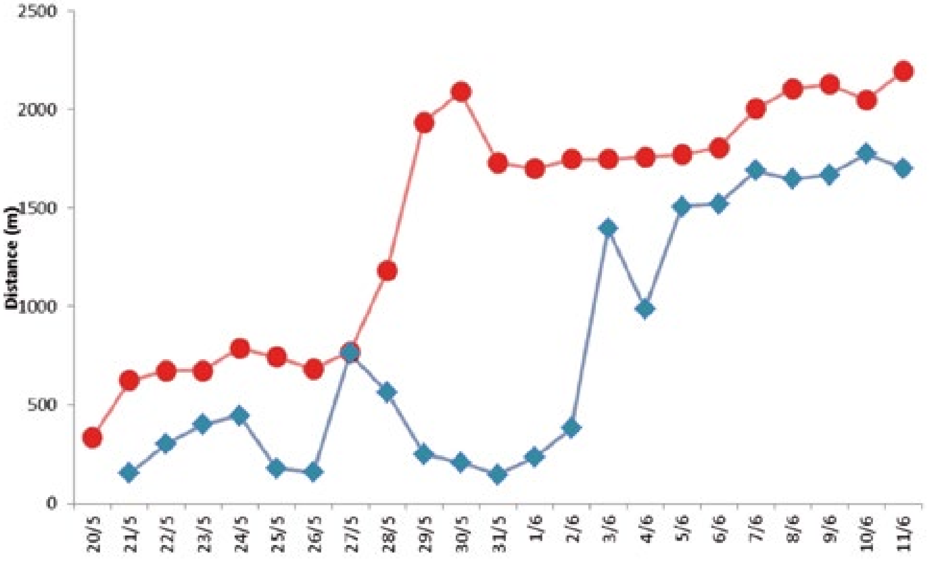


Figure 6. Mean daily distance from the capture site of the 2 chamois equipped with a GPS collar in 2014: in red the female F7 and in blue the male M5.

To sum everything up, the best site for capturing chamois among the ones tested, in the Gran Sasso e Monti della Laga National Park was the Monte Coppe. Box traps of both types worked effectively and these two mechanical methods were the most suitable among the capture methods tested, due to the orography of the mountains and the distribution of chamois in the Park. Monitoring on tagged individuals allowed us to show that captures do not affect spatial and grouping behaviour of captured chamois. Nevertheless, despite mechanical methods were more effective than chemical methods in respect both to capture efficiency and safety for the animals, chamois were highly sensitive to capture, therefore the adoption of this methods do not totally exclude the risks of injuries to animals. In conclusion, the main expected objectives of the Life Coornata Project were achieved, through the monitoring of 8 individuals (marked with ear-tag or radio collars) belonging to the targeted herds of chamois and by the translocation of 3 chamois in PNMS and 3 in PRSV.
Monitoring the marked animals and captures of free ranging individuals in the best sites individuated through the Life Coornata Project will continue also after the end of the project so that the translocation of the chamois at the Sirente Velino Natural Park will continue until achievement of the minimum viable number of chamois in the new colony.

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THE APENNINE CHAMOIS REINTRODUCTION IN THE MONTI SIBILLINI NATIONAL PARK: POPULATION MONITORING AND STATUS AT SIX YEARS FROM THE REINTRODUCTION BEGINNING

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ACRONYMS

CFS = Corpo Forestale dello Stato (State Forestry Department); CTA= Coordinamento Territoriale per l'Ambiente del CFS di Visso (Visso CFS Territorial Coordination for Environment); INFS = Istituto Nazionale per la Fauna Selvatica (National Wildlife Fauna Institute), now ISPRA; HR = Home Range; ISPRA = Istituto Superiore per la Protezione e la Ricerca Ambientale (Institute for Environmental Protection and Research); IZSUM = Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche (Experimental Zootechnic Institute of Umbria and Marche Regions); MATTM = Ministero dell'Ambiente e della Tutela del Territorio e del Mare (Italian Ministry of Environment, Land and Sea); PNALM = Parco Nazionale d'Abruzzo, Lazio e Molise (Abruzzo, Lazio e Molise National Park); PNGSL = Parco Nazionale del Gran Sasso e Monti della Laga (Gran Sasso e Monti della Laga National Park); PNM = Parco Nazionale della Majella (Majella National Park); PNMS = Parco Nazionale dei Monti Sibillini (Monti Sibillini National Park); PRSV = Parco Regionale del Sirente Velino (Sirente Velino Natural Park); UNISI = Università di Siena (University of Siena).

INTRODUCTION

The Monti Sibillini National Park covers an area of about 70.000 hectares between Marche and Umbria regions (Central Apennines), and was established in 1990 with a first delimitation and relative safeguard rules, and later on, in 1993, with a second delimitation and the establishment of a Park Authority. The Park includes the Sibillini Mountain chain, which is mainly calcareous, culminating in the Mount Vettore (2476 m a.s.l.). The presence of the chamois in the Monti Sibillini is dated back to the Holocene, through the discovery, in 1978 by A. e S. Mari, of subfossil remains dating 6000 years ago (Picture 1), attributable to the *Rupicapra pyrenaica* (Pedrotti 1983). The historical presence of the chamois on Monti Sibillini was documented in the sixteenth and eighteenth centuries (Colucci 1793), giving to the species the name of "Dama" while, in the nineteenth century, there would be more detailed and documented quotes related to hunting and to the presence of chamois, or "*camozze*", on the "Roman Apennines", the "Pontifical Apennines" and on the "Sybil Mountains of Norcia" (Dell'Orso 2014, *ex verbis*). Although these quotes suggest that the chamois has survived on these mountains until the nineteenth century, its historical presence is uncertain; the creation of a new colony of Apennine chamois in PNMS can be then more properly defined as a "conservation introduction" sensu IUCN (IUCN 2013).

PRELIMINARY ACTIONS

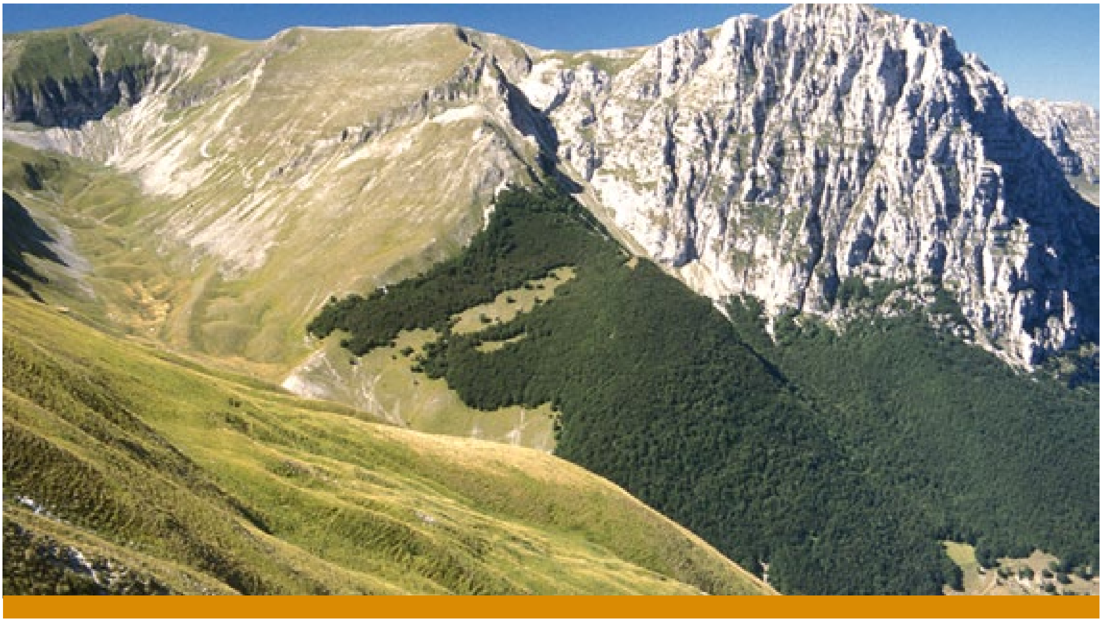
The feasibility study, conducted in 1997 by WWF Italy as part of a Life Project, proved that the Sibillini Mountain chain could be a vast ecological unicum for the settlement and the subsequent development of a substantial population of Apennine chamois (AA.VV. 1997). In 2001, the National Action Plan for the Apennine chamois (Dupré et al. 2001), drawn up by the MATTM and INFS (now ISPRA), identified as primary objective, for a long-term conservation of this subspecies, the achievement of a total of 1000 individuals, divided into 5 distinct populations; the same Plan identified, as priority action, the creation of a Apennine chamois population in the PNMS. The PNMS has then promoted a strategy (both in terms of territorial planning and through direct actions) aimed to reintroduce the Appennine chamois in its territory and also to reduce the possible factors of "interference" in achieving the objective (Fermanelli 2005).
Within the LIFE Nature Project "Conservation of *Rupicapra pyrenaica ornata*" in the Central Apennines, started in 2003, the PNMS has drawn up the suitability study for the reintroduction of the Apennine chamois and created the Bolognola enclosure for the Apennine chamois (Rossetti A. 2005). This area has been activated in 2006, on the 26 of June, with the introduction of a breeding couple of chamois coming from the Lama dei Peligni enclosure, in the Majella National Park.
The Suitability Study identified, among other areas, the Mount Bove (2169 m a.s.l.) as the most suitable to carry out the releases, due to the presence of vast grasslands and rocky habitats and its geographical location, fit for keeping the neocolony within the release area and, even during the winter months, carrying on the radiotracking monitoring and the direct observation activities. The primary release site had therefore been identified in a saddle at about 2000 m of altitude, near Mt. Bove North (2112 m a.s.l.), a suitable landing zone for the helicopter; an alternative release site was situated in Val di Bove, at about 1400 m altitude, for the releases operated with motor vehicles, by land transport, during the winter months.

Picture 1. Subfossil skull of chamois donated by G.B. Mazzarelli and preserved at the "*Museo del Camoscio*" in Fiastra (A. Rossetti).

EARLY RELEASES

The experiences gained during the chamois reintroduction activities in the PNM (since 1991) and PNGSL (since 1992) (Mari & Lovari 2005), as well as the actions carried out within the Life Nature Project "Conservation of *Rupicapra pyrenaica ornata*" in Central Apennines, have provided the necessary information and created the conditions to implement the reintroduction also in the PNMS.

After some unsuccessful attempts of capture in 2006 and 2007, the first 8 Apennine chamois individuals (3 males and 5 females, all from PNALM) were released in the PNMS (10 September 2008 – 2 October 2008). On the 7th and 10th of June 2009 were observed the first 2 wild-born kids of the Monti Sibillini, while, between the 1st of September 2009 and the 7th of October 2009 were released 5 other individuals (2 males and 3 females), these ones coming from the Lama dei Peligni (PNM) and Farindola (PNGSL) enclosures.



Picture 2. Mt. Bove massif (2169 m a.s.l.) on Monti Sibillini (A. Rossetti).

All the animals have been released with radio collars, 8 of which VHF and 5 GPS. The transport of all the animals has been carried out by CFS and Italian Army helicopters.

ID	NAME	SEX	AGE (YEARS)	RELEASE DATE	ORIGIN	COLLAR
F1	Sibilla	F	10-11	10-sep-08	Wild PNALM	VHF
F2	Nives	F	2.5	10-sep-08	Wild PNALM	VHF
M1	Stefano	M	4.5	11-sep-08	Wild PNALM	GPS
F3	Alba	F	4.5	29-sep-08	Wild PNALM	VHF
F4	Rossana	F	2.5	30-sep-08	Wild PNALM	VHF
M2	Giuliano	M	2.5	2-oct-08	Wild PNALM	GPS
F5	Buca	F	5.5	2-oct-08	Wild PNALM	GPS
M3	Alf	M	7	2-oct-08	Wild PNALM	GPS
F6	Claudia	F	2.5	24-sep-09	Captivity PNM	VHF
F7	Nami	F	2.5	24-sep-09	Captivity PNM	VHF
M4	Pippo	M	2.5	25-sep-09	Captivity PNM	GPS
F8	Cecilia	F	11-12	30-sep-09	Captivity PNGSL	VHF
M5	Pulce	M	3.5	7-oct-09	Captivity PNGSL	VHF

Table 1. Chamois released in PNMS before the Life Project COORNATA.

THE LIFE PROJECT "COORNATA"

The Project Life Nature Development of coordinated protection measures for Apennine chamois (*Rupicapra pyrenaica ornata*), called COORNATA, started in September 2010. The 4 years Project is coordinated by the PNM with the participation, as associated beneficiaries, of PNALM, PNGSL, PNMS, PRSV and Legambiente. Among the main objectives, the Project has foreseen, through the action C4, to achieve the minimum number of 30 chamois released in PNMS, number necessary to form a minimum viable population. During the Project were released another 18 chamois (5 males and 13 females) which, in addition to the previous 13 animals, permitted its objective achievement. The chamois

Picture 3. Release of chamois in PNMS, 2009 (PNMS archive).

were transferred by a private helicopter, with the exception of the individuals captured in the enclosure area of Bolognola (F9 and M6) and M9, which were transported by motor vehicle.
As shown in Table 2, the contribution of the enclosures has been fundamental for the success of the Apennine chamois reintroduction in PNMS; in fact 12 of the 31 animals released, came from the PNM, PNGSL and PNMS enclosures.
Moreover, the 25th of October 2013, a 4 years old male, called "Vettore", has been captured in the enclosure of Bolognola and transferred by a CFS helicopter on Mt. Sirente in Sirente Velino Natural Park, contributing so to the implementation of the action C5 concerning the introduction of a first group of Apennine chamois in the protected area so to establish the fifth population of the Apennine chamois, as required in the National Action Plan for the Apennine Chamois (Dupré et al. 2001).

ID	NAME	SEX	AGE (YEARS)	RELEASE DATE	ORIGIN	COLLAR
F9	Nina	F	3,5	14-sept-10	Captivity PNMS	GPS
M6	Guerrino	M	2,5	17-sept-10	Captivity PNMS	GPS
F10	Marta	F	4,5	24-sept-10	Captivity PNM	GPS
F11	Esmeralda	F	3,5	7-oct-10	Captivity PNGSL	GPS
M7	Pilato	M	2	11-jul-11	Captivity PNMS	GPS
M8	Macco	M	2	18-oct-11	Captivity PNMS	GPS
M9	Nemo	M	1,5	19-jan-12	Captivity PNM	VHF
F12	Matilde	F	2	9-aug-12	Wild PNM	GPS
F13	Andrea	F	4-5	9-aug-12	Wild PNM	GPS
F14	Nicole	F	2	9-aug-12	Wild PNM	GPS
F15	Sabrina	F	2	29-aug-12	Wild PNM	GPS
M10	Fifty	M	1	3-may-13	Wild PNGSL	/
F16	Laura	F	1	6-jun-13	Wild PNGSL	/
F17	Mary	F	1	12-jun-13	Wild PNGSL	VHF
F18	Giovanna	F	4	29-jul-13	Wild PNM	GPS
F19	Peppa	F	5	23-aug-13	Wild PNM	GPS
F20	Lucy	F	3	23-aug-13	Wild PNM	GPS
F21	Zeta	F	10	9-aug-14	Wild PNM	GPS

Table 2. Chamois released in PNMS during the Life COORNATA.

Picture 4. Chamois release in PNMS, 2012 (P. Salvi).

Picture 5. Capture of the chamois "Vettore" in PNMS enclosure in 2013 (PNMS archive).

Picture 6. Release of the chamois "Vettore" in PRSV in 2013 (PNMS archive).

MONITORING MATERIALS AND METHODS

The neo-colony of the Apennine chamois is constantly monitored with global positioning systems (GPS) collars, radiotracking, direct observations and camera traps, and through two censuses per year, in summer and autumn, with the involvement of volunteers. The monitoring includes the tourist-recreational activities as potential disturbance factor, and the grazing cattle in syntopic areas with the chamois, as regards to the quantitative, qualitative and health data.
As shown in Tables 1 and 2, 28 of 30 released animals have been fitted with radio collar, of which 10 VHF (Televilt Int®, 150 Sweden) and 18 VHF and GPS (Pro-Light-1; Vectronic Aerospace GmbH®); all the animals were also equipped with ear-tags in a unique combination of colours and symbols.
The monitoring protocol, arranged by the University of Siena, includes for the VHF collars, 42 fixes per month in 3 different time slots over the daylight hours; the GPS collars, for animals released before the beginning of the Project (Table 1), were programmed to take location every 7 hours, while for the animals released after the beginning of the Project (Table 2), the collars were programmed to make 1 fix every 3 hours during the first 3 months of their release and, subsequently, 1 fix every 11 hours. The direct observations are always made after the radiotracking activities, if the visibility conditions permitted. The camera trapping activity, from the 14th May to 5th July 2013, has shot at least one individual of chamois in 42 photos and 22 videos.
The monitoring data were analyzed by the University of Siena in GIS environment using the Animal Movement v. 2.0 for ArcView 3.2.

RESULTS AND DISCUSSION

The monitoring results show that the creation of a new population of Apennine chamois in PNMS has resulted successful till now. In particular, Table 3 shows that, after 31 animals released and 6 years from the beginning of the reintroduction activities, the neo-colony counts 72 individuals.

Picture 7. Chamois images captured with a camera trap in PNMS in 2013 (PNMS archive).

RELEASED	CONFIRMED DEAD	BORN	TOTAL NUMBER
31	11	52	72

Table 3. Status of Apennine chamois population in PNMS, in August 2014.

The number of chamois observed during the census, compared to animals actually present, results variable from 38% up to 81%: this is especially influenced by weather conditions and the number of people involved (Table 4).

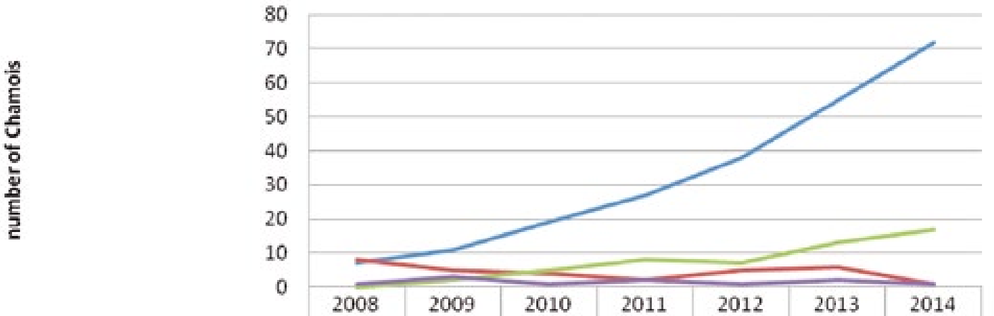
Date	Transect number	Total personnel	Volunteers number	Expected chamois (EC)	Observed chamois (OC)	OC/EC (%)
14/07/2011	11	28	15	26	**18**	69
19/10/2011	13	35	17	26	**16**	62
18/07/2012	15	43	27	35	**19**	56
09/11/2012	12	43	24	38	**31**	81
07/08/2013	11	45	26	52	**35**	67
29/10/2013	13	41	25	55	**44**	80
01/08/2014	13	29	15	71	**27**	39

Table 4. Results of Apennine chamois censuses in PNMS.

Figure 1 shows the growth trend of the population influenced by the releases and a good reproductive result, while Figure 2 shows that, over the years the number of animals with a functioning radio collar, which in 2008 was equal to 100% of the total, is progressively decreased until reaching, in August 2014, a fraction equal to the 8,3% of total number of the chamois, resulting from the births and the process of depletion of the batteries powering the devices. This inevitable trend means monitoring activities, through direct observation, become preponderant compared to the radiotracking and GPS localization.

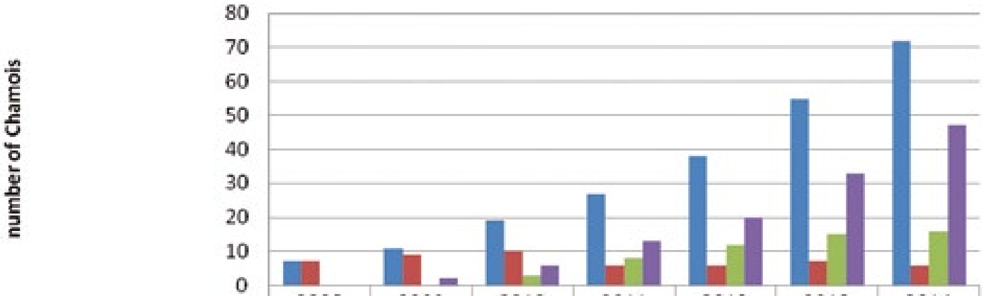
The fixes overall distribution (Figure 3) shows that the neo-colony are mainly faithful to the area surrounding its release site, the Mt. Bove massif.

It is particularly important that till now, as shown in Figure 4, all kids are observed for the first time exclusively in the area of Mt. Bove massif; moreover, this massif, and specifically the area of the Croce of Mt. Bove (1905 m a.s.l.), is also the neo-colony main wintering area.



	2008	2009	2010	2011	2012	2013	2014
Total number of Chamois	7	11	19	27	38	55	72
Chamois released per year	8	5	4	2	5	6	1
Kids per year	0	2	5	8	7	13	17
Dead Chamois per year	1	3	1	2	1	2	1

Figure 1. Apennine chamois population trend in PNMS.



	2008	2009	2010	2011	2012	2013	2014
Total number of Chamois	7	11	19	27	38	55	72
Working collars	7	9	10	6	6	7	6
Non functioning collars	0	0	3	8	12	15	16
Without collars	0	2	6	13	20	33	47

Figure 2. Collars functioning in the Apennine chamois population in PNMS.

The data analysis performed by the University of Siena have shown, among others, that founders caught in the wild (n 58) and those reared in large enclosures (n 58) differed in movement frequency (inter-fix distance per hour) and maximum distance covered (from the release site) in the first 5 months after release: both were significantly greater in wild individuals, males moved significantly more than females, wild individuals shifted their home ranges significantly more often than captive ones (Bocci et al. 2014); the analysis also showed that the chamois from captivity home ranges (HRs) resulted, in spring and autumn, significantly less extensive than the wild chamois HRs, as shown in Figure 5 (Bertini 2014). These results suggest that, in the early stages of a creation of an Apennine chamois new colony, it is favourable to choose animals coming from captivity, so to reduce the risk of dispersion.

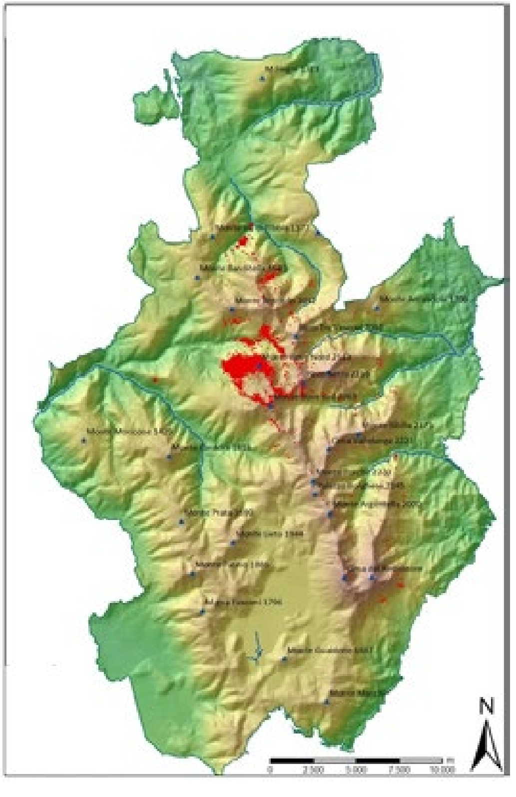


Figure 3. Fixes overall distribution of the Apennine chamois in PNMS (Bertini 2014).

The monitoring data not only confirmed the high environmental suitability area chosen for the releases, but also are of fundamental importance for the adoption of conservation and management measures aimed to the prevention and mitigation of potential threat and disturbance factors, in particular those related to tourism and recreational activities, and those linked to animal husbandry.

The chamois localization overlapped with the hiking trails and climbing routes (Figure 6) allowed to PNMS to issue specific regulations focused in time and space about the hiking and mountain climbing activities (Galluzzi 2012).

In particular, these regulations have individuated two areas, A and B, where access is not allowed, respectively, from the 1st November to 30th April and from 1st May to 31st October. At the same time it has been realized a specific marked hiking trail that allows to hike throughout the year in the area of Mt. Bove, observing chamois, with a limited risk of disturbance (Picture 8). The PNMS implemented also those activities that encourage the participation of environmental associations, mountain tourists, mountain hikers and tour operators, in the chamois conservation activities and the responsible fruition of the most sensitive areas. In fact, it has also been created the "Chamois Hotel" network, consisting of facilities that support the reintroduction project of the chamois.

The overlap of the same localizations with the grazing areas individuated trough the CFS censuses (Figure 7), has instead helped to identify farmers who lead their livestock in areas syntopic with the chamois and, therefore, involved in the Project Life COORNATA C.6. Action, related to special programs of prevention and improvement of health management of syntopic domestic animals.

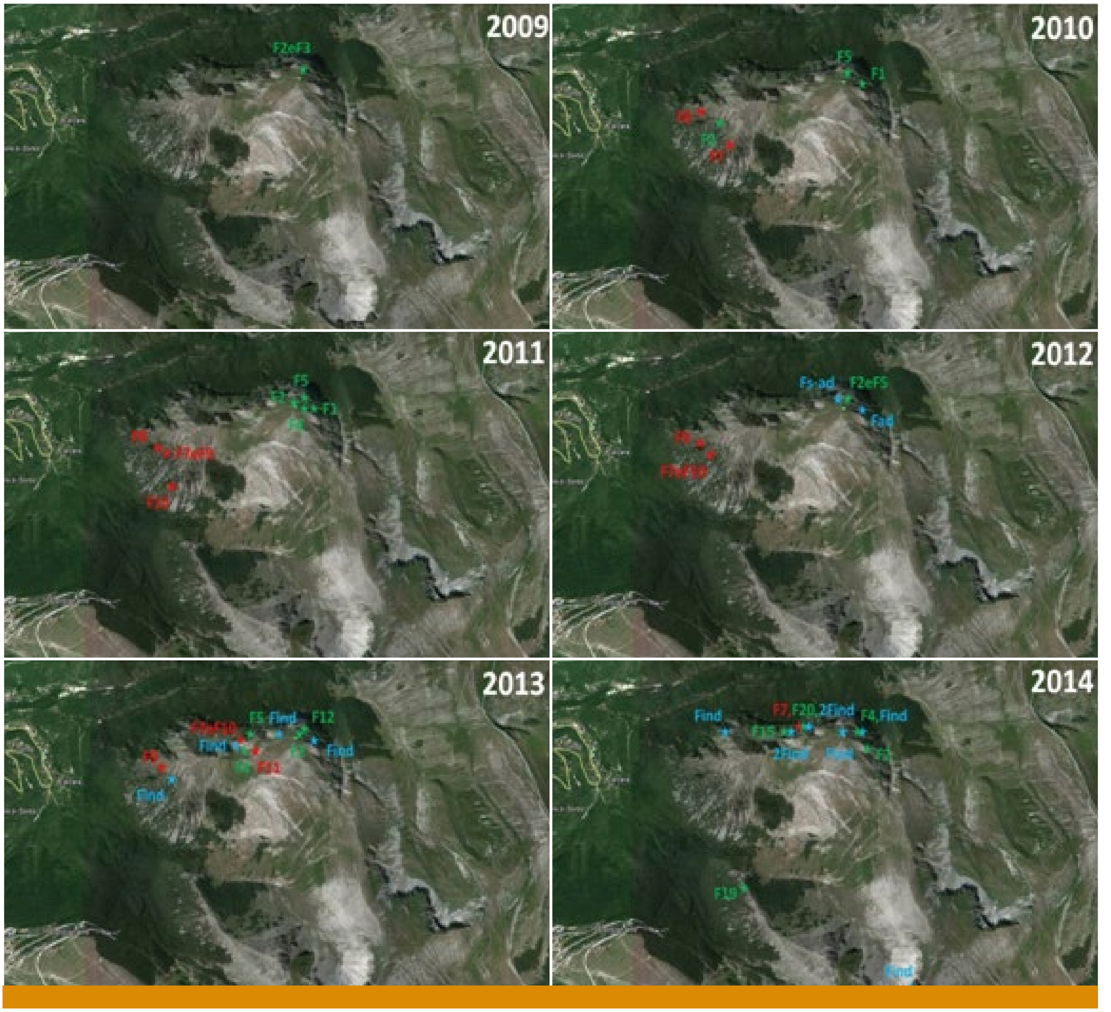


Figure 4. Localization of the first chamois kids observations in PNMS – Green: females released from nature; Red: females released from enclosure; Blue: females born in PNMS (Bertini 2014).

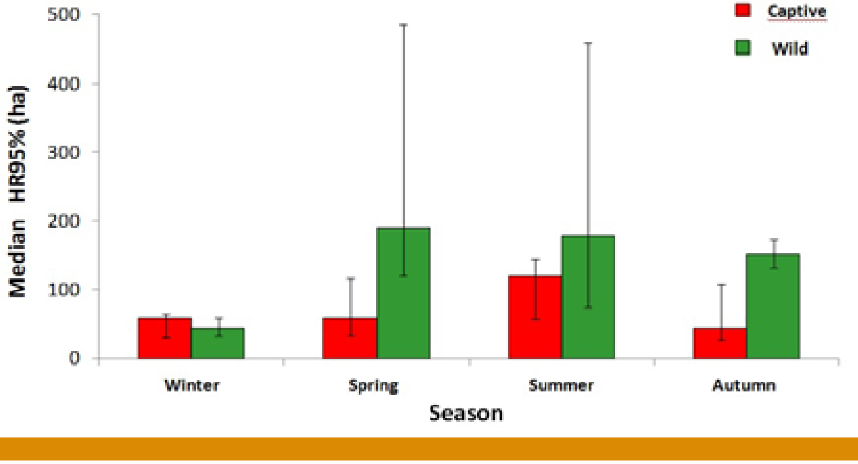


Figure 5. Comparison of the HR seasonal extension estimated through the Kernel (95%) among the chamois coming from nature and those from captivity (Bertini 2014).

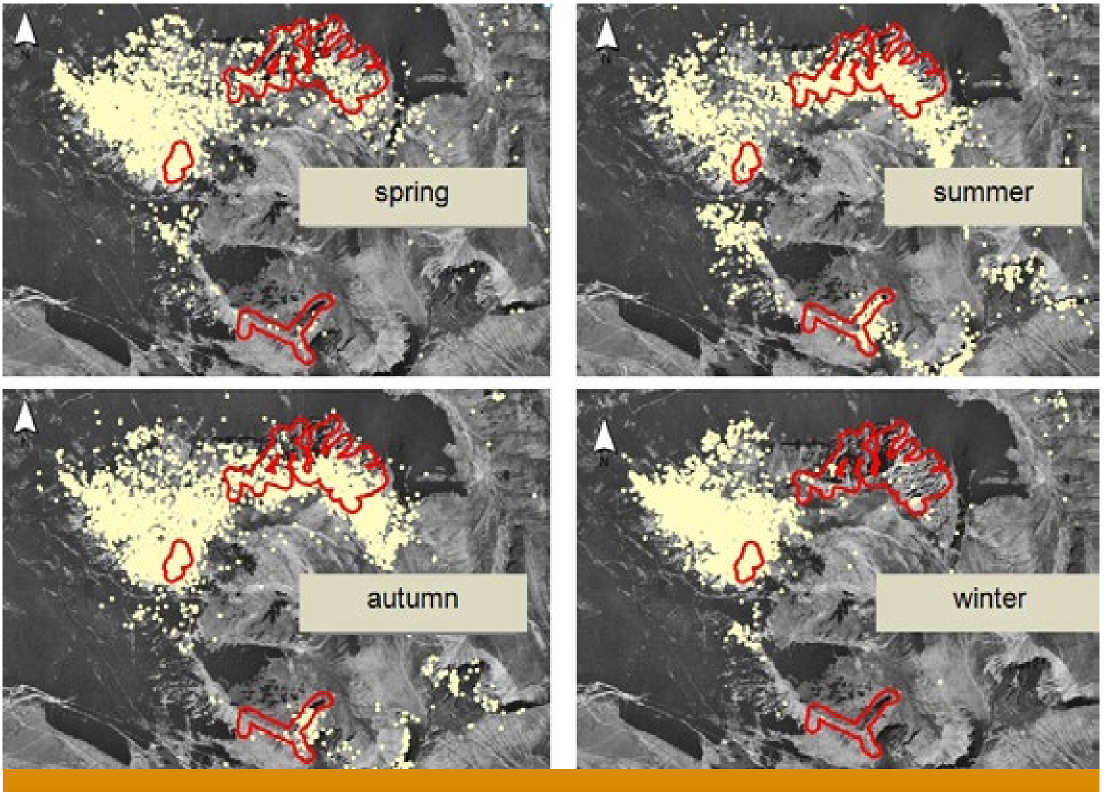


Figure 6. Overlap of fixes and hiking trails encircled with a 50 m buffer.

CONCLUSIONS

The re-introduction (benign introduction sensu IUCN) of the Apennine chamois (*Rupicapra pyrenaica ornata*) in PNMS has been successfully implemented since 2008.
From 2008 to 2014 were released a total of 31 individuals, 18 within the Life Nature Project "COORNATA".
The enclosures have played an important role, in fact 12 chamois came from captivity; moreover, animals from captivity showed less extensive HRs than those wild-caught, reducing the risks of dispersion in the early stages of the neo-colony creation.

Picture 8. Information board along the Mt. Bove trail (A. Rossetti).

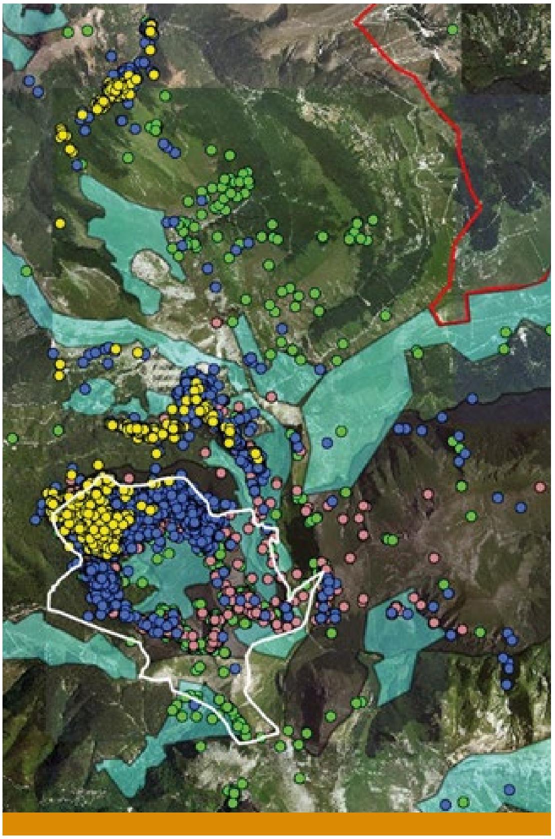


Figure 7. Chamois fixes and grazing areas overlap in PNMS.

The area chosen for releases, the Mount Bove massif, was highly suitable to host a new colony of Apennine chamois.
The results of the monitoring conducted through radiotracking, GPS collars and direct observation have provided important information for the management of potential threat or disturbance factors, such as tourist-recreational and breeding livestock activities, as well as for the creation of new populations in other areas, in particular in PRSV.

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We wish to thank, first of all, the PNALM, the PNM and the PNGSL, that provided the chamois for the releases.

Picture 9. Apennine chamois adult male in PNMS (A. Rossetti).

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THE CONSTITUTION OF THE FIRST APENNINE CHAMOIS NUCLEUS IN THE SIRENTE VELINO NATURAL PARK, FROM THE PRELIMINARY ACTIONS TO THE MONITORING OF RELEASED INDIVIDUALS

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INTRODUCTION

The Life Coornata Project (LIFE09 NAT/IT/00183, 2010-2014) was carried out, in close cooperation, by the Parks interested by the actual or potential presence of the Apennine chamois. When the project started four populations of Apennine chamois were present: one in the Abruzzo Lazio e Molise National Park (PNALM), where chamois survived; two in the Majella National Park (PNM) and the Gran Sasso e Monti della Laga National Park (PNGSL), where the chamois was reintroduced in the early ‘90s; one in the Monti Sibillini National Park, where the reintroduction started in 2008 and was completed during the Life Coornata itself.

After the first reintroductions in the PNM and PNGSL, in 1997, a feasibility study for the reintroduction of Apennine chamois in the PRSV (WWF Italia 1997) was elaborated. In this study two distinct areas for the reintroduction of the Apennine chamois, on the two massifs of Sirente and Velino, were indicated as suitable. In 2001 this feasibility study was included in the National Action Plan for the Apennine chamois conservation (Dupré et al. 2001) and the creation of a new population in the Sirente Velino Natural Park was there reported as one of the actions to be carried out to preserve the subspecies.

In 2004 in Sirente Velino Natural Park, an enclosure area with captive-breeding purpose was activated with the collaboration of the PNALM. In this 7 ha enclosure, located near Rovere (Rocca di Mezzo, AQ), is now present a couple of Apennine chamois: Orema (♀ 9 year-old) captured and transferred in 2008 from PNALM and Ago (♂ 5 year-old) captured and transferred in 2013 from an enclosure in the PNGSL.

In 2009 various institutions involved in the management of the Apennine chamois, prepared the above-mentioned Life Coornata Project to implement a series of measures aimed to preserve the subspecies.

In the Sirente Velino Natural Park the purpose of the Life Coornata Project was to start the constitution of a new fifth population of chamois in the Central Apennines. To pursue this general goal, many actions have been carried out in Sirente Velino Natural Park, namely preparatory actions, concrete conservation actions, public awareness and dissemination of results actions and overall project operation and monitoring actions.

This contribution is aimed to briefly illustrate the main actions related to the constitution of the first Apennine chamois nucleus in Sirente Velino Natural Park.

SIRENTE VELINO PROJECT’S AREA

The Sirente Velino Natural Park (PRSV), established in 1989 (L.R. 54/1989) and extended over 540 km^2 includes five Natura 2000 sites (SPA IT7110130, SCI IT7110206, SCI IT7110075, SCI IT7110090, SCI IT7110096). The altitudinal range is between 400 m and 2500 m a.s.l. Topography comprises two major reliefs (Sirente and Velino mountains), with the highest peak arising 2486 m a.s.l., and along mountain slopes narrow glacial valleys and rocky karst canyons are present.

This area has a central geographic position in the protected areas system of the Central Apennines, thus it plays an important role in ecological connection.

MAIN ACTIONS CARRIED OUT IN SIRENTE VELINO NATURAL PARK

The constitution of the new population of chamois in the Sirente Mount (Action C5) was connected to the implementation of other actions (Figure 1). Particularly the Action A7 and the Action A12 were preliminary to the release of chamois; they dealt with, respectively, the updating of the ecological suitability study and the evaluation of livestock presence in the areas where chamois would potentially spread after their release. The Action C6 was carried out at the same time with the Action C5 and it concerned the implementation of special health programs for the livestock aimed to ensure the best conditions for the chamois.

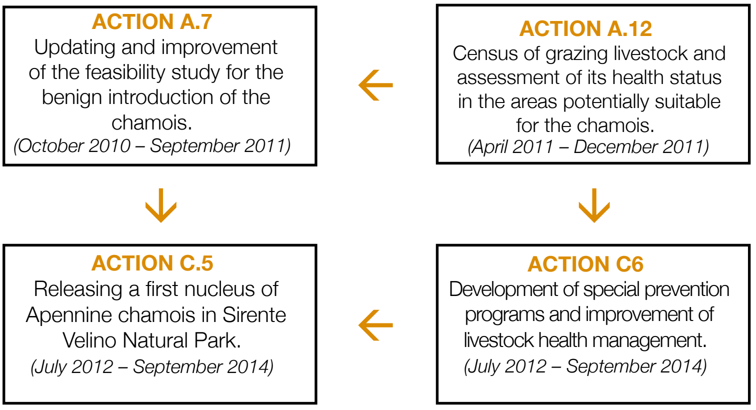

Figure 1. Chart of the connections between the different actions carried out to constitute the fifth Apennine chamois population in Sirente Velino Natural Park.

PREPARATORY ACTIONS (ACTION A7 AND ACTION A12)

In 2011 an updating of the feasibility study was carried out, with the scientific coordination of the University of Siena and according to the IUCN guidelines.
With the Action A7, the areas identified as suitable in the former feasibility study (WWF 1997) were evaluated a second time with respect to: ecological aspects such as the presence of suitable habitat during summer with high-altitude grasslands with *Festuco-Trifolietum thalii*, the proximity of rocks, the presence of wintering areas (with high slopes and different exposures), presence distribution and density of potential competitors (red deer, livestock) and predators (wolves and stray dogs); the potential human disturbance due to recreational/tourism activities and the accessibility of the area with motorized transport; the location of the area in the PRSV, with particular regard to the distance from its boundaries; the general public attitude to the introduction of chamois and, finally, the logistical aspects (evaluated with regard to the possibility to carry out both the releases and the subsequent monitoring of the individuals).
During the same time of Action A7, the Action A12 was conducted with the aim to estimate the presence of grazing livestock and also to assess its health status, in the areas where chamois would potentially spread. Pastoralism in the Sirente Velino is an ancient tradition. In the protected area, as in other parts of the Apennines, the grasslands are a public property administered by the municipalities that allow the livestock owners to use some portions of pasture. In these areas (located above 1500 m a.s.l.) the livestock is led to the grasslands during the summer after the snow melts (June-September). Livestock, if correctly managed, contributes to the conservation of the habitats of the open areas of the Mediterranean mountains, however overgrazing in areas where chamois potentially live can reduce the available food quality.
The area where the investigation regarding livestock was conducted included the potentially suitable area for the Apennine chamois (as identified with the A7 Action above 1600 m a.s.l.) and a surrounding area (comprised between 1200 m and 1600 m a.s.l.), covering the Sirente Mount and the Velino Mount for a total of 18 505 ha (34.26% of the Natural Park, Figure 2).
The main activities and achievements regarding the preliminary actions A7 and A12 are synthetically shown in Table 1.

Action A7	*"Updating and improvement of the feasibility study for the benign introduction of the chamois"*
Activities	Conducted: – cartographic analysis (altitudinal ranges, slopes, exposures, habitat type); – transects to evaluate reliefs environmental variables; – surveys for specific ecological/environmental issues evaluation (vegetation associations, food quality of grassland, potential wintering areas conformation, etc.); – evaluation of the general public attitude (with questionnaires and interviews).
Results	The results of studies conducted have: – confirmed the suitability of the areas of Velino Mount and Sirente Mount; – identified suitable sites for the release of Apennine chamois for both the areas; – found an high degree of the general public favor towards the reintroduction of chamois, both among the residents and the visitors of the protected area; – identified for the two massifs of the Sirente and Velino potential limiting factors for the reintroduction that had to be minimized before the release start (livestock, tourism and hiking).
Action A12	*"Census of grazing livestock and assessment of health status and potentially suitable area for the chamois"*
Activities	Conducted: – collection of data and mapping distribution of areas with grazing livestock (administered by the municipalities that grant to livestock owners some portions of pasture); – collection of data and mapping distribution about the number of animals per species of grazing livestock; – field surveys to verify correspondence between data collected and the actual presence of grazing livestock (distribution and number); – retrospective investigations on viral and bacterial etiologic agents that might be common to chamois and grazing livestock; – collection of biological samples (faecal samples) delivered at the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise* for parasitological examinations (qualitative and quantitative).
Results	Results: – a database concerning the livestock presence was developed, in association with GIS maps for the examination of its distribution on the territory (land-based localization of grazing areas used); – The evaluation, in a qualitative and quantitative sense, of the health status of domestic livestock highlighted low-medium parasitic charges that, at the level found, excluded risky health interactions between livestock and Apennine chamois, and could not affect negatively the population dynamics.

Table 1. Main activities and results of the preliminary actions A7 and A12 in the Sirente Velino Natural Park.

CONCRETE CONSERVATION ACTIONS (ACTION C5 AND ACTION C6)

In 2012, basing on the results of the preliminary actions, the PRSV developed an operating document to proceed to the concrete release phase, taking in particular account the potential limiting aspects in the release area, indicated in the feasibility study: the presence of livestock and the presence of tourism.

Concerning the presence of livestock, the suitable sites for the release of chamois and their surrounding areas (Velino Mount and Sirente Mount) have been checked in term of: surface and distribution of cadastral parcels with assigned or non-assigned grazing areas; number of grazing livestock farms and their grazing surface; number of heads and density of livestock for each species and overall. The surface of the grazing areas, as well as the livestock density, was greater in the Velino compared to the Sirente, the density of grazing sheep was greater in the Sirente (2.8 sheep/ha against 2.4 sheep/ha in the Velino) and, finally, the density of grazing cattle and horses was greater in the Velino than in the Sirente (0.6 cattle/ha and 0.3 horses/ha in the Velino; 0.3 cattle/ha and 0.1 horses/ha in the Sirente).
Tourism and hiking trails are present in both areas but, during the winter the potential disturbance related to the ski lifts was considered a critical issue in the areas around the suitable release area of the Velino. In addition, the release site of the Velino is near to the borders of the protected area where, even if an ecological continuity exists with the neighbouring Monti della Duchessa Natural Reserve, a continuity exists as well with a neighbouring hunting area. In the Velino Massif, thus, chamois founders could be exposed to greater risks during the exploratory phases after the release in the new area. On the basis of the above-described analysis conducted, the Sirente Mount release site was chosen.
The release site identified (Mandra Murata 1850 m a.s.l.) can be reached along a walk trail or by helicopter. Near the release site there is a logistic base having the function of wildlife observatory. The consultation of local authorities was also very important in the site-defining process: numerous meetings were held and, in September 25 2012, an agreement was signed to establish a specific protection area in the zone of Mandra Murata (Figure 3).
In the specific protection area (about 600 ha) we programmed to forbid the access along trails (ca. 16.5 km) for one year starting from the early releases and then to regulate it (forbidden access during birth period and only limited number of people may access the site during the other periods of the year).
Once the release area was identified, Action C6 was carried out. The activities undertaken (and carried out until September 2014) concerning the anti-parasitic treatments include:

- qualitative and quantitative parasitological control of faecal samples of sheep, goats and cattle;
- a first anti-parasitic treatment (before the mountain grazing period) on all livestock (sheep, goats and cattle);
- monitoring over time parasitic charges found in faecal samples;
- delivery to farmers (for sheep and goats) of immuno-stimulant salt blocks with anti-parasitic action;
- collection and analysis of faecal samples, taken from the pastures, in order to monitor the parasitic infestation and, thus, program strategies to reduce the loads on the mountain pastures;
- a second anti-parasitic treatment in September/October on all livestock (sheep and goats) before returning to the farm.

The activities were carried out in the area of future expansion of the population (Figure 4) as in the release area no livestock is present.

Monitoring activities have been carried out between July 2012 and February 2014, and involved a total of 422 cows, 3011 sheep and 65 goats, located in 23 livestock farms (6 cattle and 17 sheep/goat farms). About 20% of animals residing in each livestock farm were sampled for serological investigations. A total of 460 fresh faecal samples were collected from cattle, sheep, goats and dogs, which have been vaccinated, treated against intestinal parasites and registered in 89 canine registries. The serological tests were carried out on 65 dogs.
Checks and inspections carried out have not, at the time, highlighted relevant issues and/or risks for the first nucleus of the Apennine chamois.
The activities carried out with the Action C6 also allowed the birth of an on-going relationship of collaboration with owners of livestock as well as obtaining their trust and this, in turn, allowed the achievement of positive results in the livestock health management.
After obtaining the necessary authorizations for the release of the founders, in June 2013 the specific protection area was formally established and information about the upcoming releases were spread (panels and signs were also placed to inform about the regulation of the site access). In July 2013 the first chamois coming from the PNM were released at Mandra Murata on Sirente Mount. The capture strategy developed allowed the release of many wild-captured individuals together, and ensured the release of a first group of chamois. Thanks to a close collaboration with all the Parks partners of the Life Coornata Project, from July 2013 to June 2014 a total of 13 chamois were released on Sirente Mount.
All the individuals released (Table 2) were marked with ear tags and equipped with radio-collars GPS/GSM (Vectronic, Followit).
The monitoring activity started soon after the release and was carried out through the control of GPS locations (GPS fixes) as well as using the VHF signal. Radio-telemetric monitoring was conducted applying the monitoring protocol developed during the Life Coornata Project with the scientific supervision of the University of Siena.
Survival of individuals was checked daily, monitoring both the VHF signal and the locations received by SMS. In the same way the monitoring of the individuals movements were carried out both using GPS locations (acquired every 2 hours) and realizing daily VHF fixes. When the weather conditions allowed it, direct observations were carried out in order to verify the association between individuals, animal behaviour/activity and to check for any possible disturbance in the area (dogs, cattle, tourists etc.).
From July 2013 to April 30 2014 a total of 758 radio-telemetric data have been collected, a total of 249.28 hours of observation were conducted during 216 observations and a total of 105 positive observation sessions (i.e. chamois observed) were recorded against a total of 300 direct observations developed.
The founders of the new chamois population of Sirente have occupied the mountain ridge above 1600 m a.s.l. exploring the entire Sirente range (Figure 5).

Release date	Name	Sex	Age (years)	Provenance
17/07/2013	Eva	F	8	Nature (Maiella National Park)
17/07/2013	Lucy	F	9	Nature (Maiella National Park)
18/07/2013	Rosa	F	4	Nature (Maiella National Park)
24/07/2013	Hely	F	5	Nature (Maiella National Park)
24/07/2013	Bella	F	6	Nature (Maiella National Park)
24/07/2013	Berardina	F	5-6	Nature (Maiella National Park)
24/07/2013	Assunta	F	6	Nature (Maiella National Park)
19/09/2013	Giuseppe	M	2-3	Enclosure (Gran Sasso National Park)
24/09/2013	Francesco	M	2-3	Enclosure (Gran Sasso National Park)
25/10/2013	Vettore	M	4	Enclosure (Sibillini National Park)
27/05/2014	Fortuna	F	2	Nature (Gran Sasso National Park)
04/06/2014	Gas	M	4	Nature (Gran Sasso National Park)
05/06/2014	Girotondo	M	2	Nature (Gran Sasso National Park)

Table 2. Chamois released in the Sirente Velino Natural Park for the creation of the fifth Apennine chamois population. The individual Lucy died on July 28, 2013 for predation.

After the first few months from the release, a decrease of the area occupied by individuals, estimated as the bimonthly home range (Minimum Convex Polygon), was observed and this suggested lower exploratory activities of the individuals during the winter season, letting us assume a stabilization of the area occupied.
The altitudinal distribution of the localizations in the periods considered shows that chamois released into the new area have used the areas located between 1800 and 2000 m of altitude. In the summer period the areas at an altitude over 2000 m a.s.l. were frequented while in winter the areas located under 1800 m s.l.m. were occupied.
Chamois after their release gathered in different groups. Between December 2013 and May 2014, the nine chamois were distributed in two groups (Figure 6).
At the end of June 2014 five kids born on the Sirente Mount were observed and this reproduction event in the new area is the first concrete evidence of the establishment of a new chamois population in the Central Appennines.

PROJECT STAFF AND COLLABORATIONS

The Life Coornata Project activities have been carried out by the Sirente Velino Natural Park project staff: Oremo Di Nino (Director); Paola Morini (Biologist); Giuseppe Cotturone (Veterinarian); Paola Aragno, Sara Marini, Lorenzo Manghi (graduated wildlife technicians); Luca Maria Nucci, Francesca Ferlini, Stefano Cecala (Park Rangers); Elisenda Pasquali, Gina Di Nicola (administrative/financial staff). A special thanks goes to the President Simone Angelosante.
Scientific supervision: Università degli Studi di Siena (S. Lovari, F. Ferretti, I. Minder, A. Bocci).
Other collaboration: Corpo Forestale dello Stato, Local Municipalities involved, Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise, Aziende Sanitarie Locali.
Many volunteers have contributed to the realization of the project: National Civil Service Volunteers, Voluntary Ecological Guards (G.E.V., C.O.N.G.E.A.V.).

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Dupré E., A. Monaco & L. Pedrotti (a cura di). 2001. Piano d'azione nazionale per il camoscio appenninico (*Rupicapra pyrenaica ornata*). Quaderni Conservazione della Natura, 10, Ministero dell' Ambiente – Istituto Nazionale della Fauna Selvatica.

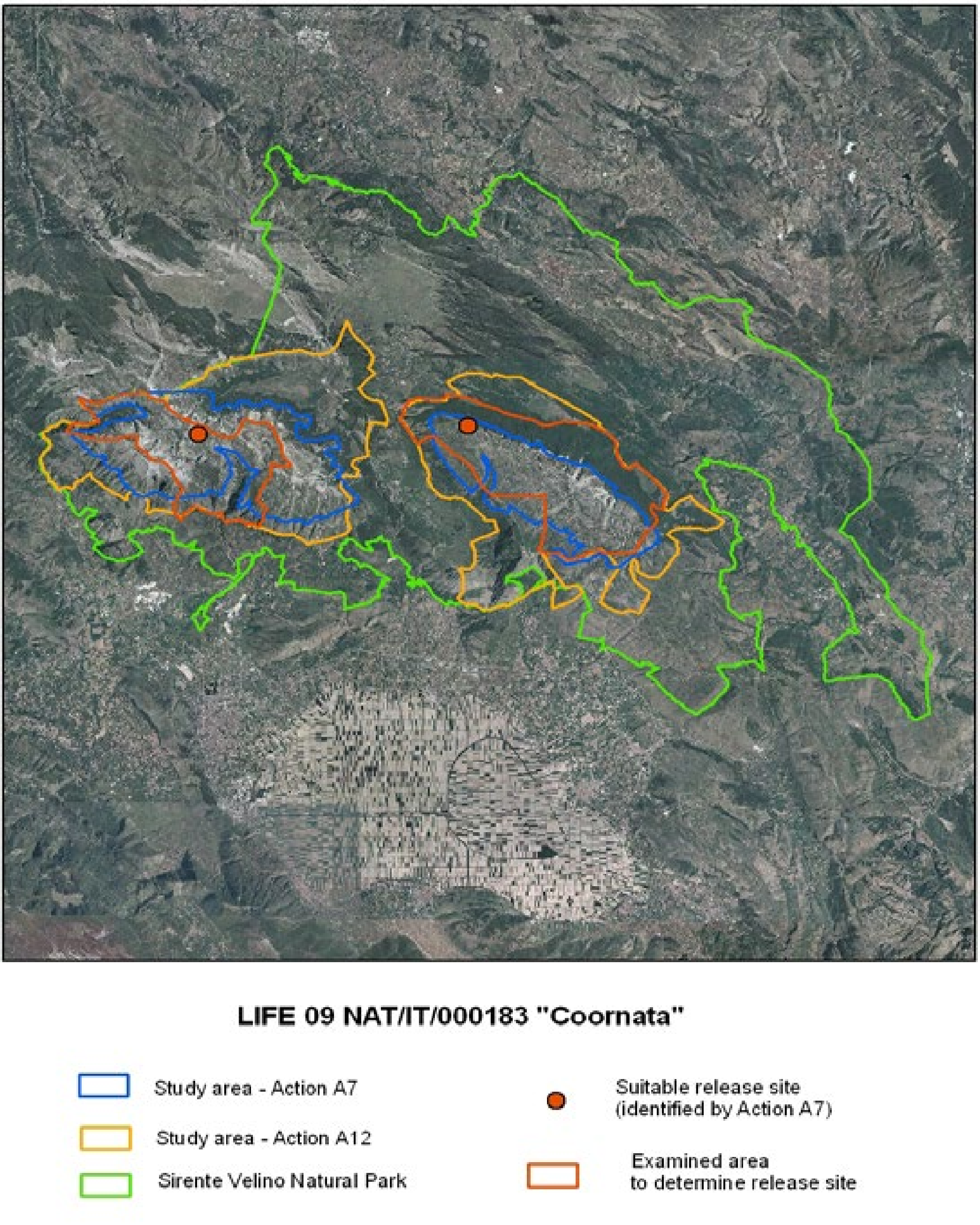

Figure 2. Areas investigated in order to identify the release site (Action A7 and Action A12) in the Sirente Velino Natural Park.

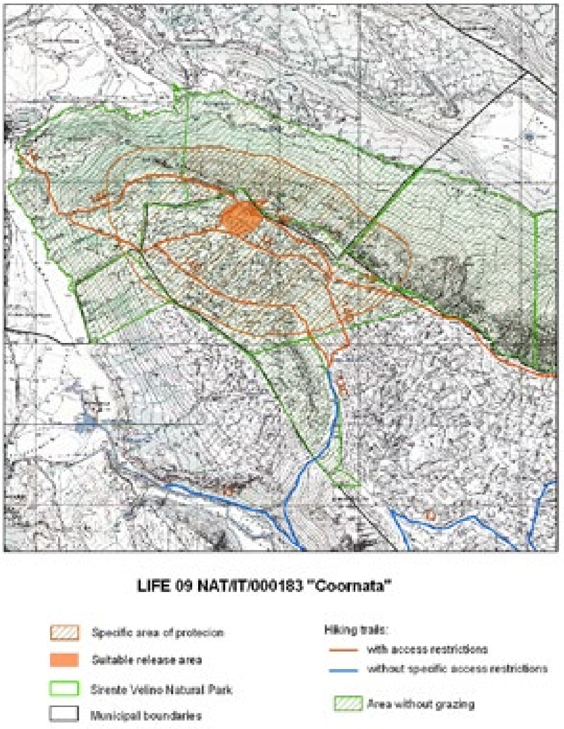

Figure 3. Protection area for Appenine chamois established in the Sirente Velino Natural Park.

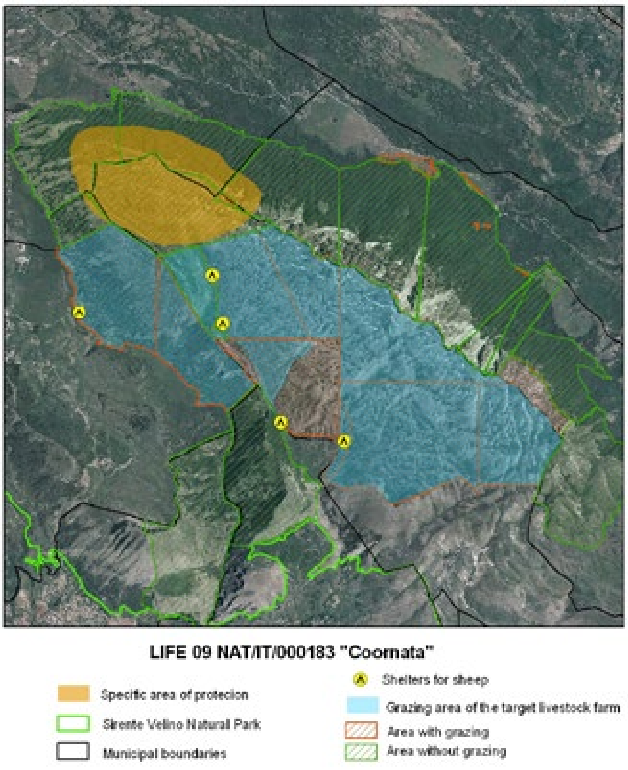

Figure 4. Area interested by the improvement of the livestock health management in the Sirente Mount.

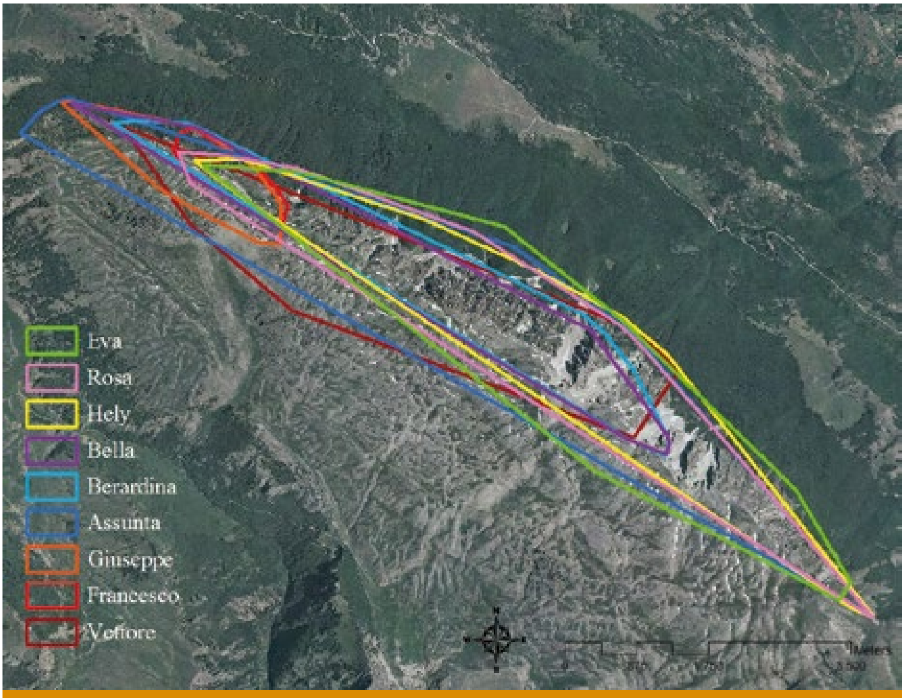

Figure 5. Total home ranges (MCPs) of chamois released from July 2013 to April 2014.

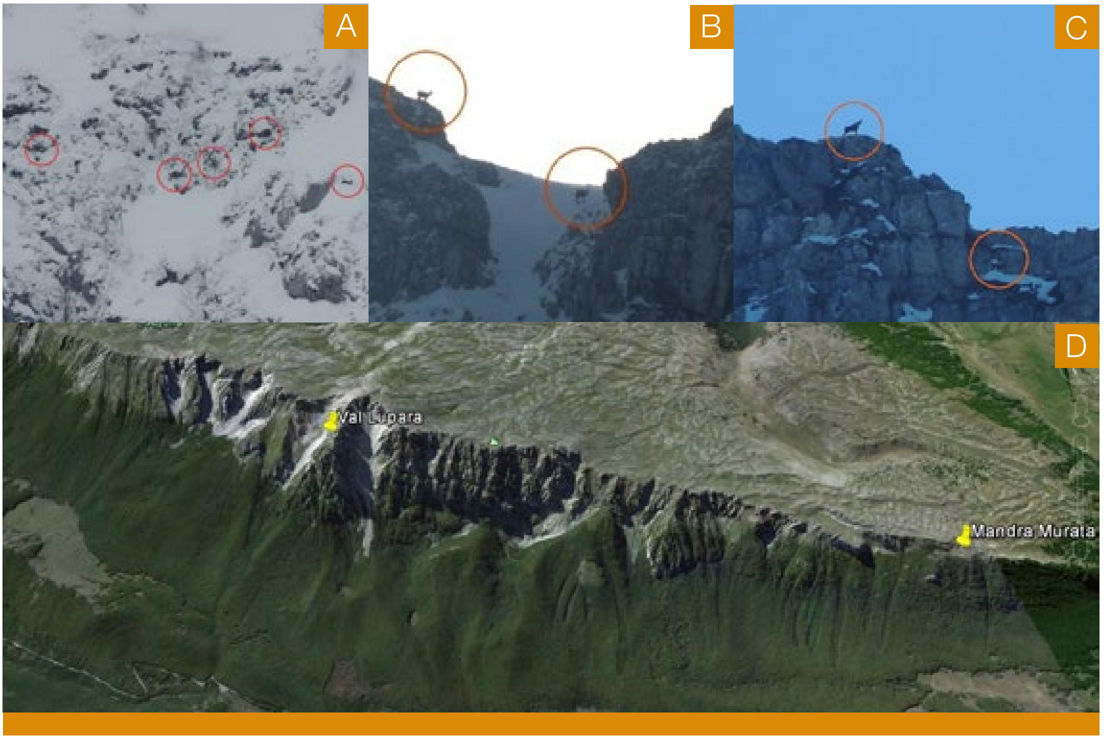

Figure 6. Chamois after the release spent the winter associated in two groups. Vettore (MA), Eva (FA), Rosa (FA), Hely (FA) frequented the Lupara – Inserrata area (pictures A-D); Francesco (MJ), Giuseppe (MJ), Bella (FA) and Berardina (FA) were associated in the area of Mandra Murata (pictures B-C-D).

POTENTIAL THREATS TO THE HISTORICAL AUTOCHTONOUS APENNINE CHAMOIS POPULATION IN ABRUZZO, LAZIO E MOLISE NATIONAL PARK: ANALYSIS, VALUATION AND MANAGEMENT IMPLICATIONS

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INTRODUCTION AND AIMS

The Apennine chamois (*Rupicapra pyrenaica ornata*) is a mountain-dwelling ungulate endemic to central Italy whose last remaining autochthonous population is in the Abruzzo, Lazio e Molise National Park (PNALM). This herd was employed as source population for establishing three new populations in three National Parks. Despite management performed following the National Conservation Plan (Dupré et al. 2001), the Apennine chamois is still facing major threats associated with its limited population size and number of subpopulations, as well as low genetic variation, slow range expansion and competition with other ungulates. These threats are particularly relevant for the historical population of PNALM.
Between 2005 and 2009, we recorded a decline of the Minimum Number of individuals alive from 645 to 518. Moreover, the winter survival rate of kids, averaging 54% (±18%) during the previous 10 years, progressively decreased dropping to 18-20% in 2009-2010. The population was then apparently destructured, with a low proportion of young individuals. Furthermore, between 2007 and 2009, successive cases of mortality during anesthesia, mostly due to respiratory problems, occurred suddenly after tens of trouble-free captures performed in the previous years.
The possible presence of a critical situation in PNALM chamois population required a specific monitoring action (C2) financed by the LIFE program. The main aims of action C2 were the following:

- capturing and marking at least 20 chamois to monitor their survival rate and assess the possible causes of mortality;
- detecting the diseases that may represent actual or potential threats for the Apennine chamois and the sintopic wild and domestic species;
- defining direct and indirect measures for a correct management of the potential sanitary emergencies concerning the Apennine chamois in PNALM;
- monitoring population trend and dynamics through annual ground counts and repeated standardized visual scans;
- to study the possible interaction and the spatial competition with other sintopic ungulates, i.e. red deer and domestic animals.

All the results obtained in these actions (along with those gathered in others) would eventually contribute to the development of an operational plan for the conservation and management of Apennine chamois in PNALM.

STUDY AREA

The study area coincides with the chamois occupancy area in PNALM, but most of the fieldwork was carried out at a fine scale in five sampling areas where the most representative herds occur: La Meta, Tartari (these two areas are adjacent so that for some analysis they were considered together as only one), Rocca Altiera (a more peripheral area of relatively recent expansion of the population), and Val di Rose and Monte Amaro which are the areas of historical presence of the chamois in PNALM.

FIELD METHODS

Captures and survival monitoring

Captures were made by tele-injection. Tele-injection is a highly specific and selective method which has been always proven successful in PNALM. Considering what had happened during the last captures, however, several measures were taken to minimize the possible problems during anesthesia: standardized handling methods, constant monitoring of the vital parameters using also pulse oximetry, oxygen therapy, and specific manipulations in case of meteorism.
Chemical immobilization was taken by two anesthesiological protocols: 1) a solution of xylazine-ketamine (0.71 ± 0.22/1.84 ± 0.66 mg/kg); 2) a solution of medetomidine-ketamine (0.05 ± 0.01/1.52 ± 0.25 mg/kg), both antagonized by atipamezole (1.20-1.80/0.4-0.6 ml). The change of drug mixture is explained by the different results we obtained about induction time and anesthesia depth, with special regard to respiratory rate (for details see Gentile et al. 2014).
An alternative capture method was also experimented: four box-traps were built and placed in Val di Rose and La Meta. They were baited with salt and equipped with camera traps and remote-control devices. The chamois became accustomed to the traps in a brief amount time, nevertheless they did not enter into them when we tried this method.

All the chamois were radio-equipped with VHF or GPS/GSM collars and constantly monitored. GPS/GSM collars' standard configuration was 1 location/7 hours, whereas 1 fix/week with direct observation was the monitoring protocol for the individuals equipped with VHF collar. Survival was checked daily for each chamois through the beacon signal.

Parasitological survey

In 2011 and 2012 fecal samples of chamois, red deer and livestock were collected in the five sampling areas in order to analyze the community of parasites hosted by these species. The 2012 sampling was the most complete and homogeneous survey, therefore the results presented here referred only to this year (results about 2011 are given in Latini et al. 2012). Lab analysis were performed by the Istituto Zooprofilattico Sperimentale di Teramo (IZS). Results are expressed as frequency of occurrence (number of feces with presence of a certain parasite group on the total sample) and intensity (number of eggs/oocysts per gram of feces, EPG/OPG) and their spatial and interspecific variation was studied.

Serological survey

Blood samples were drawn from animals of those farms whose livestock grazed in areas included in chamois range. Serum samples were also taken from captured chamois, and from deer occasionally found in chamois area. Results were expressed in terms of prevalence (number of positive samples for each disease on the total number of samples).

Population structure and dynamics

Two kinds of ground counts were performed:

1) Annual ground counts, conducted twice a year (July and October, both with two repeats) on the whole area along 25 routes performed simultaneously by several operators using binoculars and telescopes. Age classes were distinguished in kids, yearlings and adults. As main results, the survey yields the Minimum Number Alive (MNA), which represents an index of the population size, and the number of kids and yearlings, useful to assess the mortality rate in the first year.

2) Repeated ground counts, i.e. systematic and standardized repeated visual scans performed by 1-2 trained operators along the same routes in the areas with the most representative herds occurring in PNALM. Detailed age classification was made according to Lovari (1985); sex was identified also by horn's shape and thickness even in class I. This method yields finer results on population structure and permits to estimate the main demographic parameters (Table I) and assess the population dynamics. Prior to begin the fieldwork, a blind test was performed in order to verify the concordance in classifying age and sex class: the two operators resulted highly concordant (N = 218; Wilcoxon Matched Pairs test: T = 7.5, Z = 0.63, P = 0.53; power > 0.80).

Demographic parameter	Calculation
Birth rate (B)	number of kids/total number
Reproductive Index (IR)	number of kids/number of adult female
Sex Ratio (MM:FF)	number of males/number of females
Recruitment Index (IA)	number of yearlings/total number of adults and subadults
Kid survival (AS)	number of yearling y_0/number of kids y_1
Yearling Survival Index (SY)	number of Class I y_0/(number of yearlings y_1 + number of yearlings y_2)

Table 1. Demographic parameters calculated to assess chamois population structure and dynamics in PNALM.

Competition with other ungulates

Red deer density was estimated through pellet-group count according to a double-stage sampling method developed in previous years (Latini et al. 2003): a total of 80 transects of 500x2 m stratified among three layers at different red deer density (cf. Marques et al. 2001) were walked throughout the Park.

An additional pellet-group count at a finer scale was performed just on mountain grazing pastures in order to estimate the spatial overlap between chamois and red deer and to study their habitat use. This work focused on 4 sampling areas, where a total of 110 transects of 200x2 m were walked through; also in this case, the transects were selected according to a double-stage sampling method. The sample area corresponded to 0.25% of the whole study area, as the best trade-off between possible effort and expected results. Such a sampling effort is similar to other studies (e.g. Loft & Kie 1988, Marques et al. 2001, Prokešová et al. 2006), or it is even higher (e.g. Marques et al. 2001, Borkowski 2004, Aryal et al. 2010). To study habitat use, the Bonferroni confidence intervals were calculated after the goodness of fit test between use and availability resulted significant (Neu et al. 1974, Byers et al. 1984); Jacobs index was also calculated (Jacobs, 1974).

The spatial overlap between species was assessed through Pianka index.
The presence of livestock in chamois area was also recorded each time they were seen during the ground counts. Location and number of animals of each group was noted.

MAIN RESULTS

Captures and survival monitoring

A total of 23 chamois were captured. None were captured with box-traps in the two attempts made. Two chamois died during or immediately after capture operations, so that their death can be directly ascribed to capture (mortality rate: 8.6%). Another one, an adult female that was captured because one of its legs was injured, died following medical intervention. The total number of chamois monitored in the project was then 20: 18 adults (8 males and 10 females) and 2 yearlings (1 male and 1 female).
The monitoring effort (> 1000 hours of research in the field, > 5000 radio-telemetry controls, > 540 VHF fixes) permitted to recover all the 10 chamois that died during the project. Only for three of them we arrived too late on the site due to the prohibitive winter conditions. In addition, other carcasses were found during the fieldworks.
Amongst the known causes of mortality (N = 38 out of a total of 55 found in the last 10 years), pathologies was the most frequent (31.6%), followed by predation (23.7%). Amongst the pathologies, we found many cases (78.6%, N = 28) of pulmonary deficiency due to high bruncopulmonar strongyles infestation, often accompanied by parasitic pneumonia. Moreover, the pathogenic gastrointestinal parasite *Haemoncus contortus* – previously identified in the feces by Rossi et al. (this volume) – was commonly found, sometimes with very high intensity.

Parasitological survey

A total of 238 chamois fecal samples were collected according to an a priori Power Analysis which had indicated 180 as minimum sample size to get a power of 0.80 in a comparison (e.g. ANOVA) amongst 4 sampling areas; in addition, 142 red deer fecal samples were collected for comparison with chamois, again respecting the indication of the a priori Power Analysis ($\beta = 0.80$ for a 2x2 contingency table). The sampling effort resulted homogeneously distributed among areas for both the chamois ($\chi^2 = 7.6$, df = 3, P = n.s.) and the red deer ($\chi^2 = 0.55$, df = 1, P = n.s.). In addition, 62 cattle fecal samples were collected, equally distributed between the two areas of presence ($\chi^2 = 0.26$, df = 1, P = n.s.).
Sheep occurred in just one area and only 39 faeces were sampled.

Species	Gastrointestinal parasites	Bruncopulmonar strongyles	Coccidia
Chamois	65.0	76.4	96.4
Red deer	38.7	50.0	23.2
Cattle	24.2	0.0	14.5
Sheep and goats	71.8	48.7	76.9

Table 2. Prevalence (%) of parasites in the faecal samples of chamois (N = 238), red deer (N = 142), cattle (N = 62) and sheep and goats (N = 39) in PNALM.

The chamois resulted widely more infested than red deer or livestock (Table II), also in terms of intensity. Little spatial variation was detected for chamois: only gastrointestinal parasites showed a significant variation, as they were more present ($\chi^2 = 26.9$, df = 3, $P < 0.001$) at La Meta-Tartari; in this area, which is characterized by the widest overlap and the closest proximity between chamois and livestock, major intensities of gastrointestinal parasites (> 3000 EPG) were also registered. Bruncopulmonar strongyles occurrence resulted significantly higher (χ^2, $P < 0.001$) than in previous studies (Martella et al. 2003, Tomassini 2005), suggesting an infestation increase in recent years. The parasitological results seem to be consistent with the anatomopatological evidences that revealed a widely spread strongylosis at pulmonary level. Such clinical conditions may be related to several factors at population and ecological level.

Serological survey

No evidence of possible transmission between livestock and chamois population was detected so far. In fact, of 23 chamois serum samples only 7 resulted positive at some diseases, BVD being the most frequent (n = 3). On the other hand, livestock resulted positive to a wide range of diseases, mostly toxoplasmosis (44.2%, N = 502) and BVD (41.7%, N = 444), followed by Chlamidia (33.1%, N = 1932) and Border Disease (20.6%, N = 1890). Livestock, therefore, might represent a sort of reservoir for a number of diseases possibly dangerous for chamois. Considering the proximity between these animals on grazing pastures, such a situation requires a continuous and careful monitoring.

Population structure and dynamics

The MNA showed a general decrease in recent years (2006-present). Among the three years of LIFE, the first two showed a slight increase, but in 2013 the MNA dropped to a minimum of about 400 individuals (Figure 1). The population structure revealed a stable high proportion of adult females (mostly III age class) with their kids, a typical condition of a well-established population (Crampe et al. 2006, Panella et al. 2010). On the other hand, yearlings, and consequently the class I, varied substantially across years (Figure 2).

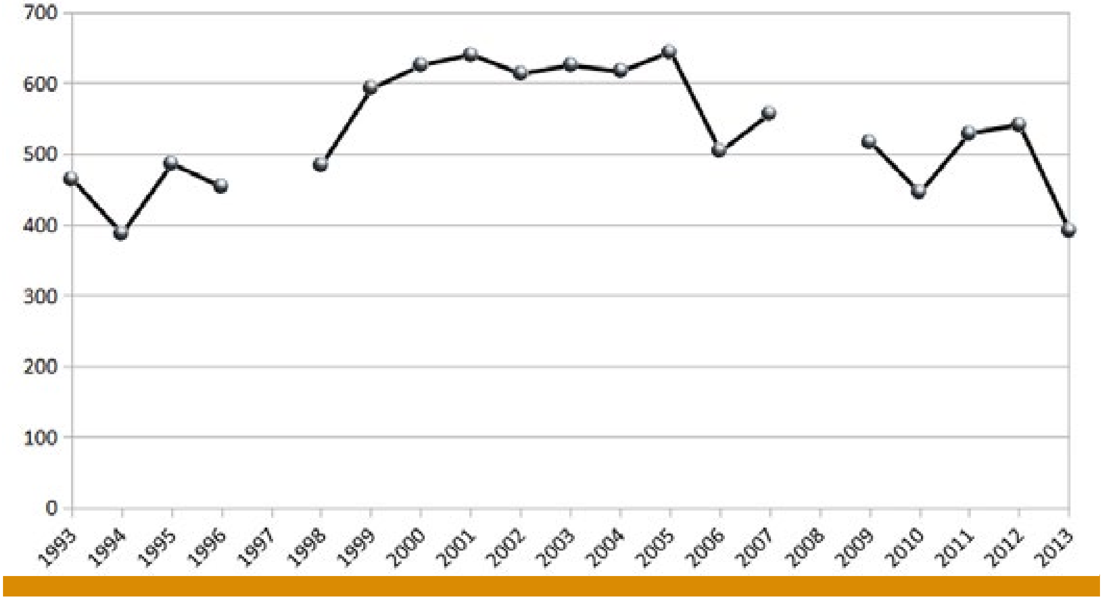

Figure 1. MNA trend of Apennine chamois in PNALM in the last 20 years.

The population productivity (B, IR) did not vary much across years, whereas kids survival (AS) and the corresponding recruitment index (IA) showed significant variation (Figure 3), as already observed in large herbivore populations (Gaillard et al. 1998, Panella et al. 2010). However, spatial differences amongst herds exists. Val di Rose and M. Amaro showed the lowest values of survival rate; moreover, M. Amaro yielded also the lowest values in productivity in 2011. Nevertheless, the decrease of kid survival rate has concerned all the areas since 2008 and it seems to be the main factor to drive chamois population dynamics in PNALM (Latini et al. this volume). This kind of demographic response is usual in mountain ungulate populations subjected to density-dependent processes (Gaillard et al. 2000, Bonefant et al.2009).

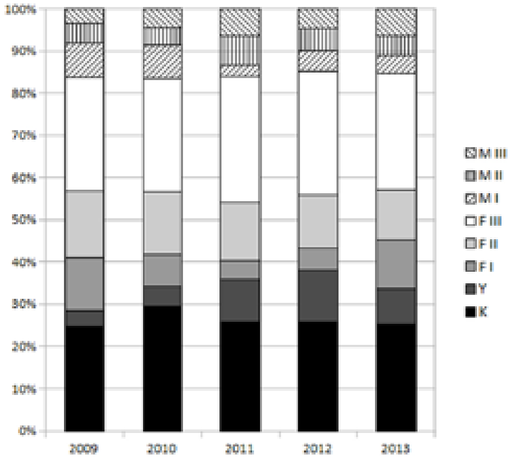

Figure 2. Chamois population structure in PNALM according to the standardized repeated counts: variation across the last 5 years. M = male; F = female; K = kid; Y = yearling; I-II-III are age classes according to Lovari (1985).

Competition with other ungulates

Red deer density in chamois area (i.e. layer 1, which overlapped the most with chamois extent of occurrence) resulted on average 18.7 red deer/km² (95% C.I. = 7-30). Nonetheless, the spatial overlap between chamois and red deer on grazing pasture was low (Pianka index = 0.35, min-max = 0.29-0.49 across the sample areas); the maximum value was registered at M. Amaro, the minimum at La Meta – Tartari. This result may be related to the different habitat use registered for the two species: according to the pellet-group count performed on grazing pastures, the chamois showed a highly significant positive selection for the steepest areas, whereas the red deer avoided them. Moreover, the red deer avoided the rockiest parts, which were instead used by chamois according to availability. Slope exposures were also differently used (see Latini et al. 2012).

Thus, it seems that the competition between the two species is more related to space use and segregation rather than overlap on feeding pastures. The undoubtedly widespread presence of red deer may contribute, along with other factors, to confine the chamois in even more restricted areas.

Livestock is present with notable numbers and diversity at Rocca Altiera and La Meta-Tartari, and much of it graze illegally. Its widespread presence might contribute to the relegation of chamois herds.

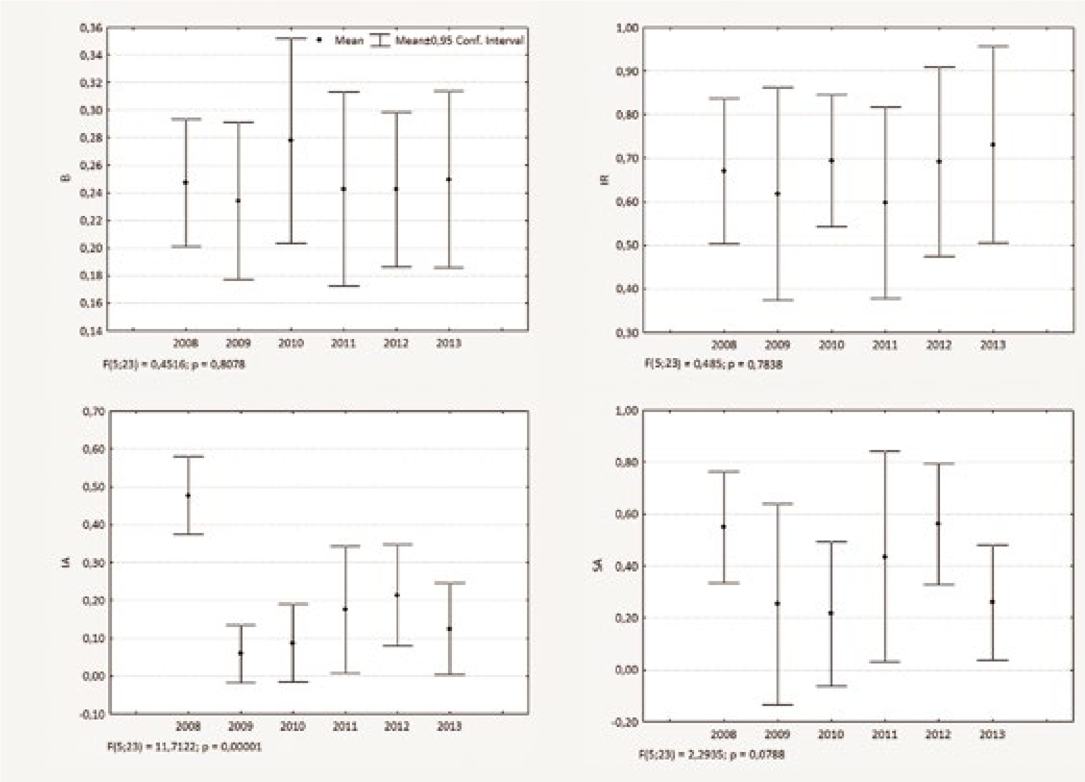

Figure 3. Temporal variation of the main demographic parameters according to the standardized repeated counts data.

MAIN CONCLUSIONS

According to our results, we can generally conclude that:

- chamois population in PNALM has known a phase of generally negative trend;
- kids survival and recruitment index have shown a negative trend, which is typical of a mountain-dwelling ungulate population under density-dependent processes;
- chamois density can be locally very high;
- there has been no further range expansion in the last 10 years;
- red deer are occurring at high local densities within chamois range;
- domestic ungulates are widespread and in close proximity with chamois herds, especially in the southern part of chamois range (La Meta-Tartari and Rocca Altiera);
- illegally grazing livestock is also widespread, mostly at La Meta-Tartari;
- spatial competition with red deer is occurring, despite the small overlap on grazing pastures due to different habitat use;
- bruncopulmonar strongyles are occurring with high prevalence and intensity in all the sample areas and the infestation in chamois population seems to be increased in recent years;
- recurrent pulmonary problems were found, mostly due to widespread strongyles occurrence, consistently with what resulted from the parasitological analysis;
- serological positive values in chamois were found only at La Meta and their very low occurrences exclude disease transmission with livestock, although livestock represents a potential reservoir for many diseases.

MANAGEMENT PLAN

For developing the operational management plan we reviewed the National Action Plan for the chamois, which dates back to 13 years (Dupré et al. 2001), considering the results gathered in the action C2 (along with others). The basic and broad aim of the Plan was to give as much as it was possible a proper space to the Apennine chamois. In order to achieve such objective, we selected a number of concrete actions to contain the presence of livestock on pastures, e.g. including some areas in the Reserve and also by persecuting illegal grazing. New legal instruments, such as a specific code regarding livestock grazing, will be provided to all the institutions involved.

This code will include also a more strict sanitary control on domestic animals, with special concern for the diseases not subjected to state prophylaxis. The local stakeholders and officials will be obviously involved in the decision-making process. Other actions at lower priority include for instance a protocol for internal translocation of individuals to facilitate the range expansion. In order to be effective, the application of the whole Plan will require also a further effort in personnel education. Within an adaptive strategy of management, a number of aspects – from population dynamics to competition with other ungulates – will be monitored to verify the achievements of the Plan.

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PARASITOLOGICAL SURVEY OF THE APENNINE CHAMOIS POPULATIONS OF THE MAJELLA, GRAN SASSO E MONTI DELLA LAGA AND ABRUZZO, LAZIO E MOLISE NATIONAL PARKS

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BACKGROUND

In the first decade of the century, poor recruitment and a negative demographic trend have been observed in the Apennine chamois (*Rupicapra pyrenaica ornata*) within the core area of the Abruzzo, Lazio e Molise National Park (PNALM). Amongst other mechanisms, a parasite-mediated competition with reintroduced and abundant red deer (*Cervus elaphus*) has been called into question. However, little is known of the parasitic community harbored by the vulnerable Apennine chamois in current distribution area.

OBJECTIVES

This study was conceived to explore the composition, prevalence and intensity of endoparasites at the ornata/deer/livestock interface, by means of coprological non invasive methods. We expected that, in case of parasite-mediated competition between deer and chamois (suggested by the fore mentioned negative demographic trend), the latter would suffer from higher parasitism when in closer contact with the former. A second objective was to add knowledge on endoparasites in the Apennine chamois.

METHODS

Within PNALM, three study areas (SA) were identified. In SA1 chamois were in close contact with deer from late spring into autumn (>80% spatial overlap; Lovari et al. 2014); in SA2, temporal overlap between chamois and deer were similar but spatial overlap was lower (approximately 50%; Ferretti com. pers.); in SA3, deer were only occasionally observed, however chamois were in contact with transhumant livestock (mainly sheep and goats) during summer. Livestock grazing is not allowed in SA1 and SA2. In the last decade, the chamois have been in negative demographic trend (>40%) in SA1 and SA2, while the density of deer has increased to >10 individuals per 100 ha (Latini et al. 2011). As opposite, chamois in SA3 have been increasing in number. During sampling sessions, Authors clearly noticed that chamois in SA3 had better recruitment rate and body condition than in SA1 and SA2.
Between June and November 2012 and 2013, fecal samples of chamois and deer were synchronously collected in the three SAs on occasion of eight monthly sessions. Samples were refrigerated and analyzed within few days with standard coprological methods. As a complement, i) fecal pools of chamois (N=11) were cultured to identify at the genus level *Trichostrongylidae* other than *Nematodirus* and *Marshallagia* (GINs); ii) aliquots of individual fecal samples of chamois (N=20) and deer (4) were preserved in 2% potassium dichromate solution to permit identification of *Coccidia* at the species level, according to available keys. To permit comparison between ornata sub-populations, additional fecal samples were collected from the chamois and the deer in the Majella National Park (PNM), and the chamois in the Gran Sasso e Monti della Laga National Park (PNGSL) on occasion of three and two sampling sessions, respectively.
Prevalence (PVL) data were analysed with Mantel-Haenszel and Yates corrected Chi-Squares, while Intensity (INT) data were analysed with Mann-Withney U test and Kruskall-Wallis test.

RESULTS

Composition of the parasite fauna

No trematodes were found. In chamois, Cestodes (fam. *Anoplocephalidae*) were present as well the following nematode taxa: *Trichostrongylidae* (including *Ostertagiinae, Haemonchus, Trichostrongylus*, *Chabertia/Oesophagostomum*, *Nematodirus* and *Marshallagia*), *Strongyloides, Trichuris, Protostrongylidae* (including *Protostrongylus, Muellerius* and *Neostrongylus*). *Coccidia* were also present, including four of the five Eimeriid species reported so far in representatives of the *Rupicapra* genus (*Eimeria alpina*, *E. rupicaprae*, *E. riedmülleri*, *E. yakimoff-matschoulsky*). In deer, we found Cestodes (fam. *Anoplocephalidae*), *Trichostrongylidae* (including *Ostertagiinae* and *Trichostrongylus*), *Dictyocaulus*, *Protostrongylidae* (including *Varestrongylus*) and *Coccidia* (including *E. austriaca* and *E. sordida*).

Diversity of endoparasites was remarkably lower in deer than in chamois. As expected from literature, the parasite community of these hosts was mainly composed of different species or genera.
Due to their prevalence, three taxa – *Coccidia* (EIM), *Protostrongylidae* (PN) and *Trichostrongylidae* other than *Nematodirus* and *Marshallagia* (GINs) – were used as "markers" to further compare parasitism amongst investigated hosts and SAs.

Coccidia (EIMs)

EIMs were present in almost all chamois (PVL=98%, a sort of "background noise" in this host), though they were less prevalent in deer (PVL=24%; P<.001). INT was also different, on average 8970 oocysts/gram (OPG) in chamois and 384 OPG in deer (P<.001). Very high INT values (≥50.000 EPG) were occasionally recorded in chamois, in association with small-sized fecal pellets eventually belonging to kids.
Amongst PNALM chamois, INT differed between SAs in four sampling sessions, with higher values prevailing in SA3 (in 3 of 5 significantly different combinations).
No differences were found between ornata sub-populations.

Trichostrongylid nematodes (GINs)

In PNALM, GINs were present in 71% of chamois and 9% of deer (P<.001). INT values were 240 eggs/gram (EPG) in chamois and 8 EPG in deer (P<.001).
INT differed between SAs in four sampling sessions, with higher values prevailing in SA1 and SA3 (two sessions each) and lower values occurring in SA1 (one session), SA2 (two) and SA3 (one). High EPG values were recorded in approximately one third of PNALM chamois (500-2000 EPG in 18.9%; >2000 EPG in 12.6%). Of 488 identified larvae, 63% belonged to *Haemonchus*, 25% to *Ostertagiinae*, 11% to *Trichostrongylus* and 1% to *Chabertia/Oesophagostomum*.
GINs were more prevalent in PNALM than PNM (32%; P<.001) though PVL did not differ between PNALM and PNGSL (54.5%). INT was significantly higher in PNALM compared with PNM and PNGSL (P<.001). No chamois in PNM and PNGSL had GIN values >500 EPG.

Pulmonary nematodes (PNs)

In PNALM, PNs were present in 47% of chamois and 3% of deer (P<.001). INT values were 171 larvae/gram (LPG) in chamois and 2 LPG in deer (P<.001).
INT differed between SAs in five sampling sessions, with higher values prevailing in SA2 (three sessions) and lower values occurring in SA1 (three sessions), SA2 (two) and SA3 (four). High LPG values were recorded in approximately one third of PNALM chamois (500-2000 EPG in 32.3%; >2000 EPG in 4.7%).
PNs were more prevalent in PNALM than PNM (18%; P<.001) whereas PVL was higher in PNGSL than PNALM (65.5%; P<.05). INT was significantly higher in PNALM compared with PNM (P<.001) though not with PNGSL.

Discussion

Evidence (and abundant though often "grey" literature) shows that PNALM chamois are exposed to intense parasitism by EIMs, GINs and PNs. Remarkably, the blood feeding *Haemonchus* is dominant genus amongst GINs.
Intensity of parasitism by GINs is obviously greater in chamois from PNALM than in the other sub-populations of *R. pyrenaica ornata*. It may be the consequence of different climatic conditions (e.g., higher rainfall and temperatures and lower altitudes in PNALM) and/or life history traits, since it is reasonable to assume that expanding populations (like in PNM and PNGSL) may be relieved from intraspecific density-dependent parasitism.
Deer are very little exposed to parasitism and taxa affecting deer are mainly different from those found in chamois. Moreover, the expectation that chamois would suffer from higher parasitism when in closer contact with deer (as in SA1) was not fulfilled. Accordingly, the hypothesis of a (direct or indirect) parasite-mediated competition to the detriment of PNALM chamois is not supported by results of this study. In the investigated model, there is still place for the complementary hypothesis that endoparasites in chamois may enhance the metabolic effects of a low quality diet due to competition with invasive deer, as recently suggested (Lovari et al. 2014). A dedicated study including experimental treatment of selected individuals (e.g., nursing females) with long-acting anthelmintics would be desirable.
Under the conditions of this study, contacts with livestock (as in SA3) did not seem to represent an important risk factor for parasitism or fitness in sympatric chamois. Hence, in the short term, strategic anthelmintic treatments of livestock do not have the potential to relieve PNALM chamois from intense parasitism which, in fact, is mostly intraspecific in origin. On the other hand, antiparasitic control schemes (as well as selected vaccinations) of livestock at the interface with chamois seem desirable in general terms to anticipate the spill-over of other pathogens.
Finally, high intensity of parasitism by GINs (mainly *Haemonchus*) and PNs in approximately one third chamois living in the core area of PNALM must be taken into account would captures and handling be necessary for research purposes. In this case, protocols should be adapted to the risk of manipulating individuals with parasite induced anaemia or reduced ventilation.

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HAEMATO-BIOCHEMICAL PARAMETERS AND STRESS MARKERS IN THE APENNINE CHAMOIS (*Rupicapra pyrenaica ornata*)

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Wildlife management programs are traditionally defined on the basis of demographic and morpho-biometric data. Moreover information about the health status of these populations and, in particular about the spread of infectious diseases, are usually taken into account in the definition of management plans. On the contrary the metabolic status of free-ranging animals is rarely adequately evaluated even if it can be useful in providing information about populations' health status. For these reasons, the Department of Veterinary Sciences and Public Health (Università degli Studi di Milano) investigated, as a part of the Life Coornata Project, (1) the haemato-biochemical parameters of captured Apennine chamois and (2) the markers of chronic stress through the evaluation of the faecal cortisol metabolites of free ranging Apennine chamois.

HAEMATO-BIOCHEMICAL PARAMETERS

The evaluation of the haemato-biochemical profile of free-ranging populations have to take into consideration biological variables, such as sex, age, physiological status (pregnancy, lactation, mating), diet, and other extrinsic stressors (capture, climatic-environmental, anthropogenic, social, intra-and interspecific competition) since these variables can influence metabolic blood parameter trend (Sartorelli et al. 1994, Geffré et al. 2009). Nonetheless the analysis of the haemato-biochemical profile of wildlife presents several difficulties: although the mechanical or tele-anesthesia capture ensures the quality of the collected sera (Pérez et al. 2003, Lopez-Olvera et al. 2006), the capture method can increase the serological stress hormone levels and thus can affect the metabolic status of subjects. There is a need therefore to collect a representative sample with a description of the physio-pathological variables and environmental factors that may have an effect on each haemato-biochemical parameter in order to establish reference ranges for the studied population. Moreover the emerged data can be useful for both an in-depth evaluation of the host-parasite relationship (Citterio et al. 2000), particularly regarding the presence of pathogens with sub-clinical manifestations, and in the definition of management plans.
A total of 106 sera (Table 1) were sampled using four different capture methods (Table 2).

Area	Sample size	Sampling year
Gran Sasso Monti della Laga National Park (PNGSL)	8	2011/2013
Abruzzo Lazio Molise National Park (PNALM)	65	1993/1996 – 2008 – 2011/2012
Majella National Park (PNM)	9	2011/2013
Fenced areas (faunistic areas)	24	1992/1995 – 2001 – 2012
TOT	**106**	

Table 1. Overall sample in relation to each Park and sampling period.

Capture method	Sample size
Tele-anesthesia	95 (4 deaths)
Net + Tele-anesthesia	3
Box-trap	2
Up-net	6
TOT	**106**

Table 2. Overall sample in relation to the capture method.

Haemato-biochemical analysis were carried out using the Cobas MIRA (Roches, Basilea, Svizzera) instrument. Below is the list of the investigated parameters and relative diagnostic techniques:

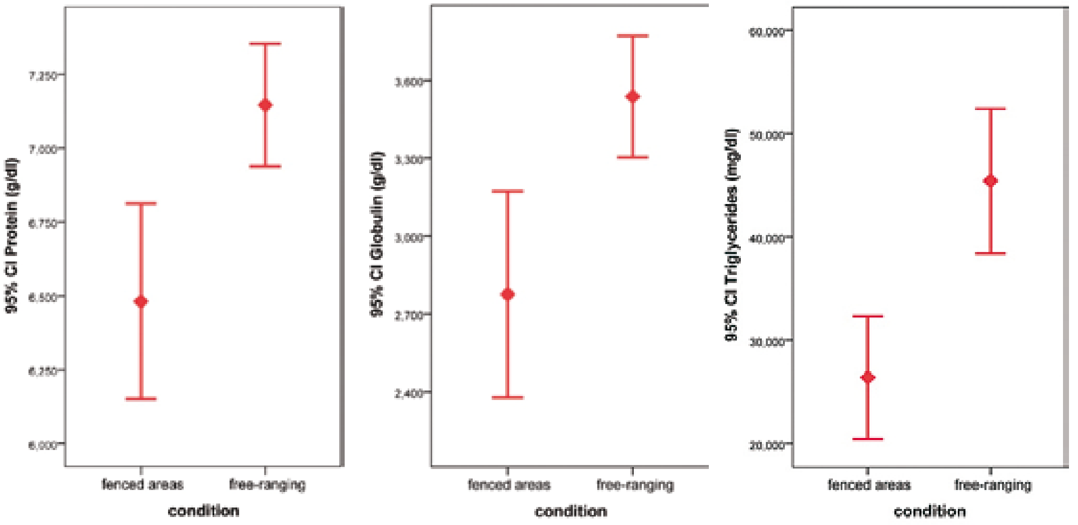
Parameters related to muscle damage:
- Creatine Kinase (CK): kinetic method (340 nm);
- Aspartate Aminotransferase (AST): IFCC method.

Parameters of lipid metabolism:
- Triglycerides: enzymatic colorimetric method;
- Cholesterol: enzymatic colorimetric test.

Parameters of protein metabolism:
- Urea: urease colorimetric method;
- Creatinine: modified Jaffé method;
- Total Protein: biuret colorimetric method;
- Albumin: colorimetric bromcresol (BCG) methods;
- Globulin: obtained by the difference between total protein and albumin.

Parameters of mineral metabolism:
- Calcium: the o-Cresolphthalein colorimetric method;
- Phosphorus: molybdenum colorimetric method;
- Sodium and Potassium: flame photometer (FP20, SEAC, Florence).

Statistical analysis points out that the values of protein (Protein and Globulin) and lipid (Triglycerides) parameters of free-ranging Apennine chamois are significantly lower (ANOVA Test, $p<0.01$) than those of subjects captured within fenced areas.



Figures 1, 2 and 3. Confidence interval (C.I. 95%) of serum Protein, Globulin and Triglycerides levels recorded in free-ranging chamois and in chamois sampled in fenced-areas.

Concerning sampling year, a significant increase of Albumin (ANOVA, p <0.01) was recorded in 2008. This fact could be ascribed to the very dry climatic conditions of this year (summer rainfall was reduced by 50% compared to normal season) that could have provoked dehydration in subjects.

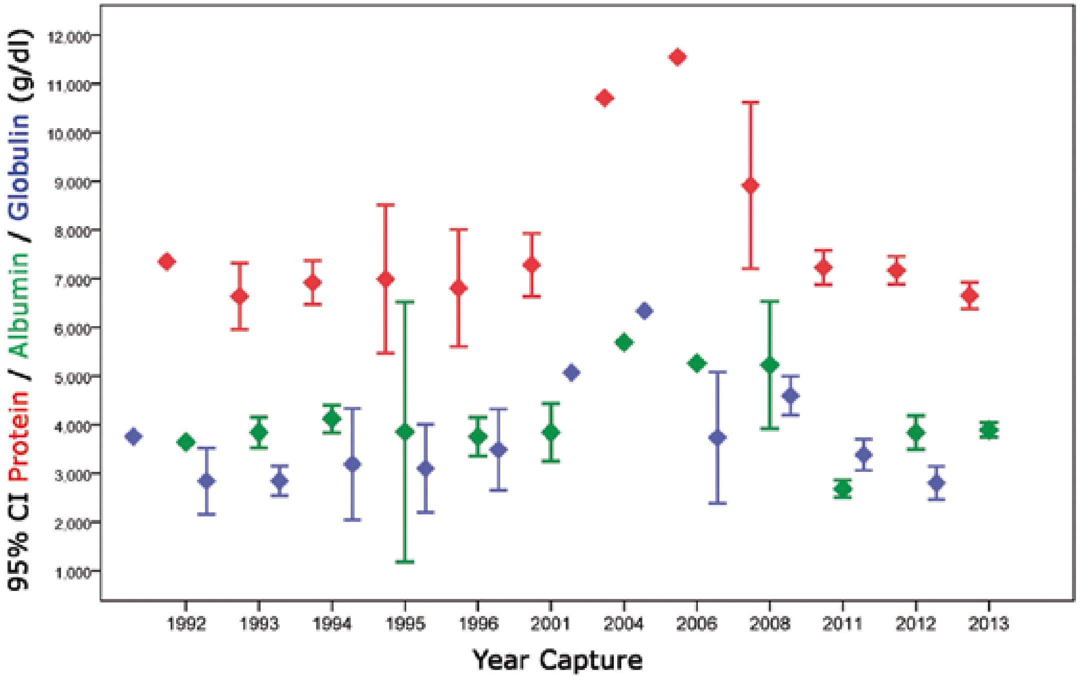
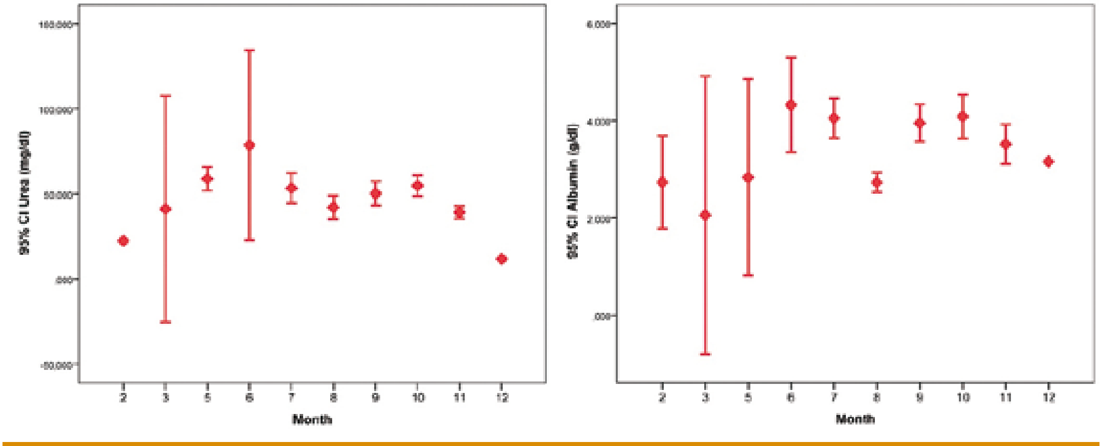
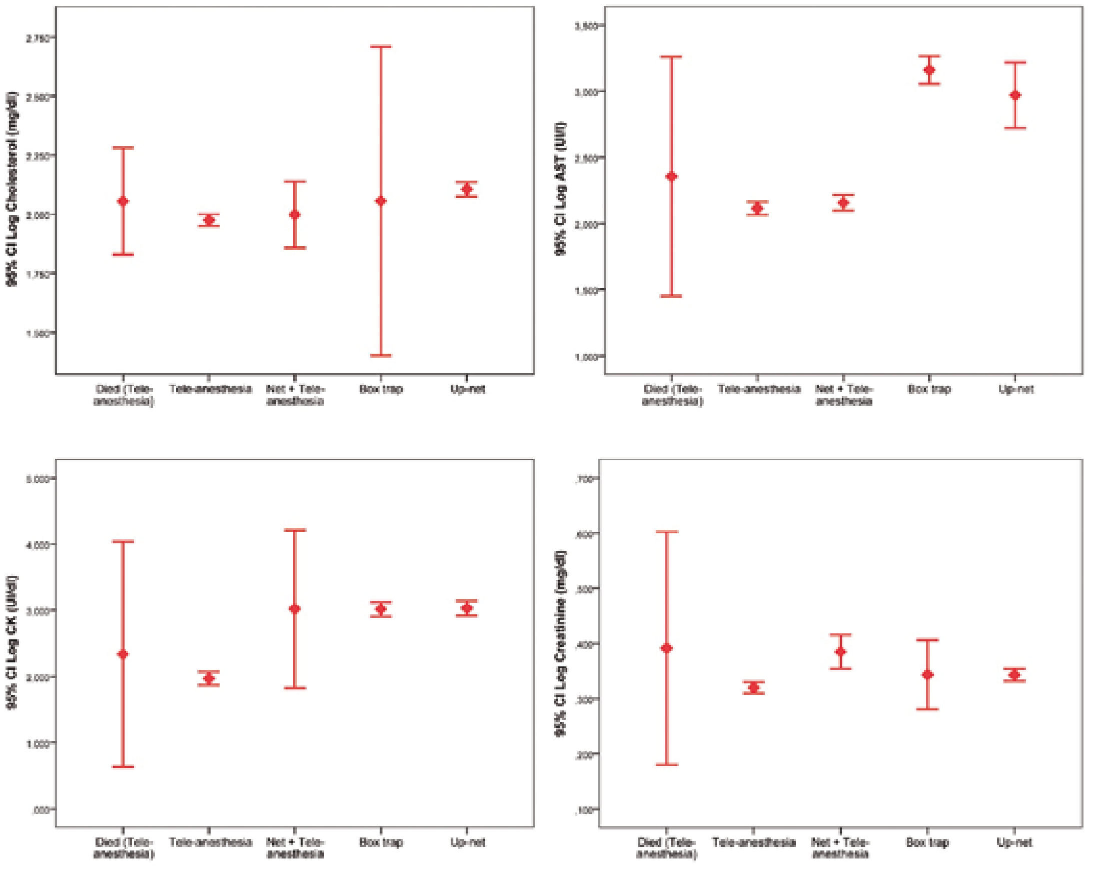


Figure 4. Confidence interval (C.I. 95%) of serum Protein (red), Albumin (green) and Globulin (blue) levels recorded in each sampling year.



Figures 5 and 6. Confidence interval (C.I. 95%) of serum Urea and Albumin levels recorded in each sampling month.

As haemato-biochemical parameters can be influenced by the season and the quality of the pasture depending by the period of sampling, Urea and Albumin show a sinusoidal pattern with higher values recorded during spring/summer and lower during winter.



Figures 7, 8, 9 and 10. Confidence interval (C.I. 95%) of serum Cholesterol, AST, Creatine kinase and Creatinine levels in relation to the different capture methods (Tele-anesthesia, Net + Tele-anesthesia, Box-trap, Up-net).

A slight increase of Cholesterol value was recorded in adult males captured in proximity to the mating (the cholesterol is indeed the precursor of steroid hormones) and in several adult females, likely during lactation. However kid Cholesterol values did not show statistical differences with adult concentrations although this parameter should be significantly higher in kids because their diet is supplemented with breast milk. This aspect requires therefore further investigations.

A significant increase of stress indicators and parameters of muscle damage (Cholesterol, Creatinine, CK and AST / GOT) was recorded in subjects died during the capture activities and in those captured using methods that can cause prolonged stress (Box-trap net and Up-net®). Moreover, values of Phosphorus of died subjects were double (13.7 ± 4.96 mg / dl) the amount of those registered in survived chamois (6.5 ± 1.81 mg / dl).

Therefore, for each parameter, the evaluation of the reference ranges was performed according to Geffré et al. (2009) considering the emerged differences between free-ranging populations and subjects in fenced areas, climatic conditions, the seasonal variability (feeding, reproduction, etc.), capture methods and mortality.

Below the estimated reference values for the studied population:

	Nr	Mean	Std Dv	Std Er	VC %	IC 95%		min	MAX
Protein (g/dl)	98	6.98	0.913	0.092	13.08	**6.80**	**7.17**	4.98	10.02
Albumin (gr/dl)	98	3.68	0.720	0.073	19.57	**3.54**	**3.83**	1.83	5.24
Globulin (gr/dl)	104	3.36	1.074	0.105	31.96	**3.15**	**3.57**	1.14	6.30
Cholesterol (mg/dl)	90	96.20	28.147	2.967	29.26	**90.30**	**102.10**	54.00	205.00
Triglycerides (mg/dl)	82	45.41	31.883	3.521	70.21	**38.41**	**52.42**	9.00	155.00
Urea (mg/dl)	81	50.87	19.228	2.136	37.80	**46.62**	**55.12**	11.80	158.00
Creatinine (mg/dl)	91	1.10	0.239	0.025	21.73	**1.05**	**1.15**	0.68	1.78
CK (UI/L)	84	97.65	87.963	9.598	90.08	**78.57**	**116.74**	6.00	545.00
AST/GOT (UI/L)	89	140.00	86.968	9.219	62.12	**121.68**	**158.32**	61.00	504.00

Table 3. Sample size (N°), mean, Standard deviation (Sta. Dv.), Standard error (Std. Er.), VC (valuation coefficient), CI 95%, minimum (Min) and maximum (Max) of haemato-biochemical parameters emerged from the analysed sera.

Considering sampling years 2011/2013:

	PNALM			PNGSML			PNM		
	Nr	Mean	Std Dv	Nr	Mean	Std Dv	Nr	Mean	Std Dv
Protein (g/dl)	23	7.38	0.682	8	6.83	0.348	9	6.77	0.432
Albumin (gr/dl)	23	3.22	0.913	8	3.45	0.702	9	3.77	0.271
Globulin (gr/dl)	23	4.16	0.991	8	3.38	0.920	9	3.00	0.537
Cholesterol (mg/dl)	23	89.65	19.768	8	86.25	12.892	9	124.44	11.534
Triglycerides (mg/dl)	24	40.92	21.291	8	88.00	29.379	9	83.33	47.173
Urea (mg/dl)	23	50.19	14.489	8	49.43	19.777	9	37.09	9.727
Creatinine (mg/dl)	23	1.04	0.208	8	1.20	0.208	9	1.20	0.045
CK (UI/L)	23	100.96	62.978	8	1858.12	1501.778	9	968.59	393.263
AST/GOT (UI/L)	24	138.58	48.600	7	255.29	119.105	9	1025.33	541.600

Table 4. Sample size (N°), mean, Standard deviation (Std. Dv.), Standard error (Std. Er.) of haemato-biochemical parameters emerged from the sera analysed during sampling years 2011/2013.

In PNGSL and PNM nets, box traps and up-net were used as capture methods. This fact appears to have provoked an increase of Cholesterol and Creatinine values: concentrations are indeed significantly higher than those registered in areas in which tele-anesthesia was the capture method.

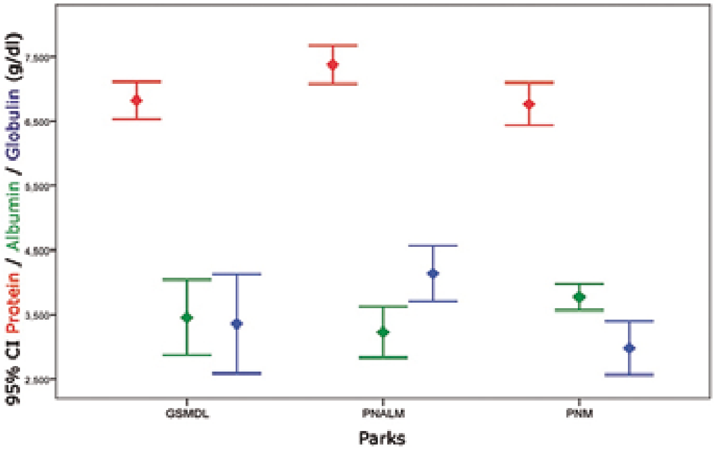


Figure 11. Confidence interval (C.I. 95%) of serum Protein (red), Albumin (green) and Globulin (blue) levels recorded in the three parks (PNGSL, PNALM, PNM).

In PNALM values of Globulins were significantly higher than those registered in the other two parks. Further investigations are desirable to deepen this aspect since this rise of concentrations could be the expression of a reaction of the population to a disease with sub-clinical manifestation that has already developed an immune reaction in infected subjects.

FAECAL CORTISOL METABOLITES (FCM)

Free-ranging populations are constantly exposed to several biotic and abiotic factors that can affect animals' fitness and their population dynamics. All disturbance factors (e.g. seasonal changes in climate, resource availability, and human disturbance) have indeed the potential to alter animals' status and to cause stress responses. Wild animals can cope with these adverse events producing glucocorticoids that help to overcome stress (e.g. to ensure survival and a progressive return to «normal» life (from Baltic et al. 2005)) although these adverse circumstances, if repeated, may induce a chronic stress state that can play a serious role in populations' decline (Baltic et al. 2005).
As concentrations of these faecal stress hormone metabolites reflect levels in the plasma, the quantification of faecal metabolites of glucocorticoids is therefore a valuable tool to biomonitor the endocrine status of wild populations (Touma & Palme 2005) and to investigate retrospectively (previous 1–2 days) their physiological stress response to adverse events. In particular, non-invasive techniques (Palme et al. 1999, Huber et al. 2003) are useful to evaluate the individual or population welfare, the behavioural ecology of free-ranging populations and can have a great application in conservation biology and in the definition of management plans. Moreover faecal samples can be easily collected avoiding any interference with the studied populations or without any animals' manipulation and handling unlike traditional techniques, such as blood sampling. In particular, traditional sampling methods can increase adrenocortical activity and thus bias blood glucocorticoid concentrations.

Overall 194 Apennine chamois fresh faeces were sampled. In September 2012, a total of 150 samples were collected in three areas:

- Apennine chamois only (C);
- overlapping of Apennine chamois and red deer (CC);
- overlapping of Apennine chamois and cattle and sheep and goat flocks (CD);

within each of the three Parks (PNALM, PNM and PNGSL) while other 44 fresh faeces were sampled in November 2012 in the three areas of PNALM (Table 5 and Table 6). Therefore, in collaboration with the Department of Biomedical Sciences/ Biochemistry at the VetMedUni Vienna, we used a non-invasive method (Sheriff et al. 2011) to investigate the physiological stress response (faecal cortisol metabolites) of free-ranging Apennine chamois induced by different disturbed areas. In particular, we made a comparison between the three Parks in order to evaluate the effects of contrasting levels of disturbance (presence of flocks and herds, anthropogenic impact, presence of red deer) on Apennine chamois hormonal stress responses.

Parks	Area	Sample size	Interspecies interactions	Colony formation	Censused chamois	Cattle	Ovine flocks	Caprine flocks	sheepdogs	predators		Infrastructures
PNGSL	Monte Tremoggia / Monte Coppe	18	Cattle	1992	457	450	0			No	No	No
	Monte Corvo	12	Chamois	2007								
PNALM	Monte Meta	20	Flocks + herds		207	1866	3281	1190	46	Sì	Reg.	No
	Monte Amaro	22	Chamois		82	22	41		4	Sì	Reg.	No
	Rocca Altiera	14	Cattle		38	1031	786	330	28	Sì	No	No
	Val Di Rose	20	Red deer		155	0	581	140		Sì	Reg.	No
PNM	Acquaviva Sud / Valle Mandrelle	40	Ovine and caprine flocks		158		130			No	Sì	No
	Anfiteatro Murelle	27	Chamois		88					No	Sì	
	Focalone / Mucchia Cara-manico	21	Red deer		40					Sì	No	

Table 5. Overall sampling in relation to the characteristics of the sampling areas within the three National Parks (PNALM, PNM and PNGSL); (Reg. = regimented).

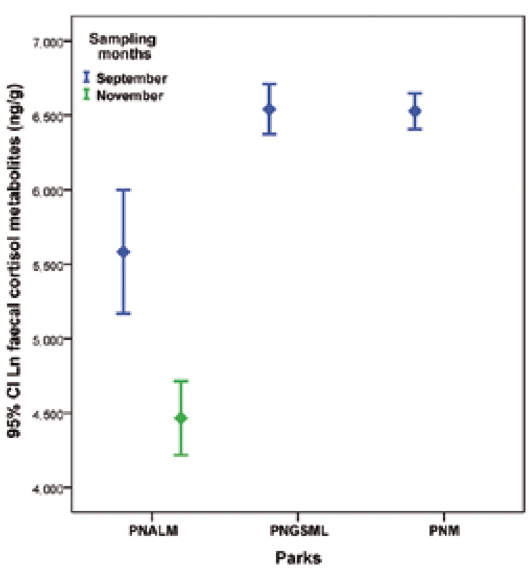


Figure 12. Confidence interval (C.I. 95%) of faecal cortisol metabolite concentrations recorded in the three parks (PNALM, PNGSL, PNM) in each sampling month (September, November).

In each park, FCM values registered in CD areas are significantly higher than those recorded in C and CC areas. Moreover no significant differences of concentrations were registered among CD areas of the three parks. Concerning the presence of livestock, FCM values indicated that the presence of sheep and goats appears to have a greater impact than cattle (ANOVA: $p < 0.05$) on apennine chamois.

In PNALM, in which sampling was carried out in both September and November, a significant difference of FCM values was observed between sampling months: levels were significantly lower in November when domestic ruminants are not grazing (ANOVA: $p < 0.001$).

		Sample size	Mean	Std Dv	CI 95%	
PNALM	**September**	12	**420.31**	302.055	228.39	612.23
	November	10	**161.54**	134.438	65.36	257.71
PNM	**September**	27	**541.59**	236.429	448.06	635.12
PNGSL	**November**	12	**876.94**	413.483	614.22	1139.65

Table 6. Sample size (N°), mean, Standard deviation (Std. Dv.) and confidence interval (C.I. 95%) of faecal cortisol metabolite concentrations in relation to the three parks (PNALM, PNM, PNGSL) and sampling month (September and November).

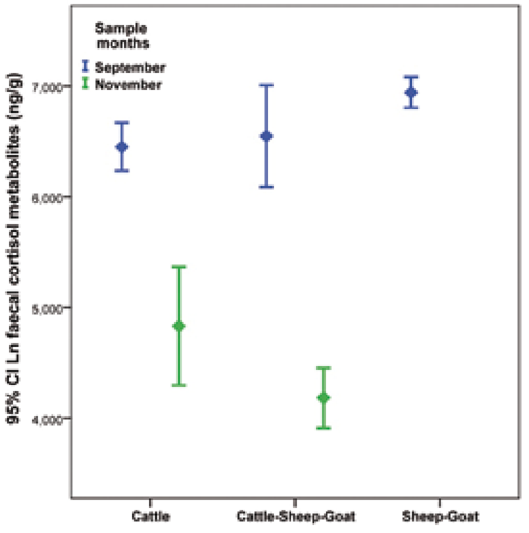
FCM values recorded in CC areas are the lowest (ANOVA: $p < 0.01$) among the whole observed concentrations.

		Nr	Mean	Std Dev	IC 95%	
September	Cattle	40	1128.84	488.072	972.75	1284.94
	Sheep-Goat-Cattle	10	852.02	617.473	410.30	1293.73
	Sheep-Goat	18	688.75	300.816	539.15	838.34
November	Sheep-Goat-Cattle	10	69.14	27.995	49.11	89.16
	Sheep-Goat	14	207.03	272.634	49.61	364.44

Table 7. Sample size (N°), mean, Standard deviation (Std. Dv.) and confidence interval (C.I. 95%) of faecal cortisol.

		Nr	Mean	Std Dev	IC 95%	
September	**Chamois**	12	420.31	302.055	228.39	612.23
	Red deer	10	101.66	68.401	52.73	150.59
	Sheep-Goat-Cattle	10	852.02	617.473	410.30	1293.73
November	**Chamois**	10	161.54	134.438	65.36	257.71
	Red deer	10	53.19	26.891	33.95	72.42
	Cattle	14	207.03	272.634	49.61	364.44
	Sheep-Goat-Cattle	10	69.14	27.995	49.11	89.16

Table 8. Sample size (N°), mean, Standard deviation (Std. Dv.) and confidence interval (C.I. 95%) of faecal cortisol metabolite concentrations in relation to the Interspecies interactions (chamois, red deer, cattle, cattle-sheep-goat) and sampling months (September, November) within PNALM.



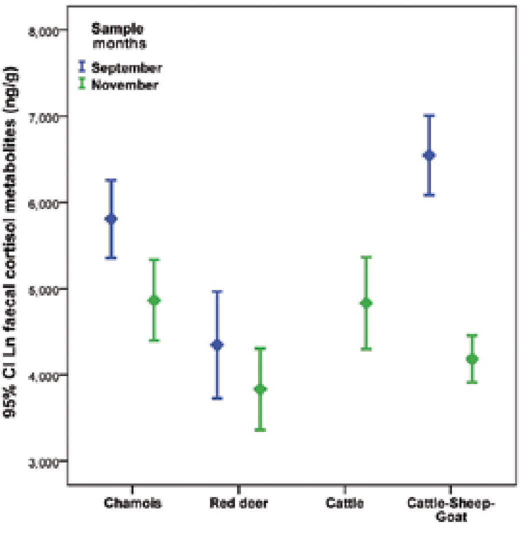


Figure 13. Confidence interval (C.I. 95%) of faecal cortisol metabolite concentrations in relation to the presence of livestock (cattle, cattle-sheep-goat, sheep-goat) and sampling months (September, November).

Figure 14. Confidence interval (C.I. 95%) of faecal cortisol metabolite concentrations in relation to the Interspecies interactions (chamois, red deer, cattle, cattle-sheep-goat) and sampling months (September, November) within PNALM.

Concerning C areas, animals from PNGSL had significantly higher values of cortisol metabolites than those in the other two parks (ANOVA: $p < 0.001$). The fact that this chamois colony is the more recently formed could support these observed most elevated values.

In conclusion, the presence of livestock, particularly sheep and goats, appears to affect apennine chamois. On the contrary red deer seem not to negatively affect chamois since these two species have distinct habitats and interactions between them are limited, at least in the sampling periods.

Further analyses are needed to investigate the hypothesis that the high FCM concentrations observed in PNGSL could be related to the recent formation of this colony.

Non-invasive method for measuring stress is much than useful to achieve information on threatened species populations, preventing animal handling and restraint, and represents a valuable tool for the health monitoring in wildlife.

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COMMUNICATION, RESULTS DISSEMINATION AND DEVELOPING OF EDUCATIONAL PROGRAMS TO FAVOUR THE BIODIVERSITY CONSERVATION: THE CASE OF THE LIFE COORNATA PROJECT

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The aspects related to communication, dissemination of results and development of educational programs implemented during the Life Coornata Project, started with two basic assumptions:

1) The protection of Apennine chamois is closely linked to the protected areas of the Central Apennines; this ungulate, to date, is present only in some Parks of Central Italy.
2) Thanks to the Life Coornata Project, for the first time, conservation activities were carried out in a coordinated manner by all the Parks of the Central Apennines.

To prepare the communication plan for the project, the first issue we pondered on was what to communicate. We identified two essential issues: the concrete actions of the project and informational aspects related to the territory and the species. We thus identified two distinct types of communication.

1) A strategic communication, to explain and divulge the EU's role in nature conservation and protection of biodiversity, the objectives and inherent value of the Natura 2000 network and the importance of protected areas in:
   - creating jobs in the field of park management, tourism, services, as well as in the development of forestry projects and territorial promotion;
   - strengthening of agriculture, forestry and pastoral activities, territorial safeguard, protection against wildfires and hydrological instability;
   - avoiding the depopulation of small towns.

2) A territorial communication, to divulge:
   - the protection of biodiversity, considering it one of the main objectives to be achieved;
   - the objectives and the value of Natura 2000 network;
   - the preservation of the Apennine chamois as an added value to the territories;
   - the main threats for the species;
   - limited number, restricted size of populations and low genetic variability;
   - demography of the historic population in the Abruzzo, Lazio e Molise National Park;
   - the need to increase the size of the population present in the Monti Sibillini National Park;
   - the need to create a new fifth population in the Sirente Velino Natural Park;
   - the health risks to be contained;
   - fauna and flora as natural heritage to be preserved and to be passed on to future generations;
   - the environment conceived as a combination of nature, culture and social cohesion;
   - protected areas as opportunities for the development in agriculture and tourism, especially in marginal areas such as mountainous small villages.

Two target groups were identified and they were:

1) A general audience, including pupils in primary schools in the territory of the 5 Parks involved in the Life Coornata Project, the teachers and the teaching staff of the schools individuated, the tourists of the areas involved in the project, the population of the municipalities involved in the project, tourism operators working in the project area, local administrators, associations, hunters, ranchers and livestock operators etc. Towards this target, communication was planned to convey, in addition to the above-mentioned values, also correct information regarding the proper behaviour to be adopted toward the chamois and its habitat.
2) Specialized audience, including the staff of the Parks and technicians, administrators, local stakeholders. In this case, communication has been focused to reiterate the importance of the system of protected areas in the socio-economical development of the territories, the opportunities of the protected areas as a driving force for the development of underutilized and marginal lands and the control and surveillance of the territory.

Regarding specifically the concrete communication actions of the Life Coornata Project, carried out under the responsibility of Legambiente, we will here illustrate the objectives pursued for each action and the results achieved.

Action D.1 – Dissemination and on-line publication of project results: the Permanent Coordination Committee.
The Committee, established in Lama dei Peligni on the 4th of November 2010 during the A2 Action, aimed to share the best strategies for the conservation of the species among all the most important administrations involved in the

management of the territories of the chamois. Particularly important is the contribution that the Committee will give to update the Action Plan for the Apennine chamois.

Action D.2 – Organization and preparation for the press conference to present the life project.

This was an Action during which it was included the organization of press conferences at the beginning and the end of the project, the publication of press releases and the elaboration of articles on local and national press.

Action D.3 – website on the Apennine chamois with pages dedicated to Life Natura Project.

During the development of this action two distinct web domains have been purchased both converging on the same web site (www.camoscioappenninico.it and www.coornata.eu). This was done to increase the site contacts and to facilitate web searches with a wide range of keywords. The website, in addition of being the site of the project, was also envisioned as a portal in which to publish all the collected news, curiosities and updates regarding the species. The site also hosts the geo-referenced database on the Apennine chamois. Additionally a Facebook page was also created to easily reach social network users, with more than 350 members to date.

Action D.4 – A brochure describing the project for Parks visitors.

The brochure is free-distributed in each of the protected areas involved at their information points. An important part in this document is the section devoted to the behaviours to have when in the mountains, in order not to cause disturbance to the animals.

Action D.5 – Production and positioning of information panels and notice boards in the Parks.

The panels produced, complete with noticeboard, were placed in the most strategic points of the footpaths of the different Parks.

Action D.6 – Educational video on the Apennine chamois.

The video, which lasts about 30 ', explains the motivations, goals, objectives of the project, starting from biology, ethology and habitat of the species, to understand the history of its recovery and the steps that led to the Life Coornata Project and its main conservation actions.

Action D.7 – Creation of an educational program for the schools of the protected areas, including an exchange of trips between classes of different villages of the Parks.

The educational program for students, which also included the creation of an educational and informative brochure targeted and designed for the specific audience, involved 51 school classes. Of these classes, a selected group constituted by representatives of each protected area (over 280 students) has been involved in field trips, planned as a contest of ideas named "Camo-show, Camosci appenninici in mostra. The contributions of all the classes involved in the educational project and the travel diary of the experience are available in the "school" section of the website. A final exhibition of the works submitted, has been part of the international congress (Action D.9). A questionnaire aimed to assess the level of knowledge of the Apennine chamois for the target of this action was made. The questionnaire was distributed to the students, but also through the pages of the website www.camoscioappenninico.it. A total sample of 523 questionnaires were processed (258 at the beginning of the action, and 265 distributed at the end). From the analysis of tabs collected it appears that among the students, before learning the prepared materials, there were major gaps in the knowledge of the subspecies in the questions concerning the size of the global population, the main risks to which the Apennine chamois are subject, the differences between the Apennines and the Alpine populations and their distribution on the Italian territory.

At the end of the educational action, the comparison of the answers given to the same questions seems to indicate a general increase in awareness of the school-aged children in relation to the knowledge of the species and its problems. In particular, they have now acquired the knowledge of the dietary habits of the chamois, the existence of the two species in Italy, they have learned the phenotype and habits of the species, as well as their principal threats. The results lead us to conclude that the material produced and the related educational experiences gained, may have had a positive effect on the knowledge of the Apennine chamois in the specific target of this action.

Action D.9 – Final meeting of the project

The International Congress whose proceedings are represented by this volume has been organized by the PNM, with Legambiente caring the communication aspects, during the Action D9. The development of this action has intersected with other communication activities, for example the event has been publicized through press releases, both with the national and local press. To call up further attention to this event, there was also a photo contest associated to the conference, widespread through the internet and social networks with the collaboration of the daily "Il Centro – Quotidiano d'Abruzzo".

Action D.11 – Organization of a press tour for journalists.

Journalists belonging to various newspapers, televisions and print media were given the opportunity to attend part of the international scientific congress and the various other sessions organized within the congress, to visit wildlife areas and typical scenarios of chamois capturing and releasing, to know the studies on the target species developed in the different Parks and to meet the technical staff of the protected areas.

Action D.12 – Periodic newsletter of the project

This was an Action during which newsletters were regularly sent to a mailing list of highly selected contacts (545 contacts). Questionnaires were spread with the first and last newsletters and the answers obtained have been compared. Results, also in this case, show an augmented knowledge by the public about all the subjects of the communication programme.

THE GENUS *RUPICAPRA*: AN OVERVIEW

THE EVOLUTIONARY BIOLOGY OF CHAMOIS: OLD VIEWS, NEW INSIGHTS AND GREY AREAS

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Over the last decade, research on the biology and ecology of chamois *Rupicapra* spp has sharply increased, with a growing number of scientific papers in peer-reviewed journals. In turn, new insights have been provided on evolutionary biology and ecology of these mountain ungulates which, in some cases, have provided support to hypotheses set up in the last century. When science is properly conducted, invariably a new finding generates new research topics: in fact, no discovery can ever be considered as the "ultimate one". A number of research issues still have to be clarified. In this article, we have summarised several main old views and some new insights on the evolutionary biology and ecology of chamois, eventually emphasising "grey areas" that will be given attention in future research.

OLD VIEWS (BEFORE THE '90S)

Several scientists distinguished themselves as those who contributed the most to stir interest and increase our information on the biology of chamois: Lorenzo Camerano (1856-1917), an Italian who wrote papers and monographs dealing with morphology, biometrics and taxonomy of *Rupicapra* spp, recognising the affinities of Iberian and Apennine chamois, and their distinction from the Alpine ones. Although he reflected the tendency of taxonomists early in the past century to split taxa into species, his observations and data have been very useful to later morphologists. The French surgeon Marcel A.J. Couturier (1897-1973) was another example: a very keen hunter, who shot hundreds of chamois, he did not just kill the animals in question, but he collected a vast number of precious data which he published later on in a fundamental book (Couturier 1938). In this Era, where only recent papers available on-line are assumed to be worth quoting, contemporary researchers may overlook the information available in Couturier's book, re-discovering insights he already had c. 80 years ago. The Austrian Wolfgang Schröeder (1941 – living) marked the time of "modern" research on chamois, with emphasis on ecology and hunting management. Over the years, he had many students working on chamois, with whom he published a number of papers. His book, written in collaboration with Werner Knaus, remains a milestone for anyone interested on chamois (Knaus & Schröder 1975). Other seminal papers kept appearing irregularly, e.g. the first detailed article shedding light on the social behaviour of chamois by Augustin Kraemer (1969), but the pioneer work of Camerano, Couturier and Schröder deserves special recognition.

Three topics may be considered as particularly important for our knowledge of chamois biology at large.
Masini & Lovari (1988) made an attempt at summarising and clarifying the phylogenesis, dispersal and palaeodistribution of chamois, concluding that the *Rupicaprini* appeared during the Miocene in Central Asia and repeatedly dispersed to Europe and to North America during the late Miocene-early Pliocene, the Villafranchian and the middle Pleistocene. To-date, the Villafranchian chamois-antelope *Procamptoceras brivatense* remains the closest known form to *Rupicapra* ancestor, in Europe. The Villafranchian North African form *Numidocapra* may be related to the chamois-antelope, but some palaeontologists think it is an alcelaphine, rather than a caprine. The chamois-antelope may have survived in eastern Europe and the Balkans up to the earliest middle Pleistocene, whereas the first fossils of *Rupicapra* date back to the middle Pleistocene, in France.

Chamois are sexually near-monomorphic mammals, during most of the year. Thus, one should expect a monogamous or mildly polygynous mating system, with comparable investment of the two sexes in reproduction. On the other hand, in the Austrian Alps, the analysis of life tables of hunted chamois showed a strongly sex-biased mortality pattern, with a life expectancy c. 1/3 lower in males than in females (Schröder 1971): a feature typical of most polygynous species. This pattern led to the believe that chamois were "highly polygynous" ungulates (Loison et al. 1999). On the other hand, more recently, studies on protected populations of chamois have suggested otherwise, with an even life expectancy for males and females (see below). It has turned out that trophy hunting determines a greater risk of mortality for males than for females, even in the relatively monomorphic chamois, perhaps because chamois hunting occurs in and around the rutting season, when males are particularly active and the most dimorphic from females (see below).

Sound information was very limited on the food habits of chamois in the Apennines, when Ferrari et al. (1988) started their study in the area with the highest chamois density, in the Abruzzo, Lazio e Molise National Park. These researchers found out that, in the warm months, forb patches dominated by clover *Trifolium thalii* are of great importance for herds of adult females, yearlings and kids (Ferrari et al. 1988). Clover and fescue patches – which are rare and extrazonal in the Apennines – have leaves rich in proteins and highly digestible, i.e. crucial food items, especially for nursing females and weaning kids (Ferrari et al. 1988). The importance of this information for chamois conservation has been appreciated some 25 years later (see below).

Krämer (1969) suggested that adult male chamois are territorial: this hypothesis was confirmed by studies conducted on the Italian Alps (Gran Paradiso Nat. Park), through radio-tracking and behavioural observations, which showed that adult males may defend territories from late spring to late autumn, when the rut occurs (von Hardenberg et al. 2000). In particular, alternative tactics of space use have been shown (Lovari et al. 2006), with territorial and non-territorial adult males (Corlatti et al. 2012a). Potential costs/benefits associated to these alternative mating tactics, in terms of mating advantages, foraging rates, parasite load and social stress, have been suggested (Corlatti et al. 2012a, 2013a-b, 2014).

Recent studies have shown that sexual size dimorphism (SSD) of chamois is seasonal, which contrasts with what found out for other polygynous ungulates, who show SSD throughout the year. In *R. rupicapra*, SSD is negligible in winter-spring, but males are c. 30-40% heavier than females, in autumn (mid-September to November; Garel et al. 2009, Rughetti & Festa-Bianchet 2011). As to *R. pyren*aica, no data are available on SSD but information on winter mass (Pyrenean chamois, Crampe et al. 1997) and seasonal changes of the kidney fat index (Cantabrian chamois, Pérez-Barberia et al. 1998) suggests that the pattern may be comparable – although less striking, which is intriguing – to that observed in *R. rupicapra*.

New insights on sex-specific survival have been provided by analyses of life tables and living populations, which showed that both sexes of chamois are unusually long-lived mountain ungulates (up to 17-22 years old, depending on study area; Loison et al. 1999, Gonzalez & Crampe 2001, Bocci et al. 2010, Corlatti et al. 2012b). These studies – conducted on protected populations – documented no sex-bias in survivorship (Gonzalez & Crampe 2001, Bocci et al. 2010, Corlatti et al. 2012), thus showing a completely different picture in respect to that obtained for a hunted population, on the Austrian Alps (Schröder 1971).

Analyses of carcass mass of chamois, shot in different study areas of the Central-Eastern Italian Alps provided data supporting hypotheses already suggested by Couturier (1938).
Mason et al. (2011) claimed that two tactics of reproductive investment may occur in male chamois: (i) prime-age concentrated investment or (ii) terminal investment. Further data are needed for non-hunted populations, to confirm this issue. Younger males were found to allocate the highest reproductive effort (RE) late in the breeding season, at a time when the RE of older males has decreased substantially (Mason et al. 2012).

On another topic, in an interesting paper where the effects of several ecological components were considered, Chirichella et al. (2013) reported that the geological nature of substrate, in interaction with aspect and snow cover, influences horn growth of yearlings. In particular, shorter horns were found in chamois living on a siliceous rather than on a calcareous substrate, irrespective of sex: another insight originally reported by Couturier (1938).

GREY AREAS

One of the main grey areas in the evolutionary biology of chamois is its phylogenetic origin, as little advancement – and no review – has been made since the '60-80s (Kurtén 1968, Masini & Lovari 1988). Taxonomic status should also be settled, as several recent papers have kept proposing that *Rupicapra* genus should be split into 1, 2 or 3 species, alternatively (e.g. Corlatti et al. 2011, for a review; Pérez et al. 2013). To this end, the interdisciplinary cooperation between palaeontologists, geneticists and zoogeographers will be unavoidable.

The effects of Climate Change on chamois should be investigated in depth: recent findings have suggested that body mass is affected by warm springs and summers over the first 2 years of life of chamois (Rughetti & Festa-Bianchet 2012), indicating a negative effect of raising temperature on chamois. However, the long term effects on population dynamics have not been unravelled, as the influence of temperatures may not be consistent across different sex-age classes (Willisch et al. 2013).

The reasons behind the unusual longevity of chamois – c. 1/3 to 1/4 longer than that of the other *Caprinae* – should be clarified. Furthermore, aspects of mating system and life histories require further analyses, which should assess costs and benefits of alternative mating tactics (Corlatti et al. 2012a), e.g. by evaluating male reproductive success through genetic assessment of paternity.

Especially for Apennine chamois *R. p. ornata*, local patterns of resource use have to be investigated in areas where these chamois have been released and have established new colonies. In particular, it should be assessed whether the newly established populations of chamois keep using clover patches dominated by *Trifolium thalii* and other forbs (cf. Ferrari et al. 1988, for Abruzzo, Lazio and Molise Nat. Park) or other plant associations. These studies could help predict the future dynamics of these populations in relation to climate changes and to the action of potential competitors (see below).

INTERSPECIFIC INTERACTIONS OF CHAMOIS REQUIRE FURTHER ANALYSES, AS IT IS A "HOT" ISSUE.

While predator-prey relationships of *R. rupicapra* have been assessed in respect to the Eurasian lynx *Lynx lynx* (Haller 1992, Molinari-Jobin et al. 2002, 2004), no data are available for *R. py*renaica, especially in the Apennines (cf. Patalano & Lovari 1993, who found out – in the Abruzzo, Lazio and Molise National Park – that chamois showed up very rarely in the diet of wolves, even when these mountain ungulates were the most abundant local wild prey species).
Relationships with livestock (especially sheep/goats) have been sampled, but results are inconsistent across studies and the potential for competition has been suspected rather than found (e.g. Rüttiman et al. 2008, La Morgia & Bassano 2010, Chirichella et al. 2013). As to relationships with wild ungulates, interactions between *R. rupicapra* and Mediterranean mouflon *O. aries* have been observed in the Alps, suggesting a potential for competition (Pfeffer & Settimo 1973, Chirichella et al. 2013, but see Darmon et al. 2012, 2014).
As to red deer *Cervus elaphus*, a great diet overlap with *R. rupicapra* has been reported (Schröder & Schröder 1984, Homolka 1996, Homolka & Heroldovà 2001, Bertolino et al. 2009), suggesting a potential for competition. In the central Apennines (Abruzzo, Lazio and Molise Nat. Park), an ongoing study has shown that grazing/trampling by red deer herds on food patches attended by chamois, in summer-autumn, affects the foraging efficiency and diet quality of female chamois and weaning kids, in turn reducing kid survival in winter (Lovari et al. 2014). The best food patches for chamois are also threatened by raising temperatures and by natural processes which would lead to the up-lift of the upper treeline (e.g. Lovari et al. 2014). The possible relationships between these factors in affecting population dynamics of chamois should be investigated further, as it may turn out a vital issue for the local viability of the threatened Apennine chamois. In the warm months, the impoverishment of key-food resources because of climate change and the ensuing competition with red deer may accelerate the local demise of chamois.

CONCLUSIONS

How to clear out "grey areas" regarding chamois biology? There is only one way: long term studies are needed.
Clutton-Brock & Sheldon (2010) wrote that many important questions in ecology and evolutionary biology can only be answered with data on recognisable individuals, followed over several decades. This type of data is lacking for chamois, as well as for quite a few other mammalian species. Chamois are long-living, K-selected mammals, with anatomical, physiological and complex behavioural adaptations to survive on mountains. Catching, individually marking through ear-tags, coloured or radio-collars, keeping a careful record of movements, measuring individual reproductive success, variation of body mass and lifespan, are all challenging tasks – but they can be accomplished, provided three assumptions are met.
Ideally, a funding agency is necessary, it has to be willing to invest in long term projects: funding should not be provided on a yearly basis, as sound results can only be obtained by careful planning done in advance. A far-sighted agency is also necessary, promoting or just allowing the conduct of these studies within a suitable study area e.g. a national park. The third requirement is perhaps the most important of all: to know what one is doing, with clear questions in mind and the competence to organise a research and find out answers. Also, publications in peer-reviewed journals have to be generated: no research can be said complete, unless its results have been made accessible to the scientific community, as well as to the public. Keeping results hidden in a drawer is preposterous, as well as a waste of (often public) money.
Is all the above possible? Yes, it is.
We have a fair number of examples of similar studies on red deer (>40 years long), bighorn (>40 years long), Rocky mountain goat (>25 years long), roe deer (>25 years long) and several other species, just to remain in the area of meso and large ungulates. The information which these studies have yielded to science has proven quite important not only to increase our knowledge of the way animal populations survive or thrive, but also to address their management and conservation, which is a legacy to future generations.
No computer simulation nor exoteric-looking statistical manipulation will ever be able to replace an extensive and appropriate collection of sound data, in nature.

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BIOGEOGRAPHY OF CHAMOIS: WHAT DIFFERENT MOLECULAR MARKERS CAN TELL US

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The chamois (*Rupicapra* spp.) is distributed over most of the medium to high altitude mountain ranges of southern Eurasia (Figure 1). At present, chamois populations are classified into two species, *R. pyrenaica* and *R. Rupicapra* (Grubb 1993), on the basis of morphological and behavioral characters: *Rupicapra pyrenaica* (with the subspecies *parva*, *pyrenaica* and *ornata*) from south-western Europe, and *R. rupicapra* (with the subspecies *cartusiana*, *rupicapra*, *tatrica*, *carpatica*, *balcanica*, *asiatica* and *caucasica*) from central and south-eastern Europe and western Asia (Lovari 1987). Since this distribution has been hardly affected by humans, chamois become an excellent model for exploring the effect of historical and evolutionary forces on diversification.

Figure 1. Geographic distribution of the subspecies of the genus *Rupicapra*. The map was modified from the distribution map on the IUCN Red List.

Among these evolutionary forces are the glaciations during the Pleistocene. Glaciation cycles during Quaternary would have periodically restricted some species into disjoint refugia (Iberian Peninsula, Italy and Greece). After the cold phases have passed, these species spread rapidly into newly available habitats and populations coming from different refugia will contact in the suture zones such as Pyrenees, Alps, Central Europe and Scandinavia (Taberlet et al. 1998).The Quaternary glacial ages also had a major effect on the phylogeography and evolution of the genus *Rupicapra* (Masini & Lovari 1988, Rodríguez et al. 2010, Pérez et al. 2011, 2014) as it did on other animals in Eurasia. All these evolutionary forces left their signature on the genetic structure of the populations.

PALEONTOLOGICAL DATA ON CHAMOIS

The caprines are thought to have originated in Asia during the Miocene period (Vrba 1985). The sudden appearance of *Rupicapra* fossils in Europe during the middle Pleistocene age has been interpreted as resulting from immigration from the east during a cold climatic phase (Masini & Lovari 1988). However, Ropiquet and Hassanin in 2005 suggested that no paleontological argument actually supports the origin of caprines in Asia and considered the centre of origin of caprines as an open question. They even suggested an African origin for the common ancestor of the *Caprinae*.
The first fossils of *Rupicapra* are recorded from the middle Pleistocene (Mindel Glacial Stage, about 750 000-675 000 years ago) in France. The distribution and abundance of remains along the posterior glacial and interglacial periods support the idea of alternating periods of expansion and contraction in the distribution range of the genus until it reached its maximum distribution limit during the Würm Glacial Stage (about 70 000-11 700 years ago). When the Holocene started the chamois were once again pushed up to high altitudes up to its present distribution (Masini & Lovari 1988).

GENETIC STRUCTURE OF CHAMOIS POPULATIONS AND HISTORICAL IMPLICATIONS

To address the genetic variability and phylogenetic relationships within and between chamois species and subspecies, different molecular markers have been employed. The markers studied were: several mitochondrial DNA (mtDNA) sequences (including one nuclear copy of the *cytochrome b*), 20 nuclear microsatellites, a nuclear gene under selection (melanocortin-1 receptor gene [MC1R]) and three Y-chromosome markers. The use of different molecular markers is important since genetic variability and phylogenetic relationships often depend on the marker studied. Different markers have different characteristics at type of inheritance, evolutionary rates, effective size, dispersion, recombination, etc. and therefore different histories. So combining data from all types of markers can give us a better knowledge of *Rupicapra* genus.

GENETIC DIVERSITY OF CHAMOIS POPULATIONS

The alpine chamois as a whole showed the highest values of genetic diversity for mostly all the markers that have been analyzed, on the other hand the *R. p. ornata* population shows extremely low genetic diversity both at microsatellites and at mtDNA. Variability in the population of the Apennines is one of the lowest ever reported in a wild mammal population. This low diversity has also been detected by Lorenzini et al. (2005) for nuclear microsatellites. The remaining populations show intermediate values of genetic diversity with *cartusiana* chamois showing low levels of diversity especially for the maternally inherited mitochondrial DNA (Table 1).

	mtDNA			microsatellites		MC1R	Chr-Y
Subespecies	n_h	% h	% p	Rs	% He	n_h	n_h
parva	9	92.38	0.8274	3.36	51.31	1	2
pyrenaica	13	91.08	0.5156	3.76	51.66	1	2
ornata	**2**	**16.67**	**0.0101**	**1.11**	**3.15**	**1**	**1**
cartusiana	3	46.43	0.0412	2.81	42.00	1	2
rupicapra **W**	9	90.85	1.7563	3.87	58.13	1	4
rupicapra **C**	8	78.42	0.5043	-	-	1	2
rupicapra **E**	9	94.55	0.7092	3.77	55.37	1	2
tatrica	4	73.33	0.1661	2.25	33.39	1	1
carpatica	11	87.50	0.6172	2.86	43.45	1	1
balcanica	6	88.89	1.2623	3.74	55.00	1	2
caucasica	4	80.00	0.6156	3.36	42.55	1	2

Table 1. Estimates of diversity for the different markers employed.
n_h, number of haplotypes observed; h, haplotype diversity; π, nucleotide diversity. Rs: allelic richness (calculated based on a minimum sample size of 7 diploid individuals); He, expected heterozygosity. R. *p. ornata* values are highlighted in bold.

The genetic homogeneity of the Apennine chamois can be related to its demography during the last centuries. Numbers of *ornata* have probably been low for the last few centuries (IUCN 2014), and they only started to increase in the 1920s as a result of increased protection. Numbers plummeted again to just several tens of individuals in the Abruzzo National Park during World War II (Lovari 1989). As a result of these severe population bottlenecks and prolonged permanence at low numbers, the genetic variability of the Apennines population showed to be extremely low.

The different characteristics of the different markers analyzed give us different insights of the evolutionary history of chamois. Besides, hybridization can result in discordant phylogenies between markers. So combining all the information we can have a better understanding of the history of *Rupicapra* genus. We have found discordant phylogenies for these markers in both shape and divergence times.

Microsatellite markers are neutral, biparental and with a high evolutionary rate so they can give us an idea about the recent history of chamois. The results from this type of markers show three clades: an eastern clade corresponding to *R. rupicapra indi*viduals, a western clade with the Iberian individual of *R. pyrenaica* and a central clade formed by the Apennine chamois, of the subspecies *R. pyrenaica ornata* (Figure 2) that groups with the their conspecific populations. A correlation of genetic and geographical distances using microsatellite markers was shown, denoting a genetic flow among contiguous populations (Pérez et al. 2002, Rodríguez et al. 2010). The same three clades have also been detected using the nuclear melanocortin 1-receptor gene (Figure 2). However in this case it is interesting to point out that the ornata clade occupies a basal position in the tree instead of grouping with pyrenaica, although the support of this tree topology is low (Pérez et al. 2013).

Results for mtDNA sequences, which give us information about the maternal side of the story, also show three main clades: west, central and east (respectively named clades mtW, mtC and mtE). However there are discordances with previous markers in the central area of the distribution (see Figure 2). *R. rupicapra* cartusiana groups with *R. pyrenaica ornata* instead of *R. rupicapra*. Besides, some individuals from the west Italian Alps belong to the Clade mtW, characteristic of the Iberian chamois. These observations indicated introgression among differentiated lineages (Rodriguez et al. 2010). Crestanello et al. (2009) argued that this introgression process is due to modern translocations, however our data show it is much older than that since no signs of recent admixture can be noted in the individual nuclear genotypes. The divergence time estimates between chamois mtDNA lineages, 1.93 million years ago, (Pérez et al. 2014) confirm that the chamois inhabited Europe at least since Early Pleistocene (Lalueza-Fox 2005; Rodriguez et al. 2007) Divergence times are much older than the age of the first fossil chamois in Europe, middle Pleistocene.

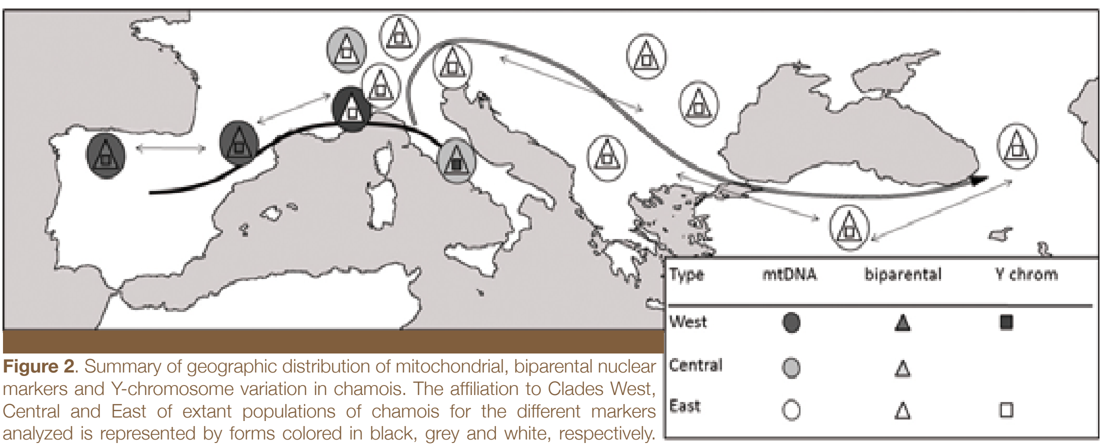

Figure 2. Summary of geographic distribution of mitochondrial, biparental nuclear markers and Y-chromosome variation in chamois. The affiliation to Clades West, Central and East of extant populations of chamois for the different markers analyzed is represented by forms colored in black, grey and white, respectively. The hypothetical dispersal of male lineages during the Pleistocene is represented by gross lines. Tiny lines represent contraction-expansion of populations within a limited geographical range (As in Pérez et al. 2013).

The analysis of the mitochondrial markers allowed the identification of a nuclear copy (numt) of the *cytochrome b* (*cytb*). When transferred to the nucleus, these mitochondrial sequences become non-functional pseudogenes, under no selection and with a lower evolutionary rate than their paralogous genes. NuMts. can be seen as living fossils that allow the study of ancient lineages, given that they represent a lineage that evolved in parallel to the mitochondrial DNA sequence. The nuclear copy should be similar to the mitochondrial copy present at the moment of the transposition to the nucleus. Comparison of *nucytb* with functional cytb from chamois and other species of caprini denoted, first, that the nuclear copy is highly differentiated from the extant mt lineages of chamois, second, that the *nucytb* copy evolved as a functional gene both in rate and pattern of substitution (Rodriguez et al. 2010). The concurrence of two highly divergent lineages, one that transposed into the nucleus and another in the mitochondria, was interpreted as a possible outcome of hybridization between highly divergent populations (Rodriguez et al. 2010).

Finally, the analysis of Y-chromosome markers, which give us information about the paternal side of the story, showed only two haplogroups that concur with the present taxonomical classification of the genus (Figure 2). However the patrilineal dispersion of *Rupicapra* was west to east, which opposes to the Asiatic origin of chamois. The level of differentiation among Y-chromosomes in chamois is remarkably low. Therefore, all modern chamois seem to descend of one very young male lineage. The time of divergence between the SRY haplotypes places the split at about 655 000 years ago, in the middle of the Pleistocene, showing that the divergence of Y-chromosomal variants took place well after the divergence of mtDNA lineages, in a time compatible with the sudden appearance of *Rupicapra* fossils in Europe. The phylogeny of SRY promoter for *Bovidae* species showed an association between *Rupicapra*, *Capra* and the *Ammotragus* (Barbary sheep). Besides, the structure of the microsatellite SRYM18 of chamois is identical to *Ammotragus* and different to most *Ovis*, but the African breed Balami of *O. aries*.

Hybridization between differentiated lineages is a major process behind the evolutionary history of chamois. In fact, we proposed two different hybridization events involving male-biased dispersal and female philopatry: one in the middle Pleistocene, between immigrant males and resident females and a more recent one (during the last Quaternary glaciations), between contiguous populations in the central area of the distribution leading to introgression of residing mitochondrial genomes into the immigrant ones. All the markers, however, showed a strong geographic signature in the distribution of the genetic variation pointing to the importance of the Alpine barrier during the Quaternary glacial-interglacial periods.

Putting all the data together (genetical and paleontological) we can speculate about the evolutionary history of chamois as follows: The three mitochondrial clades come from a common ancestor and have been differentiated *in situ* at the beginning of the Pleistocene. The present day distribution of the main mitochondrial clades is likely a reflection of isolation of populations already differentiated, followed by limited postglacial recolonization that was mainly limited by the Alpine barrier. The Clade mtW recolonized the West Alps and met there with the lineage coming from the East that occupied most of the Alps. The populations that constitute the Clade mtC were probably split by the expansion of the two main clades into the central region. Data from nuMts. point to the presence of another ancestor of chamois with a mitochondrial haplotype highly differentiated from the clades present in living chamois. This haplotype is now extinct and is just found as a nuclear copy in the contemporary chamois. This ancestral haplotype could have derived from an ancestral *caprinae* that reached the south Mediterranean during the middle Pleistocene. Males from this ancestor hybridized with the ancestral *Rupicapra* female present in Europe in a period compatible with the sudden appearance of *Rupicapra* fossils in Europe (Pérez et al. 2011). Later on, there have been probably multiple phases of isolation and hybridizations between contiguous populations, due to expansions and contractions during Pleistocene glacial interglacial periods to reach the present genetic diversity found in current populations.

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Rupicapra pyrenaica pyrenaica
Photo Javier Ara

SESSION I
STATUS AND ECOLOGY OF CHAMOIS SUBSPECIES

MONITORING AND MANAGEMENT OF PYRENEAN CHAMOIS IN ARAGON

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INTRODUCTION

In 1966, a number of Game Reserves (GR) were established in Spain, and the four in the Aragonian Pyrenees were established with the objective of recovering and conserving the population of Pyrenean chamois Rupicapra p. pyrenaica, which began the management of the subspecies in the region. Another GR was established in 1995 (Figure 1). In 2011, 3.6% of the country's surface was GR (Pita et al. 2011). In the Aragonian Pyrenees, the GR were delimited and had a permanent staff of rangers and technicians, which ensured the design and implementation of management practices and provided important direct and indirect economic benefits to local mountain communities (Domínguez & París 2011) by allowing the sustainable harvest of this resource through game hunting.

The establishment of Ordesa and Monte Perdido National Park (ONP) in 1918 and, particularly, its expansion in 1982 (15,608 ha) allowed the designation of a Protected Area, which had harboured an important non-hunted population of Pyrenean chamois. ONP and the GR form a continuous, 142,174-ha area under public management, from Navarre to Catalonia, and north to the French border (Figure 1).

Since 1995, the management of GR and Pyrenean chamois has been reviewed annually, with new policies and guidelines. Some of the guidelines were modified as new information became available and new management practices were developed. The most important guidelines are as follows:

– population distribution assessed every five years (González et al. 2013, Figure 2);
– design and implementation of a plan for monitoring the demographics of the subspecies throughout its range, regardless of the administrative status (huntable or non-huntable) of the land;
– hunting quotas set based on population surveys in the GR and on local hunting grounds;
– development of health and biometric monitoring of wild ungulates in the Game Reserves and ONP (Arnal et al. 2013 a);
– development of an annual economic assessment of GR (Domínguez & París 2011);
– promotion of citizen participation in the management of GR by including citizens on administrative boards, and the participation of hunters in field monitoring;
– material support (e.g., binoculars, spotting scopes) and courses for rangers involved in the monitoring
– annual reports on the activities and surveys of the GR;
– organization of meetings on Pyrenean chamois (2003 and 2004), Cantabrian and Pyrenean chamois (Alarcón et al. 2011), Iberian Ungulates (García-González & Herrero 2011), and the IUCN Third World Conference on Mountain Ungulates (García-González et al. 2002);
– publication of a booklet on Pyrenean chamois for hunters (Herrero et al. 2002) and a book on the status, management, and research on Pyrenean chamois in the Pyrenees (Herrero et al. 2013a);
– annual subsidies for the municipalities of ONP and GR.

This contribution presents the results of the demographic monitoring and management of Pyrenean chamois in Aragon, and describes the management decisions made for this subspecies in the GR of Aragon, which is part of a large, long-term monitoring program for wild ungulates in the region (Marco et al. 2011).

The study area included an almost continuous mountain range that has peaks higher than 2000 m on all of the mountain massifs. About 100 regional rangers do the fieldwork, throughout the distribution area of chamois (200 000 ha). Within the area are one National Park, three Nature Parks, five GR, 56 local hunting grounds, and one Biosphere Reserve. Over 90% of the area falls within the Natura 2000 network. For more information on the study area, see Arnal et al. (2013 a).
Roe deer *Capreolus capreolus* (Herrero et al. 2013 b), wild boar *Sus scrofa* (Herrero 2003), and red deer *Cervus elaphus* are the other wild ungulates present and, in summer, > 75 000 sheep graze within the area. For management purposes, the area was divided into hunting grounds and one non-huntable area, the ONP. The most important results of game] management have been the harmonization of hunting and the conservation of huntable species, economic benefits to municipalities, and access to hunting at reasonable prices. In 2014, the GR had 30 rangers and one technician, which was sufficient for the technical management of the area, its vigilance and monitoring of huntable species (Pyrenean chamois, wild boar *Sus scrofa*, roe deer *Capreolus capreolus*, red deer *Cervus elaphus*), apart from other objectives, such as public use management and endangered species monitoring and protection (bearded vulture *Gypaetus barbatus*, rock ptarmigan *Lagopus mutus*, capercaillie *Tetrao urogallus*). Most of the area of the GR is communal land that belongs to the local municipalities.

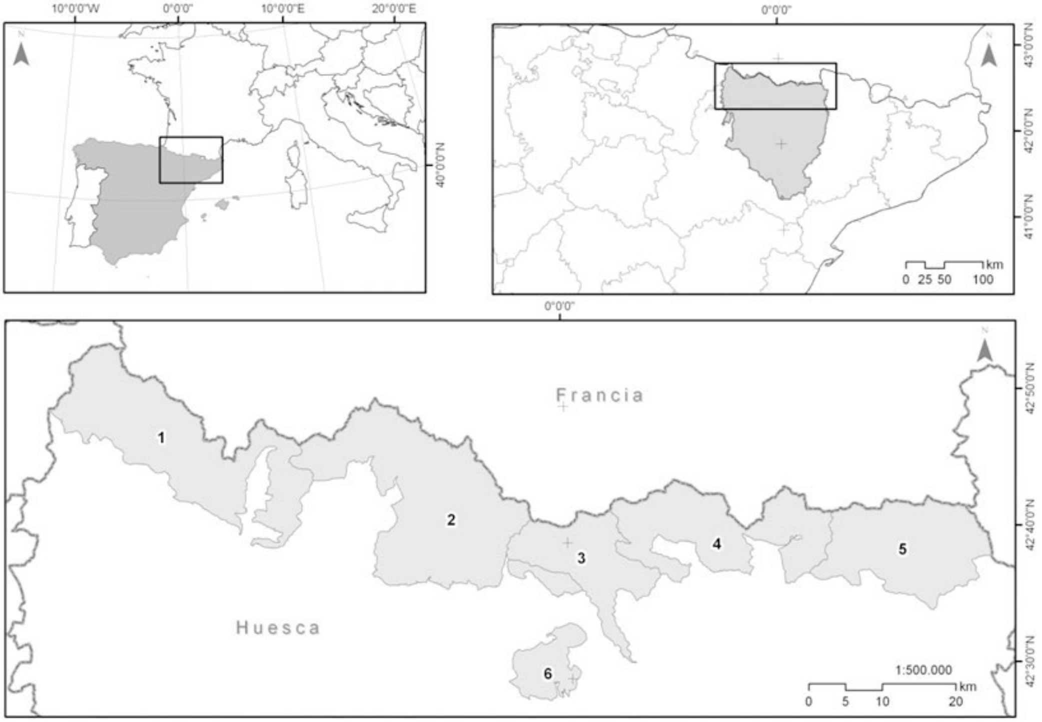

Figure 1. Chamois Game Reseres in Aragon. 1 Los Valles; 2 Viñamala; 4 Los Circos; 5 Benasque; 6 Solana de Burgasé (1995) and Ordesa National Park (3) in the Aragonian Pyrenees (Herrero et al. 2013 a).

Figure 2. Distribution of Pyrenean chamois in Aragon (2007-2011). Areas higher than 1600 m are indicated in dark grey, and the presence of the species within 10 x 10 km UTM.

DEMOGRAPHIC MONITORING

From 1982 to 1995, block counts were used to estimate the size of Pyrenean chamois populations in some areas of the Aragon Pyrenees (Herrero et al. 2013 a). ONP started its own monitoring program in 1987. In 1997, the block counts incorporated natural management units (Figure 3), the mountain massifs, including the hunting grounds managed by local hunters, the GR managed by the region, and ONP managed by the state, until 2006, when it became the responsibility of the regional government. By 2000, monitoring was evenly distributed throughout the area. Originally, small massifs were surveyed annually and large ones every five years, respectively. In the latest the itineraries that covered > 50% of the estimated minimum number of chamois were conducted annually, extrapolating results. Since 2008, all of the massifs have been included in the itineraries, and an annual report provides information on the abundance, structure, and trends in each of the subpopulations (Prada et al. 2013).

To improve health (Arnal et al. 2013 b) and demographic monitoring, in 2006, we began a bimonthly inquiry of the rangers of the GR and ONP for information on ungulate mortality.

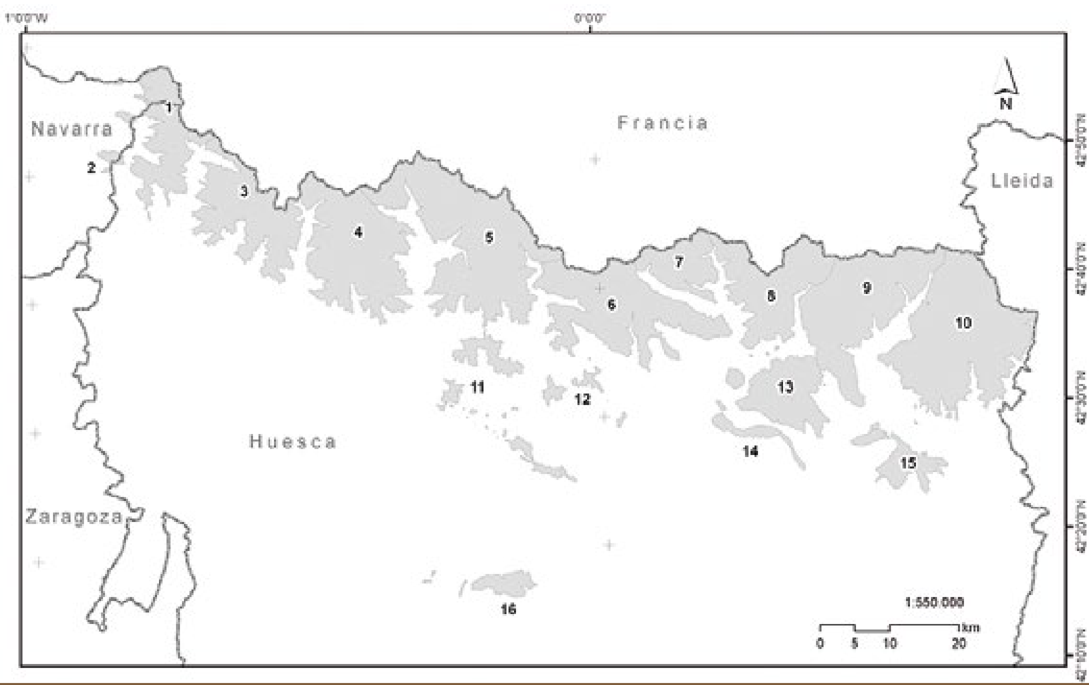

Figure 3. Management units for Pyrenean chamois in the Aragonian Pyrenees. 1 Larra-Peña Forca; 2 Ezcaurri; 3 Bixaurín; 4 Anayet; 5 Biñamala; 6 Monte Perdido; 7 Liena; 8 Punta Suelsa; 9 Posets; 10 Maladeta; 11 Oturia; 12 Sueiro; 13 Cotiella; 14 Sierra Ferrera; 15 Turbón; 16 Guara (Herrero et al. 2013 a).

METHODS

Block counts (itineraries) were conducted from early June to early July, after the parturition period, which occurs in the first half of May (Garin & Herrero 1996). In that period, the counts of adult females, kids, and yearlings are unbiased; however, the itineraries underestimate the number of adult males. For that reason, another survey is performed during the rut, from late October until mid-November, to count adult males, which provides a better estimate of the adult population sex ratio. Chamois populations in two massifs in the Pre-Pyrenees are also surveyed in April; when chamois start to graze open pastures within mainly forested land.

Simultaneous, above-the-timberline complete surveys (Berducou et al. 1982) are the most common method for counting chamois in open areas that provide good visibility in the Alps, Apennines, Cantabrian Mountains, Pyrenees, and other European mountain ranges. Mainly, that method is used because it is economical and simple for data collection, analysis and estimating the minimum number of animals, and it is accurate if visibility is good and the population density is not exceptionally high. It involves counting animals during itineraries within sectors that reflect natural management units (mountain massifs), simultaneously, which prevents animals from being counted more than once. Underestimates can be important (Houssin et al. 1994) or unimportant (Herrero et al. 2011). The natural management units have been defined as the area above 1600 m a.s.l., a height above which most chamois live most of the year in the study area, which avoids comparisons based on artificial administrative units. In addition, distance sampling has been used for forest itineraries in one massif that had a high-density population (Buckland et al. 2001), which has been used with chamois previously (García-González et al. 1992, Garin & Herrero 1997).

ORGANIZATION OF THE FIELD WORK

Itineraries (~ 230), designed by the rangers, covered all open areas above 1600 m, and each of the massifs was divided into sectors, which were surveyed on a single day (1-3 days for the entire massif). Most of the itineraries were performed by pairs of rangers or by us, although hunters and volunteers that had good knowledge of the species and the area contributed to the effort. All were equipped with binoculars, spotting scopes, transmitters, data sheets, and ad hoc maps. The age and sex (adult males, adult females, yearlings, and kids) of the individuals within groups of chamois were recorded and their locations plotted on maps.

MONITORING RESULTS

In 2013, the estimated minimum number of Pyrenean chamois was 10.935, which included two massifs that are shared with the neighbouring region of Navarre (Herrero et al. 2010). At that time, the total area occupied by the species in Aragon was ~200.000 ha (González et al. 2014). Between 2000 and 2007, the average annual increase of the population was 3%. Between 2007 and 2008, a keratoconjunctivitis outbreak reduced the population by 20% and, between 2008 and 2009, the population was reduced an additional 7%. Thus, the average annual reduction was 14%. Between 2009 and 2010, the population increased 10%, and it was stable in 2011, at a size that matched that of the population in 2000 (Arnal et al. 2013a). In 2011, a pestivirus outbreak began in the eastern massifs and, subsequently, the chamois population decreased 7% (2011-2012) and 18% (2012-2013) (Arnal et al. 2013 b).

Between 2000 and 2013, population density was 6-8 chamois km-2. Productivity was 62-76% (2000-2012), but was 57% in 2013. Between 2000 and 2007, and between 2008 and 2013, the adult sex ratio was about 60% and 70% males, respectively, because keratoconjunctivitis led to more mortality among adult females than among adult males (Arnal et al. 2013 b). Based on the number of chamois found dead, mortality was average in 2006, 2009, and 2010; however, in 2007-2008, mortality was increased because of keratoconjunctivitis and, in 2011-2013, because of pestivirus (Prada et al. 2013).

MANAGEMENT

In Spain, regional governments have the responsibility for the management and conservation of biodiversity, which includes defining which species are huntable. The Pyrenean chamois is huntable in Aragon, but still-hunting is the only legal type of hunting. The hunting period is divided into spring, from the first Sunday in April to the first of July, when only adult males may be hunted, and autumn, from the second Sunday in September until the second Sunday in December, when adult females and adult males may be hunted. Approximately 50.000 hunting licenses have been issued in the region.

Population structure, trends, and estimates of the minimum size of the Pyrenean chamois population are the basis for the annual hunting quota (~ 5%). The quota is split among the hunting grounds, and adult males and females are hunted (proportion 1:1). The distribution of the quota among types of hunters within the GR is presented in Table 1.

Type of hunter	Adult male chamois	Adult female chamois
Landowners (municipalities)	40	0
Locals	15	50
Regional	25	30
EU	20	20
Total (%)	100	100

Table 1. Distribution (%) of the hunting quotas for Pyrenean chamois in the GR of Aragon.

Harvested animals have to be tagged. The following criteria are used to set the hunting quota for each hunting ground:

- population structure and trends;
- amount of area above 1600 m;
- proportion of the Pyrenean chamois population observed during block counts;
- any natural management unit that includes an area above 1600 m and a population > 250 animals can have a hunting quota, even if animals were not observed during block counts, because Pyrenean chamois are not present in municipal hunting grounds in some months. Those grounds must contribute to the conservation of the population just as do the others, throughout the year.

INCOME FROM GR TO LOCAL MUNICIPALITIES

Based on the mission mandate of the law that created the GR, the affected municipalities and landowners receive money from the regional administration in the following ways:

– complementary income, derived from the value of the trophy after it has been harvested;

– the auction of 40% of the total GR quota, divided proportionally based on the amount of and owned by each landowner. In 2014 the price for an adult male is 2000-3000 €;

– a subsidy for the lands that were incorporated into the GR, with an understanding that the budgets of the municipalities usually are modest;

– indirect benefits derived from the presence of non-resident hunters in the tourism low season.

The annual cost of monitoring the chamois population, including the work done by rangers, technicians, and consultants is about 45.500 € (Escudero et al. 2009).

CITIZEN PARTICIPATION IN THE MANAGEMENT OF GR

Citizen participation is channelled through the administrative boards, one for each GR. The interest groups represented include municipalities, landowners, farmers, local and regional hunters, environmentalists, hunting experts, and the regional administration.

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RUPICAPRA PYRENAICA PARVA: HISTORY & STORY

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TAXONOMY AND PHYLOGENY

The first taxonomist which considered the Pyrenean chamois as an independent species (*Rupicapra pyrenaica*) from the the Alpine chamois (*Rupicapra capella*) was the French-Italian naturalist Bonaparte (1845) this was due to its slender shape, paler (washed) coat and closer horns; a few years later López Seoane (1861) following Bonaparte's theory considers the Cantabrian chamois belonging to *Rupicapra pyrenaica*. But the differences between both Iberian populations were emphasised by the Spanish mammalogist Angel Cabrera (1910) who described a Cantabrian subspecies as *Rupicapra rupicapra parva*, splitted from the Pyrenean chamois due to its smaller size and reddish summer coat, Miller (1912) raises it to a specific status. Finally Cabrera (1914) declares that this form is only a geographical type of the Pyrenean chamois because there are no differences in the skull and in the horns, except their smaller size, the coat design is still similar, with the exception of colour shade naming it as *Rupicapra pyrenaica parva*.
In the middle of the XXth century some taxonomists like Couturier (1938), Ellerman & Morrison Scott (1965), and Corbet (1978) imposed synthetic specific criteria considering the genus *Rupicapra* monospecific, as *Rupicapra rupicapra*. During the final decades of this century Sandro Lovari proposed an surprising idea based on molecular, ethological and morphological evidences of Spanish and southern Italian populations proposing to join the three western peninsular subspecies ornata, pyrenaica and parva under the same species *Rupicapra pyrenaica* (Lovari & Scala 1980, Scala & Lovar, 1984, Nascetti et al. 1985), a taxonomical status still largely recognized today.
Although this proposal was initially surprising, joining three populations spread over two different peninsulas separated by Alpine chamois *R. rupicapra*, was not an entirely new idea since it had already wriiten by Cabrera when he wrote that "Both forms [the Spanish ones *R. p. pyrenaica* and *R. p. parva*] are similar, in the in the dark bands in both sides of the neck, to *R. ornata* from Apennines, but considering their respective ranges is unlikely their specific identity" (Cabrera, 1914). Today filogeography can explain this particular distribution pattern based on the successive changes of climatic waves during Pleistocene (Massini & Lovari 1988, Pérez et al. 2002).
While Pleistocene records show that Iberian chamois occupied only the northern half of the Iberian Peninsula (Arribas 2004), during the warmer period of Holocene surprisingly chamois seems to be present in all the mountain areas, even in the southern half until relative recent periods like Bronze Age was found in Castillejos, Granada province, 5,000 years ago (Arribas 2004) (Figure 1).

Although no morphometrical studies were realized to date the reduction of size characteristic of *parva* form, Álvarez-Laó (2014) finds in a mammal assemblage dated 36.6-20.2 ky, close to the Cantabrian coast, chamois skulls with some features of the Pyrenean chamois, such as curved forward core horns, not found in the present Cantabrian chamois. A part from the size, the Jou Puerta chamois does not differ significantly from other Iberian Late Pleistocene populations but a comparison with recent Cantabrian chamois showed that this fossil specimens are visibly larger in size than recent ones. Alférez et al. (1981) found fossils of *Rupicapra* in the Sierra de Segura, Jaén province, belonging to Lower Holocene with measurements closer to Jou Puerta specimens than the recent cantabrian chamois. We can therefore make Massini's conclusion (1985) that the characteristics of living *R. p. parva*, or at least the small body size is a recent acquired feature.

HISTORICAL RECORD, DECLINE AND UPRAISE

There are no almost historical records to give us a clear picture of the decline of chamois in the Iberian Peninsula during the Middle Ages or later. Probably in the XVIII there were no chamois at all in the intermediate mountains of the Basque Country between Pyrenees and the Cantabrian mountains (Pérez-Barbería et al. 2009) and we must wait until the beginning of the 19th century where we had more abundant records obtained from two geographical dictionaries leaded by Miñano (1826-1828) and Madoz (1845-1850).
In this first half of the 19th century chamois were spread in the Cantabrian mountains in Santander, Palencia, León, Asturias, Lugo, Orense and Zamora provinces (Figure 2). Inefficient hunting laws favoured the decline of big game for centuries and a continuum was split in two large populations when chamois became locally extinct in the surroundings of Puerto Pajares, at the middle of the Cantabrian chain. Probably this split happened in the first half of the 20th century. Historically, the lowest numbers and smallest range of the species occurred between 1943 and 1966, when the species disappeared from large areas at the most westerly parts of its distribution (adjacent areas between León, Zamora and Galicia).

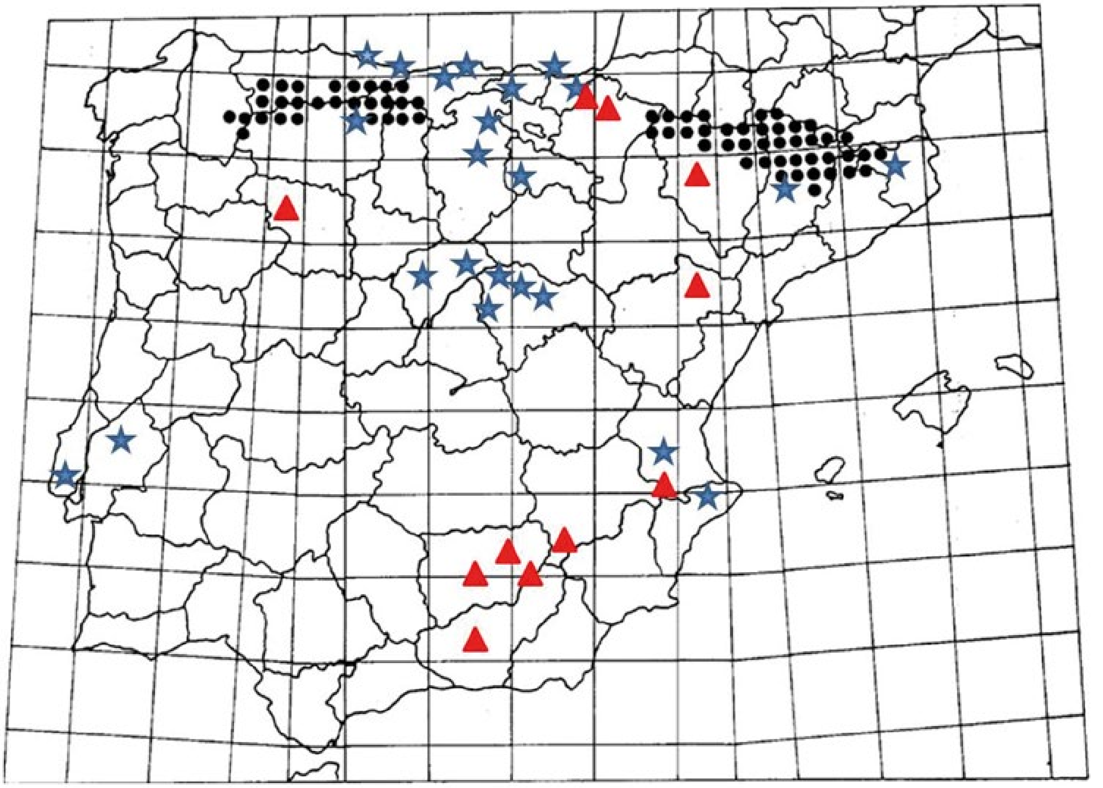

Figure 1. Range of chamois in the Iberian Peninsula during the Pleistocene (blue stars), Holocene (red triangles) and present distribution (black dots) (from Pérez-Barbería et al. 2010).

The concern for the increasing population decline did drive to the first protection measures started with the declaration of the Royal Game Reserve of Picos de Europa in 1905 followed by the declaration of Covadonga National Park in 1918, but the effort only was implemented in a small local area. A more extensive protection occurred after 1943 when more successful new hunting regulations based on private hunting grounds and the new public ones were established. Finally the harvest of chamois were controlled in a large area from 1966 onwards, when the majority of its remaining range was occupied by public Game Reservations favouring a large recovery and providing a source area to spread chamois in the surroundings.

In 1995 the minimum population number was estimated to be around 20.200 individuals with the highest densities (16-23 chamois per km^2) inside the oldest protected areas (Pérez-Barbería et al. 2009), in the core area of the eastern population, where the population seems to be stable. The densities at this moment were better explained due to its historical background rather than for its habitat quality (García et al. 2009). Then the highest density was located in the old National Park grounds where no hunting was allowed from 1918, the following higher densities were located in the oldest public hunting grounds of in the Royal Game Preserve of Picos de Europa (1905) and the National Game Preserve of Reres (declared in 1943) where the harvest was very conservative (< 3% of the population was shot) to increase their chamois densities. The remaining areas had a declining population and when National Game Preserves was declared in 1966 and 1969 there were only few tens of chamois inside them or any at all, so the recovery was slower and in 1995 their densities were weak (Figure 3).

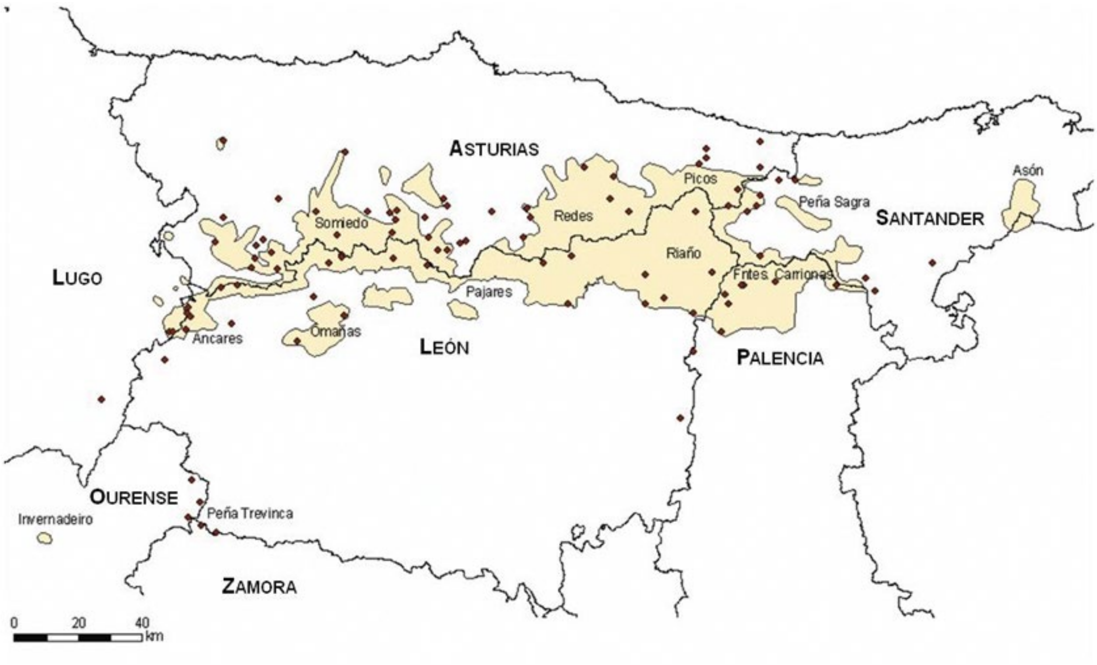

Figure 2. Present range of Cantabrian chamois (coloured area inside a closed line) and historical records during the XIX century (red dots) (From Pérez-Barbería et al. 2009).

THE MANGE OUTBREAK

Although some outbreaks did affect a part of chamois population in recent times, there was a low demographical impact from these situations (Martínez-Ferrando 1982) but this scenario has changed dramatically when a mange *Sarcoptes scaibiei* outbreak in 1993 affected the eastern population. It started to seriously affect the population by 1995, and caused an important decline in the population size reaching its minimum in 2001, when there was a 64% decline since 1995. The epizooty spreads eastwards quickly at speed of 1.3-7.7 km year-1, depending on the areas, from three different points located near the western border in an oil spot (Ballesteros et al. 1998, González-Quirós & Solano 2009).

The number of animals showing apparent clinical signs of scabies in relation to the number of observed animals (prevalence) was the highest in spring and the lowest in summer and autumn. Adult males is the most affected class of the population, consequently the sex-ratio is heavily biased to females (González-Quirós & Solano 2009). The new sex-ratio might be the cause of the reproductive success increase in the last 10 years (from 22 to 26% after the minimum peak) the population recovered slowly up to reaching 50% of the population size estimated before the outbreak (Nores & González-Quirós 2009).

The effect of the sarcoptic mange outbreak showed that in the first 2-3 years annual mortality rates were about 50%, reducing initial numbers by 70-80%. After that period annual survival rates increased (annual mortality 17%) for 2-3 years and the population reached a new equilibrium at 40% of the former population size. Some density thresholds were found: populations could reach a peak up to 23 chamois per km^2, but they remain stable over 16.8 chamois per km^2; they can fall until 4.4 chamois per km^2 three years after the outbreak front and reach a new equilibrium around 7.6 individuals km^2 in which there are some evidences of densodependence being mortality inversely related to chamois density.

In 2007-2008 the whole population size of the Cantabrian range was estimated, totalling 17,430 individuals, this was done also by considering the recolonization. The highest densities were now in the western population (16-19 chamois km^2) and in the eastern population there were of 6-15 chamois km^2 (Pérez-Barbería 2009). Fortunately both subpopulations still have a low flow of chamois which has helped to maintain the western population free of mange.

CATCHES AND TRANSLOCATIONS

Since 1970 there have been different reintroduction programmes of this subspecies. During that period the staff concerned by chamois management tried to move chamois from high density areas to help the recovery of the historical ranges of the 19th century. Finally five successful reintroductions took place since 1980s.

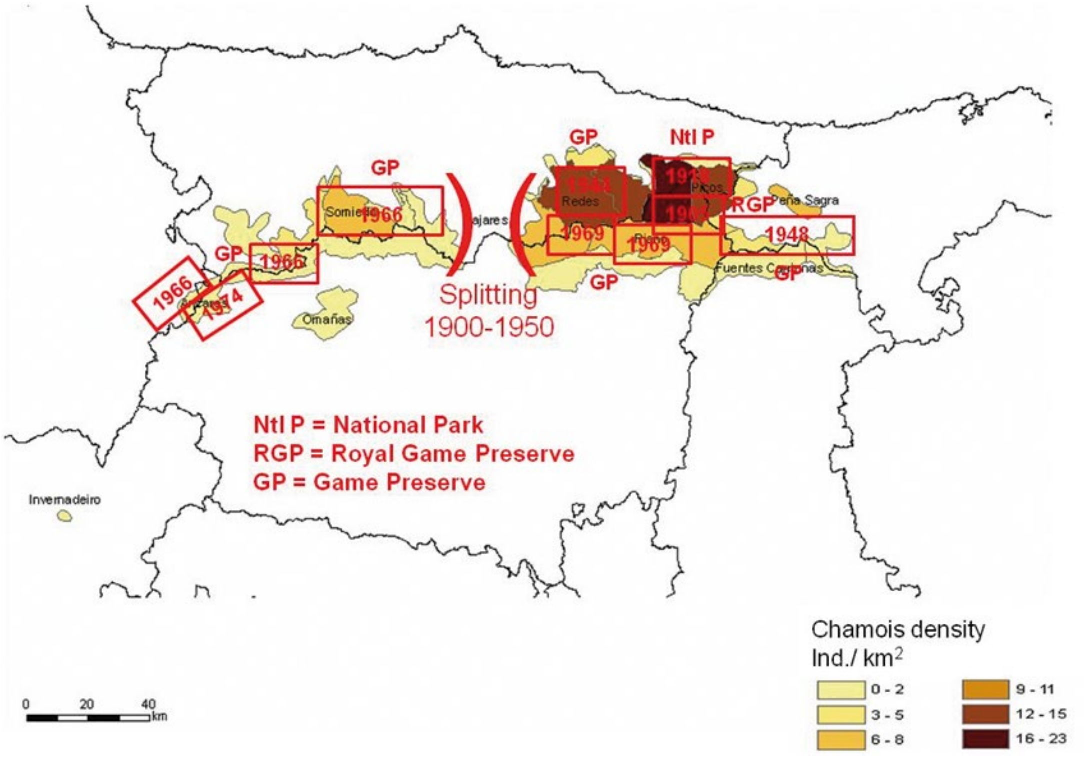

Figure 3. Present range of Cantabrian chamois (coloured area inside a closed line) and historical records during the XIX century (red dots) (From Pérez-Barbería et al. 2009).

The capture systems were anaesthetic dart guns (1990-2005), flexible leg snares (1990-1993) and vertical nets (1994-2012). With regards to capture effort, handling effects, performance and mortality after release the most efficient procedure were vertical drive nets (2.1 captures/day, with a mean mortality of 5.5%) followed by leg snares (1.86 captures/day; mortality 13.3%). Dart gun is less useful because of high mortality (25%) and low efficiency (0.43 captures/day) (Gonzáez-Quirós 2009, 2012).

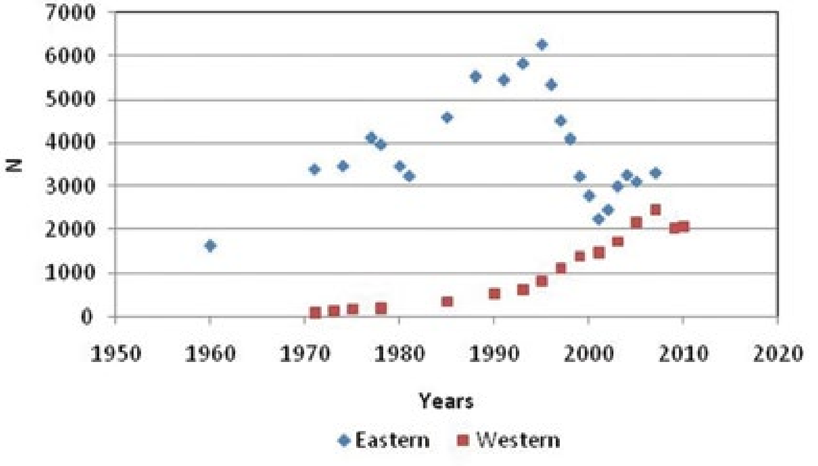

Figure 4. Historical trends of chamois populations (eastern blue diamonds and western red squares) in the Game Preserves of Asturias. The first drop of the eastern population in the final 1970s was caused to culling and keratoconjunctivitis outbreak, and the deeper second

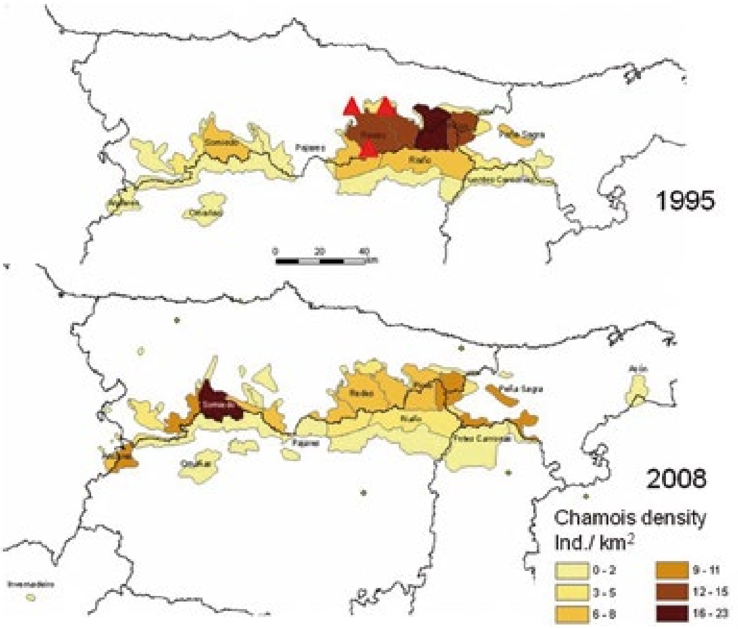

Figure 5. Changes in Cantabrian chamois densities before (1995) and after (2008) the sarcoptic mange outbreak. The three red triangles indicate the starting points of the epizooty. Now the highest densities did move from eastern population to western one (Based on Pérez Barbería et al. 2009).

ACKNOWLEDGEMENTS

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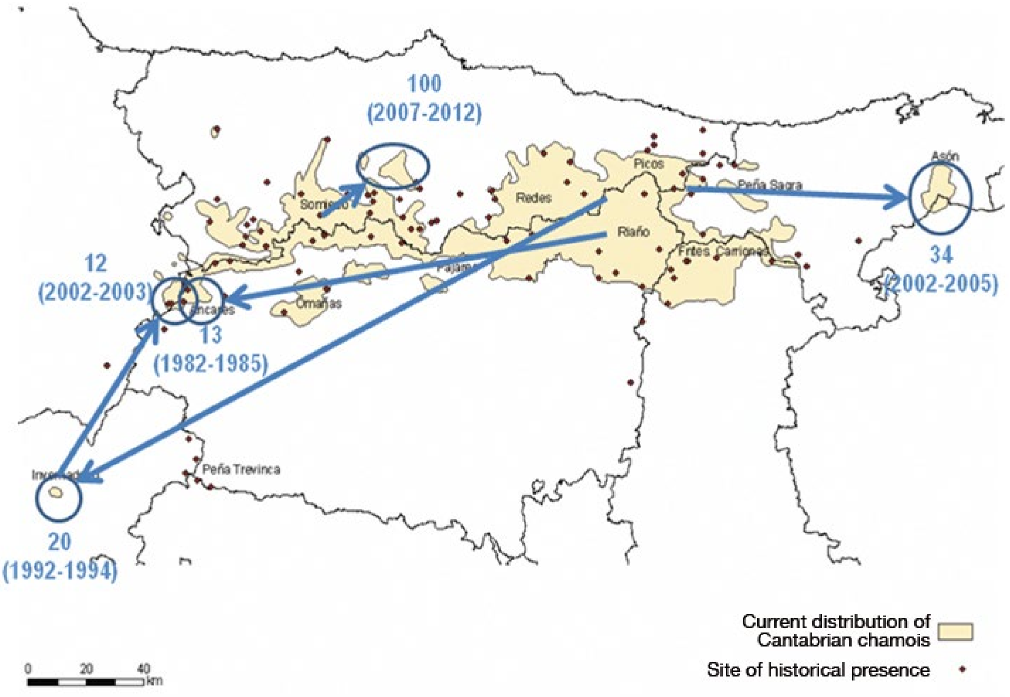

Figure 6. Translocations of Cantabrian chamois to peripheral mountain areas. Numbers represent the number of individuals and are in brackets the years in which reintroductions were done (González-Quirós 2009).

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SOME TEACHINGS DRAWN FROM THE SPATIAL MONITORING OF MARKED CHAMOIS *(Rupicapra pyrenaica pyrenaica)* IN THE PROTECTED POPULATION OF THE PYRENEES NATIONAL PARK

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SUMMARY

From 1988 to 2014, 541 marked Pyrenean chamois (*Rupicapra pyrenaica*) have been subject to continuous spatial monitoring in a sector of the Pyrenees National Park, the valley of Cauterets (Hautes-Pyrénées, France). In this area, the species is fully protected from 1956 through the creation of a 3300 ha protected reserve, and on this whole surface (10000 ha) since 1967, with the creation of the Pyrenees National Park (PNP). The absence of any major human disturbance during this long period of protection enabled several generations of chamois to organize themselves in the use of space. The analysis of the locations of marked individuals shows that the spatial occupation of Pyrenean chamois is largely determined by the relief. The Pyrenean chamois are loyal to the Alpine massif, their original area of capture. It follows, from this spatial fidelity, a spatial structure close to a metapopulation.

Some differences were found in the importance of flux between massifs that show, on one side that males migrate more easily than females, which are more attached to the central massif, on the other hand that exchanges are unbalanced between massifs.

A high level of spatial organization has been observed in females. These are organized into groups through a common home-range occupation with well-defined space boundaries. Throughout the whole annual cycle, females are loyal to a winter and summer home-range year after year. Depending on the groups, these two seasonal home-range can be far apart from each other or almost in the same area, which leads to distinguish two extreme categories of space behaviors in females: migration and sedentariness.

The seasonal behavior of the different groups leads to a concentration-dispersion phenomenon that can be inverted for each of the massifs analyzed.

The study of marked mother-daughter couples shows that the daughter adopts mainly the home-range of their mother.

Among males, several space occupation leaders have been observed ranging from an extreme sedentariness or extreme wandering. Overall, the males have higher rates of spread than females. A relatively high proportion of males settle outside the mother's home-range for the rut.

INTRODUCTION

In the mountain ungulates and particularly in chamois, the use of the space shows how individuals in a given population organize themselves for the exploitation and sharing of resources. The use of space also finds expression in the field of sexual competition in the males whose social status and participation in the reproduction most often depend on the acquisition of territory.

Two essential variables of the chamois habitat are key elements in the space occupation of that species: climate and relief. The mountain climate of the Pyrenees is characterized by an important winter snows of several months that limited greatly the exploitable areas and the trophic availability. This forces the chamois to aggregate in the winter in reduced refuge areas, leading to a very strong local density that intensifies the spatial competition.

The components of the mountain such as the altitude, the exposition or the slope, strongly determine the availability of the resources during the seasons and thus influencing the spatial occupation and the movements of the chamois. The mountains determine the boundaries of the orographic massifs that subdivide the population in separate units able to have a certain level of operational autonomy.

The long term of protection which the chamois population of the Cauterets National Park enjoyed, is probably a very favorable condition to the process of socio-spatial self-organization, notably because this enables the individuals to acquire a considerable experience in the use of space.

MATERIALS AND METHODES

Study areas

The study area (42°53'N, 0°06'W) is situated in the Cauterets valley, in the Hautes-Pyrénées department (France). With a surface of nearly 1000 hectares, it constitutes one of the six sectors of the central area of the Pyrenees National Park (P.N.P.).

Its mountains are characterized by steep slopes and the mountain's structure is composed of high ridges and deep valleys delineating three well-defined massifs: the Mayouret massif (2820 ha), the Péguère massif (5020 ha) and the Pouey Trénous massif (2160 ha). The altitude gradient ranges from 980 m in the Cauterets village to 3298 m in the Vignemale

peak. About 48 % of the area is located above 2000 m. The oceanic-mountain climate is characterized by heavy rain falls (annual average of 1340 mm in Cauterets), an important winter snowfall at high altitude (average annual snowfall from 620 cm to 1850 cm) and an annual average temperature of 7,5°C at 1000 m altitude.
The open environment has cliffs and screes and important alpine prairies where the fescue (*Festuca eskia*), the nard grass (*Nardus stricta*) and the alpine clover (*Trifolium alpinum*), as well as the dwarf juniper (*Juniperus nana*), the alpenrose (*Rhododendron ferrugineum*) and the bearberry (*Arctostaphyllos uva-ursi*) dominate. The forest covers almost 25 % of the area, with an upper limit at approximately 2200 m. According to exposures, the dominant tree species are pines (*Pinus sylvestris*, P. *uncinata*) (13 %), silver firs (*Abies alba*) (8 %), or beech (*Fagus sylvatica*) (3 %).

The chamois population of PNP in Cauterets
The chamois population of the study area has not been hunted since 1956 a protected reserve of 3300 ha has been created in 1956 and on its whole area since the creation of the Pyrenees National Park in 1967. Annual spring counts indicate a chamois population of approximately 800 individuals adults during the years 1980-2007 and a low population growth (λ = 1,02) throughout this period. The onset of foot-and-mouth diseases, of *Keratoconjunctivitis sicca* from 2007 – 2008, and then of two very cold and snowy winters in 2013 and 2014 has caused declines in numbers from 30 to 50 %.

Captures, tagging, data collection
From 1988 to 2014, 541 chamois of all ages (262 females, 279 males) have been captured on two massifs: Mayouret (129 females and 121 males) and Péguère (123 females and 157 males). They have been marked by colored necklaces and earrings enabling remote visual identification. The captured chamois age ranged from less than one year to 24 years. The sex ratio has proved to be close to balance with 1 / 0,93.
The marked chamois has been monitored continuously in the form of specific survey. A large number of occasional data have also been collected. A total of 57474 individual observations have been collected, 32864 for the females, 24610 for the males.
The maximum term monitoring has been of 16,5 years in the females, whereas 44 females and 48 males have been monitored for more than 8 years. The data have been collected on the basis of a 250 m² location grid for all the area. On a restricted area of 370 ha called « Clot-Cayan » the grid used was of 50m².

RESULTS

The intermountain exchange
The analysis of intermountain flows for gender shows that exchanges between the three mountains are reduced, unbalanced and selective.
During 26 years of follow-up, the exchanges observed between the two mountains used for capture (Mayouret and Péguère) and the Pouey-Trénous massif shows different results by type of use and by gender.
In females:

- none of the 123 marked females in Péguère has been observed in Mayouret;
- in contrast, 9 marked females in Mayouret have been observed in Péguère. Seven of them in the same group called « Bacou » were temporarily in a restricted area in Péguère overwintering. For the other two the observations have been occasional;
- 16 marked females in Mayouret have been observed in Pouey-Trénous exclusively during the diurnal grazing,they then returned to their origin massif in the evening;
- four marked females in Péguère have been regularly observed each year in Pouey-Trénous, in the summer.

In males:

- only one of 157 captured males in Péguère have been observed in Mayouret;
- 23 of 121 captured males in Mayouret have been observed in Péguère. Eight of them were born in a marked female group in Mayouret and were overwintering temporarily in Péguère. Among these 8 males, 4 have settled in Péguère when they are in rut;
- 13 marked males in Mayouret and 7 marked males in Péguère have been observed in Pouey-Trénous.

The mountain, consisting of 3 massifs, generates an occupation of the space of all the area near a metapopulation system.

The role of bridges in the inter-massif exchanges
The observation of movements between Péguère and Mayouret has highlighted the role that the presence of a walkways can play to cross an abundant and steep-banked stream.
The observations have allowed us to confirm the repeated use of the walkways called « Pas de l'ours » by a Mayouret female group who used to stay temporarily in winter on the Péguère. It was possible to observe that 8 of the 23 marked males in Mayouret were native to the female group using the walkway and that 4 of them have settled in Péguère to rut.

The exchanges observed in the peripheral areas of the 3 massifs concerned 12 females and 16 males.
Seven females have been observed every year in summer, while in winter they return to the massif used for capture; 3 have permanently settled in the surrounding areas; 2 have overwintered.

Eleven males have been observed every year in summer with return to the massif used for capture in the winter; 4 must be considered occasional settlers; 1 has definitively settled in the surrounding areas.

The spatial organization in the females

The females have showed a great fidelity to their group home range, year after year. The female's home range is strongly delimitated geographically. For example two neighbouring sedentary groups in Clot-Cayan area, comprising respectively 25 and 24 marked females and monitored during 22 years, have exclusively used areas close to 120 ha and 150 ha.

Previous work showed the existence of seasonal use spatial models different in the females captured in Clot-Cayan. These ones can be sedentary all year or oppositely migratory, spending the summer in areas far from the areas where they stayed in winter.

This same work applied in Clot-Cayan area has showed a complex space use based on the restricted winter area definition, integrating a certain mix of sedentary and migratory groups.

The monitoring of many couples of kid – mothers or of their related individuals shows that the female group composition using the same home range have a close relationship to the individuals by maternal descendants.

Some events of the annual life cycle (kid nursing, wintering) force a certain diversity of groups separated during the rest of the time.

The relief and the different effects on the seasonal concentration-dispersion phenomenon in the females

The comparison between massifs of the seasonal movements of female groups shows that the relief could induce to an inverted phenomenon of concentration-dispersion. Therefore, we observe that in Mayouret, the summer is a concentration season of some groups while the winter implies their dispersion. Inversely, in the Péguère massif, the summer is a dispersion period and the winter a concentration period of some groups.

Heritage in the field of maternity

The monitoring of 20 mother-daughter couples whose daughter has achieved a reproductive status has showed that 85% of the daughters have adopted the same home range of their mother. The monitoring of 19 mothers-sons couples whose sons have reached the age of 4 years old has showed that only 58% of the sons rut in the home range perimeter of their mother, while 42% has showed the rut in the outside part of this home range, sometimes in a different massif.

Space occupation leaders in males

The intensive monitoring of 64 marked males in the Clot-Cayan area has highlighted several spatial occupation leaders in the males. We can distinguish:

The sedentary: present all year long in Clot-Cayan area ;

The migrators: present inside Clot-Cayan in winter, outside this area in summer ;

The travellers: they move erratically in several massifs

DISCUSSION

All results drawn from the observation of the chamois population use of space in Cauterets show a high degree of global organization. Among the principal descriptive features of that organization there are:

1) a great behavioral diversity concerning the groups as well as the individuals. This diversity is expressed by particular strategies that are extremely different in terms of travel. In population, this behavioral diversity should be considered as a factor of global stability;

2) the relief is an important component of space organization, especially because it determines the distribution of resources and their accessibility during the seasons.

Important massif cleavage is able to influence genetic mixing in chamois;

3) the spatial cohesion of the female groups is based on a behavioral stability attributable to a strong maternal heritability of the spatial tradition.

A few questions arising from this outcomes:

- is home range fidelity in chamois due to their adaptability that allows the individuals to acquire more experience regarding the habitat?
- Is home range fidelity in chamois due to their adaptability that provides greater stability to their diet?
- Is the likely genetic diversity of the female groups a source of local resistance to the pathological attacks?
- Do males play a role of genetic dispersion as important as we think?
- Would the Cauterets population achieve such a high organization degree if it was intensively being hunt?
- Finally, what can we call population?

MATING BEHAVIOUR IN ALPINE CHAMOIS: CURRENT KNOWLEDGE AND FUTURE PERSPECTIVES

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Mating system may be defined as the organization of reproductive behaviour in terms of relationships between sexual partners. Different mating systems may occur: (1) monogamy, where individuals mate with the same partner in one or more reproductive events; (2) polygamy, where males mate with several females (polygyny) or females mate with several males (polyandry); (3) promiscuity, where males and females mate with any receptive partner and there is no continuing bond between individual males and females after mating has occurred. Despite the practical value of the simple framework proposed above, mating systems may intergrade (Clutton-Brock 1989). While over 90% of birds are socially monogamous, male monogamy is exceptional in mammals, which tend to be polygynous (Alcock 2005).

In polygynous species, the intense male-male competition during the rut is often associated with the development of a great male-biased sexual size dimorphism (SSD) that, in turn, imposes energetic costs that usually lead to greater mortality of males than of females (Clutton-Brock & Isvaran 2007), particularly under harsh environmental conditions (Toïgo & Gaillard 2003). Although behavioural observations (Krämer 1969) suggested that chamois are polygynous, chamois sexes are nearly monomorphic, with males weighing 30-40% more than females only at the start of the rut (Garel et al. 2009, Rughetti & Festa-Bianchet 2011), and sharing all other morphologic features, with only slight differences. Seasonal sexual-size dimorphism rapidly declines to about 6% from November to January (Garel et al. 2009); Rughetti & Festa-Bianchet (2011) further extended this investigation to springtime, showing that SSD in body mass in this time of the year is reduced to about 4%, and that SSD in skeletal size is also very limited. These data may suggest a unique conservative strategy to accumulate fat resources in summer (Pérez-Barbería et al. 1998) to be used up during the rut and possibly reduce mortality costs over the winter (Bruno & Lovari 1989). In fact, there is growing evidence for an equal mortality of the two sexes (e.g. Bocci et al. 2010, Corlatti et al. 2012a). Altogether, these characteristics may suggest the adoption of a more conservative mating strategy (i.e. a less intense and less energetically demanding competition among males), compared to that of highly dimorphic species.

In turn, because mating system is related to the intensity of sexual selection (Jones 2009), these findings suggest that the pressure of sexual selection may be weaker in male chamois than in males of more dimorphic species. Recent research on Alpine chamois reported the occurrence of a compensatory mechanism in body and horn growth (Rughetti & Festa-Bianchet 2010): individuals with greater horn growth in the first years of life will show smaller growths in the following years and vice-versa; larger yearlings not necessarily will develop into larger adults. In turn, this may suggest the occurrence of little selective advantage, in reproductive terms, for male chamois possessing longer horns or larger body mass. Behavioural studies also suggest that male mating success in chamois does not seem to be related to horn size. A recent work conducted in the Gran Paradiso National Park –Italy– (Corlatti et al. 2013) investigated the behavioural repertoire of Alpine chamois and showed that male chamois, during the rutting season, make large use of indirect forms of aggression, such as 'marking' or 'neck-up' and that intrasexual competition is mainly based on behaviours that only partially rely upon horn size. Altogether, these data may reinforce the hypothesis of a relatively weak pressure of sexual selection in male chamois.

However, this suggestion requires some caution: on the one hand, sexual selection might have exerted pressure on other features, for example fostering the development of a marked behavioural dimorphism. Indeed, male-male contests in chamois are based on a great variety of behavioural patterns, the majority of which are not present in females (Corlatti et al. 2013). Furthermore, male chamois may not have great advantages in growing large body masses, when they have to chase other males on the Alpine terrain: if so, environmental features may somehow have constrained the development of a marked SSD and favoured other features such as speed or agility. Contextually, some forms of selective pressures may act on female chamois: as long as physical features such as larger body mass favour intrasexual competition in females, e.g. competition for food resources and/or mating, we may expect a reduction in SSD.

So far, from a life history perspective, data on chamois clearly show that: i) the sexual size dimorphism is weak, but the behavioural dimorphism is remarkable; ii) the survival rates show small differences between sexes. Yet, 'grey areas' in our knowledge about chamois mating system still persist, and we currently have no reliable information on the intensity of sexual selection (degree of polygyny) in this taxon. The main problem with verbal descriptions of mating system (e.g. 'highly polygynous', 'weakly polygynous'), is that they fail to capture the diversity of mating systems. Mating systems may intergrade, they may change between populations, and change over time within the same population. Ideally, we would need a more quantitative description of mating system, for example using parameters such as the 'opportunity for sexual selection', which equals the ratio of variance in male reproductive success to the square of the mean male reproductive success (Shuster & Wade 2003). The higher the value of opportunity for sexual selection, the higher the level of polygyny. This parameter ideally requires reliable estimates of reproductive success of males and females, which certainly represents the biggest gap in our knowledge about chamois mating system.

Whatever the level of polygyny, information is still needed to understand the mechanisms underlying variation in male reproductive success. Males may adopt different strategies to achieve reproductive success, i.e. Alternative Mating Tactics (AMts.: Taborsky et al. 2008). Behavioural and spatial observations suggest that, during the rut, some males (i.e. territorial) patrol a relatively small area in which they try to keep females and chase away intruders, whereas other males (i.e. non-territorial) display following behaviour and territory intrusions (Krämer 1969, von Hardenberg et al. 2000, Corlatti et al. 2012b). It is still unclear, however, what kind of territoriality does occur in male chamois: von Hardenberg et al. (2000) suggested that territories during the rut, very small and clustered, may resemble a lek system. Yet they appear somewhat attractive to females during the rut, as if they encompassed food resources. Altogether, these data may suggest the occurrence of a form of territoriality intermediate between resource-based territoriality and true leks, although this aspect still needs to be fully clarified.

Two main questions may be asked about AMts.: i) how do AMts. develop? (i.e. is territoriality a genetic feature or not?); ii) how can AMts. co-exist within the same population? (i.e. what are the mechanisms that allow the maintenance of AMts.?). Unfortunately, no data are available as far as the former question is concerned. As regards the latter, when fitness of AMts. depends on their relative frequency in the population, we encounter frequency-dependent selection (Shuster & Wade 2003). There are no data, in chamois, on this potential mechanism of maintenance, yet other studies on ungulates suggest that frequency-dependent selection is poorly supported in this taxon (Isvaran 2005). Another mechanism that may explain the maintenance of AMts. within populations is status-dependent selection, or condition-dependent selection: the relative fitness of AMts. depends on variation of internal variables such as hormonal status, age or health status (Shuster & Wade 2003). More recently, a further mechanism has been proposed to allow the maintenance of AMts.: each tactic may show a trade-off between costs (e.g. mortality) and benefits (e.g. reproductive success), and this trade-off can be mediated by internal factors such as age, health status, hormonal status, or external factors such as weather conditions, predation, density of females.

In a recent study conducted in the Gran Paradiso National Park we explored this latter mechanism in Alpine chamois (Corlatti et al. 2012b). Specifically, we investigated if variations in mating effort (used as a proxy for mating benefits, see Corlatti et al. 2013) between the pre – and postrut were positively associated with variations in physiological costs (using the load of lungworm parasites as a proxy), if AMts. (territorial and non-territorial males) showed different values of mating effort and related physiological traits, and the proximate mechanism underlying the expression of mating effort and parasite burden (e.g. levels of androgens). Territorial males sharply increased mating effort, faecal androgen and cortisol metabolites, and parasite levels during the rut, whereas non-territorial ones displayed a similar pattern only for androgen metabolites (Figure 1).

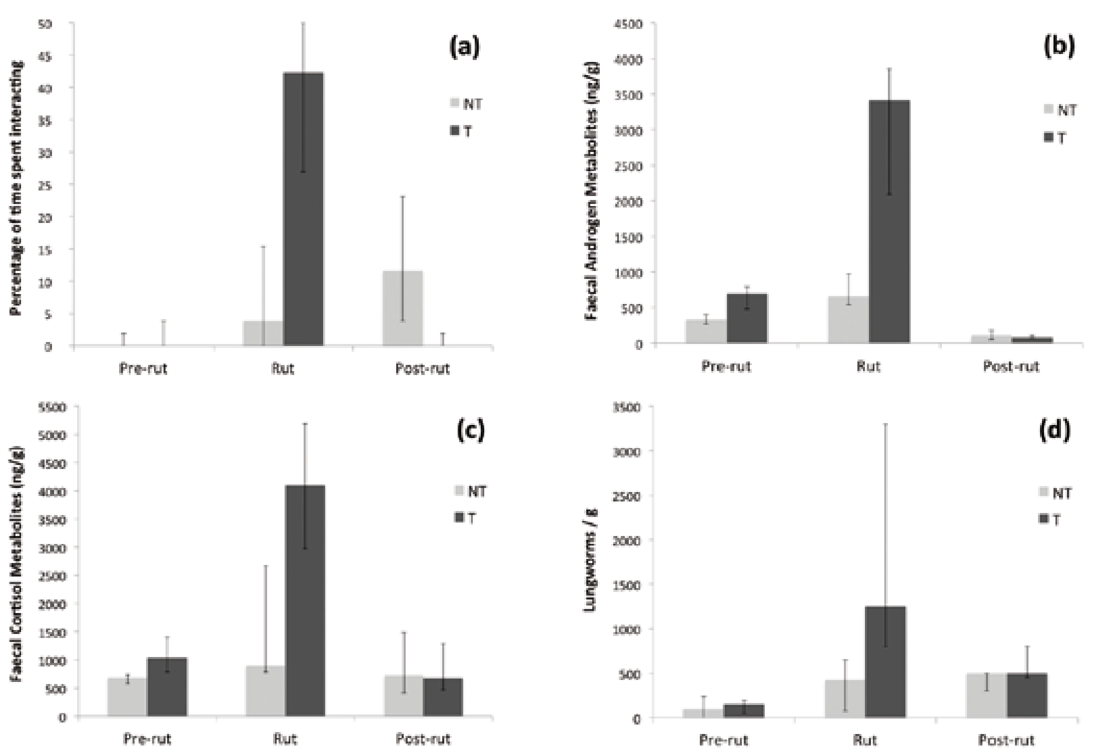

Figure. 1. (a) Percentage of time spent interacting, (b) levels of faecal androgen metabolites (in ng/g), (c) levels of faecal cortisol metabolites (in ng/g), and (d) faecal counts of parasite larvae (number of lungworms/g) of territorial (T) and non-territorial (NT) male chamois from the pre – to the postrut 2011 in the Gran Paradiso National Park. Values are medians ± interquartile ranges. (Corlatti et al. 2012b).

Territorial males invested in mating activities almost exclusively during the rut, whereas non-territorial males interacted more often in the postrut. This pattern is likely due to the synchronisation of female oestrus over a few days in the second half of November (Krämer 1969) that led territorial males to increase the intensity of rutting behaviours to ensure access to females. This may have precluded access to females by non-territorial males, which, in turn, may have concentrated their reproductive effort afterwards. The increase in androgen metabolite levels is in line with the sexual cycle of chamois and other artiodactyls (Mooring et al. 2004, Hoby et al. 2006), while the pattern of cortisol metabolite levels underlies differences between AMts..

Variations in parasite burden suggest the presence of an immunosuppressive effect (Folstad & Karter 1992) in territorial males, whereas the trend in non-territorial males may be largely influenced by the lungworm seasonal cycle (Štefančíková et al. 2011). During the rut, territorial males invested more in rutting activities, while having higher levels of hormone metabolites and greater faecal counts of parasites than non-territorial males. Before and after the rut, differences between male types (territorial and non-territorial males) were smaller. The greater mating effort of territorial males during the rut suggests potentially higher mating benefits (i.e. greater access to females). Data on mating success (Corlatti et al. 2013) support this hypothesis. Territorial males have higher levels of androgen and cortisol metabolites during the rut. There is increasing evidence that dominant individuals have high androgen and glucocorticoid levels more often than do subordinates (Creel 2001, Mooring et al. 2006, Oliveira et al. 2008, Corlatti et al. 2014). These results are consistent with the 'stress of domination' hypothesis: individuals engaged in energetically expensive behaviours are more stressed than subordinate individuals (Mooring et al. 2006).

The greater parasite susceptibility observed during the rut in territorial males, compared to nonterritorial males, may be an important cost in terms of overwinter survival, also considering the high mass loss that occurs during the rut (Rughetti & Festa-Bianchet 2011). Although several studies found a positive correlation between reproductive effort and parasitism in various taxa (Deerenberg et al. 1997, Nordling et al. 1998, Pelletier et al. 2005), the causal relationships among behavioural, endocrine and health variables remain unclear. A path analysis conducted on the same data confirmed the existence of a life history trade-off among reproductive opportunities on one side and metabolic stress and increased level of parasites on the other; moreover, we showed how the mechanism underlying such a trade-off is mediated by androgens.

These results suggest that a trade-off between mating effort and parasitism exists, and that the proximate mechanism underlying this pattern may be found in the secretion of androgen metabolites. The greater investment in rutting activities, which territorial males make, suggests potentially high mating benefits. However, mating benefits could be counter-balanced by greater risk of injuries, consumption of fat reserves and higher hormone levels, which might favour the suppression of immunological defence and the subsequent decrease in parasite resistance. These data are limited to only one rutting season, and it would be worth investigating this pattern in the long term, to account for temporal variations. Furthermore, the trade-off between costs and benefits may depend upon a great number of variables. While we only investigated the role of hormones, Lovari et al. (2006), investigating the spatial behaviour of the same male chamois population, suggested that different phenotypes may be maintained within populations because of variations in snow cover conditions. In years with high snow cover, territorial males may be favoured from the reproductive standpoint, because females would be forced to dwell at lower elevations, where mainly territorial males are found. On the other hand, in years with little snow cover, non-territorial males may be favoured, because females would tend to stay at higher elevations, where mainly non-territorial males are found.

CONCLUSION

The evidence for a highly seasonal SSD, together with the weak differential mortality of the two sexes in Alpine chamois, suggests the occurrence of a conservative strategy unique among ungulate species. On the one hand, the pressure of sexual selection might not have been strong enough to fix more conspicuous physical features in males, as compared to females. On the other hand, the fat and muscles resources accumulated by males over summer can be used during the rut and possibly reduce mortality costs over the winter. These characteristics, together with the compensatory body/horn growth observed for young males, the surprisingly long lifespan and the absence of differences in age and size-related traits between territorial and non-territorial males, seem to suggest the adoption of a less risky mating strategy. However, other forms of dimorphism, e.g. behavioural, appear remarkable in chamois, or selective pressures on features that do not result into great SSD may occur: data on genetic paternity are urgently needed to clarify this issue, and to provide a more quantitative description of mating system. Whatever the level of polygyny within chamois populations, attention has increasingly grown towards variation in male mating behaviour. Territorial males may enjoy greater reproductive success than non-territorial males. Such benefits, however, could be counter-balanced by greater risks of injuries, consumptions of fat reserves and higher hormone levels, which favour the suppression of immunological defence and the subsequent decrease in parasite resistance, possibly increasing mortality rates. This mechanism may partially explain the maintenance of AMts. within Alpine chamois populations.

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LIFE IS A RISKY BUSINESS: STATUS AND CONSERVATION PERSPECTIVES OF THE LAST ANCIENT POPULATION OF ENDEMIC APENNINE CHAMOIS *(Rupicapra pyrenaica ornata)*

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INTRODUCTION AND AIMS

The Abruzzo, Lazio e Molise National Park hosts the historical population of Apennine chamois (*Rupicapra pyrenaica ornata*). Around the beginning of World War I its size was estimated at about 30 individuals located on the steepest parts of the so-called Camosciara. In 1922 the National Park was established to protect these remaining few individuals. The population increased until the beginning of the World War II, when heavy hunting pressured by the local population in need of food caused another population bottle-neck.
Since its institution the National Park has developed a number of actions to promote the conservation of the chamois, such as:

1) Conservation of the last autochthonous population:
- establishment of the Total Reserve;
- touristic regulation.

2) Establishment of new populations:
- feasibility studies;
- genetic screening;
- ex-situ conservation.

Since the '90s the PNALM has consistently contributed to two most important operations: the reintroduction of the Apennine chamois in Majella and Gran Sasso area. Furthermore, in 2008 some other individuals were translocated to the Sibillini National Park to establish a fourth population; this operation was implemented during the LIFE Coornata Project. Last year, as part of the LIFE Project, the fifth colony of chamois was established in the Sirente Velino Natural Park (this time with individuals coming from the recovered populations of Majella and Gran Sasso).
These main conservation measures brought in 2013 the Minimum Number Alive to a total of 1742 individuals and the number of subpopulations to 5. This means that the main aims of the Action Plan have been achieved (Duprè et al. 2001), therefore in 2008 the taxon was down-ranked from "Endangered" to "Vulnerable" in IUCN Red List.
During the last years, however, the chamois population in PNALM has undergone an apparently critical situation, which was firstly studied within a former project carried out thanks to the collaboration between PNALM and ARP (Regional Agency for Parks of Lazio region) and then further analyzed in the LIFE Coornata Project. The overall results are presented and discussed here.

RESULTS

1) Area of Occupancy (AOO) and Extent of Occurence (EOO)
By analyzing and georeferring 7.150 opportunistic direct observations done in 1931-2014, we could reconstruct the chamois distribution range in PNALM in successive periods (Figure 1). It seems clear that chamois range had a slow but progressive expansion, especially towards the southern part of the Park. However, no further substantial expansion was detected in the last 10 years.

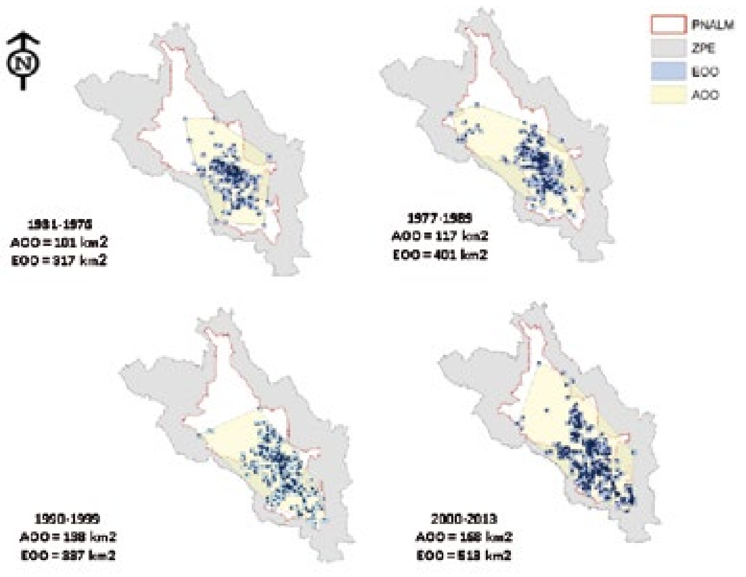

Figure 1. Area of Occupancy (AOO) and Extent of Occurence (EOO) of chamois in PNALM in different periods.

2) Population size trend (MNA)

On the whole, a total of 4314 direct sightings were recorded during the annual ground counts. The population trend was analyzed using the Minimum Number Alive (MNA, i.e. the maximum total number of animals sighted among the 3-4 annual ground counts) as an index of population size (Figure 2). Since 1993 ground counts have been performed following a standardized field method, so they are comparable with each other and may be used for a broad population analysis. Between 1993 and 2001 population size has shown a positive trend, then it has fluctuated around the maximum values until 2005. Since 2006, however, the population trend has been generally negative, yet it has shown annual oscillations. The finite growth rate of increase estimated for the last period (2006-2013) was λ = 0.97 (95% C.I. = 0.93-1.00). As a comparison, in the same period the finite growth rate of increase for the Majella population was λ = 1.15 (95 C.I. = 1.12-1.19).

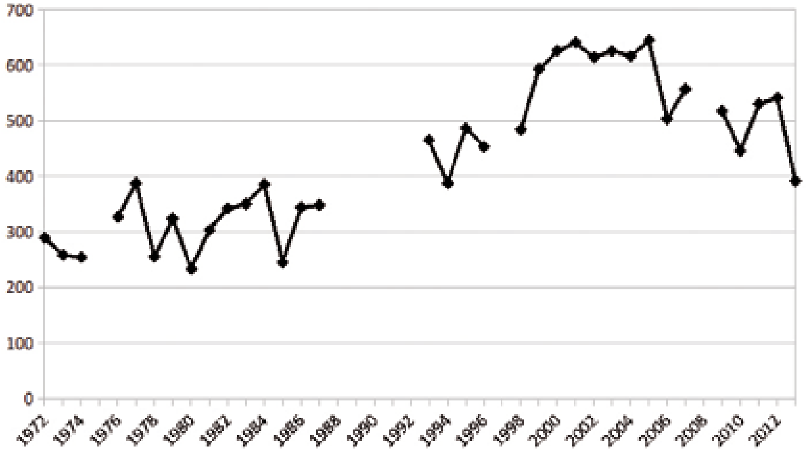

Figure 2. Trend of population size (MNA) in PNALM from 1972 to 2013.

3) Vital rates and population structure

Through systematic and standardized repeated visual scans performed by 1-2 trained operators along the same routes in the areas with the most representative herds (accounting for nearly half of the total PNALM chamois population), it was possible to estimate the main demographic parameters (Table 1).

The overall sex ratio showed a bias toward females, as usual in chamois (Corlatti 2007, Panella et al. 2010). This result may partially depend on the different sighting probability of the two sexes; in fact, the sex ratio in age class I was unbiased, which also means there is no bias at birth (Table 2). The birth rate and the reproductive index reflected a constant productivity of the population, as highlighted by their lowest coefficient of variation (Table 2).

The survival rate of kids and, consequently, the recruitment index are instead very variable (Table 2). This is something generally reported for large herbivores, especially mountain ungulates (Gaillard et al. 1998, Panella et al. 2010). However, by analyzing the survival rate of kids in periods at different growth rate, it appears evident the progressive long term decrease, the lowest values being achieved in the most recent years (Tabel 3).

Demographic parameter	Calculation method
Birth rate (B)	number of kids/total number
Reproductive Index (IR)	number of kids/number of adult female
Sex Ratio (MM:FF)	number of males/number of females
Recruitment Index (IA)	number of yearlings/total number of adults and subadults
Kid survival (AS)	number of yearling $_{y0}$/number of kids $_{y-1}$
Yearling Survival Index (SY)	number of Class I $_{y0}$/(number of yearlings $_{y-1}$ + number of yearlings $_{y-2}$)

Table 1. Demographic parameters calculated to assess chamois population structure and dynamics in PNALM.

	B	IR	MM:FF	MM:FF – I	IA	AS	YS
Mean (2008-2013)	0.256	0.643	0.330	0.752	0.121	0.309	0.665
SD	0.017	0.072	0.027	0.256	0.060	0.143	0.080
CV	0.067	0.111	0.083	0.340	0.498	0.463	0.120

Table 2. Vital rates (mean ± s.d.) of chamois in PNALM in the period 2008-2013 (see Table I for calculation methods). MM:FF – I refers to sex ratio in age class I (2-3 years). CV = coefficient of variation.

Period	AS
1993-2005	52.4% ± 16.2%
2006-2013	44.6% ± 22.9%
2009-2013	37.0% ± 14.6%

Table 3. Kids survival rate in three periods at different growth rate of the PNALM chamois population.

The variation of the parameters related to kid survival and recruitment may be the main factors that have driven population dynamics in PNALM. In fact, in a simple linear regression, the sole AS explained the 44% of λ variance ($F = 11.2$, $P = 0.004$; Figure 3).

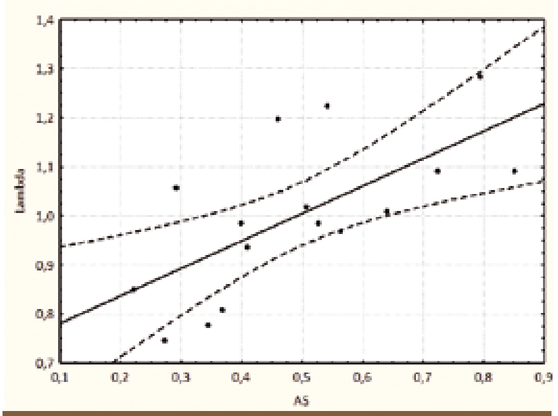

Figure 3. Survival of kids (AS) plotted against the finite growth rate of increase (λ) using the data of the annual ground counts from 1993 to 2013 (N = 16). The straight line was obtained by simple linear regression (r^2 = 0.4437; r = 0.6661; P = 0.0048; y = 0.725 + 0.5593x).

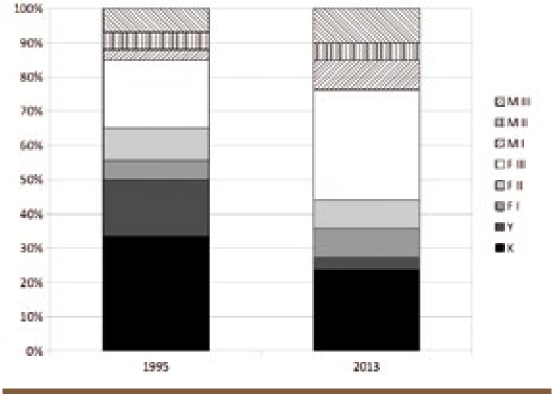

Figure 4. Population structure in Val di Rose: comparison between 1995 and 2013 according to standardized repeated ground counts data. M = male; F = female; K = kid; Y = yearling; I-II-III are age classes according to Lovari (1985).

A significantly high mortality rate seems to have also involved the yearling class (Table 2), because on average 34% of them did not reach the class I. This index is indeed tricky, as it involves two cohorts – 2-year and 3-year-old animals (see Table 1) – thus it must be interpreted with caution. In order to test its reliability, in 2013 we split the class I by distinguishing on the field between 2 and 3 years old animals, and we calculated the yearling survival index also as direct rate between the number of 2-year-old individuals counted the present year on the number of yearlings counted the past year. The result revealed an underestimation of yearling survival when the class I is not split in two (49.4% of survival against 56.0). If this were a general rule, the number in Table 2 might then represent a small underestimation of the real value. It is worth pointing out, however, that the overall mortality before reaching adulthood (i.e. adding yearling mortality to kids mortality) resulted really severe in the last years, as we can estimate that, on average, less than 15 % of the newborns may have reached the 2 years of age.

In Val di Rose, for which it is possible to compare our data with those collected in 1995 with the same field methods (repeated standardized ground counts), the population structure has substantially changed (χ^2 = 13.7, df = 7, P = 0.056): in 2013 the percentage of yearling was smaller, whereas the percentage of adult third class females was larger (Figure 4). A larger proportion of adult females is a typical condition of a well-established population (Crampe et al. 2006, Panella et al. 2010).

Group size has changed as well, since larger groups (> 40 individuals) disappeared in recent years, whereas smaller groups increased in number; singleton class was the most frequent in 2008-2013, whereas 2-5 class was the most frequent in 1995-96 (Figure 5). Such a trend in group size distribution seems to be related to variation of local population density (Asprea et al. 2014).

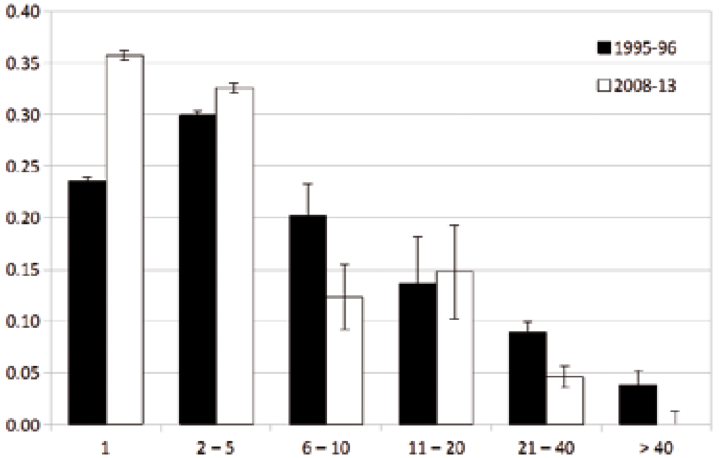

Figure 5. Group size (mean ± s.d.) in Val di Rose in 1995-96 (black) and 2008-2013 (white) according to the standardized repeated ground counts data performed in summer. Group size classes were defined according to literature (e.g. Berducou & Bousses 1985, Richard-Hansen et al. 1992).

4) Interspecific competition: red deer and livestock

The red deer (*Cervus elaphus*) was considered to be extinct in the PNALM already at the beginning of the XX century. In 1975 about 50 individuals were released in the core of PNALM. Now the population is still increasing and it has reached a mean density of 18.7 deer/km² (95%CI = 7.5-30.0) in the core of its range, which is also the part that overlaps the most with the chamois range. Nonetheless, according to a pellet-group count based on 110 transects of 200x2 m selected by double stage sampling, the spatial overlap between red deer and chamois was quite low in all the sample areas investigated (Table 4). This outcome may be related to the different habitat use within grazing pastures: all the environmental variables (slope, exposure and percentage of rocky terrain) showed a significantly different use between the two species (Latini et al. 2012). Sampling effort, expressed in terms of sampling area coverage (0.25%), lies within the range of similar studies (e.g. Loft & Kie 1988, Marques et al. 2001, Borkowski 2004, Prokešová et al. 2006, Aryal et al. 2010). Furthermore, the GPS tracking data confirmed the pellet-group count results, for chamois at least (Latini et al., unpublished data).

Area	Sections with presence of both species	Sections with presence of red deer	Sections with presence of chamois	Pianka index	Jaccard index	P
M. Amaro	5	21	15	0.49	0.12	<0.01
Meta-Tartari	19	289	30	0.29	0.06	<0.01
R. Altiera	1	22	5	0.39	0.04	<0.01
Val di Rose	9	72	20	0.41	0.09	<0.01

Table 4. Spatial overlap between chamois and red deer according to the pellet-groups count performed in the sample areas.

Livestock is widespread in PNALM, especially in the western and southern part of chamois range. Part of the livestock often grazes illegally in Total Reserve near chamois herds. Not only may this proximity generate competition for space and for food resources but also there is a higher susceptibility of disease transmission and other sanitary problems. Moreover, livestock breeding has deeply changed during the last fifteen years, shifting from mostly sheep to mostly cattle. This substantial change has also certainly affected the evolution of pasture vegetation and led to interactions with wild ungulates.

5) Sanitary status

The parasitological analysis revealed that the chamois is much more infested by parasites, mostly *Coccidia* and bruncopulmonar strongyles, than red deer and livestock. The level of infestation seems to have increased in the last 15 years, most of all regarding bruncopulmonar strongyles (cf. Martella et al. 2003, Tomassini 2005). Moreover, among gastrointestinal parasites the highly pathogenic species *Haemoncus contortus* has been identified for the first time in *Rupicapra pyrenaica ornata* (Rossi et al. this volume). The anatomopathological picture is consistent with the parasitological one: 94% (N = 59) of individuals showed pulmonary problems due to strongyles infestation and nearly half of them had also parasitic pneumonia. It is worth pointing out that the highest prevalence of gastrointestinal parasites in chamois was recorded in the area with the most widespread livestock presence (La Meta-Tartari). Serological analysis did not show any evidence of disease transmission between livestock and chamois. The low titles of positivity observed in chamois (n = 7 out of 23 serum samples drawn during chemical immobilization), associated with the lack of symptoms related to the various pathologies, excluded the occurrence of an active infection and only suggested contact with different pathogenic agents. This result is in accordance with what reported in a previous study carried out in the same area 20 years ago (Gentile et al. 2000). Nonetheless, the few positive values in chamois were all found at La Meta-Tartari, where livestock are most widespread. Moreover, we found many positive values in livestock, mostly for toxoplasmosis (44.2%, N = 502) and BVD (41.7%, N = 444), followed by Chlamidia (33.1%, N = 1932) and Border Disease (20.6%, N = 1890). Therefore, livestock may constitute a reservoir of several diseases and this would require careful monitoring to be undertaken in order to avoid all problems with infectious disease spread in the future.

CONCLUSIONS

The question we have tried to answer was: is the chamois population in PNALM in reality declining? Our data have shown that this population is obviously mature. The observed frequency distribution of the annual finite growth rate of increase (λ) and the intrinsic rate of increase (r) neither differed significantly from a normal distribution (Shapiro-Wilk test = 0,97; Figure 6), nor were significantly skewed relative to it, as typical with stable populations (cf. Hone 1999).

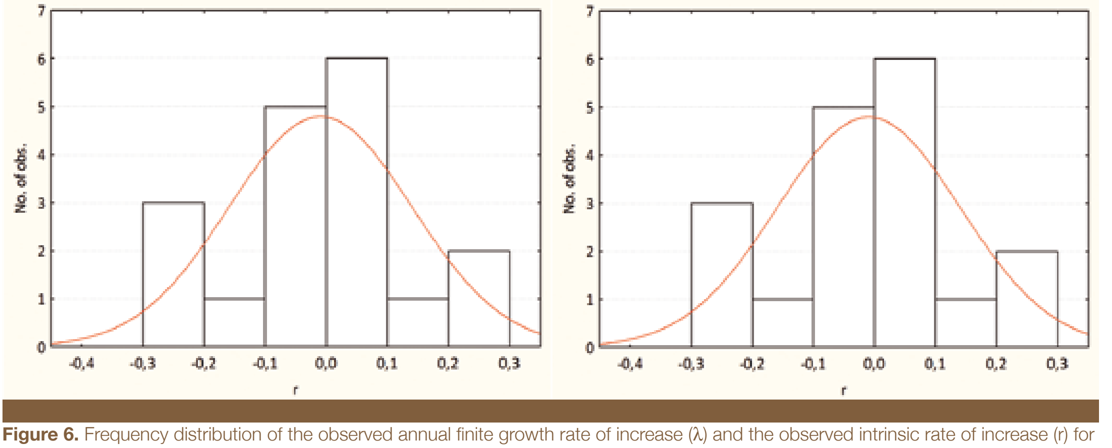

Figure 6. Frequency distribution of the observed annual finite growth rate of increase (λ) and the observed intrinsic rate of increase (r) for chamois in PNALM (r: Skewennes = – 0.26. Kurtosis = – 0.29; λ: Skeweness = 0.08. Kurtosis = – 0.27).

The PNALM chamois population appears to be stable, but has been facing environmental and ecological changes over the last years, as other conspecific populations (e.g. Panella et al. 2010). It is worth pointing out that the ecosystem has radically changed in 30 years. Today more wild ungulate species occur and livestock has changed as well. Thus, the chamois has to share space and food resources with other ungulates. Furthermore, pasture themselves have been probably evolving under global climatic and local ecological changes. In addition, after reaching very high values, especially in its chore area, chamois density may have undergone density-dependent processes, as suggested by this study. High local densities, along with the other above mentioned environmental factors, may facilitate parasitic infestation, thus leading to what we found in our chamois population. Therefore, it appears unavoidable that the whole system, now much more complex, will evolve towards a new equilibrium at which the chamois population itself, likewise the other species, should adapt.

Considering the historical and ecological importance of the PNALM Apennine chamois population, however, it is required that the Park continues to monitor the on-going process and to adopt all possible proactive management actions to improve the chamois conservation status. The final outcome of Action C2 of the LIFE Coornata Project should identify the most appropriate management tools (for more details about, see Latini et al. 2014, this volume).

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CURRENT STATUS AND CONSERVATION MANAGEMENT OF BALKAN CHAMOIS *(Rupicapra rupicapra balcanica)* IN GREECE

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SUMMARY

Balkan chamois distribution in Greece is divided into 24 geographically distinct populations, which are grouped in 6 main population blocks. Only four of the above populations number more than 100 individuals (100-300 ind.), with all four currently demonstrating significant population increases. All the other (20) populations are smaller than 90 individuals, with most of them demonstrating insignificant population change, whereas 6 populations are only remnants (less than 15 ind.) of former much larger populations. Although Balkan chamois is a strictly protected species, according the Greek legislation and most of its range is situated within the borders of protected areas (Natura 2000 sites, National parks, Wildlife Sanctuaries), poaching still remains the main threat for the species. However, at a national level, *Balkan Chamois* population size is on the increase, currently numbering twice as many individuals (1180-1605 ind.) than what was recorded only a few years ago ('90s-'00s). Monitoring plans regarding the chamois – among other Community interest species-are implemented for the first time in Greece in all known chamois localities, both inside and outside Natura 2000 Network and/or nationally established protected areas (National parks). In order to improve the species conservation status, it is important that road accessibility in crucial chamois habitats should be banned or severely restricted and poaching incidents should be eliminated, through an effective anti-poaching game warden body. Environmental awareness should also be promoted especially in areas of close proximity to chamois habitats, and conservation oriented research regarding all aspects of chamois ecology (space use, demography, genetics, current and future threats etc.) should be advocated.

INTRODUCTION

Although Balkan chamois is a very important grazer on medium and high altitudes throughout Europe and Asia Minor, it is one of the least well studied mammal species in Greece. Only few years ago there were only scarce reports regarding nothing more than the hazy presence of the species in a few high mountains of Greece. An overall report on the species status in Greece was published a few years ago based mainly on field data, bibliography and additional information, covering the period between 1992-2002 (Papaioannou & Kati 2007). In this report 30 sites with existing or recently extinct chamois populations were identified across the whole Greek mainland, and 477-750 individuals were recorded at a national level. This article concerns an updated version of the current distribution and population status of the species in Greece, including information regarding threats and conservation management.

DISTRIBUTION AND POPULATION STATUS

Balkan chamois current distribution in Greece includes 24 sites in several mainland mountainous areas. Most populations hold steady in numbers or demonstrate insignificant increase or decrease. However 4 of them have recently surpassed the threshold of 100 individuals, as the result of an apparently continuous population increase. Contrastingly 6 of the above populations represent only remnants of former much larger populations and seem to be close to extinction. Furthermore there are 8 additional sites where local chamois populations are now considered extinct. All Greek chamois populations are grouped in 6 distinct population blocks with no current contacts between individuals belonging to different population blocks. An exception could be between pop. block A and pop. block B. However it is clear that contacts between certain population blocks and others, has stopped long ago, eg Mt.. Olympus (D, 19).

a. Northern Pindus mountain range
This area is located in NW Greece and includes some of the highest mountains of Greece: Smolikas Mt. (2637m), Grammos Mt. (2520m), Timfi Mt. (2497m). There are 9 distinct populations, 2 of them being remnant populations (Hatzirvasanis 1991, Papaioannou 1991, Papaioannou 1999a, Papaioannou 1999c, Papaioannou 2003, Papaioannou & Kati 2003, Papaioannou 2005, Papaioannou & Kati 2007, Papaioannou 2009a, Papaioannou 2009b, Papaioannou in press). Some of the largest chamois populations in Greece are found in this area (Smolikas Mt., Grammos Mt., Ligos/ Valia Calda/ Tsouka Rossa Mt.s) including the largest of all on Timfi Mt.. The area is home to 485-625 individuals overall, with most of them (300-350 ind.) found on Timfi Mt.. Most of these populations are stable or exhibit a slight increasing tendency. On the other hand the Timfi Mt. population demonstrates a steady population increase during the last 15 years. Its population size increased from an initial number of 55-70 ind. at the end of the 80s (Papaioannou 1991) to 64-86 ind. in 1997-98 (Papaioannou 1999c), to 120-130 ind. in 2001-02 (Papaioannou & Kati 2003, Papaioannou & Kati 2007), kept

growing to 150-155 ind. in 2005 (Papaioannou 2009a) and finally reached 300-350 ind. in 2014 (Papaioannou, anectodal data). At the same time there is an expansion of the species distribution range, as the species gradually recolonizes sites within its historic range on the same massif, including localities from where the species has not been reported for more than a century. In addition, dispersing male individuals have been occasionally recorded moving (mainly) from Mt. Timfi population towards adjacent populations of the same population block (except the one on Grammos Mt.) (Papaioannou, anecdotal data). Population composition of the Timfi Mt. population was studied during the period 2001-2005 and at 2002 was recorded as follows: (males: 30%, females: 38%, yearlings: 9%, kids: 23%) (Papaioannou anectodal data, Papaioannou et al. in press).

In contrast, the two chamois populations of this population block located along the Greek-Albanian border, demonstrate a slow but steady decrease, which may soon drive both populations under the 10 ind. threshold. Grammos Mt. population range stretches mainly within the Greek borders, but the most important part of the population is found exactly on the border line (Papaioannou 1991, 1999a, 2000b). The opposite occurs with the Nemertsika Mt. population (Papaioannou 1991, Papaioannou 2005), where the main part of this population occurs into Albania. The two remnants populations in this population block (Central Zagori and Vasiilitsa) only occasionally host chamois individuals.

b. Central & Soutrhern Pindus mountain range

This area is located in central Greece and includes two extensive massifs with several distinct mountains in both sides of Aheloos river. Six population groups exist in the area, 3 of them being remnant populations (Papaioannou 2005, Papaioannou & Kati 2007, Papaioannou 2007). In general, population sizes are low as only 75-115 individuals exist in this whole area. The most important population in the area is the one in Peristeri/ Kakarditsa/ Tzoumerka/ Pahtouri/ Stefani mountain complex, which numbers 30-40 individuals scattered in small groups across a few isolated pockets in an extensive area. The recently documented presence of the Aracthos gorge chamois population, counting 15-20 ind, indicates that chamois populations can survive even in low altitudes (Arachthos gorge alt: 300-1000m). Mt. Hatzi still hosts a small population of 20-30 ind. On the other hand, there are no recent data confirming the continuous chamois existence on Trigia Mt. and only few data regarding the presence of very few chamois individuals on Avgo and Kokkinolaka Mts., where the species still seems to cling to a precarious existence. All the latter populations are considered as remnants of the species former distribution.

c. Central Greek mainland mountains

Located in Central Greece this area represents the southern limit of chamois distribution in Europe. Giona and Vardousia are two of the highest and most steep mountains of Greece and together with the adjacent Iti Mt. host 215-290 individuals. Most of them reside to Giona Mt. (150-200 ind.), which holds one of the largest chamois populations in Greece, one that also seems to demonstrate a steady increase during the last 10 years; 110 ind. were counted here in 2007 (Papaioannou 2008a, Papaioannou et al. 2012, Papaioannou et al. 2014). As far as population structure was concerned : males constituted 36%, females 35%, yearlings 8% and kids: 21% (Papaioannou et al. 2014). Mt. Iti chamois population, considered close to extinction (10-30 ind., Hatzirvasanis 1991), bur recently started to exhibit a slight increase in both population size and range, counting currently 40-60 individuals (Papaioannou 2014). On the other hand, Vardousia Mt. population still remains restricted in both size and range, despite the abundance of suitable habitats, though some recent records of scattered males in the main massif have been reported.

d. Mt. Olympus

The highest mountain in Greece (alt. 2917m) and one of the highest in the Balkans, hosts one compact chamois population. It currently numbers 180-250 individuals, displaying a steady population increase during the last 15 years. The first detailed count, which took place in 2008, gave a number of 110 ind. (Papaioannou 2008b), while all the previous reports gave numbers lower than 100 individuals (Hatzirvasanis 1991, Papaioannou & Kati 2007). This population seems to be isolated long ago from all the other chamois populations in Greece.

e. Rhodopi/ Falakro Mts.

This area is located in Northern Greece and hosts 4 distinct populations totaling all together 215-305 individuals. Two of them are close to the border with Bulgaria. Rhodopi (Northern core/Fracto forest) population is one of the largest chamois populations in Greece currently numbering 130-180 individuals It is a cross-border population that at least a part of the population uses habitats within Bulgaria. During the last 15 years this population also demonstrated significant increase in both population and range (Birtsas et al. 2013, Papaioannou anecdotal data). Detailed counts of this population in 1997-98 revealed a pop size of 60-80 individuals (Papaioannou 1999b, Sfougaris et al. 1999, Sfougaris et al. 2004, Papaioannou & Kati 2007). The Rhodopi (South-Eastern core) population numbers 60-90 ind. and also seems to demonstrate a recent slight increase in population size, as in 1999-2000 only 15-30 individuals had been recorded (Sfougaris et al. 1999, Sfougaris et al. 2004, Papaioannou & Kati 2007). This population is located in 4 – very close to each other – distinct areas (Birtsas et al. 2013, Papaioannou anecdotal data). Falakro Mt. populations are located further away from the other two populations of the Rhodopi/ Falakro block (Birtsas et al. 2013) and numbers very few individuals (25-35 ind. in two separate cores). Although it has been suggested that the previous mentioned populations are the result of colonization from individuals originating from Frakto forest (Birtsas et al. 2013), we consider that they are local (indigenous) populations which following tremendous adversities due to heavy poaching, only now take their very first steps towards recovery. Reports of local people support the theory of the continuous presence of the species in these areas (Dipotama 1953, 1971 & Falakro Mt.: 1985, 1988, 1998, 2005) (Papaioannou anecdotal data). It is worth mentioning that according

Birtsas et al. (2013) the numbers regarding the above-mentioned populations are: Rhodopi (Northern core/Fracto forest): much more than 86 – 148 individuals, Rhodopi (South – Eastern core): 97-112 individuals, Falakro Mt. populations: 32-42 individuals.

f. Tzena & Pinovo Mts.

This area is located in the north of Greece along the borders with FYROM and it hosts a single population, which uses territories in both sides of the border (cross border population) (Papaioannou 2005, Papaioannou & Kati 2007). There are no recent scientific data regarding this population, but it is considered to number 10-20 ind. Tourism infrastructure in the FYROM part of the mountain represents a possible threat regarding habitat degradation and increased disturbance (as well as poaching). It is considered that a second population existed until the 70s in the area, at the eastern slopes of the nearby Voras Mt. (Kaimaktslan), but there are still no available enough proves to be sure about this (Papaioannou anecdotal data).

g. Other populations

Five chamois populations went extinct many decades ago (Voio, Tamburi, Mitiskeli, Axladias-Tsoukes, Parnassus Mts.) (Papaioannou & Kati 2007), followed by a few more (Zigos, Agrafa, Voras) (Papaioannou & Kati 2007, Papaioannou anecdotal data). It is worth mentioning again, that the presence of two recently discovered populations (Falakro Mt. and Aracthos gorge) are not considered the result of recent colonization.

THREATS

The main threat for the Balkan chamois in Greece was and continues to be poaching. **Poaching** affects more or less all populations, with some of them still under great pressure (Hatzirvasanis 1991, Papaioannou 1991, Adamakopoulos et al. 1997, Papaioannou 2003, Papaioannou & Kati 2003, Papaioannou 2005, Papaioannou & Kati 2007, Papaioannou 2010, Papaioannou et al. 2014, Papaloannou et al. in press). Chamois populations at the border line-hitherto protected during the Cold War due to the Iron Curtain-are now points of interest for poachers from both countries. So Grammos Mt. population (pop block 1) remains small endangered owing to the fact that Albanian poachers systematically visit Greek territory. Taking into account that the most remote and inaccessible localities (at least from the Greek side of the mountain) for this population, can be easily reached by poachers from Albania, it becomes apparent that the future of this population is far from ensured. Problems with local as well as "imported" poaching also concern other chamois populations such as the ones in Nemertsika Mt. (Greek-Albanian border), Tzena-Pinovo Mts. (Greek-FYROM border) and Frakto forest (Greek-Bulgarian border). Regarding the last locality, it was long known that Bulgarian poachers occasionally visit the area of Frakto forest. However this habit has become more common in the last few years and according to Bulgarian colleagues (Valchev K. pers. contact) it is a serious threat. A dirt road, which has been constructed close to the borders from the Bulgarian side of the mountain, resulted in further increases in poaching incidents.

Disease outbreaks have never been reported on chamois in Greece (Papaioannou & Kati 2007), except some not clear reports from local people regarding dead chamois in Ligos Mt. (pop. block A) during the end of '60s (Papaioannou anecdotal reports). There was also an incident of a sick individual in 2013 –which afterwards died-in Mt. Timfi, which still remains unclear if it was actually a disease or not.

Livestock rearing generally regarded as negatively affecting chamois populations through direct competition for resources or disturbance (Rebolo et al. 1993, Fankhauser et al. 2008, Chirichella et al. 2013), but in Greece does not seem to be more than a meager disturbance (Papaioannou 2014, Papaioannou in press), especially if one takes into account the ever decreasing livestock numbers in chamois habitats of mountainous Greece. It is not known how the shift from sheep breeding to cattle breeding – brought about by changes in the EU's agricultural policy – affects chamois populations.

Feral dogs have been reported to affect negatively chamois populations in Greece (Hatzirvasanis 1991, Adamakopoulos 1997), but we have never recorded something like this. Thus we consider that it only occurs on isolated cases. On the other hand, herding and hunting dogs usually disturb chamois forcing them towards the margins or far away from their most suitable feeding grounds (Papaioannou anecdotal data).

Legal **hunting** could be considered a problem due to the disturbance it induces. The presence of hunters-usually accompanied by hunting dogs-into crucial chamois habitats (especially during autumn), force chamois towards the most inaccessible terrain within their range (Papaioannou anecdotal data).

Finally, **road construction** in-or in proximity to-crucial chamois habitats is a significant problem, as it leads to increased disturbance due to legal hunting and primarily because it facilitates poaching (Papaioannou 1991, Adamakopoulos et al. 1997, Papaioannou 2003, Papaioannou & Kati 2003, Papapioannou 2005, Papaioannou & Kati 2007, Papaioannou et al. 2014, Papaioannou et al. in press). This is in accordance with the negative effects of the roads on biodiversity (Laurance et al. 2014). A road in a previously inaccessible area means easy access to the chamois habitat for the poachers as well as a quick getaway. The situation is aggravated by the complete insufficiency of the state game warden body (of Forestry Service and/or National Park authorities) and the fact that hunting association game warden bodies only recently starts responding to calls of non-game poaching.

As far as **natural predators** are concerned, all chamois populations are sympatric with wolves and the golden eagle, while all the western and northern Greek chamois populations are sympatric with the brown bear. No indisputable evidence for the continuous existence of lynx in Greece has been presented for many decades. However, chamois predation by wolf or bear has never been reported and therefore they are considered to be extremely rare. A few records of golden eagles trying to catch chamois newborns do exist (Papaioannou anecdotal data).

Chamois has been played an important role as a game species for prehistoric communities for many thousands of years, as archaeological evidence has revealed – among other places – in Vodomatis river gorge on Timfi Mt. (Gamble 1997, Kotjabopoulou 2008). Balkan chamois continued, up until the '70s, to be a valuable trophy for the people of the mountain communities, which used to organize special chamois hunting activities every year. However, the widespread availability and use of more effective guns, and even war rifles from the beginning of 20th century onwards, created major challenges to still existing chamois populations. War rifles were used more systematically after the Greek civil war (1946-1949), as those citizens living in the mountain villages-especially close to the borders – that belonged to the militia, had the privilege to bear such weapons. Some of them illegally albeit systematically used these rifles for chamois poaching; several empty calibers from that period are commonly found in chamois habitats (Papaioannou anecdotal data, Papaioannou 2007, 2014). Fortunately, this rapid decrease of all chamois populations was recognized by the Forestry Service and the State totally banned chamois hunting-among other threatened species-throughout the country in 1969 (Law 86/69). This is the main Law regarding the Balkan chamois protection in Greece, and is still in action.

In addition, the Forestry Service, acting either on its own initiative or under the pressure of local communities, implemented additional measures with regards to wildlife conservation. In order to ensure the protection of threatened mammal species, including chamois, and taking into account the fact that in most cases it is impossible to tell the difference between a legal hunter and a possible poacher, the Forestry Service started banning all hunting activities in several crucial pockets of protected species ranges, thus establishing the-so called in Greece-Wildlife Sanctuaries.
Most chamois populations were negatively affected by the policy changes that followed Greece's integration into the EU for two reasons. Firstly, by the improvement of the economic situation of several people living in small towns, close to chamois habitats, which now had the opportunity to obtain and use 4X4 motor vehicles together with plenty of free time to spend at hunting activities. Secondly, by the funds given to the Greek state for economic development, a significant portion of which was used for the construction of thousands of km of roads on the mountains-including those with chamois habitats-for livestock breeding and logging purposes. Although it is not clear how much these roads eventually contributed to the economic development of the rural areas, it is clear that they offer easy access to anyone –including poachers-into or close to chamois habitats. In addition, the widespread use of new and improved hunting guns as well as communication devices (VHF etc.) greatly facilitated hunting activities and hence made chamois poaching much more effective. Moreover, a social disruption in the neighboring country, Albania, during the mid 90s, resulted-among other things-in the looting of huge amounts of army weapons that for the right amount of money found their way into Greece. Thus, there was a period ('90s and '00s) where certain chamois population, usually those located close to the borders or even further (mainly pop. block A) were systematically hunted with the use of war rifles like the AK-47.

For all the above reasons, most of Greek chamois populations came close to extinction. However, those populations located in the most remote and steep mountains, usually with extensive free-road areas (Timfi Mt., Giona Mt., Olympus Mt., Frakto forest) succeeded in preserving viable populations (50-80 ind) through the end of '90s and the beginning of '00s.
No accurate/ official data exist in relation to chamois population sizes and/ or ranges before the 1980s. In general, during the pre-1980 period the presence of the species in several sites across the Greek mainland was known only to the local communities and in some cases to the Forestry Service as well. The first scientific or popularized publications and articles regarding Balkan chamois appeared in the early '90s. During the same period a brief study of a few selected populations was included in a small number of projects at the end of '90s and during '00s. An overall account of the species presence in Greece was published in 1991 (Hatzirvasanis 1991) and 1997 (Adamakopoulos et al. 1997), followed by a book (monograph) for the Balkan chamois in Greece (1st edition in 2003 and 2nd edition in 2005) (Papaioannou 2005) and finally a detailed publication in 2007 (Papaioannou & Kati 2007), making the species status well known to everybody (scientists and non-scientists alike). Especially the 2003-5 popular – but scientifically documented-book was distributed in more than 3000 copies to all responsible authorities, the local stakeholders close to chamois populations and to several people living in proximity with the species habitats.
It is worth mentioning that an important role during the period ('90s-'00s) was played by individuals and/ or local environmental NGOs, national NGOs, local mountaineering clubs and local environmental centers which contributed in promoting environmental awareness for the species to local communities. In certain circumstances-exasperated against poachers-local communities launched patrolling schemes in and around chamois habitats, which eventually lead to the termination of all poaching activities. In some cases during the same period (e.g. in Frakto Forest), the Forestry Service along with the game warden body of the Hunting Associations reacted properly and contributed at the local elimination of poaching.

Finally, the chamois populations that reside in the most popular mountain tourism hotspots (Olympus Mt., Timfi Mt., Giona Mt., Frakto forest), started exhibiting a slow but steady population increase from the early '00s until now. It is interesting that although such eco-touristic activities are considered a disturbance in other countries (Hamr 1988, Pepin et al. 1996, Gander et al. 1997, Bogel et al. 2002), in Greece they seem to have a positive footprint to chamois conservation by scaring away the poachers (Papaioannou anectodal data). There were some conflicts between hikers/ naturalists against poachers and videos or photos with poachers in action published in local media.

CURRENT CHAMOIS MANAGEMENT

Chamois hunting totally banned throughout Greece since 1969. A significant part or even the whole range of several chamois populations, are located within the limits of Natura 2000 areas, either SPAs (Special Protected Areas) or SCIs (Sites of Community Interest) (Papaioannou & Kati 2007). In addition, half of the chamois populations are located inside National parks. However, the one management measure that currently most seriously contributes to the Balkan chamois conservation is the establishment of Wild Life Sanctuaries-meaning areas without hunting activities-in crucial chamois habitats; fortunately, most of Balkan chamois sites throughout the mainland already belong to this conservation status.

Greek State authorities have decided for the first time to implement Monitoring projects in all Natura 2000 sites regarding mainly species belonging to the Annexes of European directive 92/43 EU. As chamois belongs to Annexes II & IV, it is included in the list of species of community interest that are covered by the above monitoring projects. All these projects have been divided in two categories in relation with the management status of the area. All protected areas with a management authority (national parks etc.) implement their own monitoring projects, whereas in the rest of Natura 2000 areas (outside national parks) a common monitoring project is implemented. All the above monitoring projects focus mainly to the Natura 2000 sites and especially for chamois – and other species except birds – to SCIs, though part of the monitoring activities take part in surrounding areas as well.

According to all the above, it is expected that by the end of 2015 all the relative monitoring projects will have been implemented and recent accurate data regarding all Greek chamois populations and their conservation status will be available.

CONSERVATION MEASURES

A set of conservation measures should be implemented, in order to guarantee the long-term maintenance and increase of Balkan chamois populations in Greece. These measures include mainly poaching elimination, a systematic monitoring scheme, conservation-oriented research and a suite of other conservation measures of local, national and international character.

Poaching elimination could be achieved through:

– maintenance of the current national legal frame for chamois conservation, and better implementation in terms of juridical sanctions enforcement for illegal chamois hunting activity, as well as rifle use for hunting in general;

– setting up an efficient ranger body and improving current Forest Service patrol system, towards protecting adequate chamois habitats from illegal activities;

– controlling or blocking the access to those forest and mountainous dirt roads which provide access to poachers towards chamois habitats, under a specific five-year schedule at Prefecture level.

Monitoring should include:

– a systematic monitoring scheme on bi-annual basis, updating the population size and distribution of Balkan chamois in Greece;

– monitoring disease presence in Balkan chamois population, focusing on increasing populations;

– monitoring hunting activities in chamois habitats.

Research should focus on:

– the genetic variation between all the 6 population blocks, considering mainly the Olumpus Mt. population vis-à-vis those in Pindus mountain range;

– conservation oriented projects regarding population density, population demography, home ranges, possible threats (competition with livestock, and so);

– the effect of climate change on the southern populations of the species (pop. block C).

Other conservation measures:

– an action plan for Balkan chamois for the whole Balkan region, as well as at national scale;

– maintaining and enlarging the current Wild Life Sanctuary network (non hunting areas), established for the protection of chamois populations;

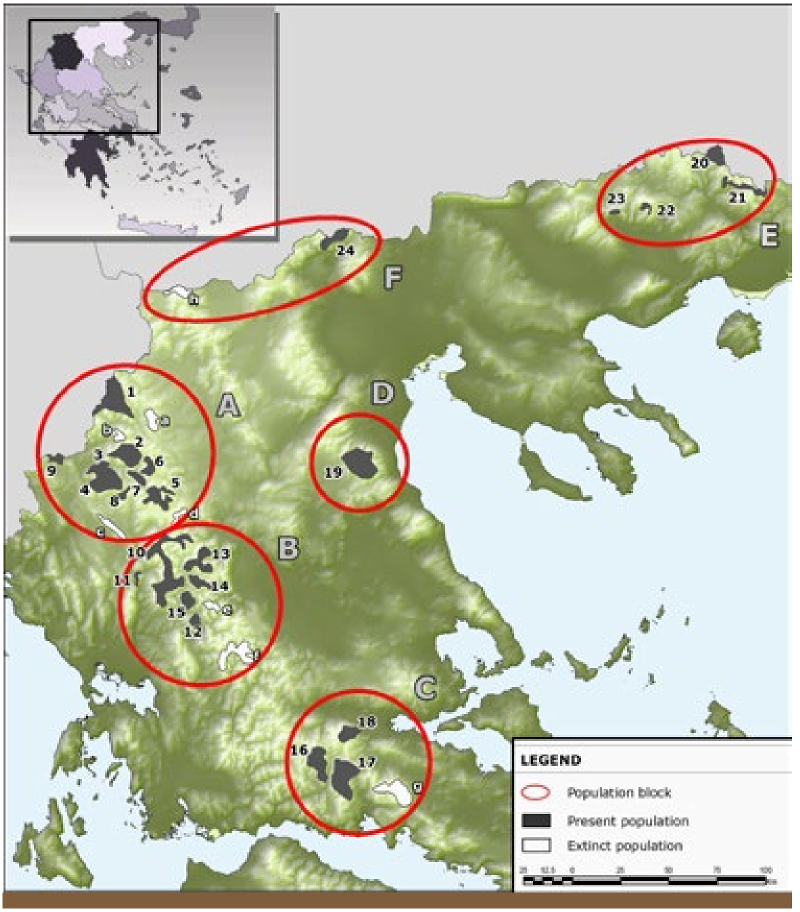
- setting up corridors as non-hunting areas to enhance the movement of individuals and the gene flow among different populations within the same, even different (pop. block A/ pop. block B) chamois population blocks

- international cooperation in the fields of public awareness, conservation and research in order to ensure the future of the cross-border populations;

- specific environmental awareness activities targeting local communities, local hunting clubs and local stakeholders.

Population block			Site name	Population size		Remnant pop.	Border pop.	Extinct pop.
				min	max			
A. Northern Pindus	1		Grammos Mt.	25	40		B	
	2		Smolikas Mt.	40	60			
	3		Trapezitsa Mt.	30	40			
	4		Timfi Mt.	300	350			
	5		Ligos/ Valia Calda/ Tsouka Rossa Mts..	60	80			
	6		Vassilitsa Mt.	0	5	R		
	7		Kleftes-Flabouro Mt.	10	20			
	8		Central Zagori Mts.	5	10	R		
	9		Nemertsika Mt.	15	20		B	
		a	Voio Mt.	0	0			
		b	Tampuri Mt.	0	0			E
		c	Zigos Mt.	0	0			E
		d	Mitsikeli Mt.	0	0			E
			Total	**485**	**625**			
B.Central & Southern Pindus	10		Peristeri/ Kakarditsa/ Tzoumerka/ Pahtouri/ Stefani Mts.	30	40			
	11		Arachthos gorge	15	20			
	12		Kokinolakka Mt.	5	10	R		
	13		Trigia Mt.	0	5	R		
	14		Avgo Mt.	5	10	R		
	15		Hatzi Mt.	20	30			
		e	Ahladias/ Tsouke Mts.	0	0			E
		f	Agrafa Mt.	0	0			E
			Total	**75**	**115**			
C.Central Greece Mts.	16		Vardousia Mt.	25	30			
	17		Giona Mt.	150	200			
	18		Iti Mt.	40	60			
		g	Parnassus Mt.	0	0			E
			Total	**215**	**290**			
D.Olympus Mt.	19		Olympus Mt.	180	250			
			Total	**180**	**250**			
E.Rhodopi/ Falakro Mts.	20		Rhodopi (Northern core/Fracto forest)	130	180		B	
	21		Rhodopi (South-Eastern core)	60	90		B	
	22		Falakro Mt. (Eastern core)	10	15	R		
	23		Falakro Mt. (Western core)	15	20			
			Total	**215**	**305**			
F.North-western border Mts.	24		Tzena/Pinovo Mts.	10	20		B	
		h	Voras Mt.	0	0		B	E
			Total	**20**	**20**			
			Total	**1180**	**1605**			

Balkan chamois populations in Greece.



Balkan chamois geographical distribution in Greece.

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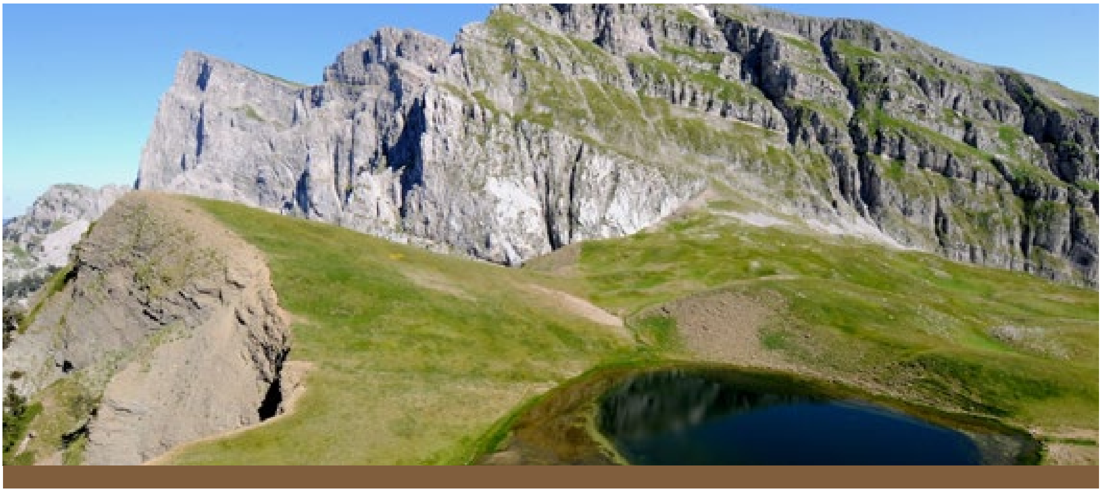
Balkan chamois habitat in Grammos Mt.

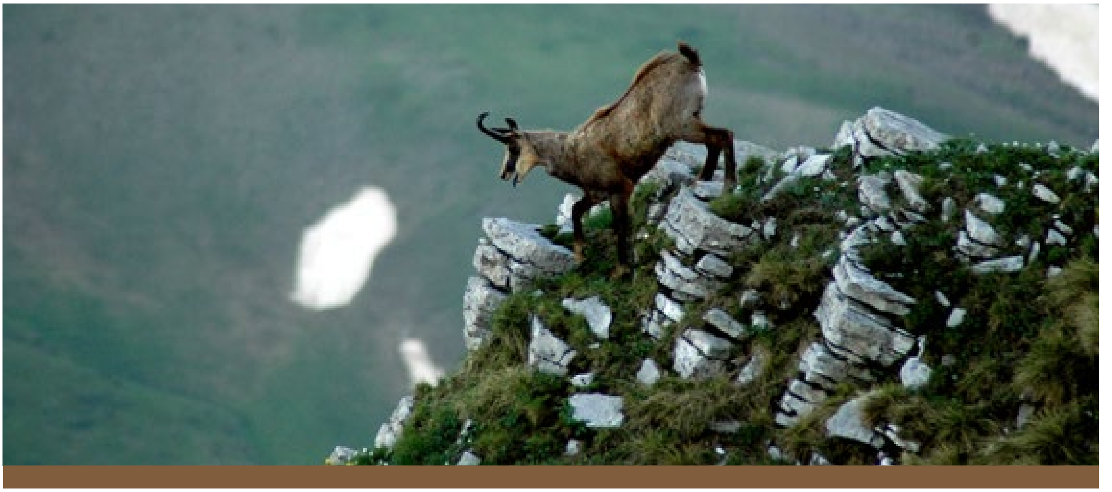
Balkan chamois habitat in Frakto forest.

Balkan chamois habitat in Olympus Mt.

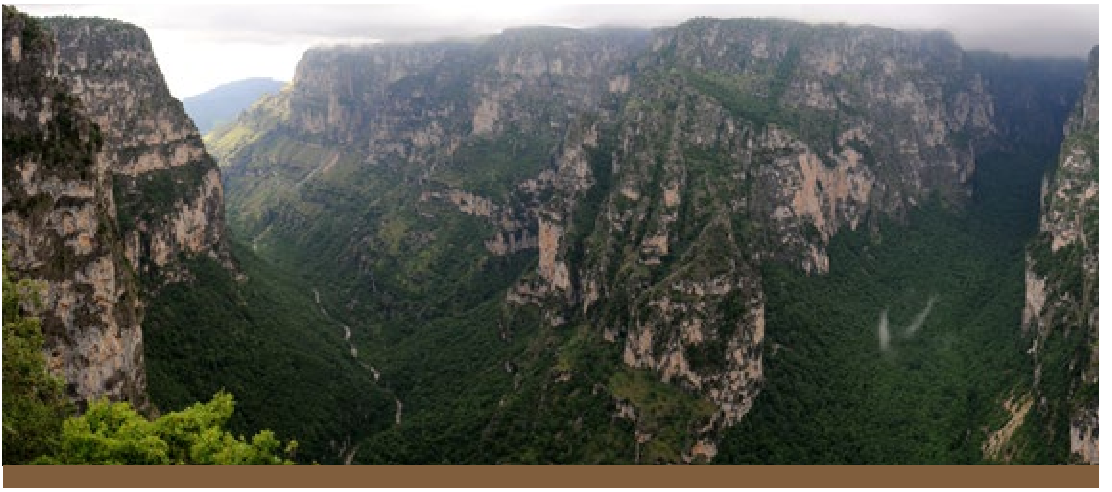


Balkan chamois habitat in Timfi Mt.

Male and female Balkan chamois in Olympus Mt.



Male Balkan chamois in Timfi Mt.



Natural recolonization of Balkan chamois is taking place in Vikos gorge (Timfi Mt.).

Northern slopes of Timfi Mt.

Poaching in Giona Mt.


Male Balkan chamois in Giona Mt.
Photo Haritakis Papaioannou

MAPPING AND DEFINING FAVORABLE CONSERVATION STATUS OF BALKAN CHAMOIS *(Rupicapra rupicapra balcanica)* IN BULGARIA

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Bulgaria is a country located in the south-eastern part of the Balkan Peninsula with area of 111 000 km² and a population of approximately 7 million people. Over 1/3 of the country is mountainous. The highest peak is Musala in Rila mountain – 2925 m a.s.l. The rocky complexes and surrounding areas suitable for Balkan chamois are estimated to be around 4000 square km (Valchev et al. 2006), according to our estimation during the current study the suitable areas are 3268.6 square km. The number of chamois in Bulgaria is estimated to be between 2000 and 2500 individuals (about 2400 in 2013). Occupied chamois habitats are located in the mountain massifs:

Rila is a mountain range with glacial origin where is located the highest mountain in the Balkan Peninsula, Musala (2925 m a.s.l.). Mountain peaks along the main ridges rise to an average height of 2700 meters above sea level. Rila contains large meadows, over 140 peaks rising above 2000 meters, as well as a variety of rocky complexes, precipices, caves, deep canyons, moraines and waterfalls. Its territory is dotted with over 120 glacial lakes. In Rila Mountain we have Rila National Park (80000 ha), the largest national park in Bulgaria, Rila Monastery Nature Park (27 000 ha) and 4 reserves. Over 40 000 ha is a treeless area and over 70 000 ha is a wooded area. The forests are mainly composed by *Picea abies*, *Fagus silvatica*, *Pinus peuce*, *Pinus silvestris*, *Pinus heldreichii*, *Pinus mugo* etc. (Valchev et al. 2005).

Pirin is also a glacial mountain. The highest peak is Vihren (2917 meters a.s.l.). Pirin contains large meadows and many peaks rising above 2000 meters, as well as a variety of rocky complexes, precipices, caves, deep canyons and moraines. Its territory is dotted with over 120 glacial lakes. On Pirin Mountain Pirin National Park (40 000 ha) is located. The chamois in Pirin inhabits almost the whole alpine and subalpine zone of the mountain and also some areas under the tree line. The forests are mainly composed by *Picea abies*, *Fagus silvatica*, *Pinus peuce*, *Pinus silvestris*, *Pinus heldreichii*, *Pinus mugo* etc. (Valchev et al. 2005).

Stara Planina (Balkan Mountain) stretches in the middle of Bulgaria from Serbia to Black sea. Chamois is now found mainly on the territory of Central Balkan National Park.

Central Balkan National Park was established in 1991 with an area of 71 670 ha, Botev highest peak (2376 m) many peaks above 2000 meters a.s.l., as well as a variety of rocky complexes, precipices, caves, deep canyons, moraines, waterfalls and meadows. There are a 27 668 ha treeless area and a 44 000 ha wooded area. The forests are mainly composed by *Fagus silvatica*, *Carpinus betulus*, *Quercus sessiliflora* etc. (Valchev et al. 2005).

In the The Rhodope (Rhodopi) Mountains the highest peak is Golyam Perilik with its 2191 m a.s.l. There are many peaks around 2000 m a.s.l., deep rocky gorges and canyons, precipices, meadows and forest. The main tree species in the chamois habitats are: Picea abies, Pinus silvestris, Pinus nigra, Fagus sylvatica and on the lower altitude Querqus sp., Carpinus betulus, Corylus avellana etc. (Valchev et al. 2005).

The Balkan chamois has been reintroduced in Vitosha Mountain.

Balkan chamois is considered as a differentiated subspecies *Rupicapra rupicapra* balcanica by Bolkay in 1925. The subspecies is listed in Annexes II of European Directive 92/43/EEC and Annex III of Bern Convention. The chamois is included in Bulgarian Red Data Book as an endangered species. The Balkan subspecies is listed in the Lower Risk category (Least Concern) of the IUCN Red List of Threatened Animals (Aulagnier et al. 2008).

The Balkan chamois nowadays are found in several isolated localities in the mountains of the Balkan Peninsula. Population size of Balkan chamois has been estimated to be around 17 000 individuals in 1997 (Adamakopoulos et al. 1997, Giacometti et al. 1997, Gjiknuri 1997, Krystufek et al. 1997, Spiridonov & Genov 1997).

The number of chamois in Bulgaria was stable and relatively abundant to the end of the 19th century. During and after the World war I and the World War II the number and distribution of chamois rapidly decreased (Genov & Massei 1989). The species started to recover after the 1960s (Genov & Massei 1989) reaching over 2000 individuals in the early 1990s (Valchev et al. 2005).

At the beginning of 1990s political and socio-economic changes started in Bulgaria. The changes led to political instability which resulted in insufficient control of illegal hunting and bad implementation of the country's legislation. The lack of control and inadequate implementation of law resulted in very high level of illegal hunting in the whole country. At this period, contrary to what happened in the 1980s when the number of chamois was underestimated, the actual decreasing of the chamois number was often not reported by the managers of the different units (Valchev et al. 2005).

Even though the official estimates show that the highest number of chamois in Bulgaria was reached in mid and late 1990s due to the above mentioned fact we believe that the peak of the population number had been in the 1980s or in 1992/3.

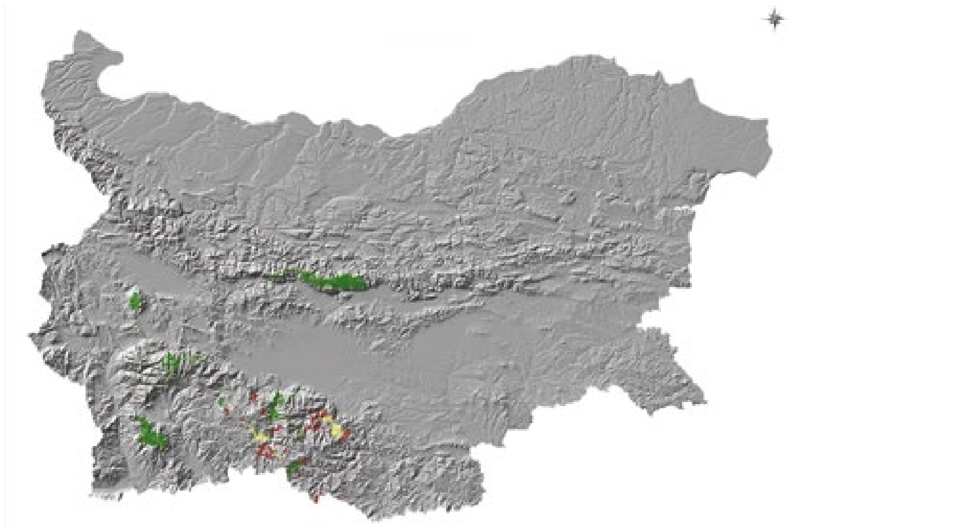

Figure 1. Distribution of Balkan chamois in Bulgaria, scale 1:350000.

Picture 1. Female chamois and her kid shot illegally in the middle of June 2005 in Rila NP.

In the 1990s the distribution of chamois has significantly decreased as well as the number. In the massifs Rila, Pirin and Central Balkans the number decrease at least twice due to poaching. At the same time in the Rhodopi Mountains the trend was stable and even increasing (Valchev et al. 2005).

Illegal hunting is considered as the most influential negative factor for the Balkan chamois in Bulgaria.

In 2011 under the Operational Program Environment started a project called: Mapping and Defining the Favourable Conservation Status of Habitats and Species Phase I – 2011-2013.

The project's main aim as the title suggests was the mapping and defining of favourable conservation status of habitats and species under Annex II of habitats Directive EEC 92/43. In Bulgaria by now 229 areas are designated as of Site Community Interest (SCIs) and further designations continue. The total area of SCI is over 37 000 km², approximately 34% of country's territory.

Priority species and habitats included in the study of the sites were 90 habitats (Annex I) and 119 species (Annex II).

Estimated area of survey for Balkan chamois was around 3000 km². The total number of person/days for the study was limited to 330.

Out of 229 SCIs only in 12 of them Balkan chamois were found (table 1) and there were not reliable information for 2 sites but they were considered important as corridors (stepping stones) or suitable but not populated by the species or to have very low density due to overhunting in the past and possibly even now.

Figure 2. Distribution of SCIs important for chamois conservation.

A preliminary deductive model has been developed based on expert assessment and Habitat Suitability Indexes, HSIs. The Model uses tools that overlay vector layers that contain expert's assessments for every pixel. Expert assessment defines the rules on which the assessment of pixels is based. Main variable used were: altitude, land cover, disturbance/(accessibility for humans) based on distance from settlements, asphalt roads etc. (cost slope), steepness of the terrain.

Within the model development ARCGIS/Corridor Designer has been used in order to create Habitat Patch Map (Figure 7). The minimum patch size was chosen to be 250 ha – area large enough to support at least one breeding pair for at least one breeding season. Population patch was chosen to be 1000 ha suitable habitats due to the requirement to be large enough to support breeding for 10 years or more, even if the patch is completely isolated from interaction with other populations of the species.
As seen from Figure 8 most of the suitable habitats for the species according to the deductive model are located within the borders of SCIs.

SITE CODE	SITE NAME	SIZE km^2
BG0000209	Pirin	403.6
BG0001021	Mesta River	194.0
BG0001030	Rhodopi – Zapadni	2719.1
BG0000494	Central Balkan	716.7
BG0001493	Central Balkan – Buffer	1294.1
BG0000495	Rila	810.5
BG0000496	Rilski manastir	258.3
BG0001028	Sreden Pirin – Ali botush	684.1
BG0001031	Rhodopi – Sredni	1548.5
BG0000113	Vitosha	273.6
BG0000372	Tsigansko gradishte	95.6
BG0001386	Yadenica	170.2
TOTAL		**8764.5**

Table 1. Names and size of SCIs important for chamois conservation.

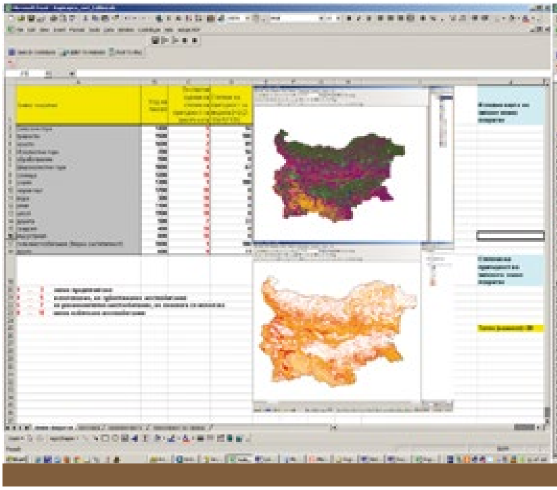

Figure 3. Layer – Land cover.

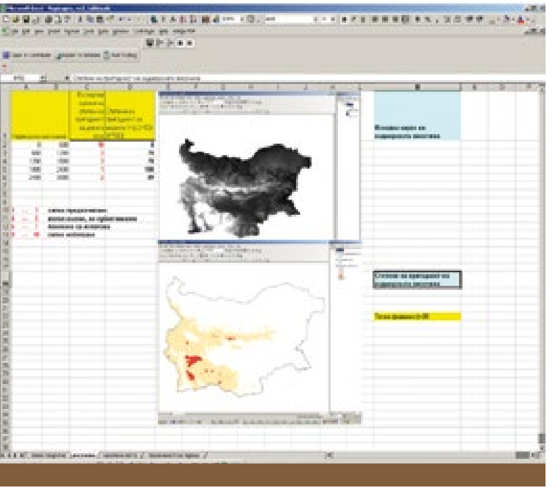

Figure 4. Layer – Altitude.

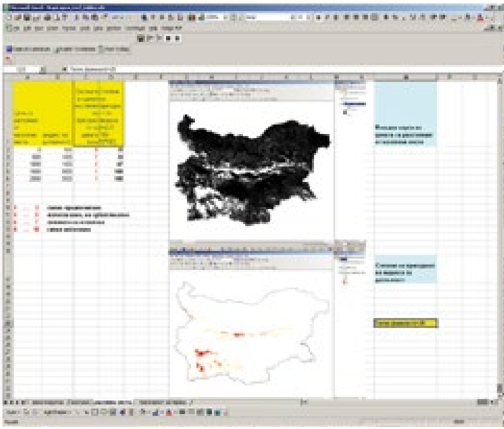

Figure 5. Layer – distance from settlements. (cost slope).

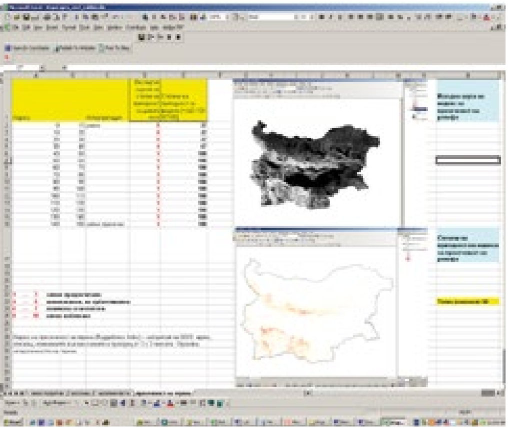

Figure 6. Layer – steepness of slopes.

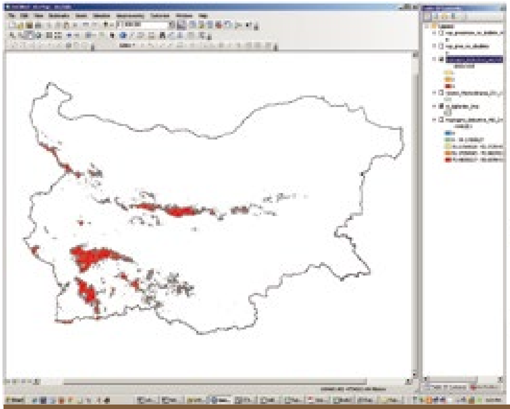

Figure 7. Deductive model.

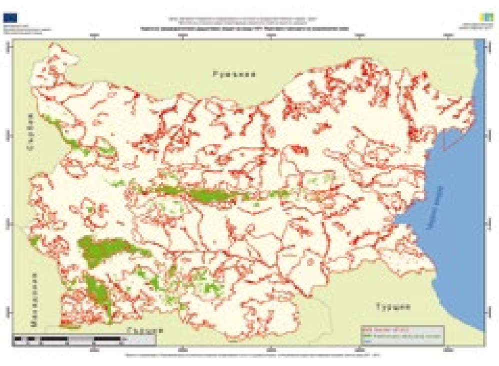

Figure 8. Map of preliminary deductive model of Balkan chamois in National level.

Methodology for field work has been developed (Valchev et al. in press) and due to preliminary deductive model detailed planning of the sites, transects, person days, etc. has been done as follows:

SITE CODE	SITE NAME	SIZE km²	PERSON/DAYS
BG0000209	Pirin	403.6	40
BG0001021	Mesta River	194.0	10
BG0001030	Rhodopi – Zapadni	2719.1	60
BG0000494	Central Balkan	716.7	50
BG0001493	Central Balkan – Buffer	1294.1	20
BG0000495	Rila	810.5	60
BG0000496	Rilski manastir	258.3	20
BG0001028	Sreden Pirin – Ali botush	684.1	30
BG0001031	Rhodopi – Sredni	1548.5	20
BG0000113	Vitosha	273.6	6
BG0000372	Tsigansko gradishte	95.6	6
BG0001386	Yadenica	170.2	8
TOTAL		**8764.5**	**330**

Table 2. Names and size of SCIs important for chamois conservation and planned person/days.

RESULTS

The field survey was carried out on 330 transects with average length of 8.6 km. The total length of the transects was 2844.9 km. During the field study chamois were registered on a total of 1089 locations that included direct observations, tracks, excrements etc. (figure 9). Data about habitats and threats for the species have also been collected in the specially developed field forms. Evidences of poaching have also been found (Picture 1, Picture 2).
The field data has been used for the purpose of mapping chamois habitats, estimation of their numbers and threats for the species.

MAP OF POTENTIAL HABITATS FOR THE SPECIES AT NATIONAL LEVEL

The map was created on the base of inductive modelling combing locations of the species and ecological and geographical factors related to its distribution. Software MaxEnt version 3.3.k has been used. The obtained data were farther developed with ArcGIS – Corridor designer v.0.2.
Ecological and geographical factors are: wetness index, steepness of the slopes, distance from the pasture grounds, altitude (DEM), land cover, distance from the settlements (costd distance), distance from the roads, surface specific points, curvature, terrain ruggedness index, etc.
The raster received from MAXENT – habitat suitability indexes – was further developed by Corridor Designer – II. Habitat modelling was based on the creation of habitat patch map. The minimum patch size was chosen to be 250 ha – an area large enough to support at least one breading pair for at least one breeding season. The population patch was chosen to be 1000 ha suitable habitats due to its requirement to be large enough to support breeding for 10 years or more, even if the patch is completely isolated from any interaction with other populations of the species.

Picture 1. Poachers in Rilski manastir NP.

Picture 2. shot signs in Rila NP.

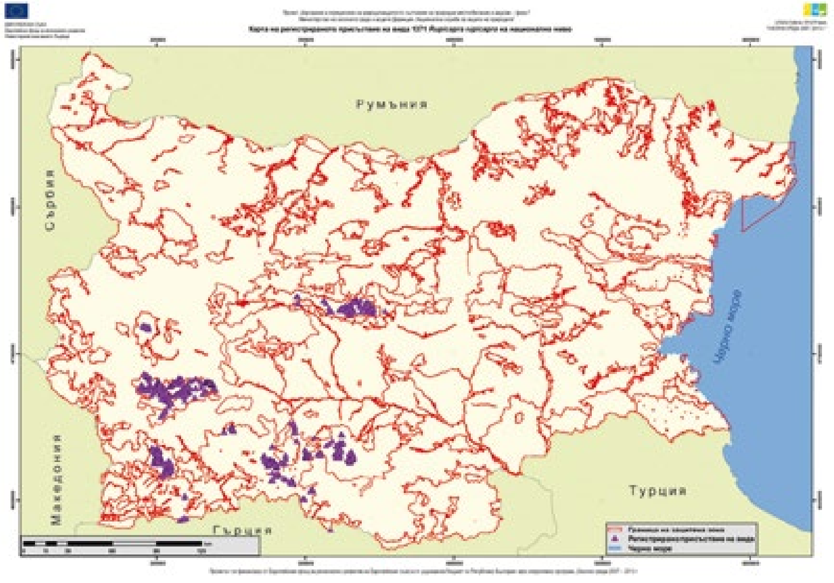

Figure 9. Map of all registered Balkan chamois during field survey.

VERIFICATION OF THE INDUCTIVE MODEL

The shape of ROC curve (far from the diagonal) the surface between the curve and diagonal (AUC=0.988) as well as the SD=0.002, show that the model is stable and reliable (figure 11).
As seen in Figure 12 almost all analyzed variable are related to species distribution, excluding land use.

The layer from the model was used for the preparation of the map on a national level as well as for all 12 Sites of Community Interest (SCI). The following maps have been prepared:

- map of registered presence of the species within the borders of the SCI;
- map of Potential habitats for the species within the borders of the SCI;
- map of habitats with low quality or deteriorated habitats of the species within the borders of the SCI;
- map of barriers for the species if there is any within the borders of the SCI;
- map of effectively occupied habitats by the species within the borders of the SCI;

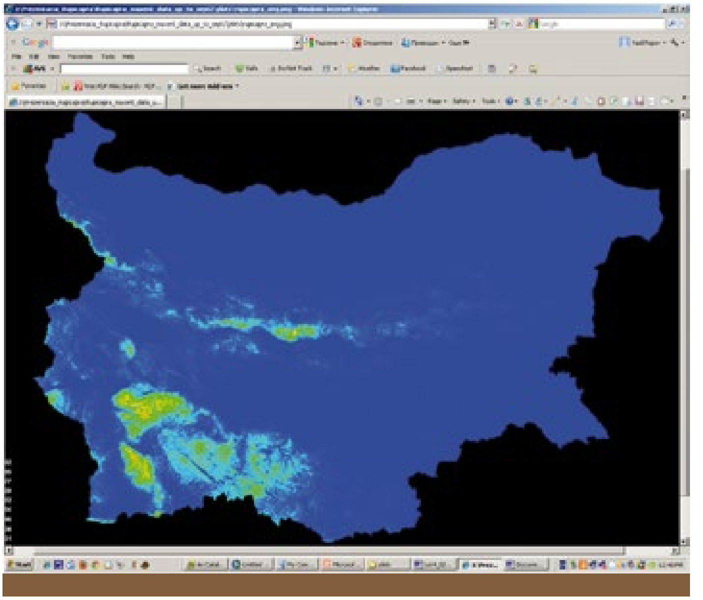

Figure 10. Inductive model – MAXENT – habitat suitability indexes.

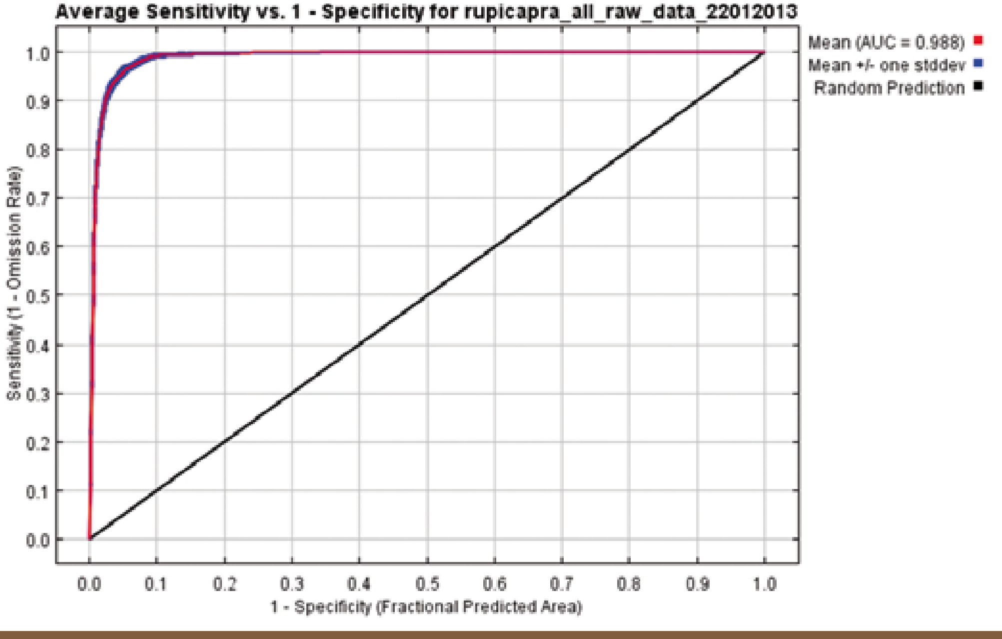

Figure 11. Average Sensitivity of the model.

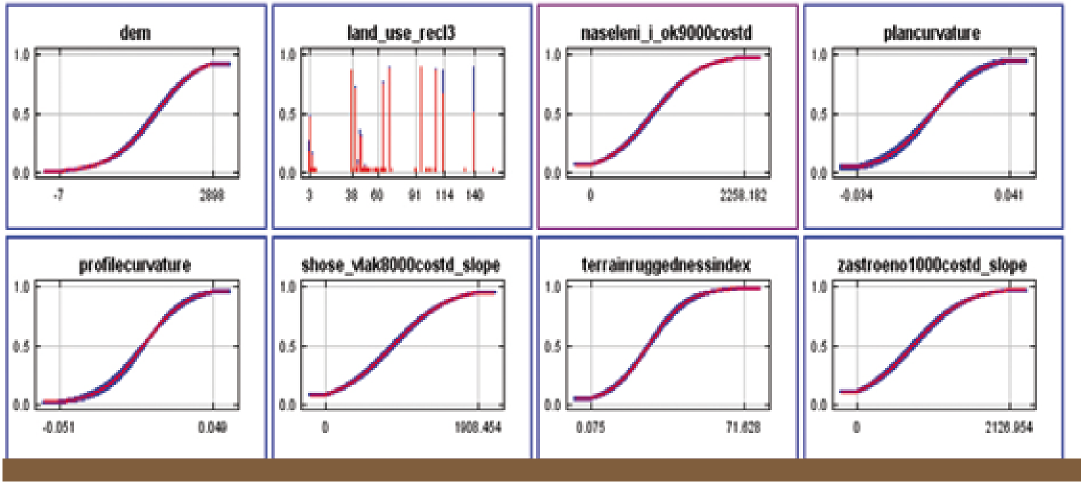

Figure 12. Response of the species to the variables.

FAVOURABLE COSERVATION STATUS

A methodology for assessing the Favourable Coservation Status (FCS) has been developed according to Article 1i (Directive EEC 92/43), Guidelines for the Assessment, monitoring and reporting under Article 17 of the Habitats Directive and Guidelines for assessment FCS or nature habitats (Annex I) and species (Annex II) of Natura 2000 network in Bulgaria.

The following main criteria have been used to assess the FCS:

Criterion 1: populations within the site – 5 parameters:

- parameter 1: number/density in the site;
- parameter 2: sex structure;
- parameter 3: age structure;
- parameter 4: reproduction rate;
- parameter 5: mortality.

Criterion 2: suitable habitats within the site – 3 parameters:

- parameter 1: total size of the habitats;
- parameter 2: size of the optimal/key habitats;
- parameter 3: size of effectively ocupied habitats;

Criterion 3: structure and functionality of the habitats – 6 parameters

Criterion 4: future perspective (threats and influences) – 4 parameters

A matrix for the purpose of assessment has been developed – Figure 13

A general report on National level has been prepared.
The report contained maps of:

- effectively occupied habitats;
- barriers;
- suitable habitats for the species were estimated to be about 3266 km² of which:
  - area of suitable habitats for the species in Alpine Biogeo. Region – 2984 km²;
  - area of suitable habitats for the species in Continental Biogeo. Region – 282 km².

As seen above less than 10% of the suitable habitats for the chamois are located in an Continental Biogeographical Region.
During the study population size of Balkan chamois in Bulgaria was estimated to be about 2400 individuals.

Parameters	Size, thresholds, measures, etc	*Favourable Conservation Status in the site*	*Unavourable – Inadequate Conservation Status in the site*	*Unavourable – Bad Conservation Status in the site*
Criterion 1: Populations within the site				
Parameter 1: number/density in the site				
Parameter 2: sex structure				
Parameter 3: age structure				
Parameter 4: reproduction rate				
Parameter 5: mortality				
Total assessment by Criterion 1				

Figure 13. Matrix for assessment of the Favourable Conservation Status.

According to the above mentioned criteria the assessments of the SCIs are the ones reported in Table 3.

SITE CODE	SITE NAME	SIZE km^2	*FCS*
BG0000209	Pirin	403.6	Unfavourable - Inadeguate
BG0001021	Mesta River	194.0	Unfavourable - Inadeguate
BG0001030	Rodopi – Zapadni	2719.1	Unfavourable - Inadeguate
BG0000494	Central Balkan	716.7	Unfavourable - Bad
BG0001493	Central Balkan – Buffer	1294.1	Unfavourable - Inadeguate
BG0000495	Rila	810.5	Unfavourable - Inadeguate
BG0000496	Rilski manastir	258.3	Unfavourable - Bad
BG0001028	Sreden Pirin – Ali botush	684.1	Unfavourable - Inadeguate
BG0001031	Rodopi – Sredni	1548.5	Unfavourable - Inadeguate
BG0000113	Vitosha	273.6	Unfavourable - Inadeguate
BG0000372	Tsigansko gradishte	95.6	Unfavourable - Inadeguate
BG0001386	Yadenica	170.2	Unfavourable - Inadeguate
TOTAL		8764.5	

Table 3. Assesment of FCS of Balkan chamois for SCI.

THREATS

The threats have been ranked in order of their importance. The most negative influence as research in the past showed was poaching (illegal hunting). Other negative factors were grazing of livestock in chamois habitats, disturbance and habitat connectivity and deterioration.

Threat	b) Ranking
F03.02.03 – trapping, poisoning, poaching	H – high importance
A04 – grazing	M – medium importance
G01.03.02 – offroad motorized driving	M – medium importance
J03.02 – anthropogenic reduction of habitat connectivity	M – medium importance

Table 4. Main threats for Balkan chamois and their ranking.

Measure	Type	Ranking	Location	Broad evaluation of the measure
6.1 – Establish protected areas/sites	Administrative	H – high importance	inside	Maintain Long-term
6.3 – Legal protection of habitats and species	Legal	H – high importance	Both	Maintain Long-term
7.4 – Specific single species or species group management measures	Recurrent	H – high importance	Both	Maintain
8.2 – Specific management of traffic and energy transport systems	Administrative	H – high importance	Both	Long-term
9.1 – Regulating/ Management exploitation of natural resources on land	Legal Administrative	H – high importance	Both	Long-term

Table 5. Measures for long term conservation of the species and their importance.

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TATRA CHAMOIS *(Rupicapra rupicapra tatrica)* AT ITS TOP: THE STORY OF 145 YEARS OF PROTECTION

Tomasz Zwijacz-Kozica[1], Barbara Chovancová[2] and Filip Zięba[1]

1 Tatra National Park, Poland
2 Tatra National Park, Slovakia

The Tatra Mountains are the highest mountain range of the whole Carpathian Arch. The Tatras are quite distinct from its surrounding area, they look like an island from the distance, and in a way they really represent an island of the high mountainous environment, with their fauna and flora. This mountain range occupies an area of 785 km², of which about 22% belongs to Poland and 78% is in Slovakia territory. The whole area of the Tatras is bilaterally protected by Polish and Slovakian national parks. Tatrzański Park Narodowy on the Polish side encompasses 216 km², while Tatranský národný park is 738 km². Symbolic animal for both parks is the Tatra chamois *Rupicapra rupicapra* tatrica. This is the most recently described subspecies of chamois, endemic for the Tatra Mountains (Blahout 1972).

As the Tatra chamois avoids forested parts of the mountains, its natural range is much smaller than the Tatra Mountains itself, and consists only of the highest parts, which cover about 300 km². The Tatra range of chamois is not only one of the smallest among all chamois subspecies, but also the most northern. Additionally, it is isolated. The distance to the nearest chamois natural populations in the Alps is about 300 km as a crow fly. The nearest chamois original population in the Carpathians is even a bit further (400 km).

The isolation of Tatra chamois diminished in 1913-1914 when alpine chamois were introduced in Jeseniki Mountains in the Czech Republic, about 200 km north-west form the Tatras. In the 1960s, alpine chamois from introduced Czech populations were relocated to the Great Fatra Mountains, about 55 km south-west from the Tatras, and to the Slovak Paradise Mountains, about 35 km south-east from the Tatras (Martínková et al. 2012). In 1969-1976 a reserve population of the Tatra chamois was established in Low Tatra Mountains, about 25 km south from Tatra Mts.. (Bačkor & Velič 2008). All these three mountain ranges are separated from the High Tatras by deep and densely populated valleys, thus, gene flow is rather impossible. Endemic subspecies of Tatra chamois did not seem to be threatened by hybridization in its cradle.

The permanent settlements at foothills of the Tatra Mountains started in the 12th century on its southern side, and 200-300 hundreds years later on the northern side. Hunting, probably also of chamois, was a very important source of food for those first inhabitants from the start. Sixteenth century books contain information of using chamois blood as a medicine Meat of chamois was recommended as a delicacy. Additionally, some advices on how to hunt chamois in the mountains can also be found. Until 19th century, such stories prevailed, together with fantastic tales about chamois hanging on rocks and tree branches with the help of horns instead of using legs (Gąsienica-Byrcyn 2012).

Since the beginning of the nineteenth century information about the negative impact of hunting on the population of the Tatra chamois started to appear. For example, in 1851 Ludwik Zejszner wrote: It is very likely, that if government will not take action and not hamper hunting, chamois will be extinct in the Tatras. He claimed that on the Polish side there were less than 100 chamois at that time. As the local inhabitants (called the Polish Highlanders) were first to blame, in 1865 a priest named Eugeniusz Janota published an anonymous brochure “A Reprimand to the citizens of village of Zakopane, and all others inhabitants of Podhale region urging not to destroy marmots and chamois”. This brochure was approved by a local government and by a catholic bishop. In 1866, Janota, together with the professor of zoology from the Jagiellonian University in Cracow Maksymilian Nowicki, hired two of the most famous poachers to be wardens of chamois and marmots in the Tatras. In 1868 a monograph about Tatra chamois by Maksymilian Nowicki was published. The profits from the book sales were dedicated to the protection of Tatra chamois and marmots.

Mainly thanks to Nowicki and Janota’s work, in 1868 the Polish national parliament of Galicia (semiautonomous province of the Austro-Hungarian empire) passed a law which protected chamois and marmots in the Polish Tatras. To gain legal force it had to be signed by Austrian emperor Franz Josef I, which happened in 1869. This was the beginning of the legal protection of chamois on the Polish territory. According to this act, hunting and trading of these animals were banned under a penalty of 5 to 100 gulden or 1 to 20 days in jail. Additionally, any specimen dead or alive, kept by citizens were supposed to be confiscated; if still alive it should have been to set free. It must be stressed that the main purpose of the protection was not preserving chamois as game animals for the benefit of rulers and landowners, but as a pivolat element of the alpine landscape for enjoyment of the people visiting this area. Since that time until now, hunting chamois in the Polish Tatras has been considered as a crime against the law.

In 1873 Towarzystwo Tatrzańskie (Tatra Tourist Association) was created in Galicia. One of its goals was to protect chamois and to support wardens of chamois and marmots in the Tatras. In spite of all these efforts, poachers were still active. Hunting chamois was part of Polish Highlanders’ heritage. Additionally, the strict protection of chamois was not enforced on the Slovak side of the Tatras, which was part of the Kingdom of Hungary, not Galicia. In that country chamois was a game animal. One of the famous hunters of those times was Christian Kraft, Fürst zu Hohenlohe-Öhringen, who bought part of the Slovak Tatras in 1879, and created large game reserve for hunting purposes. He shot himself more than 1000 chamois, although not solely in Tatras.

Chamois population recovery was interrupted and altered by wars, when any additional source of food was highly demanded and nobody could take really care of the protection of nature. After the Second World War there were only

26 chamois left in the Polish Tatra, and 280 on the Slovak side. In 1949 a national park was created in the eastern part of the Slovak Tatra. The number of chamois in this new national park was estimated as 235. There were also about 100 or more chamois in an adjacent unprotected area of Slovak Tatras; this area was included into the park 50 years later. In 1954, when the whole Polish Tatra became protected as a national park, the number of chamois was estimated there as 60 individuals.

In the new established national parks sheep grazing was reduced. Since the 1980s there has been no sheep on the alpine meadows in Tatras, so the chamois are not disturbed by sheep, shepherds and their dogs. However, an increasing number of tourists has become a new challenge for the Tatra mountains environment. The Polish part is visited by approximately 3 million people every year, while the Slovak Tatras, much bigger, have similar numbers. Recent studies conducted in the Polish Tatra have shown that chamois occupying area close to frequently visited tourist trails are more stressed than those living in areas closed for the public (Zwijacz-Kozica et al. 2013).

In 1957 both parks started to cooperate in monitoring the chamois population in the Tatras. Simultaneously, the staff of both parks counts the animals, patrolling the entire area where chamois are present. It is conducted in autumn, during the rut, when their dark fur makes chamois more visible, and when solitary males are close to herds of females. This is probably the oldest transboundary monitoring of animals in Europe (Bobek & Vingada 2012). As the Tatra chamois stay in open areas, the accuracy of the applied method is predicted to be around 80-90%. However, to obtain such accuracy, a great number of observers have to take part in the chamois counting during an optimal weather conditions (Chovancová et al. 2006). Thanks to these inventories, the rapid decrease of the chamois population in Tatra Mountains that had begun in mid eighties was detected. In 1999 there were less than 250 chamois in the whole Polish and Slovak Tatra mountains, so further existence of this endemic subspecies in its original range was critically endangered. Many different causes of this decline were suggested, including climatic and trophic conditions, diseases, parasites, predators, inbreeding, pollution (heavy metals), human impact (tourism, skiing, mountaineering, climbing, frequent helicopter flights, poaching etc.

To check if a low reproduction rate could be one of the causes for this population decline, a spring inventory was started in 1999, as newborn kids are easy to recognize from the distance during their first two months of life. According to the results of spring inventories conducted in 1999-2014, the mean percentage of newborn kids out of the total number of chamois in the Polish Tatras was 22.3% (range 16.0%-27.5%).

A detailed monitoring of the cases of chamois mortality is also conducted. Since 1980, 73 chamois carcasses have been found in the Polish Tatras. Among them, 29 were killed by avalanches, 11 by lynx, 3 by wolf, 1 by bear, 2 by lightnings and 5 probably died after falling down from a cliff. During this time 24 cases of chamois poaching were documented, the last one in 2004.

Since 1999, the trend changed and the number of chamois has been increasing. The last autumn counting, conducted in October 2013, shows that there were 1186 chamois in Tatra mountains – 872 in Slovakia, and 314 in Poland (Figure 1). On the Polish side this represents the highest number ever recorded. At the moment, after 145 years of strict protection on the Polish side it is easy to observe chamois in their natural environment. They are unique jewels of the high mountain landscape, and one of the main reasons why people come to visit Tatra National Parks.

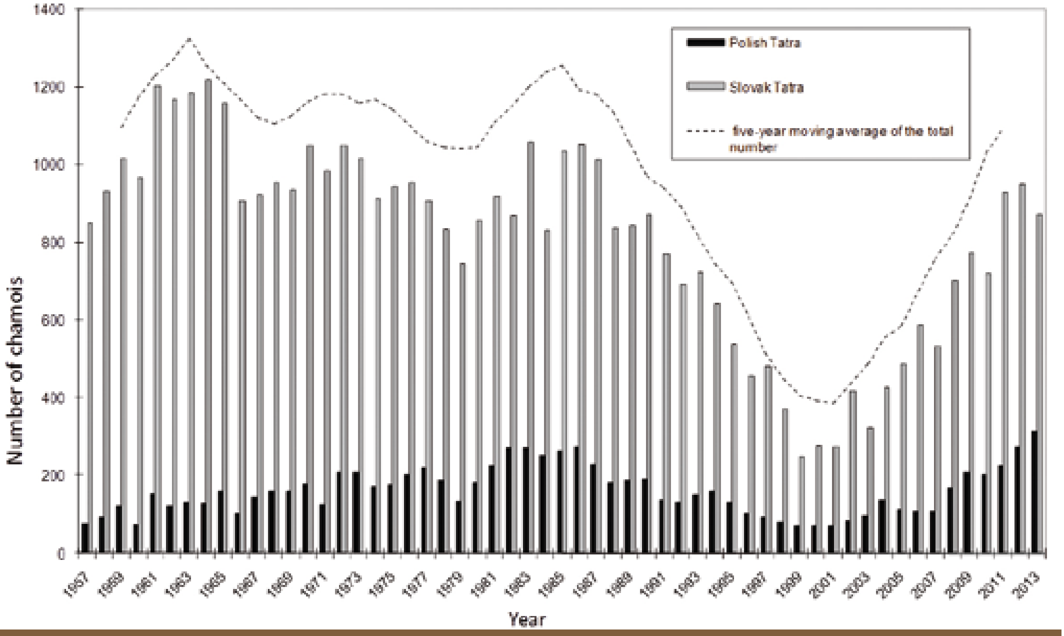

Figure 1. Results of the transboundary monitoring of the Tatra chamois population conducted jointly by the Polish and Slovak National Parks in autumn since 1957.

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STATUS AND MANAGEMENT OF ANATOLIAN CHAMOIS *(Rupicapra rupicapra asiatica)*: IMPLICATIONS FOR CONSERVATION

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Anatolian chamois is the only subspecies categorized as Data Deficient by IUCN due to its vagueness in population size and distribution. There is a limited number of studies about chamois and we know little about the ecology of the species in Turkey. Previous distribution maps by Turan (1984) and Lovari & Scala (1984) showed the eastern Anatolia including the Mount Ağrı and Cilo in regards to the chamois distribution but population size and distribution decreased sharply in the last three decades. The species is a fully protected species by the land hunting law (Official Gazette of Turkish Republic 2003) and the illegal hunting fee is about 5000 Euro. However, there has been constant trophy hunting since 1989 and poaching still continues mainly on the northeastern Black Sea region. To protect chamois and stop the population decline in the 1990s, five wildlife reserves were established, but now they don't have viable populations of chamois except the one in the Bingöl province. All populations of chamois in these wildlife reserves either declined or were extirpated as a result of poaching of and over-trophy hunting.
Therefore, I aimed to reveal the distribution and effects of human disturbances by doing direct observations and field trips, interviews with locals, hunters, game wardens and provincial directories of Game and Wildlife Departments between 2003 and 2010 and organizing an inventory with local national park directors and game wardens at Kaçkar Mountains in 2010. I also determined the population status of Anatolian chamois by applying IUCN criteria. Distribution range of chamois were concluded by making field trips and surveys during three Gap Analysis Projects (2004-2010): Hunting Associations Conservation Network Project (2006), GEF-II Camili Biosphere Reserve Project (2002-2007), and Süphan and eastern Anatolia Mountains mountaineering expedition during 2002. The entire border with Georgia was examined from 2003 to 2006 during various projects aforementioned and two Georgian national parks near to borders of Turkey were visited in 2010.
The Anatolian subspecies currently only occurs in the northeastern mountains of the Black Sea, eastern parts of Anatolia and southwestern part of Georgia at about 1.500 to 3.500 m asl. I revealed that chamois distribution range declined in whole Turkey and Georgia border and specifically became almost extinct in the Ordu, Giresun and Trabzon provinces at the northern and western part Eastern Black Sea Mountains. There are occasional observations on the Verçenik Mountains Wildlife Reserve in İspir, Erzurum and near to the Bayburt province at the southern part of Kaçkar Mountains. In Turkey, there are five Game and Wildlife Development Areas situated mainly in northeastern part of Turkey and assigned to only protect chamois but none of them except in the one in Bingöl has a viable population. The total protected area for chamois about 187.029 ha and all of them were visited during field trips and site visits but field trip couldn't be done at Bingöl-Kığı Mountains where chamois were supposed to have viable sub-populations.
I found the following threats to chamois populations: over trophy hunting, poaching, habitat degradation and isolation by logging new roads to alpine habitats, constructions of hydro-electrical power plants above 2000 meters, increasing tourism activities, heli-skiing causing avalanches and disturbing the animal during pregnancy and chasing individuals at refuge areas, and potential highway constructions at high plateau for mass tourism. Impacts of human disturbances were observed to cause a decline in population size, group size during courtships and females without kids. In the past decade, every year hunting quotas up to 55 tags in northeastern part of Turkey were given to tourism firms to be sold by the Game Department. However, for example in Artvin, the decline of the animal population size also affected the number of animals which were hunted during hunting seasons. Therefore only the half of the given quotas could actually be hunted in Artvin, where the population was supposed to be a good viable population, but the density of chamois is one of the lowest in the world, 5/100km^2 (unpublished data).

Two main subpopulations occur in refuge areas between Erzincan and Tunceli; Rize and Artvin provinces. However, these pre-connected subpopulations became isolated populations at least for a decade due to human disturbances. The populations located in Georgia mainly were formed by trans-boundary subpopulations including southwestern part of lesser Caucasus and southwestern part of Georgia. The last chamois inventory was conducted by us including group of pre-educated game wardens and hunters in the northeastern parts of Kaçkar Mountains. The population size was about 80 individuals (Ambarli et al., 2010). Besides, Rize population was about 150-200 individuals in 2009. In conclusion, overall population size was about 230-280 individuals at northeastern part of Turkey due to high number of unsustainable trophy hunting quotas and poaching. The groups size in the 1990s sharply decreased from 40 or 50 individuals at the most 15 individuals (usually 3 to 7) during the mating or spring seasons between 2006 and 2012. Observed chamois were mostly alone or two to three individuals with kids during field observations and population censuses (Ambarli et al. 2010). The main reasons of population decline and extirpations in the past decade were concluded as follows: the first one is that given quotas were determined preemptively and not on the basis of a real inventory in the field. Secondly, poaching was still ongoing due to logging new roads to high alpine mountains and alpine pastures and increasing easiness of access to refugee areas. Thirdly, females also were hunted and poached due to the difficulty of discriminating the sex of the individuals during hunting. Only at one location, in Artvin, the local population status of chamois was intermittently determined to be usable for trophy hunting quotas in the last decade. I here suggested some precautions and preventive measures to recover from population declines which should be taken seriously into consideration by the department of wildlife and game animals.

Suggestions to protect the Anatolian chamois:

- trophy hunting should be stopped until making a reliable population census in Turkey;
- killing of female chamois must be stopped during the trophy hunts;
- local game wardens should be employed and educated about species ecology;
- new roads constructions at alpine habitats above 2000 meters should not be undertaken;
- the last refuge areas of chamois at the northeastern Black Sea Mountains should be protected by declaring a new wildlife corridor reserve between Kaçkar Mountains National Park and Hatila Valley National Park (Ambarli et al. 2010);
- IUCN category need to be changed from DD to EN;
- a chamois breeding station should be established in the Kaçkar Mountains;
- ecology of the Anatolian chamois should be studied by using GPS-GSM collars;
- monitoring of populations should be regularly conducted in a year and kids should be counted during inventories;

In conclusion, Anatolian chamois population have been declining sharply for a decade at least, due to the impact of intensive human disturbances, therefore Anatolian chamois should be categorized as an endangered species following IUCN criteria EN A2(a,b,c); B1b.(i and v); C2a(i). If the General directory of Game and Wildlife Departments and their local province directors do not take necessary precautions to stop the population decline, this species may be enlisted in the critically endangered ungulate species of Turkey like fallow deer (Dama dama) and Anatolian mouflon (*Ovis gmelinii anatolica*) in the near future.

ACKNOWLEDGEMENTS

I would like to thank the collaborators in the field Sıtkı Eraydın, Özgür Alaçam, Yaşar Kuşdili, Casim Cihan and game wardens of Artvin, Rize, Erzurum and Erzincan. I am also grateful to organizations: Kaçkar Mountains Sustainable Forest Use and Conservation Project, Nature Conservation Centre, TEMA Foundation, General and Artvin Directory of Nature Conservation and National Parks, Hunters Association of Artvin.

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STATUS AND CONSERVATION OF THE CHAMOIS *(Rupicapra rupicapra)* IN GEORGIA, THE CAUCASUS

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Information about chamois (*Rupicapra rupicapra*) Caucasian population is quite limited. This subject was poorly studied, and the only significant information that we have is Dinik (1911). Dinik described chamois distribution through all the great Caucasus Mountains, and through the Lesser Caucasus.
Now the distribution is the same, but population has declined especially in regards the Lesser Caucasus and Meskheti ridge, where only few individuals have been observed. The Lesser Caucasus hosts part of Turkey's population. Chamois are distributed from Adjara highland till Meskheti Ridge, where we can individuate only a small number of animals. Few studies were done to determine a census of chamois.
The main population of chamois inhabits the Great Caucasus. Of course Great and Lesser Caucasus populations are connected to each other. Within Georgia's boundaries, the population is fragmented, but this doesn't mean that all of the population of this species is fragmented. We have no information about North Caucasus.
In the Lesser Caucasus, the Adjara region is the most populated one, and very small numbers of individuals are distributed in other parts of the Caucasus.
In Georgia, till 2012, census of population was only episodically carried out, this is why we have no significant information about size of Chamois population. In 1990, 15000 chamois were counted in Georgia. In the great Caucasus 10000 individuals and in the Lesser Caucasus 5000 individuals.
In 2000 a total 5000 individuals were counted, 4500 individuals in the great, and 500 individuals In the lesser Caucasus. In the protected areas we have a variety of data, but a broad analysis about a chamois was not carried out. Chamois still remains one of the least studied species in Georgia.
From 2012, censuses are being done in Georgia, which include large mammal survey. The main object of the research was the Tur, but also important for us was to study the chamois population number, because the exact numbers and current situation was unknown. The Caucasus is very large, hardly accessible and the number of researchers is limited; so, we decided to make an aerial survey, accompanied by a ground survey. Aerial surveys were done in the winter, in this season it is easy to see animals on the snow and it is also easy to spot their footprints. The results obtained are the following: chamois population: total number 3551 ind, in the Great Caucasus – 2781 individuals, in the lesser Caucasus – 770 ind.
In 2013, a survey was held only in the Great Caucasus. We used again an aerial survey, by using an helicopter. In the great Caucasus we counted 3200 individuals.
In addition to the overall assessment of the Caucasian population, it was interesting for us the distribution of the population. In the Great Caucasus there are some protected areas: Lagodekhi reserve, Tusheti National Park, Kazbegi reserve. Surveys were not done in the territories where there are regional conflicts, in the south Osetia and Abkhazia, because we cannot enter this territory. According to the survey, we obtained data from the years 2012 and 2013 in Lagodekhi, Tusheti and Kazbegi-.
Surveys were also held out of the protected areas. All these protected areas are located in the central and eastern Caucasus. In the Western Caucasus, so called Racha and Svaneti Caucasus, our calculations gave us much poorer results. In this region was observed a very small number not only of chamois, but also of the West Caucasian tur.

Lagodekhi Protected area
In Lagodekhi reserve, in winter, chamois comes in the lower zone of the forest. This territory is well protected. Here we counted 270 individuals.

Tusheti and Khevsureti region
In Tusheti and its bordering southern slopes we recorded 1600 individuals.
In Khevsureti we recorded 200 individuals. It should be noted, there is a protected area now, which will significantly improve the conservation status of the chamois population.

Kazbegi region
We discovered chamois only in one ravine, Truso ravine. Number of animals ca. 300.

West Caucasus
Western Caucasus inludes the so called Racha and Svaneti Caucasus; Surveys were not held in the conflict regions, in Abkhazia; The calculation gave a rather poor results, 500 individuals were counted; In this region it was observed not only a very small number of chamois, but also of West Caucasian tur.

Lesser Caucasus

Lesser Caucasus is populated by an extension of Turkey's population, coming from Adjara highland and distributed till Meskheti Ridge.
Small numbers of animals are coming in from the Georgian territory;
The most populated place is Adjara region and very small numbers of individuals are living in other parts of Caucasus;
In the Meskheti ridge, only few individuals have been observed.
In 2012 the total number of chamois in lesser Caucasus was of 700 animals.

THREATS

The Main threat is poaching, but chamois is not a main target for the poachers. The Main target is tur, but when poachers are hunting for tur they also kill chamois, so hunting seriously affects the population number.

Habitat degradation, which is the result of overgrazing, recently reached a normal level, but the number of animals lost cannot be restored.
Regional conflicts are also one of the main threats. Soldiers often kill these animals, but we cannot enter this territory and a proper evaluation is therefore not available.

SESSION II
THE ROLE OF REINTRODUCTIONS IN CHAMOIS CONSERVATION

GUIDELINES FOR REINTRODUCTIONS AND OTHER CONSERVATION TRANSLOCATIONS AND THEIR ROLE IN UNGULATE AND MOUNTAIN ECOSYSTEMS

Pritpal Soorae

IUCN Re-introduction Specialist Group

This contribute has not been received.

REINTRODUCTION OF BALKAN CHAMOIS (*Rupicapra rupicapra balcanica*) IN VITOSHA NATURE PARK, BULGARIA

Simeon Arangelov Arangelov

Balkani Wildlife Society, Bulgaria

RESUME

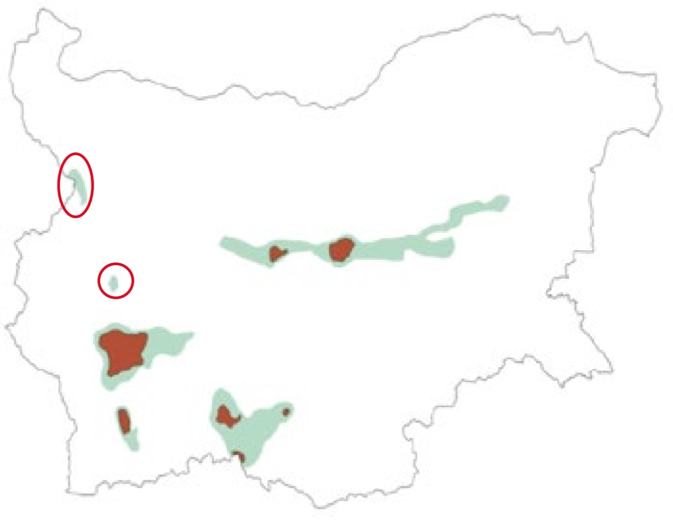

Figure 1. Distribution of chamois in Bulgaria in the past and present. In aquamarine blue: distribution in the past; in brown: distribution in the present; red circles: two enclosed isolated populations.

The fastest and most effective way to restore these populations was realizing reintroductions thus, in 2002, the project to reintroduce the Balkan chamois in Vitosha began. Key partners in the project were the Vitosha Nature Park, the State Game Enterprise Vitoshko-Studena and the Balkani Wildlife Society. Economic resources for the project were provided by various funds and organizations, most importantly: National budget of Vitosha Nature Park, NCEF, the Frankfurt Zoological Society and financial tools of the European Union for the environment. In 2013 a second project began to restore the population located in the Chuprene Municipality.

Chamois that were captured to be reintroduced were selected in order to ensure the establishment of a new genetically pure population of the Balkan chamois subspecies (*Rupicapra rupicapra balcanica* Bolkay 1925). One of the challenges to deal with during the realization of reintroduction in Vitosha Nature Park, was the proximity of this Nature Park to the capital of Bulgaria, Sofia, a city with a 1.7 million people population. However in Vitosha already lived species such as roe and red deer, wolf, brown bear and golden eagle. The area of the Vitosha Nature park is 27 078 hectares, of which about 8000 are suitable habitats for chamois. It is estimated that this suitable habitat can support about 600 chamois.
In the summer of 2002, a 30 hectares adaptation enclosure was built at an altitude of 1670 m a.s.l. Near the adaptation enclosure a base for chamois monitoring and security was positioned in order not to disturb the animals and, at the same time, to have a good view of the enclosure. In 2003, the first two chamois were brought into this enclosed area, 8 chamois were brought in 2004, 7 in 2005, 2 in 2006, 1 in 2007, 5 in in 2008, 2 in 2009, 2 in 2010, 3 in 2011, 1 in 2012 while none was brought in 2013. In 2014 the team working on the project set the goal to bring to Vitosha Nature Park an additional large number of chamois to finish the animals release in the population of Vitosha Nature Park. Up to that moment all the chamois were captured from the Rhodope Mountains. In order to diversify the gene pool of the Vitosha chamois population, it was decided that the chamois that had to be transferred to the Vitosha Nature Park in 2014 would have been caught from Rila National Park and Pirin National Park in Bulgaria.
In 2006 the first chamois were released outside the adaptive enclosure. In the first years the largest numbers of chamois were freed (Figure 2) while in the successive years the enclosure was not used, except for adaptation and for breeding purposes, and each year few chamois were set free (Figure 2).

Release of chamois from the adaptation enclosure

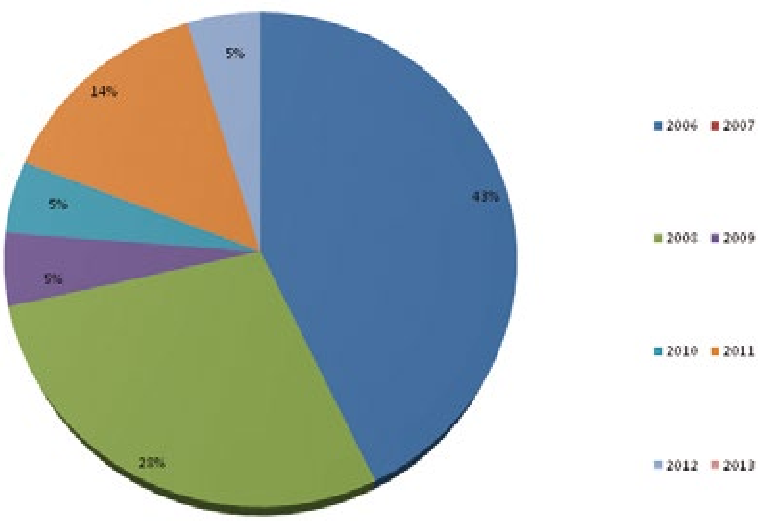

Figure 2. Release of chamois in Vitosha Nature Park from the adaptation enclosure.

Causes of chamois mortality

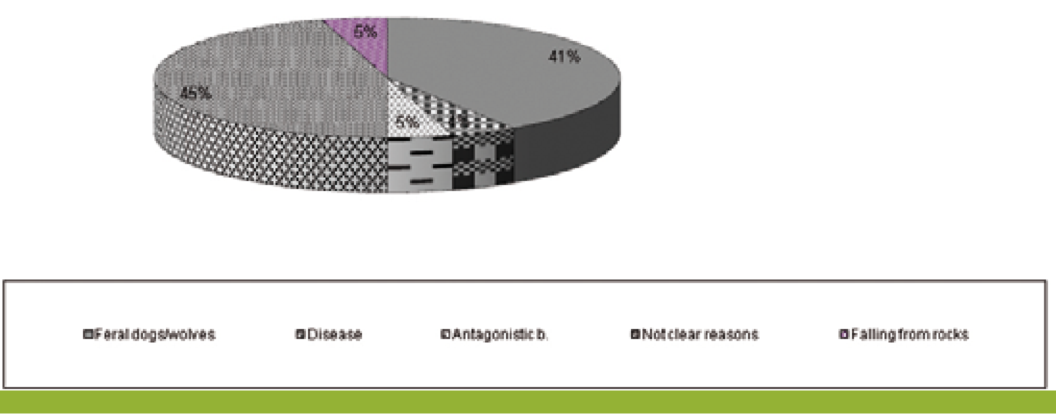

Figure 3. Causes of chamois mortality in Vitosha Nature Park.

Mortality rate in the new chamois population in Vitosha Nature Park is medium-high. The highest percentage of chamois known causes of death is due to stray dogs (41%), 5% of dead chamois died falling from rocks, 5% died because of antagonistic behaviors and 4% died because of diseases. The 45% of the mortality rate could not be determined. Mortality in newborn kids after the first year is about 20%.

The total number of chamois at present (2014) is about 50 individuals. The increasing dynamics of the newly created population is shown in Figure 4:

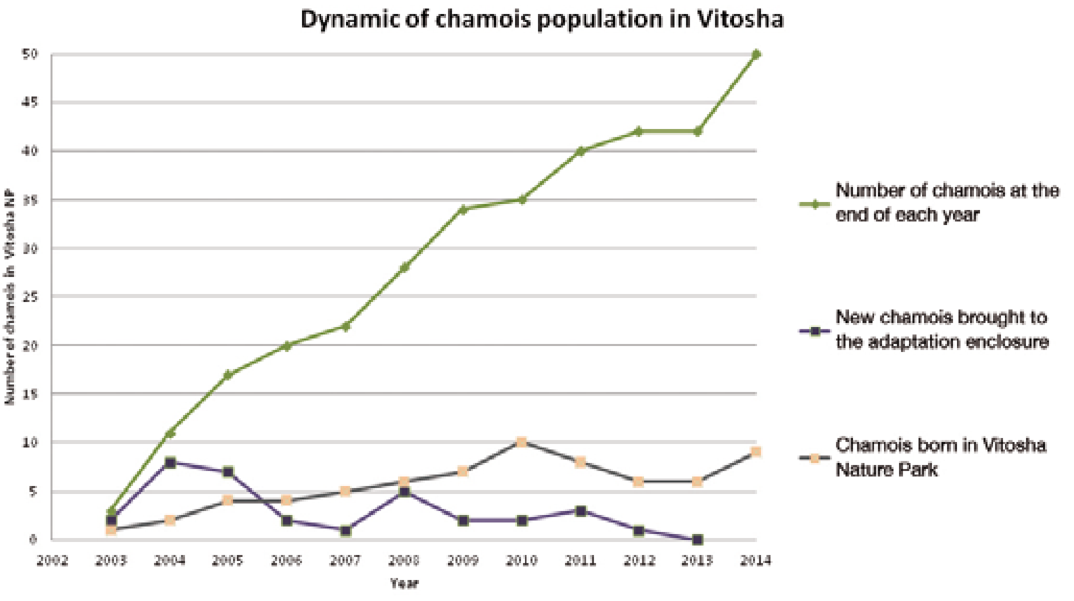

Figure 4. Dynamic of chamois population in Vitosha Nature Park.

Birth rate in Vitosha Nature Park is shown in Figure 5:

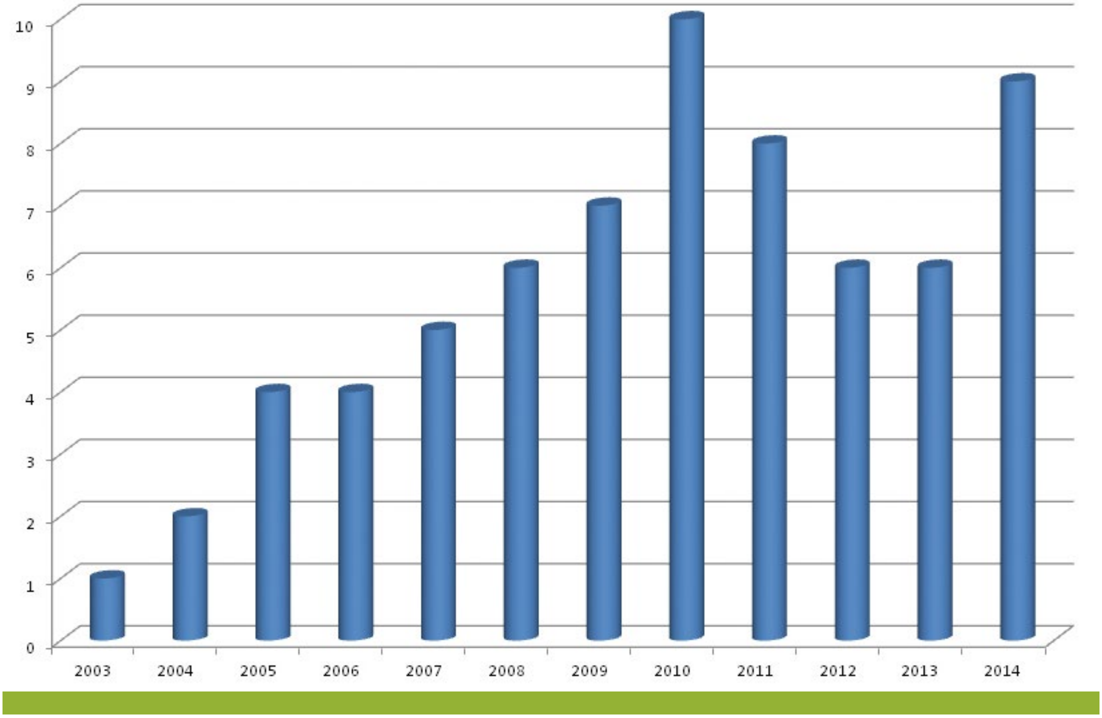

Figure 5. Number of chamois born in Vitosha Nature Park each year from 2003 to 2014.

Inside the adaptation enclosure at the present (2014) there are about 25 chamois with the age structure showed in Figure 6:

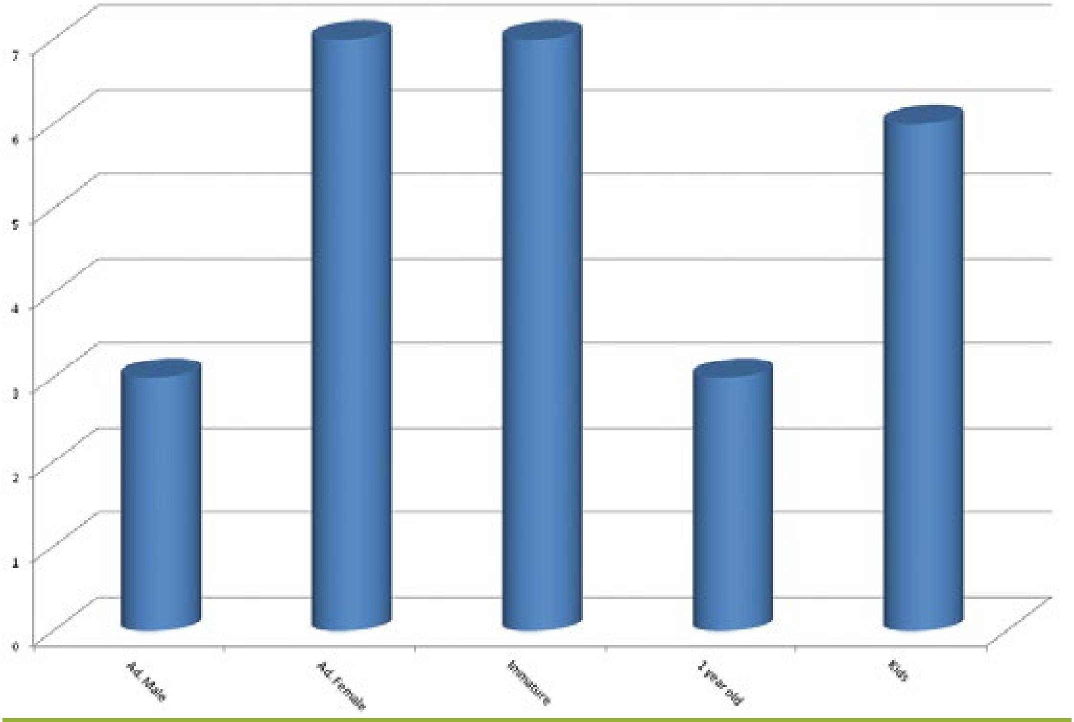

Figure 6. Chamois in the adaptation enclosure in Vitosha Nature Park (updated to June 2014).

Outside the adaptation enclosure at the present (2014) there are about 25 chamois with the age structure showed in Figure 7:

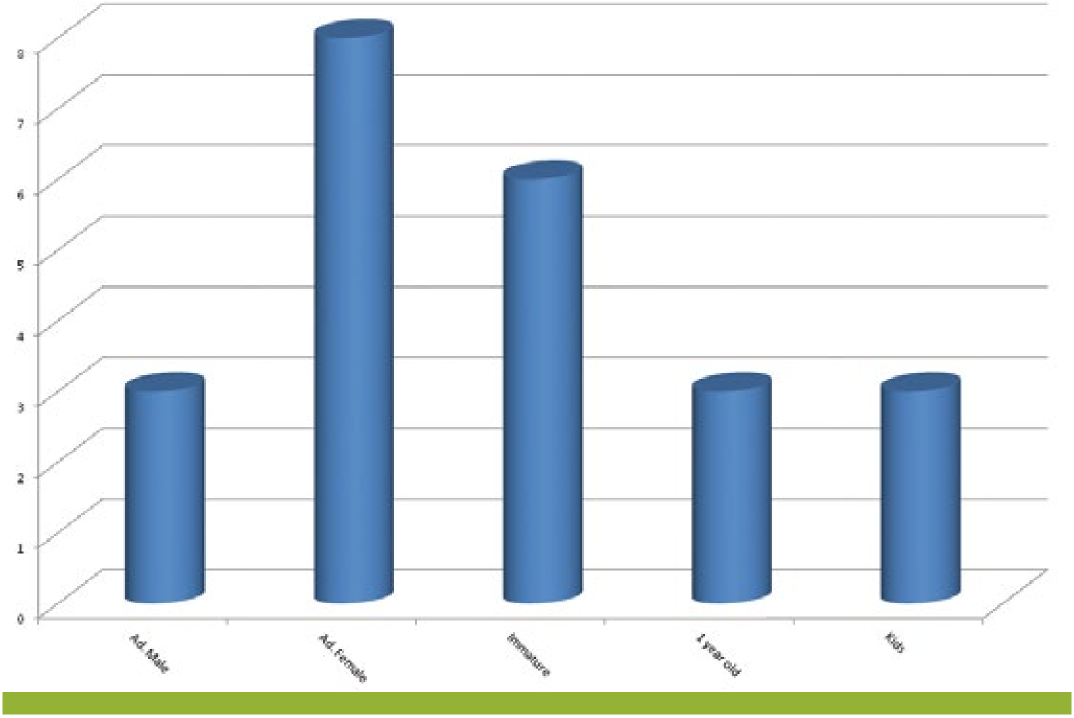

Figure 7. Chamois living out of the adaptation enclosure in Vitosha Nature Park (updated to June 2014).

Permanent activities related to the observation and management of chamois in Vitosha Nature Park:

– monitoring;
– evaluate the possible distribution of the chamois;
– analyze the breeding success in new conditions;
– carefully monitoring any threat.

Capture Methods:

We tried different kinds of traps, over the years various methods were used to capture chamois, the main ones are:

- strech nets;
- tele-Injection;
- fall-down nets;
- leg holding snares (which gave the best results);
- "Uprising net trap" (a new method used from 2013).

After chamois were captured the following steps were developed:

- a face mask was positioned to reduce the stress;
- the animals were placed in canvas and transferred to the nearest road;
- the chamois were transported in special wooden boxes;
- a blood sample was taken;
- animals were deloused and disinfected;
- animals were ear-tagged
- animals were equipped with VHF or GPS-GSM collars;
- biometric measures were taken.

The result of the project, 12 years after the start of the first activities, is that in Vitosha Nature Park live 45 to 50 chamois. The project will finish in 2015, when all chamois will be set free out of the enclosure.

RE-ESTABLISHMENT OF TATRA CHAMOIS *(Rupicapra rupicapra tatrica, **BLAHOUT 1971**)* TO THE NÍZKE TATRY MTS. – HISTORICAL OVERVIEW

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INTRODUCTION

The distribution range of the endemic and critically endangered Tatra chamois (*Rupicapra rupicapra* tatrica Blahout 1971) is restricted to the Slovak and Polish side of the Western Carpathians (Blahout 1976). In Slovakia, the species currently survives in two small isolated populations restricted to a sub-apline and alpine zone of the Tatry Mts. (Západné, Vysoké and Belianske Mts..) and Nízke Tatry Mts.. Tatra chamois are in the Slovak and Poland Red list of threatened animals in category CR (Žiak & Urban 2001, Anonymus 2008).

From a scientific point of view, a number of osteologic chamois findings from the Nízke Tatry Mts.. was recorded by Obuch (1977, 1981). Chamois as a glacial relict of Slovak fauna belongs to the group of young animal species since the first paleontological findings date back no earlier than the Middle Pleistocene with the majority of findings placed into the Late Pleistocene (Obuch 1981). Nevertheless, the skeleton findings from the Nízke Tatry Mts.. caves are much more common. Obuch (1977) presumes that chamois inhabited the Nízke Tatry Mts.. during the last glacial era, that is from the Dryas to the end of the Holocene.

HISTORICAL BACKGROUND

Historical chronology about data of chamois in the Nízke Tatry Mountains:

– 16th. – 18th. Century: some data were found in myths, legends and fairly tales from Liptov Region (Northern part of Nízke Tatry Mts..). Also, drawings of chamois can be found in the coat-of-arms in Šumiac village (Eastern part of Nizke Tatry Mts..). The Chamois origin and the number of chamois is unclear.

– 1856 – Perhaps we have a first attempt of acclimatization under the monarch Coburg, who brought some individuals to the locality Čertova svadba in the middle part of Níkze Tatry Mts.. Chamois origin and number of chamois is unclear.

– 1900 – Monarch Szentiványi also tried to acclimatize four individuals of Tatra chamois in the Nízke Tatry Mts.. (to locality Krčahovo – Demänovská valley). All individuals died (Karč 1979).

– 1916 – At the beginning of the last century, there was an attempt to release two pairs of chamois into the area around Ďumbier peak. There is, however, no archive evidence to verify the credibility of this attempt (Karč 1979). Chamois origin and number of chamois was unclear.

– 1935 – The first real effort of acclimatization of chamois in the Nizke Tatry Mts.. was in Orlová dolina (Orlová valley) in 1935 (Karč 1979). In This year a small acclimatization enclosure was built. In December 1935 the first tree chamois individuals were brought (two adult male and one subadult individual) from Vysoké Tatry Mts.. (Mengusovská valley and Popradské Lake). However they all died during that winter, see Picture 1 (Karč 1979). This unsuccessful attempt was only poorly documented.

– 1969 – 1976: The last and successful attempt. In 1969 12 individuals were brought (5 males and 7 females) from Vysoké and Belianske Tatry Mts.. (see Pictures 2 and 3). The avalanche that occurred in January 1970 caused only minor damage to the enclosure; the chamois survived without injuries and were continually monitored as they approached the release area (see Picture 4). In 1970, 8 additional chamois were released into the enclosure. In the following years, there were several chamois releases (1972 – 1 specimen, 1973– 1, 1974 – 1, 1975 – 3, 1976 – 4). The enclosure was 300x250 m in size (9 ha) with a wire netting fence with 46 wooden pillars and a chamois shelter in its front part (VELIČ pers. comm.). There were also plans to build a hunting shelter for rangers. During the whole introduction, only three chamois perished. The first was an adult female which perished during the transport to the hauling point in the Belianske Tatry Mts.. capturing in August 1969. The second perished individual was an adult female brought to the enclosure from the Tatra Mts.., it died in the enclosure on 9th of July 1972. The third loss came on 7th July 1972 when an adult female perished during the transfer.

FUTURE PERSPECTIVES

Some unanswered questions are found about the acclimatization process and about the history of chamois in the Nízke Tatry Mts.. First of all there is the denomination of the process of chamois acclimatization to the Nízke Tatry Mts.. Generally, the chamois were present in the early Holocene and then became extinct. Probably the main reasons of this extinction were the local environment conditions in the interglacial period in that very small area. From our point of view the right term to be used should be the re-established chamois population in the Nízke Tatry Mts.. and not the introduced population, because that would mean that a species has been brought into an area where it does not naturally occur, outside its known historical range as an alien species or a non native species (Park 2007). Re-established means something close to its original condition.

The second question is “can chamois survive between two allochthonous populations?”. On both the corners of massive Nízke Tatry we found two introduced populations of Alpine chamois (*Rupicapra rupicapra rupicapra*). In 1963 6 individuals (4 female and 2 male) were introduced in Slovenský raj Mts.. The origin of chamois was from Jeseniky Mts.. (Czech Republic) or more precisely from Mürzsteg Alps (Austria, see Martínková et al. 2012). In 1960, 21 individuals were introduced in the Veľká Fatra Mts.. from Lužické Mts.. and Jeseníky Mts.. (Czech Republic) and they were all from the same origin. The main reason of both introduction activities was hunting and game management in those areas. The population in the Veľká Fatra Mts.. has more than 60 individuals (Hurta 2009) and the population in the Slovenský raj Mts.. approximately 100 individuals (Hájek & Ogurčák 1981).

Finally the third and most important question is “how is the genetic structure of chamois in the Nízke Tatry Mts..?” Some authors have gathered chamois samples (mostly non invasive methods of collecting faeces) from the whole chamois population in Slovakia (Alpine and Tatra). The preliminary result could show low chamois genetic variability from Nízke Tatry Mts.. (Zemanová et al. 2007). Addictionally, some analyses demonstrated extremely low genetic diversity and probably hybridization between Alpine and Tatra chamois (Zemanová et al. 2011, 2015). From a conservation point of view, if the hybridization is confirmed, the scientific focus should be mainly on this population.

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Picture 1. Winter chamois transfer in 1935 to Nízke Tatry, reprophoto.

Picture 2. Capture box trap in 1969, Vyské Tatry Mts.., photo by Milič BLAHOUT.

Picture 3. Transfer of chamois from Monkova dolina (Belianske Tatry Mts..) to vehicle, photo by Milič BLAHOUT.

Picture 4. "First herd" of chamois in 1970, photo by Ervín VELIČ senior.

Picture 5. Adult male of Tatra chamois in Nízke Tatry Mts.., photo by Peter BAČKOR.

THE RE-INTRODUCTION OF THE APENNINE CHAMOIS (*Rupicapra pyrenaica ornata*): THE STORY OF A SUCCESSFUL CONSERVATION ACTION

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1 Majella National Park, Italy
2 Abruzzo, Lazio e Molise National Park, Italy
3 Sirente Velino Natural Park, Italy
4 Monti Sibillini National Park, Italy
5 Gran Sasso e Monti della Laga National Park, Italy

"Dedicated to Maurizio Locati and all the friends involved in the conservation of Apennine chamois"

This short contribution is divided in two main parts: the first is devoted to describe the first re-introduction program for the Apennine chamois from its story to the animals release phase; the second is focused on what we have learned from these activities and how we used this knowledge for the creation of the nuclei in Sibillini and Sirente massifs during the Life Coornata Project, co-funded by the European Union.

THE FIRST REINTRODUCTIONS OF THE APENNINE CHAMOIS

As explained in other texts of this volume, thanks to a re-introduction program the Apennine chamois is now present with about 1700 individuals in five populations geographically isolated, located inside Protected Areas: Abruzzo, Lazio e Molise National Park– where the source population survived, Majella National Park, Gran Sasso e Monti della Laga National Park, Monti Sibillini National Park and, with a first nucleus, in the Sirente Velino Natural Park. Therefore with this situation, in 2014, it's almost reached the goal for the Apennine chamois long term conservation suggested by the IUCN Action Plan (Shackleton et al. 1997) and by the Italian Action Plan for this subspecies (Dupré et al. 2001): the achievement of at least 1000 chamois, divided in 5 populations.
To reach this situation a long run occurred and we will here describe the milestones, starting from the situation in historical time, when chamois presence was reported for Abruzzo, Lazio e Molise National Park (PNALM) and for Gran Sasso e Monti della Laga National Park (PNGSL) in which the last animal was shot in 1862 on Saint Vito Mountain. No data are available for Majella and Sirente Velino massifs while in the Sibillini Mountains area the presence of "wild goats" is described by Colucci in 1795, but without a clear reference to chamois.

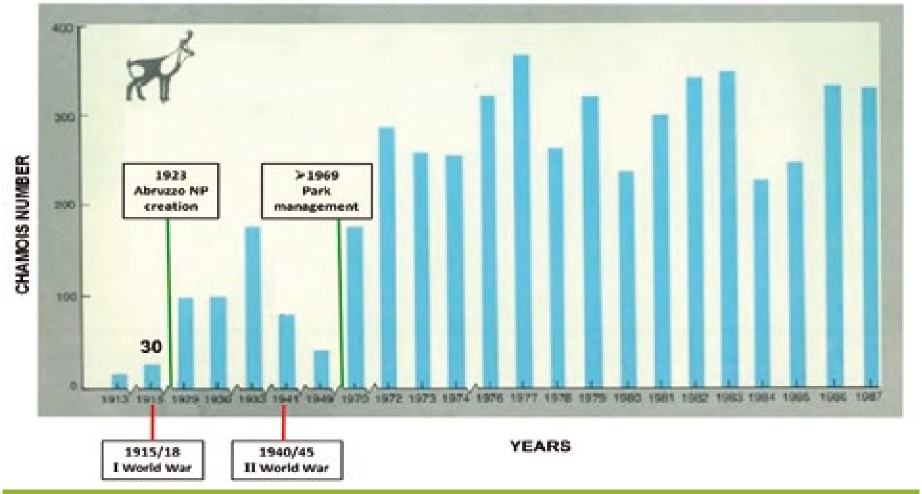

Figure 1. Trend of the Apennine chamois population in Abruzzo, Lazio and Molise National Park. From Lovari (1989).

So, following the IUCN Guidelines for Re-introductions and Other Conservation Translocations (2013), only the release program in Gran Sasso can be considered a re-introduction, while the others are benign introductions for the subspecies conservation.

In 1915, at the beginning of the First World War, only a small group of no more than 30 Apennine chamois survived in the rocky area of Costa Camosciara (Figure 1) that, in 1923, would be part of the just-declared PNALM.
The status of this last population remained critical till the 1969 when an improvement of the conservation measures by the new Park's management favored the increase of this nucleus that reached a total number of 250-350 individuals at the beginning of the 1990s. Thanks to the PNALM enlargement in 1991, the population increased until reaching about 600 individuals in the year 2000.
Despite these good results, due to the lack of genetic variability and to the localized distribution, it was clear that other measures had to be activated to promote the long term conservation of this sub-species.
Even if in 1974 a first proposal to release chamois outside the PNALM was developed by Sandro Lovari and Franco Perco, on behalf of the Apennine Ecological Study Centre of PNALM, we have to wait the year 1991, when the "Chamois Operation" started, to see the first chamois leaving the PNALM. However, during the years 1974-1991 many important activities were developed, creating the background for the re-introduction planning:

1. the first studies on this subspecies were developed by Sandro Lovari with the support of Maurizio Locati, providing information on the biology of the chamois, in particular on its behaviour and ecology;
2. the first captures of wild Apennine chamois were performed using darts with a mixture of ketamine and xylazine;
3. a captive breeding program started in October 27th, 1979 with the capture of the "Chamois of the balcony", a five years old male that jumped on a balcony of an house in the village of Civitella Alfedena to escape a wolf chase.

All these activities helped the realization in 1986 of the "Marsicano Operation", the first capture, transport and release of 6 Apennine chamois on the Marsicano Mount, inside the PNALM.
The crucial point for the Apennine chamois long term conservation was the above mentioned "Chamois Operation", carried out from 1990 to 1994 on behalf of the Apennine Ecological Study Centre, with the aim to enlarge the chamois range on Majella and Gran Sasso massifs. We underline that the realization of this program allowed to reach another important result linked to the conservation of the whole Apennine area: the creation of the two National Parks of Majella and Gran Sasso.
The program was funded by the PNALM, the Italian Alpine Club, the WWF and the European Union trough the Life program. It was carried out by Maurizio Locati for the ecological aspects, and Leonardo Gentile (PNALM) for the veterinary activities, with the support of Cinzia Sulli (PNALM) for the botanical aspects. Franco Mari was involved in the field work, succeeding later to Maurizio Locati, deceased in 1992.
The period from 1990 till July 1991, when the first release was performed, was focused on the development of the preliminary activities, that is, the first two steps of the Operational Plan (Figure 2) as indicated in the IUCN Guidelines (1978).

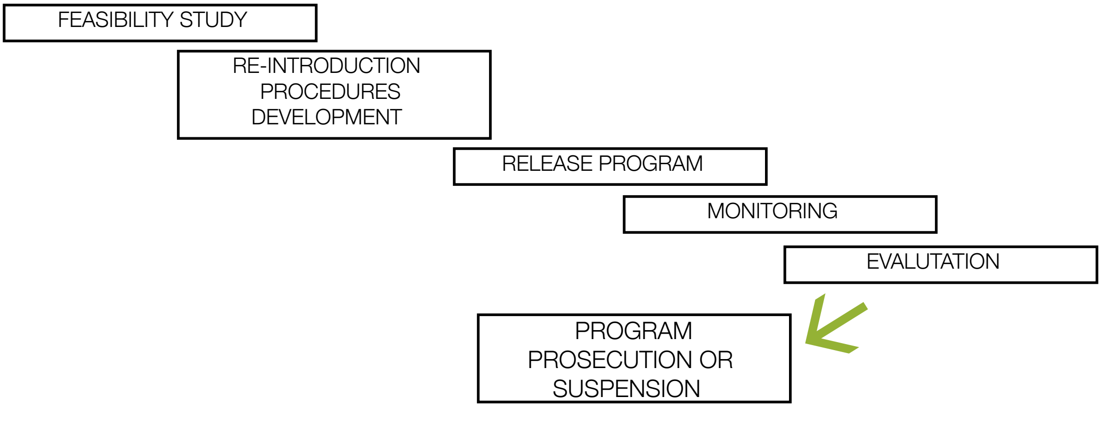

Figure 2. Operational plan for re-introduction following IUCN guidelines (1978).

Feasibility study and Re-introduction procedures development (step 1, 2 Figure 2)

The main activities were devoted to:

1. Choice of the suitable areas in Majella and Gran Sasso.

– An Habitat Suitability Model for the Apennine chamois was not available, so we used an expert's opinion based approach, considering:
– available studies and related indications;

– protection status of the areas;
– habitat analysis;
– presence of and possible competition with wild ungulates and livestock;
– health status of wild ungulates and livestock;
– potential impact of human activities;
– poaching;
– presence of predators and stray dogs;
– attitude of the local communities; regarding this important topic, several meetings to directly involve the local authorities and communities were developed, also to support the creation of the Majella and Gran Sasso e Monti della Laga National Parks.

2. Creation of chamois enclosures.

– Chamois enclosures were realized both in Majella (March 1990 in Lama dei Peligni, starting with a wild male and 5 captive females) and in Gran Sasso (July 1992 in Farindola, with 1 captive male and 2 captive females; July 1993 in Pietracamela, with 1 captive male and 1 captive female) with the aim to improve the involvement of local communities in the re-introduction program, and at the same time to enlarge the captive breeding program for this subspecies. We here underline the importance that this captive breeding program has had in the whole re-introduction program of the Apennine chamois: till now it provided about the 50% of the released animal.

3. Improvement of capture procedures

Tolazoline and Idazoxan were tested on chamois as $\alpha 2$ agonist (Locati et al. 1991). These substances were used to antagonize the effect of the xylazine, and to rapidly reverse the narcosis assuring the complete reactivity of the released animal.

4. Choice of the founders and the release procedures

The following issues were considered to establish the release strategy:

– Minimum Number of Founders (MNF): this was chosen as 20 – 30 chamois, considering that the PNALM population recovered from 30 individuals in 1915 (see Figure 1);
– sex ratio at release: the optimal one was considered the 1:2 sex ratio, in order to favour the fast increase of the released nucleus;
– capture and release of females of same herd: this was chosen in order to maximize the probability of cohesiveness of the released nucleus;
– release timing: females and sub-adults in summer, males in October near to the rut period. This timing was chosen in order to release the animals in the new areas during the most favourable season and, for males, in order to avoid as much as possible the post release dispersion.

<u>Release program (step 3, Figure 2)</u>

The key features of this phase have been the following:

– chamois were captured using a xylazine/ketamine mixture, darted with a CO_2 rifle (Telinject);
– a ll the animals were marked at both hears with 4.5 x 4.5 cm plastic tags (Prima Flex by Casley) of different colour, and implanted with a subcutaneous transponder (DATAMARS) on the left shoulder;
– adult animals (> 3 years old) were fitted with VHF collars: 176 grams and 23 months of lifespan for females, 260 grams and 36 months of lifespan for males;
– a maximum of 5 animals at a time were transported with an helicopter, under narcosis, blinded and with the legs tied, without the use of a case;
– no use of a pre-release enclosure in the release area: the choice not to use adaptation enclosures was due to the difficulties linked to their building and management in high mountain; this choice was made even if their use was suggested in the first release proposal for this subspecies in 1974 and in Tosi & Toso (1992) to limit the initial dispersion of the chamois.

At the release site a "V" shaped line of people was used to direct the chamois from the release point. For each group of chamois transferred, the $\alpha 2$ agonist was injected in one animal only when the previous one completely recovered from narcosis; in this way all the chamois were able to move away keeping in contact one another.

WHAT WE HAVE LEARNED

The monitoring of the released animals and the analysis of of Majella and Gran Sasso populations trends, gave us the possibility to develop suitable protocols for the successive re-introductions of Apennine chamois. In particular the most relevant consideration concern the following issues:

1. Choice of the release areas.

The first topic we would like to discuss is the importance of taking into account the presence of recreational activities. Several papers described the disturbance of human activities on chamois behaviour, having these direct impact on grazing time even inducing the abandonment of suitable habitats; the consequence is a worsening of the body conditions and, consequently, of the reproductive success (Cederna & Lovari 1985, Schaal & Boillet 1992, Gander & Ingold 1997, Schnidrig-Petrig & Ingold 2001).

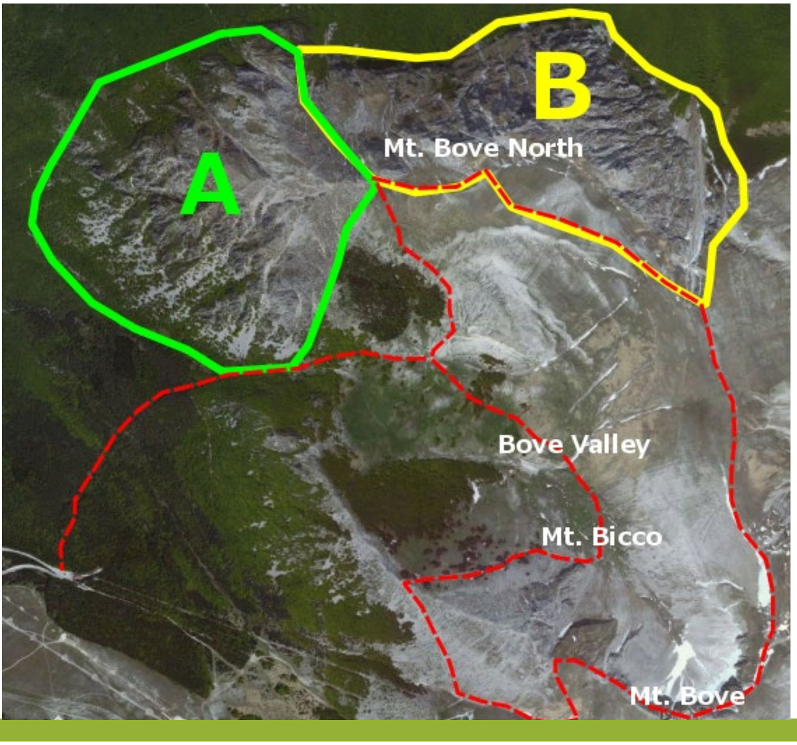

Figure 3. Regulation of the access to the chamois area in Sibillini National Park during the implementation of the second re-introduction of Apenine chamois (see text for details). Area A= wintering area; Area B= summering area.

In the Gran Sasso in 1992 the release area of Val Maone was chosen.
Due to the disturbance caused by the recreational activities present in that area, the chamois moved to a new quieter zone, at higher elevation. For this reason for the releases of 1993 and 1994 the new area of Mount Saint Vito, with low human activities, was chosen (see Figure 4B).
To avoid this problem, when planning the second Apennine chamois re-introduction in Monti Sibillini National Park (started in 2008), the chosen release area in (Mount Bove Nord) was closed to any recreational activity before starting the releases. Successively, as from the monitoring program emerged a different habitat use for the summering and wintering areas, a specific regulation was developed to open this area to the public.
A ring trail (Figure 3) for trekkers was developed to assure the possibility to easily observe chamois, avoiding any impact on the pastures. In the wintering area (A area, Figure 3) the access is not allowed in the period November 1 – April 30, while in the summering area (B area, Figure 3) the forbidden period is May 1 – October 30.
Now, at 6 years from the reintroduction starting, an experimental opening of the most important climbing routes is under development, in cooperation with the Alpine Guides of Marche Region.
Basing on the above-described experiences gained during the first and the second reintroduction, the same procedure has been applied in the release area of Sirente Velino Natural Park, during the reintroduction started in 2013.
The second topic we would like to discuss is the importance of taking into account the presence of the captive breeding enclosures when choosing the release areas. As already mentioned one of the preparatory activities for the first re-introduction program was the creation of chamois captive breeding enclosures in Majella (Lama dei Peligni) and Gran Sasso (Farindola and Pietracamela). Both in the initial phase of the re-introduction program and in the following years, some wild animals, mainly 1-2 years old males, were attracted by the chamois present in the enclosure and jumped inside it. We think that this behaviour was related to the short distance between the release area and the enclosures (2.1 Km in Majella, and 4.5 km in Gran Sasso, Figure 4).

Figure 4. Distance between release areas (blue dots) and chamois enclosures (red dots), in Majella and Gran Sasso massifs.

2. Number, age of released chamois and population trend

Twenty-two (7 males, 15 females) and 26 (10 males, 16 females) chamois were released respectively in the Majella and Gran Sasso (Table 1 and Table 2).

Year	Release	Wild		Captive		TOTAL
		Males	Females	Males	Females	
1991	9/10 July	0	2 (6-8)	3 (2-3-5)	3 (1-2-2)	**8**
	14/16 October	2 (8-8)	0	0	5 (0.5-1-1-2-3)	**7**
1994	26/29/30 October	2 (5-6)	4 (3-4-7-9)	0	1 (4)	**7**
	RELEASED	**4**	**6**	**3**	**9**	**22 (7M – 15 F)**
	FOUNDERS	**4**	**6**	**2**	**6**	**18 (6M – 12F)**

Table 1. Released chamois in Majella during the “Chamois Operation” (1991-1994). Age in brackets.

Year	Release	Wild		Captive		TOTAL
		Males	Females	Males	Females	
1992	2/7 October	0	0	2 (1-6)	5 (0.4-0.4-6-7-9)	**7**
1993	27/29 September 12/13 October	3 (4-6-6)	4 (4-5-6-6)	1 (1)	1 (5)	**9**
1994	25/27/29 July	2 (2-6)	4 (5-6-6-7)	2 (2-3)	2 (1-7)	**10**
	RELEASED	**5**	**8**	**5**	**8**	**26 (10M – 16 F)**
	FOUNDERS	**5**	**7**	**4**	**4**	**20 (9M – 11F)**

Table 2. Released chamois in Gran Sasso during the "Chamois Operation" (1991-1994). Age in brackets.

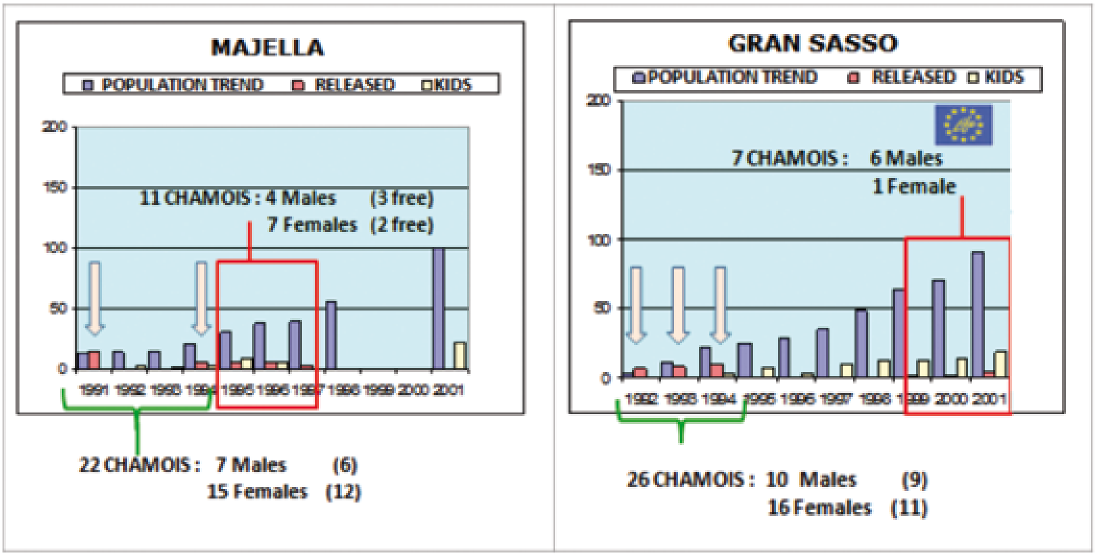

Figure 5. Population trend in Majella and Gran Sasso on 10 years from the first release (see text for details).

The number of released animals did not coincide with the number of founders. It is important to underline the difference between released animals and founders: the first are the chamois released during the operations, the second ones are the animals that have actually contributed at the increase of the new colony. That is for males, the chamois present at the first rut (November/December) after their release; for females, the animals present at the first rut and at the following birth time (June-July) after their release (Mari 2004).

In Majella during the "Chamois Operation" 22 chamois (7 males and 15 females) were released in two different years (1991 and 1994, see arrows Figure 5), but only 18 (6 males and 12 females) can be considered as founders. From 1995 to 1997, 11 additional chamois (4 males and 7 females) were released opening the gate of the enclosure in Lama dei Peligni. Their contribute to the new colony growth was very low, because only 5 animals (3 males and 2 females) joined the free ranging chamois, the others died or returned in the enclosure.

In Gran Sasso 26 chamois (10 males and 16 females) were released in 3 consecutive years (1992-1994) within the "Chamois operation". Only 20 (9 males and 11 female) can be considered as founders. In the period 1999-2001 7 additional chamois (6 males and 1 female) were released during a Life project (LIFE97NAT/IT/4143), co-funded by the European Union.

Trends of Majella and Gran Sasso populations after 10 years from the first releases (1991-2001) were evaluated (Figure 5).

Even if there were kids since the second (Majella) or third (Gran Sasso) year, in the first two years after the releases the new colonies remained quite stable, with a small increase due to the fact that the number of the kid born balanced the dead animals or the animals that returned in the enclosures. After this initial phase the two populations started the expected exponential growth, with females giving birth to kids starting from two year-old (Bonfede 1996, Artese 1998) instead of three year-old as observed in the mature population of the PNALM.
The experience gained during the first reintroductions gave us useful elements to choose the age and the sex of animals in order to maximize the founders /released animals ratio and the increasing capability of the just-released nuclei.

INDICATION FOR THE DEVELOPMENT OF THE SECOND REINTRODUCTIONS OF THE APENNINE CHAMOIS

On the basis of the previous experiences, above described, we have developed some indication used for the reintroduction in Sibillini and Sirente massifs during this Life Coornata Project, that are resumed in the following main points:

– Minimum Number of Founders (MNF): 30 chamois released within 1-3 years;
– sex ratio: 1: 2 ;
– no release of chamois < 1 year-old;
– release of females of the same herd. A good support for this topic derived from the use of the up-net® (Dematteis et al. 2009) to capture wild chamois (Di Domenico et al. this volume).
– release of females in summer and males in October, suggested but not obligatory;
– no pre-release enclosure;
– marking with hear tags and subcutaneous transponder;
animals > 2 year-old fitted with VHF and GPS collars (now available); use of expansion collars for 1 year-old chamois;
– no chamois enclosure near the release site;
– transport with helicopter is preferred.

Given the time passed from the first reintroductions until the development of the Life Coornata, some changes in the reintroduction strategy have been, obviously, implemented following the changes in the materials available and the knowledge. For example, contrarily to what happened during the first reintroductions the veterinary staff of all the Parks in which captures for translocations were performed during the Life Coornata Project (PNM, PNGSL) preferred, basing on the most recent literature, not to transfer chamois under narcosis. The captured animals were sedated, monitored, marked and fitted with radio collars, put in a wooden case and waked up before being loaded on the helicopter.
The actual size of Majella National Park and Gran Sasso e Monti della Laga National Park populations (Di Domenico et al. this volume, Scillitani et al. this volume) and the good results obtained during the reintroductions in Monti Sibillini National Park (Rossetti this volume) and Sirente Velino Natural Park (Morini et al. this volume) witness both the success of the first reintroductions and the good use of the experience gained.

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A 25-YEAR LONG STORY OF CARTUSIANA CHAMOIS *(Rupicapra rupicapra cartusiana)*: WHAT ARE THE RESULTS OF THE RESTORATION PLAN?

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INTRODUCTION

The Grande Chartreuse massif is situated in the Northern Prealps between Grenoble and Chambery. This area of 353 Km² is located at an altitude of 400 to 2000 meters.
Weather is very humid (more than 2000 mm per year), temperatures, likewise, are rather low in summer and very cold in winter. The snow cover is thick and stays for an extended period of time.
The forest covers 60% of the area of 42 500 ha. In the subalpine region (below 800m), beech forest is the characteristic vegetation. At the extreme southern extent, the Mediterranean stands are present with pubescent oak and common box. Between 800 and 1500 meters the beech-silver maple forest predominates. Meadows and mountain pine are covering the whole massif between 1500 and 2000 meters.
In 1800 the population was estimated to more than 1500 chamois. It had dropped during the Second World War to less than 100 animals. The population was then confined to the centre of the massif in the State Forest. Rangers assured protection from poaching between 1950 and 1980. During this time the reintroduction of roe deer, red deer and mouflon was carried out by hunters and forest administration. An interspecific competition between the species appeared quickly, associated with the intensive poaching of chamois.
Rupicapra rupicapra cartusiana seems to possess a phenotype that distinguishes it from other chamois: it is heavier, bigger, darker and its horns are larger in diameter.
In 1938 Dr. Marcel Couturier described it as a subspecies with the following characteristics:

– stocky appearance;
– cranial features;
– characteristics of their horns;
– darker coat.

Dr. Couturier estimated in 1938 that the home range of the population was confined about 500 km ² of Chartreuse in the inaccessible areas in the center of the massif.
Up to 1985 the chamois were not very numerous and their main distribution area only included the north western slope and the central part of the Grande Chartreuse mountain massif
In 1990 the area occupied was again decreased and restricted only to the state forest and its immediate periphery.
Between 1985 and 1986 only 150 chamois were counted in the centre of the massif.
The estimated number of chamois on the eastern slope was a few individual animals.

THE RESTORATION PLAN

In 1984 hunters were aware of the drastic reduction of the chamois population. They proposed that a restoration plan of this subspecies had to be established.
Aware of this situation and under the pressure of the local hunters, the natural environment chief (*fédération départementale des chasseurs et l'ONF National Forest Agency*) wanted to know what would be the fate of this subspecies.
In 1986 the government decided to prohibit the hunting of chamois for a minimum of 10 years.
A managment committee, under the administration authority, launched a restoration plan to be implemented by the French National Hunting and Wildlife Agency.
Within the scope of this program a strict management plan for the existing population cores was adopted, as well as a resettlement program of the sub-population in the south-east slope.
The most important condition to start the translocation program was to verify the existence of the subspecies "cartusiana".
A study on the revision of the taxonomic status has been assigned to two genetic laboratories: University College London (Pemberton) and Sciences Institute of the evolution of Montpellier.
The same muscle, liver, kidney and heart samples were analyzed by the two laboratories.
Genetic variation in 53 individuals representing 6 Alpine chamois populations was investigated by starch gel electrophoresis. It was concluded that the cartusiana population was the most distinct, but no loci displaying fixed differences between populations were detected.

The conclusions proposed and retained by the administrative authorities were as follows.
The differences between populations exist but they are weak.
There was no inbreeding in the population of Chartreuse.
The conclusions of S. Lovari that were accepted:
"….the results show that cartusiana is quite different from other populations of chamois. It is important to preserve its genetic integrity...".
In 2008 a new study was performed with new techniques like DNA isolation, and sequency. New muscle samples collected from animals killed by hunters were sent to the Institute of medical biology of Vienna University (Austria).
It shows that cartusiana subspecies is confirmed and is similar to the *rupicapra pyrenaica Ornata*.
The decision to retain the specificity of cartusiana was therefore a good decision.
The following decisions were taken by the administrative authorities:

- protection of the sub-species with a hunting prohibition of chamois on the massif;
- the prohibition period shall be set for at least 10 years;
- translocation of 30 chamois from the central area (national forest) to the east of the massif;
- the program needs to bring all the partners together (governments, hunters and naturalists).

Since it was not certain that the south-eastern slope of the massif would be spontaneously and rapidly colonized, a reintroduction campaign took place between 1990 and 1992. To ensure that the whole mountain massif would be populated by the same subspecies, several chamois captured on the western slope were translocated to the eastern slope.
To guarantee the success in capturing the animals, the decision to focus in capturing in the state forest has been taken.
An expert group has been constituted by local hunters, forestry agents and rangers. Their knowledge of the terrain allowed a quick selection of the best areas.

Between 1990 and 1992, 26 animals (9 males and 17 females) were captured on the western slope and subsequently released on the eastern slope. Seven males and 3 females in April 1990 1 male and 8 females in April 1991 1 males and 6 females in April 1992.
At the moment of the capture the males were between 1 and 5 years old, the females between 1 and 12 year-old. All the animals were kept in a 2 ha enclosure, set up at the site of release, where they remained for a period between 15 days and 3 months. This protocol allowed the release of the animals in groups, and all the animals captured in a given year were freed together.
These animals were all fitted with VHF collars and monitored over periods varying between 2 months and 3 years, depending on the transmitters lifespan. They were all monitored throughout the year, although in the months of March and April a much greater monitoring effort was carried out.
A systematic health examination was performed.

MONITORING ANIMALS

The average home range sizes used throughout this study, as measured by the minimum convex polygon method, were 8244 ha for males and 2244 ha for females, by the 100% cluster method respectively 6201 ha and 1789 ha, and by the 90% cluster method respectively 437 ha and 333 ha. Distance between home range center and point of release was 3400 m for males and 1449 m for females. If its home range center was more than 2000 m away from the point of release we considered an individual to have left the release site.
85 % of the animals settled down in their release site.
75% of the released animals (2 males and 2 females) left the reintroduction site and returned to their range of origin.
Apart from 3 males with a very large home range (16 000 ha, 18 000 ha and 26 000 ha MCP) the home range of all the other males and females were more or less of the same size (2200 ha). Nevertheless, the oldest animals had a tendency to occupy larger home ranges than younger ones.
For this reason when dealing with reintroductions by translocation we recommend taking relatively young animals, to set the date of release in early April (near birth date) and to release many animals (between 20 and 30) together, preferably in groups, with an unbalanced sex ratio in favor of the females.

THE MANAGEMENT PROGRAM

For the management, the massif was separated into two subunits: the central areas where the original population was (Number 8) and the eastern part (Number 9) where the translocation was performed.
Every year a committee of experts (local hunters, rangers and administrators) proposes the rules for the population management.
All hunters have followed several courses on biology and management for the privilege of hunting chamois.
Ten years after the prohibition on hunting the first shots of chamois were allowed in the unit number 8 (the central areas) with 5 animals killed.
For the eastern slope (subunit 9) the first shots of chamois were allowed in 2000 with two animals killed.
Today the hunting plan is 154 chamois in the subunit 8 and 52 in the subunit 9.
The shooting rules are distributed between 3 age and sex classes: kids, yearling and adult males and females.

For a successful management of large herbivores like chamois, we need to consider not only the fate of the population, but changes in both population and habitat features, as well as their interaction.
Managers require information on trends in both the animal population and habitat quality in order to interpret changes in the interaction between these two compartments.

We select a set of indicators of animal performance, population abundance, habitat quality and herbivore habitat impact that provides relevant information on the population habitat system.
Monitoring temporal changes in these indicators provides a new basis for setting hunting quotas to achieve specific management objectives. This sort of adaptive management is employed widely in France for managing roe deer *Capreolus capreolus*.

NEWS TOOLS FOR MANAGING POPULATIONS

Censusing chamois populations and detecting trends in population size over time is an important task in the conservation and management of this species.
In France we have developed a monitoring method to know the functioning of a demographic population of chamois (Loison et al. 2006).
Consistent results between the use of an index and the CMR (capture-mark-recapture) suggest that the index could be used to monitor trends in population size.
In our case we calculated an index of population size as the mean number of animals observed on a 10.7 m transect surveyed repeatedly.
Resampling techniques, however, pointed out that the index is only reliable when calculated over a sufficient number of surveys per year (4 in Chartreuse) and over a sufficient number of years of monitoring (about five years).
The relative abundance of the two subpopulations is stable even if a slight increase in the western slope has been noticed.
Regarding ecological indicators the quality and performance of individuals in a population is quite important.

All young chamois are weighed and adult's horns are measured.
In the subunit 8 the body mass of kids decreased significantly while in the eastern slope (subunit 9) the weight is stable.

In order to have all the indicators, we measure every year the animal impact on the forest using a sample of 150 plots.
Because of the presence of red deer, roe deer and mouflon it is difficult to attribute the share of consumption to each of these species.

During a pedestrian transect, the surveyed information on the percentage of Kids per female are noted.
The reproductive index measured during the last 8 years complies with the other populations studied. Its value will vary between 0.6 and 0.75.
The set of indicators measured on the two subpopulations shows that the management conforms to the objectives that are to continue to increase the number of chamois. Monitoring the evolution of indicators is necessary to avoid the effects of density dependence.

Today the population is estimated over 1000 chamois.
All the indicators show that the translocation project is successful. Current management guidelines are set to maintain quotas and to continue monitoring this population.

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SESSION III
THREATS AND CONSERVATION

EVOLUTIONARILY SUSTAINABLE MANAGEMENT OF CHAMOIS AND OTHER UNGULATES

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INTRODUCTION

The conservation of chamois (*Rupicapra spp*.) can be considered a success. Populations in the Alps (*R. rupicapra*) and in the Pyrenees (*R. pyrena*ica) are much larger than they were a few decades ago, and generally increasing (Corlatti et al. 2011, Dubray 2014). The status of Apennine chamois (*R. p. ornata*) has improved tremendously over the past 20 years, thanks mostly to reintroductions into suitable habitat from the surviving nucleus in the Abruzzi, Lazio and Molise National Park. There are now possibly as many as five times more Apennine chamois than when reintroductions first began in 1991. As reported in these proceedings, the conservation status of other populations is mixed. Some populations and subspecies in parts of the Balkans, Turkey and the Caucasus are affected by problems including poaching and possible introgression of non-native genes from ill-advised extralimital translocations of the Alpine subspecies. The major persisting threat to chamois is contagious diseases, particularly those transmitted by domestic livestock (Degiorgis et al. 2000, Pioz et al. 2008). In addition, climate change may affect the distribution, habitat availability and persistence of some populations (Rughetti & Festa-Bianchet 2012) and is a new threat that needs to be considered in future research and management plans.

Chamois management is mostly based on selective harvest of individuals of particular sex-age classes. Similarly to other mountain ungulates, many chamois hunters wish to harvest a male with large horns (Rughetti & Festa-Bianchet 2010). Selective hunting, one presumes, may lead to selection. While wildlife managers are often justifiably concerned with demography and habitat quality, recent studies have underlined the potential phenotypic and evolutionary consequences of selective harvest (Festa-Bianchet 2003). In this chapter I will briefly review the evidence that selective hunting, particularly in the case of intense trophy hunting, may select for small-horned males in mountain ungulates. I will conclude by suggesting that trophy hunting of chamois is probably less likely than in other species to cause artificial selection for small-horned males, because of the apparently limited role played by horn size on male reproductive success.

SPORT HUNTING AS A SELECTIVE FORCE

In many sport-hunted populations of ungulates, harvest is the main cause of death, particularly for males (Mysterud et al. 2005). Often, the sex-age distribution of harvested animals is very different from that of animals that die of natural causes (Wright et al. 2006), possibly altering selective pressures for age-specific reproductive effort and the level of competition for mates among males. While there is substantial evidence that commercial fisheries have altered life-history tactics in exploited populations, often selecting for younger age and smaller size at maturity (Hutchings 2009), the limited evidence available for ungulates does not currently suggest that life-history effects are widespread (Proaktor et al. 2007, Mysterud et al. 2009). Both hunter preference and hunting regulations can have profound effects on the sex-age structure of the harvest. For example, in populations where female chamois do not reproduce until 3 or even 4 years of age, regulations prohibiting the harvest of females with a kid at heel lead to intense harvest of 2-year-old females (Rughetti & Festa-Bianchet 2011a). These young females have a very high reproductive potential (Gaillard et al. 2000, Festa-Bianchet et al. 2003). In management areas where penalties for shooting lactating females are not as severe, many fewer 2-year-old females are harvested. The regulation protecting lactating females is motivated by an expectation that orphaned kids would have lower survival. No data on the survival of orphaned chamois kids exist, however, and evidence from other species is mixed, sometimes suggesting a negative effect of orphaning and at times suggesting weak effects on growth and no effects on survival (Festa-Bianchet et al. 1994, Andres et al. 2013). If the hunting season is in October or later, chamois kids are likely weaned (Ruckstuhl & Ingold 1994) and the impact of orphaning should be minor. Therefore, a regulation intended to reduce the impact of female harvest on population dynamics by reducing the harvest of lactating females may have the perverse effect of increasing that impact by encouraging the harvest of females with high reproductive potential (Rughetti & Festa-Bianchet 2014). Cultural preferences for harvesting females without young exist for other species (Nilsen & Solberg 2006) and it has been suggested that if harvests are heavy biased towards non-lactating females they may select for higher reproductive effort (Zedrosser et al. 2013).

Most of the attention towards the possible selective effects of sport hunting has been on the consequences of trophy hunting, particularly for wild sheep and goats. An analysis combining phenotypic and pedigree information for an isolated population of bighorn sheep (*Ovis canadensis*) in Alberta, that had been intensively hunted for 'trophy' males, revealed a decrease in breeding value of horn length over 35 years, or approximately 5 sheep generations (Coltman et al. 2003).

Rams were hunted under a legal definition that restricted harvest to those with horns describing at least 4/5 of a curl, so that small-horned rams could not be harvested and rams with rapidly-growing horns were shot as young as 4 or 5 years of age. That age – and horn-specific selective harvest is important, because large horns allow bighorn rams to achieve high dominance rank and high reproductive success at about 7-8 years of age (Hogg & Forbes 1997; Coltman et al. 2002). For younger rams, horn size may affect dominance rank, but it has little effect on mating success because only older rams can adopt the highly successful tactic of defending estrous ewes (Hogg & Forbes 1997; Pelletier and Festa-Bianchet 2006). The phenotype-based hunting regulations, therefore, meant that a ram with rapidly growing horns, that should have been highly successful had it survived to 7-8 years, was instead shot at 4-5 years, drastically curtailing his contribution to future generations and favoring instead the reproduction of small-horned rams. A key message of that research, therefore, was that age-specific reproductive success of males, and the effect of horn or antler size on that age-specific male reproductive success, will likely have important consequences for whether or not selective harvests based on horn or antler size may have evolutionary consequences. For example red deer (*Cervus elaphus*) do not reach full antler size until they become successful breeders, and continue to grow large antlers even after they enter reproductive senescence (Kruuk et al. 2002). Therefore, a moderate level of trophy hunting may not remove many stags before they have a chance to breed, and there is no evidence of a temporal decline in antler size for this species (Rivrud et al. 2013). Our knowledge of how selective hunting may affect the distribution of matings, however, is limited by the very small number of ungulate species with reliable data on age-specific male reproductive success (Festa-Bianchet 2012).
There are no data on male reproductive success of any chamois species.

Bighorn sheep on Ram Mountain are the only hunted populations of ungulates that has been the object of long-term monitoring programs, including the construction of a detailed pedigree. The paper by Coltman et al. (2003) led to a chorus of protestations, some entertaining but mostly data-free (Festa-Bianchet et al. 2008). Later developments in the analysis of pedigrees in the wild suggested that the genetic effect of selective harvests may have been overestimated in that study (Postma 2006). Additional research is required to better quantify the evolutionary consequences of selective harvests, but the required pedigree information requires a very long-term commitment and is very difficult to obtain.
Modeling approaches are an alternative (Mysterud & Bischof 2010), but in most cases suffer from an insufficient basis of empirical data, and must rely on implausible series of concatenated assumptions. Record books are a good source of information on what harvested animals are listed in record books (Monteith et al. 2013), but are unlikely to have any biological relevance. Because they are strictly based on a minimum score, they represent an extreme form of biased sampling and it is questionable whether they could detect any population-level trends in horn or antler size.
An alternative approach involves an analysis of long-term records of harvested animals, taking advantage of the dedicated work of many wildlife managers and agencies that have collected morphometric data over decades. Harvested animals have been a source of useful data in ecology (Mysterud et al. 2001, Mysterud et al. 2008), but before data from sport-harvested ungulates are analyzed, it is essential to consider possible biases. Some of these biases may be induced by hunting regulations, such as the example mentioned above for Alpine chamois (Rughetti & Festa-Bianchet 2011a), others may be due to cultural preferences, such as a reluctance to harvest lactating females (Solberg et al. 2000) or a preference for males with large antlers or horns (Mysterud et al. 2006). Finally, some types of animals may behave in ways that increase or decrease their vulnerability to harvest (Ciuti et al. 2012). These biases mean that the sample of harvested animals may not be representative of the population at large. For example, small-horned bighorn or Dall sheep (Ovis dalli) rams will not be sampled in areas where sheep are harvested under a minimum-curl rule and rams with slow-growing horns will survive longer as they will take more years to reach minimum legal horn size: these rams will only enter the harvested sample at an advanced age (Loehr et al. 2006). A comparison of trophy-sized rams with all rams in the Ram Mountain population in Alberta showed that sport harvest would have severely underestimate a declining trend over time (Pelletier et al. 2012). Therefore, analyses of harvest records must bear in mind that slow-growing animals will likely be overrepresented among older age classes and that declines in horn or antler size over time will almost certainly be underestimated.

Despite those biases, a number of studies have shown declines in horn size of harvested mountain ungulates that are consistent with the hypothesis of artificial selection favoring small-horned males. In British Columbia, horn size of harvested bighorn rams declined by about 4% over 28 years (Hengeveld & Festa-Bianchet 2011). A similar decline was observed in Alberta over 37 years (Festa-Bianchet et al. 2014), where it was accompanied by a drop in the proportion of rams aged 4 and 5 years in the harvest, from about 25-30% in the early 1980s to less than 10% in recent years. While many rams aged 4 and 5 years fit the definition of legal rams a few decades ago, fewer young rams are legal now, presumably because of slower horn growth (Festa-Bianchet et al. 2014). A similar result was obtained for one population of Iberian wild goats (*Capra pyrenaica*) where intense trophy hunting was correlated with a decrease in horn size over time and an increase in age of harvested males, presumably because it took more years of horn growth to reach a size that hunters considered a trophy (Pérez et al. 2011). A decline in horn size following years of intensive trophy hunting was also reported for an introduced population of aoudad (Ammotragus lervia) in Spain, although in that case the average age of harvested males declined over time (Pérez et al. 2011).
Selective hunting of European mouflon (*Ovis aries*) led to a decrease in horn size but also a change in horn shape, as rams with widely flaring horns are preferred by hunters and decreased in proportion over time in a population in France (Garel et al. 2007). Finally, work in progress on harvested Stone sheep (*O. dalli stonei*) rams from northern British Columbia, Canada, suggests a similar pattern, with a decline in horn size in heavily-hunted areas and no decline in an area with very difficult access and a lower hunting pressure (Douhard et al. in prep.).

Together, evidence from bighorn sheep in Alberta and British Columbia, Iberian wild goats and aoudad in Spain, mouflons in France and Stone sheep in British Columbia suggest that intensive trophy hunting can lead to a phenotypic shift in horn size over a few decades. Data from the intense monitoring at Ram Mountain suggest that this shift is at least partially based upon a change in genotype, suggesting an evolutionary effect of artificial selection (Coltman 2008). While these results are concerning, they also point the way to a possible solution. Trophy harvests run counter to natural selection: males with horn attributes that would normally increase fitness suffer an early death. There are at least three management initiatives that can overcome, or weaken, those selective effects. First, the harvest rate must be lowered to allow some large-horned males to breed. Currently, there are no quotas on the number of licenses sold to provincial residents in most of Canada, where harvests are limited only by the availability of rams that fit the legal definition of 'trophy' (Festa-Bianchet et al. 2014). Evolutionary enlightened management would suggest a limit in the number of licenses issued (Festa-Bianchet & Lee 2009), reducing the harvest rate of large-horned rams and allowing some to survive to the age when large horns provide a fitness benefit through increased mating success (Coltman et al. 2002). Second, a network of protected areas and temporary closures may provide a source of unselected immigrants to weaken the selective effects of the trophy hunt (Hogg 2000, Tenhumberg et al. 2004, Hogg et al. 2006). Finally, regulations that encouraged the harvest of older rams would also alleviate the selective effect of the hunt, by reducing the number of large-horned rams that are shot before they have a chance to reproduce. Generally, selective pressures applied later in life are much less effective than those occurring early in life (Monaghan et al. 2008).

WHAT ABOUT CHAMOIS?

Where they are hunted, chamois are often considered a trophy species, and cultural preferences lead to most hunters seeking to harvest a large-horned male. Recent increases in population size in both the Alps and the Pyrenees have been accompanied by generally low harvest rates. Although harvest rates are likely to differ substantially among jurisdictions, in at least some areas the presence of a substantial proportion of males aged 8 years and older in the harvest suggests that even the hunting pressure on mature males is not particularly high (Rughetti & Festa-Bianchet 2010; Mason et al. 2012). Although no information is available on male reproductive success of chamois, multiple lines of evidence suggest that horn size may not play a large role in determining mating success. Male chamois use their horns in intrasexual aggression (Lovari 1985), but may not be advantaged by having large horns. First, horn growth is very rapid: by the time they are 4 years of age, male chamois have horns that have nearly reached their asymptote in length (Bassano et al. 2003).

Behavioral observations and seasonal changes in mass, however, suggest that males are reproductively successful at a much later age (von Hardenberg et al. 2000, Mason et al. 2012, Corlatti et al. 2013). Second, horn growth shows a very strong level of compensation: males with rapid horn growth in the first 2 years of life grow short increments in the following 2 years, and males with small horns as yearlings boost their horn growth over the next 2 years (Rughetti & Festa-Bianchet 2010). That pattern is very different from that seen in ibex or wild sheep, where horn size affects male mating success and horn growth in successive years tends to be positively correlated (Bergeron et al. 2008, Bonenfant et al. 2009, Toïgo et al. 2013). Strong compensatory horn growth in male chamois argues against a role of horn size in mating competition. Male mountain goats (*Oreamnos americanus*) show a number of similarities with chamois: horn length nearly reaches an asymptote at 4 years of age and horn growth in the first few years of life shows a compensatory pattern, although not as strong as that exhibited by chamois (Festa-Bianchet & Côté 2008). In mountain goats, male horn size plays no role in mating success, which is instead mostly determined by body mass (Mainguy et al. 2009). It is unclear whether or not body mass plays a role in male mating success in chamois, but among adult males it is very weakly correlated with horn length (Rughetti & Festa-Bianchet 2010), so that hunters that preferentially harvested males with long horns would not necessarily also harvest large-bodied males.

Overall, the apparently weak link between male horn size and reproductive success in chamois may suggest that the selective effects of trophy hunting may be weaker than in other mountain ungulates. A hunter removing a large-horned mountain sheep or ibex will likely remove what would otherwise have been a successful breeder, and rapid horn growth in ibex or mountain sheep males will likely lead to an earlier age at harvest (Hengeveld & Festa-Bianchet 2011, Büntgen et al. 2014). Neither condition is likely to apply to chamois, although a very intense level of selective hunting for large-horned males may still favor the fitness of those with smaller horns. Yet, there is evidence that chamois in the Alps are getting smaller: in both northern Piedmont, Italy and in Ticino, Switzerland, harvested adult males are now about 2-5% lighter than they were in the 1990s (Rughetti & Festa-Bianchet 2012). That decline in mass, however, appears more likely attributable to global warming than to selective hunting, because of a strong negative relationship between spring-summer temperature and mass of yearling chamois of both sexes. That negative environmental effect of early development appears to be maintained at later ages (Rughetti & Festa-Bianchet 2012), underling the need for further research into the potential effects of climate change upon chamois ecology and conservation. Interestingly, a recent study on Alpine ibex (*Capra ibex*) found the opposite trend, suggesting that ibex horn growth is positively affected by increasing temperatures (Büntgen et al. 2014). The difference between ibex and chamois in the consequences of climate change may be due to ibex using higher elevations, where warmer weather may increase plant nutritional quality.

CONCLUSION

It is urgent to determine what characteristics of male chamois affect variability in reproductive success. That research will likely provide some surprises, and it will have both fundamental and applied implications. Chamois show less sexual dimorphism in horn and skeletal size than most other ungulates, yet males gained so much mass over the summer that by the time the rut starts they weigh about 40% more than females, apparently losing that extra mass over the next few weeks (Garel et al. 2009, Rughetti and Festa-Bianchet 2011b, Mason et al. 2012). Those changes in mass, combined with behavioral observations (Corlatti et al. 2012) suggest that perhaps endurance, agility or aggressiveness are key to male chamois reproductive success. Until molecular data to assign paternity will become available, the determinants of male mating success in chamois, and even its level of polygyny, however, remain unknown. Should an investigation of male reproductive success reveal that territorial males monopolize matings (von Hardenberg et al. 2000, Corlatti et al. 2013), then it would be important to examine whether territorial behavior may be disrupted by the sport hunt. Presumably, territorial males are more vulnerable to harvest than non-territorial ones.

Finally, the conservation and management of Apennine chamois would benefit from a long-term study based on marked individuals, that would allow to determine trade-offs between life-history components and examine the environmental and phenotypic determinants of variability in reproductive success. Monitoring of marked individuals would also provide knowledge on population dynamics and in the evolutionary ecology of this species (Clutton-Brock & Sheldon 2010). Studies or marked chamois in the Alps and the Pyrenees have underlined the important role of individual differences in these species (Crampe et al. 2006, Loison et al. 2008) and a similar initiative would hold much promise for the Apennine subspecies.

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THE CHAMOIS IN ROMANIA AND IN THE PIATRA CRAIULUI NATIONAL PARK EVOLUTIONS AND CHANGING AFTER HUNTING BAN IN NATIONAL PARKS

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1. INTRODUCTION

Romania is a Central European country, placed at half distance between the Equator and North Pole and respectively between the Atlantic Ocean and the Ural Mountains, in the Danube and Black Sea basins.
With an area of 238.391 sqkm and a population of 20 million, it is considered a medium sized European country, representing 6% of the European territory and 4% of its population.
The variety and the relative balance between the geomorphological conditions – 28% mountains, 42% hills and plateaus and 30% planes – represent unique features in Europe and are rare at global level. Romania is the only country in the EU

Figure 1. Biogeographical regions in Romania.

hosting 5 biogeographical regions: continental, alpine, Pannonic, Pontic and steppic.
Romania hosts over 50% of the Carpathian Mountains and 97.8% of its territory falls in the Danube watershed.
Romania is a country with rich biodiversity (ecosystems, species and genetic diversity) and a high percentage of natural ecosystems – 47% of the land area of the country are covered with natural and semi-natural ecosystems. Since almost half of all forests in Romania (13% of the country) have been managed for protection rather than production, Romania has one of the largest areas of undisturbed forest in Europe. The natural integrity of Romanian forest ecosystems is indicated by the presence of the full range of European forest fauna, including 60% and 40% of all European brown bears and wolves, respectively. Europe's largest wetland, the Danube Delta, also lies predominantly in Romania. Major grasslands, caves, and an extensive network of rivers add to the ecosystem richness.
The high level of geographic diversity in Romania and the consequence of its location in a biological meeting place, has produced a floral diversity that includes over 3,700 species and a fauna diversity estimated to be more than 33,802 species. These figures include a large number of endemic and sub-endemic plants (228) and animals (1000) specifically adapted to local conditions and only found in Romania. Species that once thrived in many parts of Europe are now only found in Romania or found in Romania in large or significant populations.
Although rich in biological resources and important as a corridor for the movement of species (biogenetic material), Romania has suffered the consequences of human activity. Pollution, the damming of rivers, hydrological works, industrial

agriculture, overexploitation of natural resources, among other factors, have all taken their toll in decreasing biodiversity. Highly sensitive mountain ecosystems are also particularly threatened by inappropriate forms of tourism and by associated infrastructure development. This trend is likely to increase if appropriate measures to reduce the effects of pollution and of economic pressures connected with the overexploitation of natural resources will not be undertaken.
The organized and formal biodiversity conservation activities in Romania started in the beginning of the last century, with several specific laws and the first national park declared in 1935 – Retezat National Park.
Presently, the national system of protected areas covers around 7.5% of the territory (13 national parks – 1.4%), while the Natura 2000 network covers around 25%. 1.4%), while the Natura 2000 network covers around 25%.

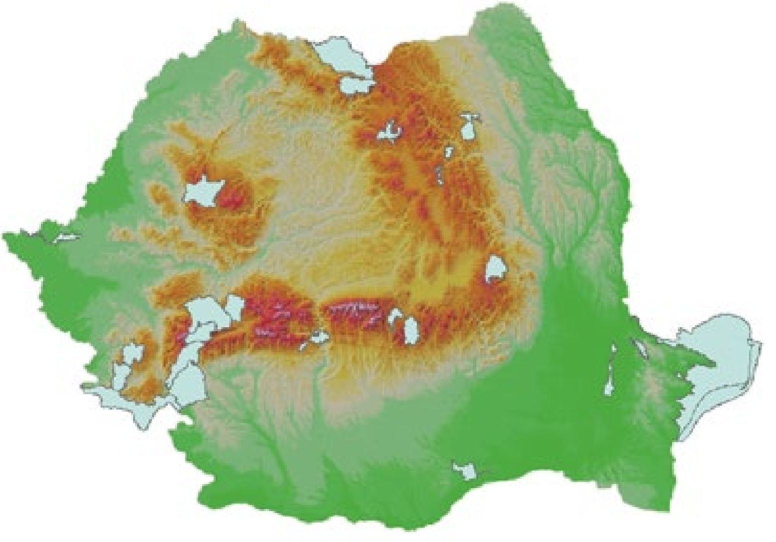

Figure 2. National and nature parks in Romania.

Most of the national and nature parks are located in the Carpathian Mountains and host the populations of the Carpathian chamois (*Rupicapra rupicapra* ssp. carpatica).
Romania hosts the largest populations of large carnivores in Europe, brown bears, wolves and lynxes and most of those populations are located in the Carpathian Mountains, overlapping with many areas that represent the chamois habitat.

Figure 3. Natura 2000 network in Romania.

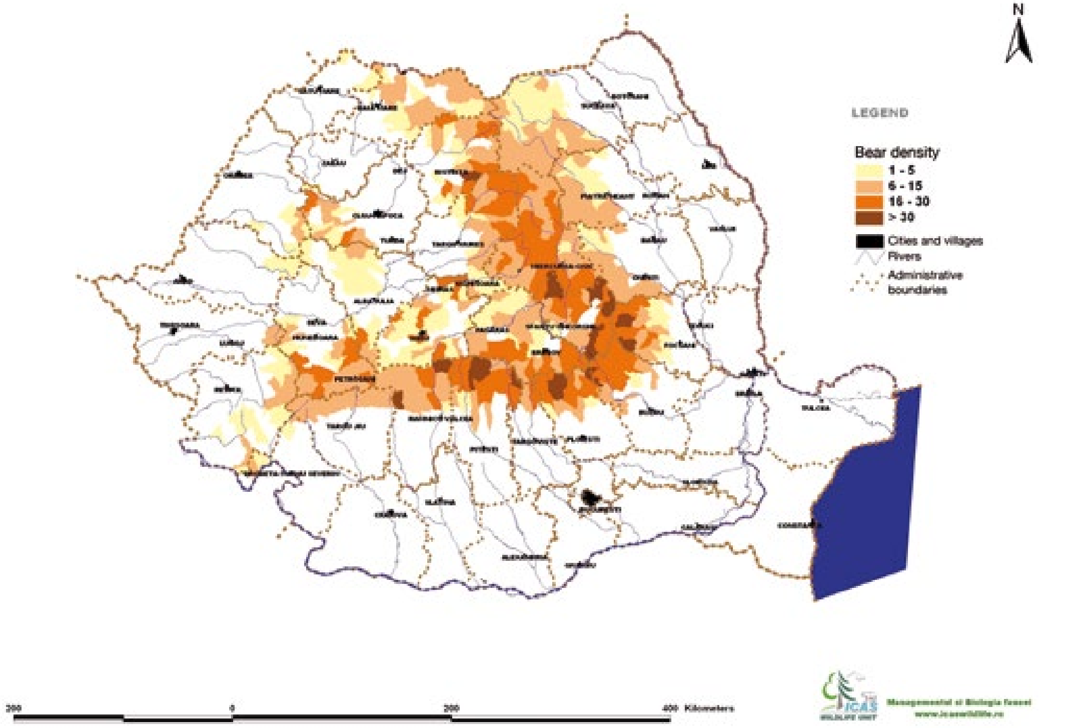

Figure 4. Bear distribution in hunting areas in Romania – Ovidiu Ionescu.

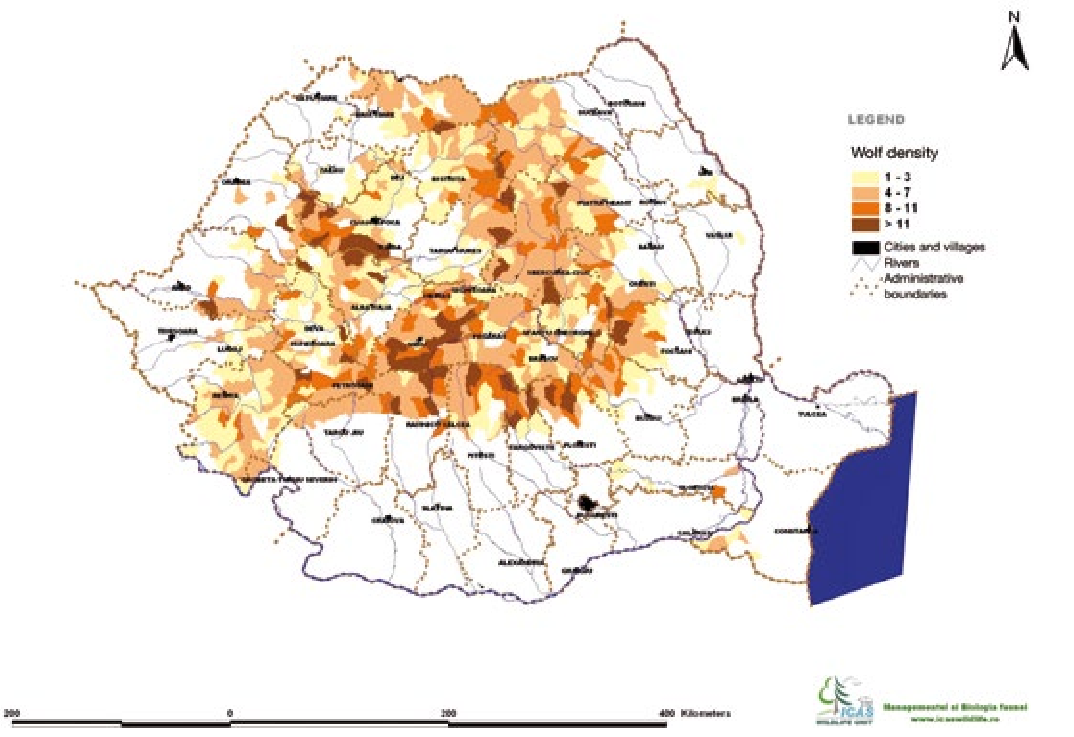

Figure 5. Wolf distribution in hunting areas in Romania. Ovidiu Ionescu.

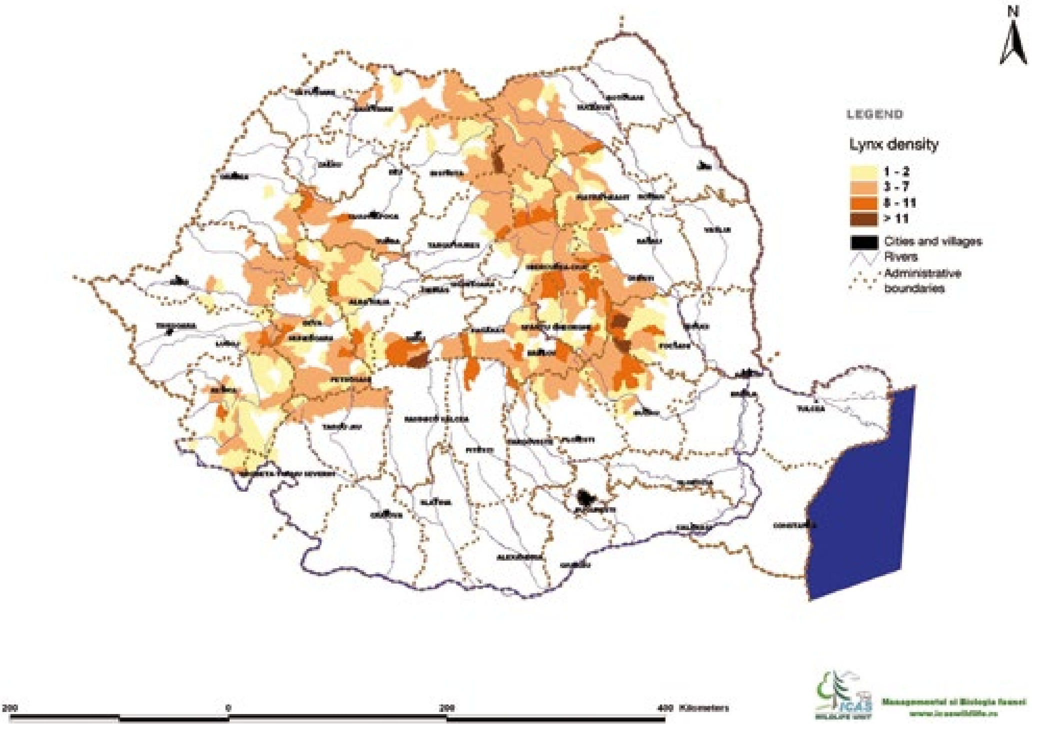

Figure 6. Lynx distribution in hunting areas in Romania. Ovidiu Ionescu.

The chamois population in Romania in estimated presently as being between 8000 and 9000 individuals, all of them located in the Carpathian Mountains.

2. HISTORICAL DATA

The high number of discovered fossils in Europe shows the area where the chamois existed on our continent. The oldest fossils discovered in Romania came from the Mid Palaeolithic, discovered in the Muierilor Cave (Daicoviciu et al. 1953). Other chamois fossils were found in 1891 in the Magdalenian deposit at Somesu Rece (close to Cluj), bone remains in an archaeological site from the stone age in 1934 near Bod (Brasov), a skull in 1946 in the Scarisoara cave glacier (Apuseni) and bone remains in 1954 at Negrului cave and Draganului Valley (Witting 1936).

All these areas are relatively far from the actual habitat in Romania, suggesting that in the past the species existed on a much larger area.

The oldest written document about chamois in Romania comes from 1520, when a hunted animal was given as a present to a certain Iacobus Thornaly (Witting 1929).

In 1532, in *"Sources for the history of Brasov"* (Quellen zur Geschichte der Stadt Kronstadt) it is shown that during a festive meal for Stephanus Werboczy, *"regiae majestatis summus tum cancellarius tumuque secretarium"* chamois meat has been served (Nedici 1940).

In 1716, in *"Descriptio Moldaviae"* written by the great scholar Dimitrie Cantemir, translated from a German text from Bosching since 1771, edited in Romania in 1955, the Moldova fauna is described, and chamois is mentioned among the other species. There are some doubts about the translation, which does not match the Romanian Academy one, from 1875 (Stavros 1989).

Later, in Nova Dacia, written in 1743-1744 by the Jesuit monk Francisc Fasching who lived in Transylvania, there is a description of the Harghita mountains and fauna as follows: "Mons hic, Siculis Hargita dictus … nutritque non modico numero lynces, martes, *rupricapras*, …, ursos, etc.". (Nedici 1940).

In a geographical study on Poland and Transylvania (Compendiulum regnorum Sclavoniae et Transsylvaniae geographicum) published in 1777 we can find: "Montes Transsylvaniae … animalibus: uri …, ursi, apri, lynces, rupricaprae, martes, etc". (Nedici 1940).

In 1805 the Sibiu doctor Andreas Wolf, in his book (Beitrage zu einer statistich-historischen Beschreibung des Fursthentums Moldau) edited in Sibiu, says about Moldova: "Regarding the game species, this country is like a natural zoological garden, where we can find a great number of red deer, roe deer, bear, wild boar, wolf, chamois, hare, fox and

others". (Nania 1977).
In the memories of the principle Nicolae Sutu (Memoires du prince Nicolae Soutzo, 1899), published postum in Vienna, by Panaioti Rizos, it is mentioned: "in 1830, in the Carpathian mountains there were bears, wild boars, red deer, and on some peaks, even chamois".
Later, in 1842, in a magazine ("Unterhaltungsblatt fur Geist, Gemuth u. Publicitat") some chamois hunters are cited, Cartisoara Romanian peasants. (Witting 1936).
The first hunt with foreigners was mentioned in 1843, when prince Albert of Prusia, the Russian prince Korsakovsky and a boyar "highly situated" from Vallachia, together with the Brasov hunters, hunted chamois in the Bucegi and Piatra Craiului Mountains (Pop 1957).
Ioan Ghernita, a hunter from Zarnesti, was mentioned in 1844 in a magazine (Blatter fur Geist und Gemuth und Vaterlandskunde) as shooting in the Piatra Craiului Mountains 120 chamois, 27 bears and 70 wild boars (Witting 1936).
In 1854 the hunter writer Alexandru Ujfalvy mentions in a manuscript: "on Retezat and Ineu (Rodna Mts..) one can see a group of 30-40 chamois; but also on Tibles chamois can be seen". He also says: "the chamois lives on the peak of the mountains, between the volcanic eruption rocks, where only the rich hunters can reach, the poor can't reach those areas. So in these quiet places, the chamois can breed very well". (Nedici 1940).
In 1877, Iosif Sterca – Sulutiu (1827-1911), a well known hunter, describes a hunt in the Fagaras Mountains (Cirtisoara) from 1871 and he remembers shooting for the first time a chamois (even after many years of hunting), together with a Romanian peasant. (A.Stavros,1989).
E.A.Bielz (Die Fauna der Wirbelthiere Siebenburgens) notes in 1888, about chamois: it still lives, in larger or smaller groups, in all the Transylvanian Mountains higher than 2000m, more on retezat, Parang, Rodna and Fagaras, and few on the Barsa Montains – Bucegi and Piatra Craiului (Nedici 1940).
G.Deutsch, mentiones the chamois in the North-East Carpathians 1893, in the book "Zur Geschichte der Jagd in der Landern der Stefanskrone".
The first hunting law, called "on game police", appeared in Romania established a hunting season for chamois from the 15th of June until the 15th of October. The Parliament debated on this law for over 5 years, from 1886 (Nedici 1940).
In Transylvania the first law establishing hunting seasons appeared in 1751, but the chamois was not included among the species (Witting,1936).
In 1872 appears in Transylvania the first hunting law where chamois was excepted from hunting from the 15th of November until the 15th of July (Witting 1936).

3. CHAMOIS POPULATION EVOLUTION IN ROMANIA IN THE PAST

According to E.C.Gheorghiu, in 1901, the numbers were quickly declining, due to hunting with hounds, large sheep flocks and the lack of guarding in most of the areas with chamois.
According to Dragos Navrea (hunting inspector) in an article in the Carpathians magazine, the chamois numbers in Bucegi suffered a marked decline at the end of the 19th century, the proof of this were the protective measures taken by the Hunters Society from Brasov, in 1902. At the end of the First World War the population was of 200-220, that later declined due to poaching, down to a minimum 30-40 in 1936. After the strong protection measures started in 1937 by the Federeation of chamois protectors and hunters, the numbers increased to 140-160, at the end of the Second World War.
Alexander Florstedt, whom in 1896, rented a part of the best hunting areas on the Northern side of the Fagaras Mountains, where on approximately 100.000 ha there were only 80-100 chamois, started a strong campaign for protecting and hunting of the chamois at a high level, never met until then. He built lodges, hunting trails, salt points and pastures were rented for the exclusive use by the game species. He further intensified these measures by severely guarding the area; this was done with foreign rangers. The results came fast, and after 10 years, the numbers increased to 3000 chamois.
In Retezat, where the Kendeffy family owned 24.687 ha of forests and alpine meadows (Von Spiess,1933) where there were organized hunts with the rich people of the period, numbers of chamois increased. August von Spiess, diretor of the royal hunts (1921 – 1939), estimated the chamois population in 1933 at 2000 individuals in the whole massif.
In Rodnei Mountains, where G.Nedici (1940), before the First World War there was the most valuable chamois population in Romania, the last animals were killed by poachers at the end of the 1920s.
The first world record for chamois, obtained at the International Hunting Fair in Vienna (1910), a trophy was awarded to the Rodnei Mountains in 1902. After 1918, at the end of war many military rifles where easily available, the number of chamois decreased and even disappeared, like in the case of the Rodnei Mountains.
There were also other factors contributing to this, the main one being the dissolution of the large estates in the high mountains. That's the reason why a multitude of hunting areas appeared in the chamois zone, here a large number of individuals were hunted, much higher than their natural reproduction levels.
Another important factor was grazing, which took an unprecedented development and restricted the chamois access to the feeding areas during summer. This is the main reason the population numbers in the '30s were 60% less than the ones from 1916.
The hunters who published several articles in the Carpathians hunting magazine (led by Ionel Pop) gave out several alarm signals. Due to this on the 16th of July 1937, following a general assembly held in Sibiu, the "Federation of chamois protectors and hunters in Romania" was created, in Sebes, Alba county.
According to the statute, the main goal was "the rational guidance of the chamois numbers, in all the massifs which are hosting or could host this noble species, until the population will reach the carrying capacity level". Successively the county offices of the Federation were formed and a close cooperation with the Hunting Directorate begun. The measures

taken, like 13 warden groups (each with a head warden and 2 wardens) and the limitation of hunting permits, all this led in a very short time to unexpected positive effects.
At the end of 1939, A. Vatamanu was writing in the Carpathians magazine: “I never saw in this country such a successful game protection action with such fast and tangible results”. The Federation functioned even after the war, with the last General Assembly on the 24th of May 1948.

4. ACTUAL SITUATION IN ROMANIA

After the Second World War, after a short period of decline, the chamois numbers continuously increased during the communist era, until 1990.
Following the efficient protection and small yields, the chamois numbers increased at the end of the ‘80s at 9000, being spread on approximately 400.000 ha.

After 1970, the research team “The biology of game and Salmonidae species” led by Horia Almasan, established the chamois capture and repopulation methods, which were used for the reintroductions during this period. The activities were done with the support of the foresters, in difficult conditions and with huge physical efforts.
Thus, in the Rodnei Mountains – a number of over 40 chamois were reintroduced from Bucegi (14 pcs), Piatra Craiului (6 pcs), Fagaras (5 pcs), to which some young raised in captivity were added. In 1990 the numbers in Rodnei reached 350.
In Ceahlau and Hasmas Mountains, 24 chamois were reintroduced from Retezat, Piatra Craiului and Bucegi; this led to the existence of 2 populations in the Hasmas-Cheile Bicazului National Park (over 120 pcs) and Ceahlau National Park (around 100 pcs)

In 1972-1973 the Siriu Mountains were populated with 16 chamois from Bucegi, Piatra Craiului and Retezat. Presently the population is around 70, with an increasing trend. In 1975-1976 the Ciucas Mountains were populated with 12 chamois from Bucegi. Presently the population is around 60.
In the Apuseni Mountains 12 chamois were reintroduced from Retezat. Presently, in the Apuseni Nature Park the population is 100.
In the Calimani Mountains, 14 chamois were reintroduced from Retezat, in 1980. Presently, in the Calimani National Park the chamois is not mentioned, as the hunting area is being “managed” since 1996 by a private hunting association.
From 1982 to 1983 chamois were reintroduced in the Vrancea Mountains. The 13 chamois brought from Retezat (11) and Bucegi (2) found a very good habitat. Today there are over 200 chamois, living in the Putna Vrancea Nature Park.

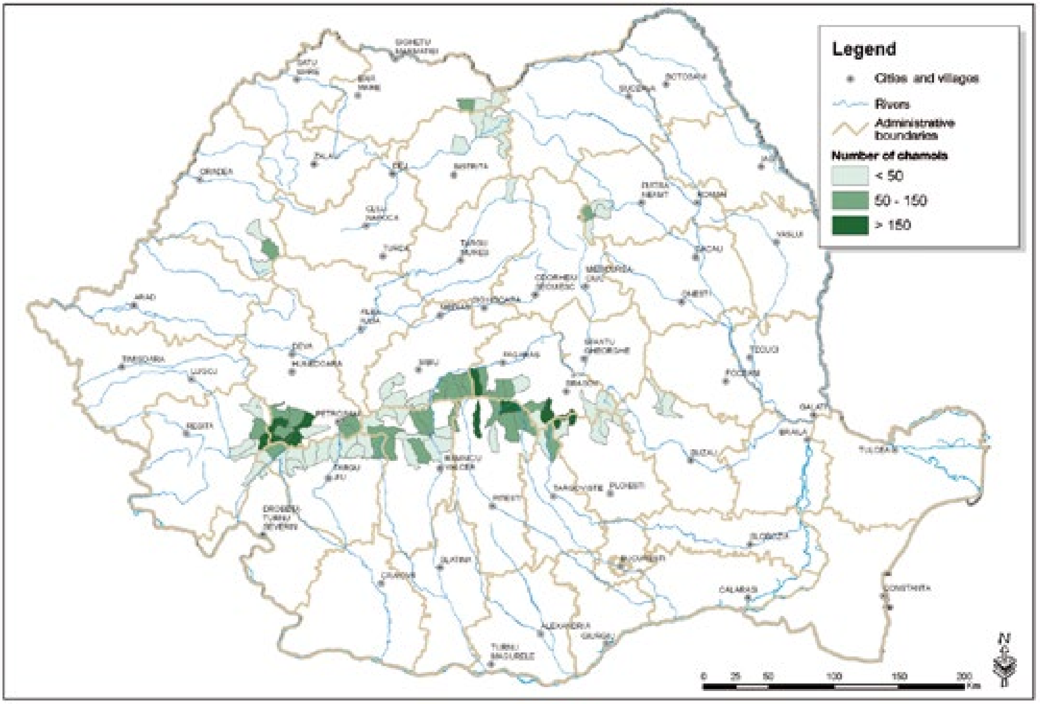

Figure 7. Chamois distribution in the hunting areas in Romania. Ovidiu Ionescu.

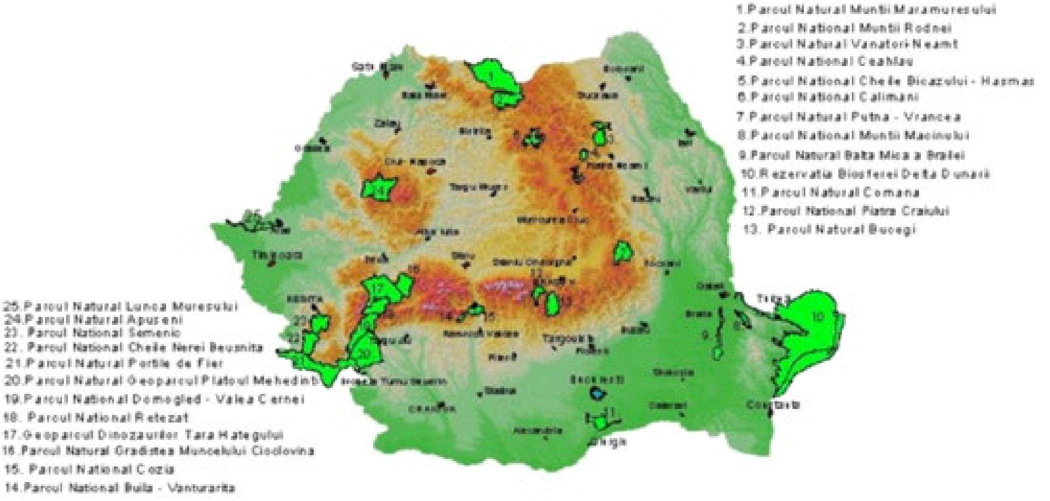

Figure 8. The network of national and nature parks in Romania.

The inventories of the favourable habitats for chamois showed the existence of other areas with chamois populations, but of small dimensions (Ionescu 2002). The main populations of chamois (except the reintroduced ones) can be found in the following areas:

– Fagaras Mountains – population 3000, main areas Tarita – Podragu (formal royal game reserves), Laita, Negoiul, Arpasul, Arpaselul, Ucea, Girdomanu, Vistea Mare, Vistisoara, Simbata, Urlea;
– Retezat Mountains – the second important area for chamois, evaluated with a population of over 1000.
The areas with a higher density are Galesu, Virful Mare, Gemenele Scientific Reserve, Bucura, Peleaga, etc.
The Retezat National Park, with an area of 38.047 ha, is the first national park created in Romania.;
– Bucegi Mountains, now a natural park, represent the third largest population with 600 chamois. Most of the chamois are located on the Prahova and Brasov sides, at V.Jepii Mici, Caraiman, V.Alba, Costila, V.Cerbului, V.Morarului, Bucsoiu, V.Malaiesti, V.Tiganesti, Velicanu, V.Ciobotea, Lancia, V.Gaura and Gutanu.
The Bucegi Nature Park has an area of 32.610 ha of which 10.000 ha are suitable for the chamois. From the first 10 Romanian chamois trophies, 7 are from Bucegi;
– Piatra Craiului Mountains were always appreciated for the value of the chamois. Presently, in the Piatra Craiului National Park (14800 ha) there is a growing population of over 200 chamois.;
– Paring, Lotrului and Vilcan Mountains host a smaller number of chamois (few hundreds);
– at the NE of Capatana Mountains there is a population of around 40 chamois, at lower altitude, in the Cozia National Park (17,100 ha) and also in the Buila-Vanturarita National Park (4200 ha);
– there are populations also in the Godeanu, Tarcu and Cernei Mountains with relatively small numbers.
In the Cerna Mountains the Domogled-Valea Cernei National Park (61.211 ha) was established, hosting a population of over 110 chamois.

There are also other smaller areas, more or less closer to the high mountains which are hosting small populations of chamois. Most of the chamois areas in Romania are located in protected areas, and currently the populations are constant or slowly growing. Only in the Fagaras Mountains, where there is only a Natura 2000 site, on some hunting areas, there is a decline, due to unrealistic evaluations, which are followed by unsustainable harvesting quotas.

Even if the numbers in Romania are much smaller in comparison with other parts of Europe (Alps), the subspecies *Rupicapra rupicapra* ssp. carpatica is recognised as the most vigorous. The relative small numbers are caused by the coexistence with the large carnivores, especially the wolf and the lynx, and also by the grazing activities, which are overlapping in many cases with the summer feeding areas for the chamois.

I – Rodnei Mountains National Park

Rodnei Mountains is one of the most important national parks in Romania, the second largest with an area of over 40.000 ha. It is also a Biosphere Reserve, and hosts important species of flora and fauna, containing also a large number of geological and geomorphological features.
In Rodnei Mountains there was the most valuable chamois population in Romania, the last animals being killed by poachers at the end of the '20s.
In the '70s, a number of over 40 chamois were reintroduced from Bucegi (14), Piatra Craiului (6), Fagaras (5) along with some captivity raised young. In 1990 the chamois population in Rodnei reached 400.
After 1990, the number started to decrease again, due to both over hunting and poaching, after the fall of the communist regime. The numbers went down to 60 by the end of the '90s.

In 2003-2004 the first administration for the Rodnei Mountains National Park was created, so chamois hunting was stopped, and since 2007 the hunting was banned for all the species inside the national parks in Romania. It was a huge effort from the park administration to fight against poachers, and even now there are still some hunting attempts. Thus, the number started to increase again, and the evaluations conducted by the park administration are presented in the graphic below.

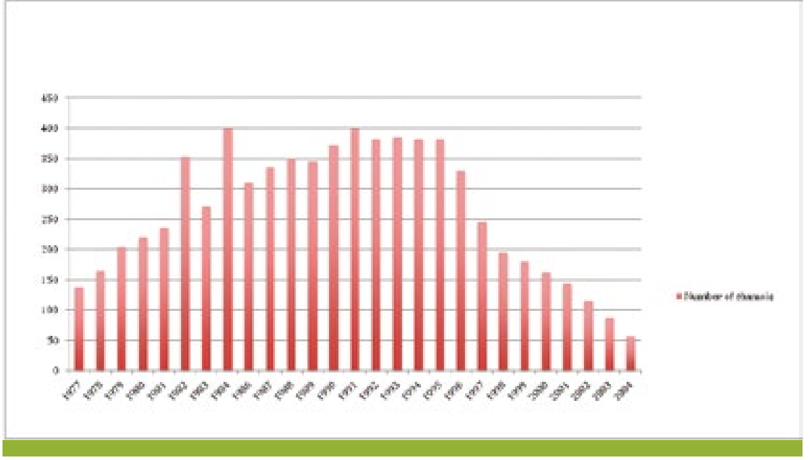

Figure 9. Chamois presence evaluation in Rodnei Mountains National Park

In 2005 a reintroduction action took place, with 3 chamois from Retezat and 4 from Bucegi. In was the only one done in Romania after 1990. The chamois were caught using nets, and during transport 2 of the 4 from the Bucegi died, due to the long transport distance and time interval between the catch and the release – over 24 hours.

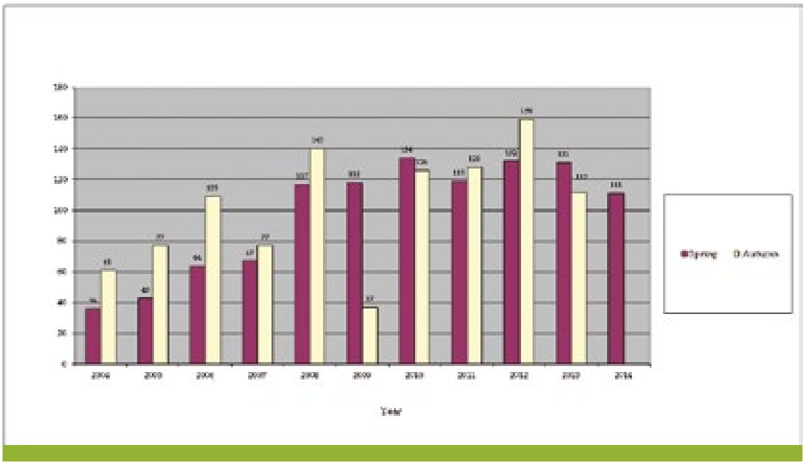

Figure 10. Chamois presence evaluation in spring and autumn in Rodnei Mountains National Park.

Grazing in the Rodmei Mountains is also a limitative factor for the development of the chamois population. After 2000, the grazing activities diminished, and the livestock decreased. But after Romania joined the European Union and subsidies were paid to the animal owners, the numbers oh sheep and cattle started to increase again, together with the renewal of the infrastructure – roads in the alpine area and sheepfolds.
This is reason why, during the evaluations, there is an area inside the national park where chamois were not seen and counted, due to the high density of sheepfolds and grazing activities, even of the habitat is as suitable as in the other areas of the park.

II – Piatra Craiului National Park

The Piatra Craiului National Park is located in the centre of Romania, 25 km West of Brasov. The park includes the Piatra Craiului Massif, a 25 km limestone ridge, with altitudes of over 2000m.
The first protection action of this area started in 1938 when 440 ha were declared as a nature reserve, "for the beauty of the landscape and the existence of rare species of flora". The Law 5/2000 enlarged this area to 14,800 ha, as a national park. In 2003 the external limits and internal zoning were created. Since 1999 a park administration has existed and since 2005 a management plan has been in place. The park received the European Diploma for Protected Areas from the Council of Europe in 2005, and it was renewed in 2011.
In the national park area there are about 300 fungi species, 220 lichen species, 100 mosses, over 1100 species of superior plants (a third of the number of all plant species found in Romania), 50 Carpathians endemic species and also two endemic species for Piatra Craiului.

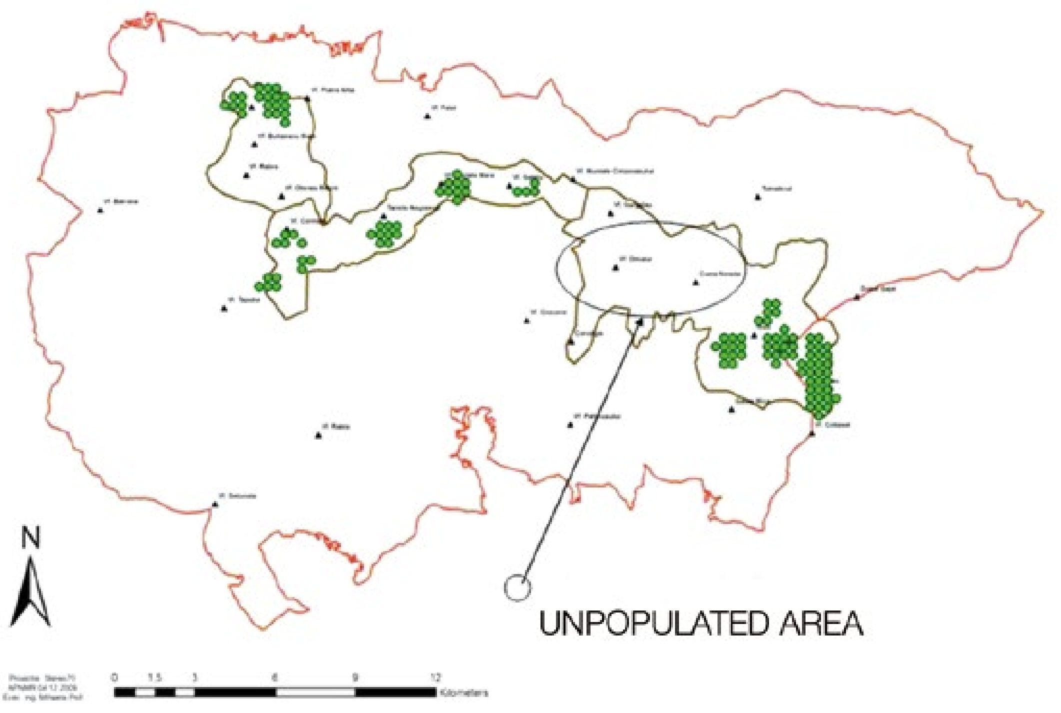

Figure 11. Chamois presence evaluation in Rodnei Mountains National Park during 2008. Green spot= individual identified.

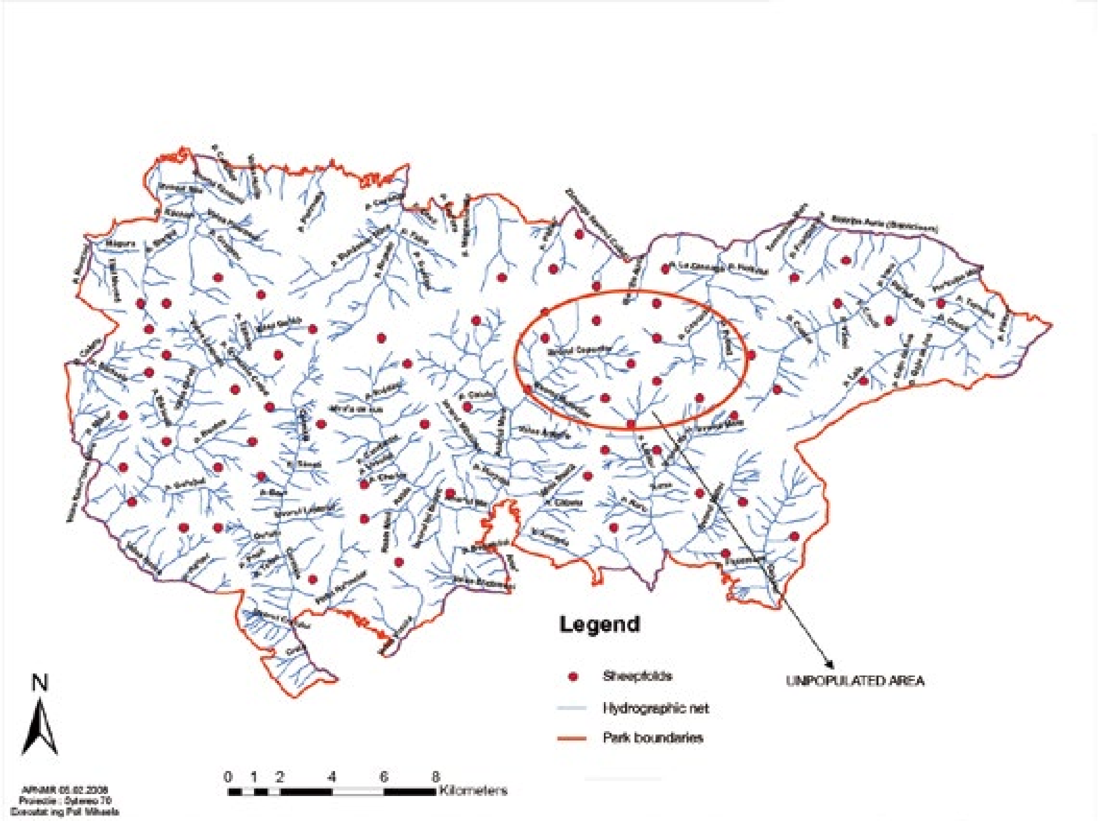

Figure 12. Area with an higher density of sheepfolds (red spots) and no chamois in the Rodnei Mountains National Park.

There are also two endemic species of spiders, 270 butterfly species, amphibians and reptiles, 110 bird species (50 listed in the Bern Convention and 6 in the Bonn Convention), 17 bat species, chamois and other large herbivores and also many large carnivores (wolves, brown bears, lynx) living in the national park.

The chamois was always an iconic species for Piatra Craiului. The chamois population from Piatra Craiului, even if not the largest in Romania, was always considered one of the most important ones, together with the ones from Fagaras, Retezat or Bucegi. The special conditions given by the rocky limestone walls, the habitat mosaic from the alpine and subalpine area, the hard access made the chamois the king of the upper part of this mountain.
It is impossibile to imagine Piatra Craiului without this species, which enriches the landscape and thrills the lucky visitors who have the opportunity to see it in the ridge area.

As in the other Romanian areas, the chamois population in Piatra Craiului was at its optimal level (over 200) during the '70 and the '80s. The chamois from Piatra Craiului were also a valuable source of repopulation for other areas in Romania.
After 1990, the numbers started to slowly decrease, due to over evaluations and unsustainable hunting, along with the increase of poaching, leading to a population decline at around 50 individuals.
As an example, only on a hunting area on 25% of the park, in 2000, the private hunter association managing it asked for a harvesting quota of 24 chamois. Since 2000, when the park administration was established, the chamois hunt was stopped through administration efforts, who demonstrated that the reported numbers were not accurate and the proposed harvesting quotas had nothing to do with the reality in the field. Later, in 2005, the first approved management plan and park regulations did not allow hunting inside the national park, and later, in 2007, the new protected areas law and hunting law totally banned hunting inside the national parks.

Normally, this led to a population increase, and now the chamois population in Piatra Craiului is again of over 200 individuals.
But what was the most significant and visible change was the behaviour of the animals. While in the early 2000s the visitors could rarely see the chamois, and when they were lucky this happened from a far distance. The animals were afraid of people and were running away and hiding, even if the people were situated at long distances – few hundreds of meters.

In the late 2000s and especially after 2010 this situation totally changed. Now, the chamois can be seen up close, even closer than 30 m, they do not seem to care very much about the people and they carry on their activities regardless of the human presence.
This permitted also to monitor the chamois population in the winter, when they are descending to the lower areas of the park (Raportul de activitate al Parcului National Piatra Craiului – 2013, 2014).
The park administration could also document the relations between the chamois and the lynx on one of the valleys inside the park.
During the 2011-2012 hard winter, only in one spot 5 chamois were killed by lynx, especially when the animals came on the bottom of the valley, on areas with thick snow, leaving the safe sunny slopes where they usually fed during winter.
In January 2014, after finding another chamois killed by the lynx, the park administration succeeded to document with video and photos the lynxes activity.

6. CONCLUSIONS

Due to the outstanding presence of large carnivores in the Carpathian Mountains, chamois distribution is restricted to the alpine areas and rough terrains were there are enough escape areas to avoid predation. If the lynx is a permanent predator of chamois (in Romania, chamois is placed second regarding the lynx diet, after roe deer), wolf predation occurs mainly in winter and bears predation is just occasional.

Population density is low compared with Alps or Cantabrian Mountains. Populations are limited in their growth by the carrying capacity of the winter refuges and by the predation in protected areas. Beside these factors, the main limiting factor is the competition for food with sheep and goats, that are also a vector of disease that spreads in the chamois population.

E.U. Agriculture Policy encourages through subventions the increase of sheep and goat livestock, regardless of the correlations with the carrying capacity of the grazing areas. In the last years the competition with sheep further increased as well as the number of guard dogs brought by the shepherds in the chamois areas. These dogs restrict the habitat used by chamois and predate on calves and sometimes even on adults. They are also responsible for spreading some diseases for which they are an intermediary host.

Generally the chamois harvest level is low, but in some particular areas legal harvest added to illegal poaching and natural and other human induced mortality creates a negative trend of the populations.

The behaviour of chamois changed in the areas where hunting and poaching does not occur anymore. Observation possibility was increased and flaying distance was reduced.

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DISEASES OF RUPICAPRA SPP.
AT THE INTERFACE WITH LIVESTOCK AND OTHER UNGULATES

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Diseases and parasites have long been recognized as drivers of evolution in free-ranging wildlife, domestic animals and man (Combes 2001). In recent years, evidence is accumulating that the demographic impact of selected transmissible diseases may result in substantial modifications of the structure and genetics of affected wild targets (Lachish et al. 2011), similarly as weather constraints and the presence of predators. Accordingly, views of scientists and resource managers are changing regarding the opportunity to interfere, and if this is feasible, with wildlife disease dynamics (Wobeser 2002). Amongst ruminants in the Holartic, wild *Caprinae* are by far the most frequently exposed to a range of transmissible diseases with remarkable demographic impact in the short term (Gavier-Widen et al. 2012). However, current evidence shows that large-sized and well connected populations of wild *Caprinae* (eg, Northern chamois in the Alps) are not threatened, at least in the long term, by any known disease-related emergencies. Oppositely, from a conservation perspective there is strong and justified concern on the effects that transmissible diseases may cause in small-sized and isolated populations (eg, transmissible pneumonias in Desert bighorn sheep in the Rocky Mountains, or in Flare-horned markhor in Hindukush). Noteworthy, such concerns has been the rationale of the successful redistribution program of the Apennine chamois from the sole population survived (Herrero et al. 2008).
Several diseases and parasites of wild *Caprinae* are in common with domestic ruminants, particularly with the so called small ruminants (sheep and goats) due to closer zoological relationships. In the mountain ranges in Europe, wild and domestic *Caprinae* are used to share range on a seasonal basis, when transhumant flocks are allowed access to the montane, sub-alpine and alpine meadows, usually not earlier than late May and not later than early November. Under these circumstances, wild and domestic *Caprinae* may get in direct or indirect contact (Ruttiman et al. 2008), permitting the inter-specific transmission of pathogens. For several reasons – amongst them the obvious increase in number of wild *Caprinae* throughout Europe – the fore mentioned contacts have become closer in the last decades, and reports of outbreaks have raised in parallel, suggesting emergence of a specific two-ways management problem at the livestock/wildlife interface (Richomme et al. 2006). In this contribution we will review the main epidemic and endemic diseases of *Rupicapra* spp. in Western and Central Europe, and try to give an answer to the following two questions: Q1) are domestic ruminants the actual origin and the reservoir of these diseases in the major outbreak areas?; Q2) in this case, are there any tools and/or strategies available that are meaningful to control and prevent the cross-transmission of the agents between domestic flocks and sympatric chamois?
There are four transmissible diseases known to have major demographic effects in chamois: infectious kerato-conjunctivitis (IKC), pestivirosis (PV), scabies or sarcoptic mange (SM) and the "transmissible pneumonias" (TPs). However, since inconclusive results have been obtained so far on the complex etiology of TPs (Citterio et al. 2003), little can be inferred on the cross-transmission of candidate pathogens at the livestock/chamois interface. Accordingly, this contribution will deal with the remaining three diseases.

Outbreaks of IKC are due to virulent strains of *Mycoplasma conjunctivae*, an atypical bacteria (class Mollicutes) lacking a cell wall, hence having extremely poor off-host environmental persistence. Transmission occurs via direct contact and the mechanical eye-to-eye transport operated by flies over short distances. In the frame of a long-term study, Crampe et al. (2008) have shown clear connections between the spread of IKC and the space use by different social units of the investigated chamois.
Onset of a novel IKC outbreak in unaffected chamois areas is usually perceived as a problem that occurs during the summer, characterized by high incidence, relatively low mortality and lethality and the biased distribution of clinical cases (significantly more often in females than in males, and in adult females compared with kids). The symptoms and behavior of affected chamois and the presence of orphan kids have a strong emotional impact on mountain visitors, that are especially numerous and active in this season. In contrast, spread of IKC during winter is characterized by lower incidence, higher mortality and lethality and lower visibility by a large public. Overall, decrease rates may range, locally, from approximately 5 to more than 30% (Giacometti et al. 2002a).
A striking characteristic of IKC outbreaks is the rapid spreading potential over large areas, at the speed of over 15 km/year from the index case (Degiorgis et al. 2000). Since the last decades of the past century, IKC outbreaks involving large areas (e.g., of above ten thousand hectares) have been reported in the Alps, Pyrenees and Cantabrians though not in the Apennines. In recent years, outbreaks with a particularly large spatial extension – the largest ever known – have occurred in the Western Alps and in the Central Pyrenees (Arnal et al. 2013). However, also sporadic cases and small foci with limited spatial spread are known to wildlife professionals and resource managers in the Alps. On the other hand, IKC does not persist endemically in the same area and, at the small scale (eg, some hundred or a few thousand hectares), the epidemic wave is used to vanish within a few months, suggesting little role for herd immunity.
M. conjunctivae is frequently isolated from the eyes of sheep and goats, and IKC is a well known condition amongst small

ruminant farmers worldwide. Sheep to chamois transmission has been observed (Giacometti et al. 2002a). It is a largely accepted view that: a) domestic flocks are reservoir of *M. conjunctivae*; b) IKC outbreaks in chamois originate, most frequently, from occasional spill-over of virulent strains from the domestic reservoir; c) chamois IKC is not maintained in chamois (nor any wild *Caprinae*) populations (Giacometti et al. 2002b). Amongst other evidence, a strong argument in favor of this "classic" view is the rare and timely spaced occurrence of IKC outbreaks in large chamois herds monitored over long time-series (eg, within National Parks and Hunting Reserves), and the first occurrence of epidemic IKC in chamois in New Zealand, some 40 years after the introduction of only 8 individuals from the Austrian Alps. However, the "classic" view is being put in question by the molecular-based isolation of *M. conjunctivae* in the eyes of healthy chamois in Switzerland (Mavrot et al. 2012). Although it is not clear if positive asymptomatic animals are true healthy carriers or are in an incubation phase or not yet cleared of a previous infection, such recent findings suggest "that an endemic presence of *M. conjunctivae* in wild mountain ungulates cannot be excluded on large territories used by interconnected subgroups of wild ungulates, although this would not rule out sheep as a potential source of infection" (Mavrot et al., 2012). Interestingly, however, the Alpine ibex (*Capra ibex*) seems better candidate than chamois to a reservoir role complementary to domestic flocks (Ryser-Degiorgis et al. 2009). More epidemiological studies are needed to define if cohabitation with ibex is a risk factor for occurrence of IKC outbreaks in chamois.

At the interface with livestock, little can be done for the benefit of unaffected chamois provided that: i) healthy carriers of *M. conjunctivae* are frequent amongst transhumant sheep and goats; ii) no vaccines are available; iii) no mass chemoprophylactic protocols have been evaluated for efficacy, economic sustainability and compatibility with the consumer-friendly production of valuable meat and cheese. As a result, enhanced clinical surveillance of sheep and goat flocks about to move to chamois land and the isolation and treatment of clinically affected individuals remains the only feasible (though weak) option at the moment.

In the early years of the current century, a novel Pestivirus (Fam. *Flaviviridae*) of the "Border Disease Virus" (BDV) group was isolated from sick chamois in the Central and Eastern Pyrenees. The agent of Pestivirosis (PV) in chamois is described as a specific variant belonging to the BDV4 genotype, which is the same genotype as the BDV circulating in sheep in Spain (Marco et al. 2009).

PV in chamois is clinically characterized by variable degrees of cachexia, alopecia (often associated with skin hyperpigmentation) and neurological disorders (eg, depression, weakness and difficulty in moving) prior to death. The signs of secondary infections magnified by the immunosuppressive effects of BDV4 infection (eg, dyspnoea due to bacterial bronchopneumonia) are also frequent findings (Gavier-Widen et al. 2012).

The demographic effects of PV are extremely variable, from a mild impact on reproductive performance to severe die-offs with mortality rates between 40 and 85%, as observed in the Eastern Pyrenees (Marco et al. 2009). The reasons of such variability, though still to be fully elucidated, include the viral strains involved, the epidemiological phase of the infection (epidemic vs. endemic), the herd immunity eventually influenced by contacts with related viral strains of domestic origin, the social and spatial structure of the affected host populations, and their genetic variability (Fernandez-Sirera et al. 2012, Cavallero et al. 2012). Nevertheless, it is estimated that the whole chamois population of the Central and Western Pyrenees has decreased of approximately one third since 2001 (Gavier-Widen et al. 2012).

Persistence of BDV4 infection after a first PV outbreak has been demonstrated, as well as the opposite scenario of viral extinction. Interestingly, recovery of the affected chamois population was weak in the first case and rapid in the second, though return to a viral and serological naive status of the second population is now a matter of concern for resource managers, since BDV4 infected chamois are still present in neighboring chamois herds (Fernandez-Sirera et al. 2012).

As to the origin of this emerging conservation problem, an innovative phylogenetic study of available viral sequences suggests that: i) the chamois clade originated from sheep BDV4, generating a founder effect; ii) the "capture" by the new sylvatic host was recent event, that can be dated back to approximately two decades ago. In addition, the study shows that intra-specific subclading of the BD "chamois" variant is already detectable along the Pyrenees (Luzzago et al. this volume).

Based on available information, it seems that sheep (and goats) have no role in maintaining the circulation of the BD "chamois strain" within the infected range in the Pyrenees. Accordingly, control of BD in livestock (if feasible, in the absence of an effective and safe vaccine) would be of no help for control in current outbreak areas. As opposite, it is tempting to figure out that contact with flocks endemically infected by "their" BD strains may result in a sort of natural and beneficial cross-vaccination of sympatric chamois, enhancing herd immunity against the "chamois strain" or other putative novel "chamois" strains, in future. If that is the case (more field studies are necessary to confirm), sympatry with such flocks would be desirable, in contrast with traditional views by resource managers. Similarly, implementation of active sero-surveillance schemes in managed chamois populations is warranted to check the herd immunity in front of any variants of the BDV, and design management according to the epidemiological status, without inappropriate generalizations. Outside Pyrenees, seroreactors to Pestiviruses of livestock origin have been frequently found amongst chamois surveyed in the Western Alps (Riekerink et al. 2005, Martin et al. 2011) and, to a lesser extent, in the Central Alps and Cantabrians (Gaffuri et al. 2006, Falconi et al. 2009), while no seroreactors were found in an isolated chamois herd in the Apennines (Fernandez-Sirera et al. unpublished).

Scabies or Sarcoptic mange (SM) is caused by the burrowing mite, *Sarcoptes scabiei*. Several varieties of the mite are traditionally described, each of them able to successfully infect a limited range of related hosts. For example, mites infecting the Northern chamois in the Alps, usually referred as *S. scabiei* var. *rupicaprae*, are naturally or experimentally cross-transmissible to the Alpine ibex and the domestic goat, and more unfrequently, to domestic sheep, mouflons (*Ovis aries musimon*), roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*) (Alasaad et al. 2013).

As of May 1993, there was a single SM outbreak area affecting chamois in the Eastern Alps (across Austria, Germany, Slovenija and Italy) eastbound of a line connecting two large rivers, Inn and Adige (Miller 1986). Since then, a new outbreak area established in the Cantabrians, involving the Eastern population of *R. pyrenaica parva* (Fernandez-Moran et al. 1997). Evidence shows that chamois living in the Pyrenees and in the Western and Central Alps are SM-free.

Persistence (for centuries in the case of the Austrian Alps) and relatively low spread (3-6 km/year on average) are well known characteristics of SM in chamois. Seasonality is another feature, since the majority of deadly cases are reported in winter and spring, suggesting interaction of the disease with natural factors (eg, winter starvation and other climate constraints) (Rossi et al. 2007).

On a large scale, mortality is mainly related to the life history of affected populations, namely to previous contacts (or absence of contact) with the disease. In the case of a first epidemic wave of SM in previously unaffected areas, the demographic impact is remarkable, eg. in the recently affected Dolomite Alps and Cantabrians, it is estimated that population size has decreased of approximately two thirds (Rossi et al. 2007, Perez-Barberia & Palacios 2009), with maxima well above 80%. As opposite, in the case of successive contacts, usually occurring in form of minor waves at 10-15 years intervals, mortality is rarely exceeding maxima of 25% (Rossi et al. 1995). In the Cantabrians (though not as clearly in the Alps), a new equilibrium characterized by a lower population size of approximately two thirds the pre-outbreak one was reached as the cumulative effect of the epidemic and the subsequent endemic phase of SM (Perez-Barberia & Palacios 2009). However, other factors may influence the outcome of SM at a smaller scale, namely the host genetic structure and variability, which are currently the object of stimulating studies (Mona et al. 2007, Schaschl et al. 2012).

Though suspected, the responsibility of infected livestock (domestic goats and less likely sheep) in triggering SM in naive chamois in the Eastern Alps and the Cantabrians has never been unambiguously demonstrated. Experimental infection trials have been successfully carried out in both directions (Lavin et al. 2000), and a spontaneous SM outbreak in domestic goats originating from naturally infected chamois has been reported (Menzano et al. 2007). Actually, however, livestock does not play any significant role in the dynamics of SM in the two recognized endemic areas. Finally, chamois are more likely to infect other sympatric wildlife than the opposite occurring, as in the case of the several colonies of Alpine ibex in the Eastern Alps (Rossi et al. 2007), and a single isolated colony of Iberian ibex (*Capra pyrenaica*) in the Cantabrians.

From a conservation perspective, attention to the livestock/wildlife interface should be focused on preventing that infected goats may turn into long distance carriers of *Sarcoptes mites* (eg., to the large SM-free chamois land which still exist across Europe). Awareness on this neglected trade related risk should be raised primarily at the institutional (international and national) level.

Back to questions Q1 and Q2, that prompted this contribution, we conclude that:

a) there is evidence or plausibility that pathogens transmitted to chamois by domestic sheep and/or goats may have been at the origin of IKC, PV and SM in the major outbreak areas known in Central and Western Europe;

b) in these areas, it is recognized that transhumant sheep and goats represent the main reservoir of *M. conjunctivae*, whereas chamois themselves are the exclusive reservoir of *S. scabiei* and the specific BDV4 variant;

c) little can be done at the livestock/chamois interface to control running emergencies. As an exception, cohabitation with BDV endemically infected flocks should be encouraged in order to strenghten the herd immunity of chamois against PV;

d) prevention of IKC outbreaks seems unlikely, and little can be done to anticipate that new BDV strains may adapt to chamois, as occurred in the Central Pyrenees. In contrast, active surveillance of caprine flocks about to move to chamois land (and their mass treatments of with injectable miticide drugs, if appropriate) is pivotal to contrast the risk that SM may spread to unaffected chamois, namely entire subspecies (*pyrenaica* and *ornata*, amongst other) and the subpopulations of *R. rupicapra rupicapra* and *R. pyrenaica parva* so far protected by natural and artificial barriers. Europe wide eradication of SM in domestic goats should be the optimal standard to achieve in the near future;

e) with rare exceptions, no specific guidelines can be given at the regional scale to optimize the conservation-oriented management of livestock health. However, since the priority is for early detection of emerging/re-emerging diseases which may potentially impact on the demography of chamois, focus and resources should target the effective and sustained (passive and active) surveillance of selected disease in livestock and the sympatric chamois.

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Picture 1. Severe presentation of Infectious Kerato-conjunctivitis (IKC) caused by *Mycoplasma conjunctivae*. Corneal ulceration and vascularisation can be observed in addition to abundant ocular discharge. Obvious signs of blindness (circling amongst them) were visible from distance.

Picture 2. Generalised scabies in a parva buck from the Cordillera Cantabrica, Spain. Severely affected individuals are often attracted by water and may even drown, as in this case. Saponification of crusty lesions is visible.

Picture 3. Dry crusty lesions caused by Sarcoptes scabiei are frequently localized in the head and neck. In this yearling, contrast between the dark and bright parts of the face has vanished. Condition of the affected individuals rapidly deteriorates when lesions involve the mouth parts.

Picture 4. Scabies may be croos transmitted between domestic goats and their wild counterparts. In this case, recorded in the Eastern Alps, Italy, spill-over occurred from the traditional chamois reservoir. The opposite has likely occurred in the early Nineties of the past century in the Cordillera Cantabrica, Spain.

ALPINE CHAMOIS *Rupicapra rupicapra* POPULATION DYNAMICS: THE ROLE OF INFECTIOUS DISEASES

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Diseases can greatly impact local species populations by causing temporary or permanent declines in population. In the same conditions, pathogens can even interact with other driving factors, such as habitat loss, climate change, overexploitation, invasive species and environmental pollution to contribute to local and global population crash or extinction. Regrettably, our current lack of knowledge about the diversity and abundance of pathogens in natural systems has made it difficult to establish the relative importance of disease as a significant driver of species extinction, and the context when this is most likely to occur (Smith et al. 2009). Nonetheless, infectious disease must be considered as a natural phenomenon with a natural evolution even if they can become a risk for the ecosystems when this affects keystone species, like top predators, and when this undermines ecosystem support systems (Foresight 2006).

1. EFFECTS ON SURVIVAL AND POPULATION DYNAMICS

Micro – and macro-parasites, as cause of morbility and mortality, may regulate wild populations mainly by increasing adult, juvenile or kid mortality or reducing fertility (Anderson & May 1978). The first reaction that elicits the discovery of a wildlife disease is what kind of intervention to implement and, even in recent times, the first and only action that is put in place immediately is the systematic destruction of the entire population (see, for example, the total extermination of the Alpine ibex population in Bargy, France). Effective management of an infectious disease depends critically on understanding the epidemiological dynamics of the pathogens. Development of appropriate interventions requires detailed data on transmission pathways between reservoirs and wildlife populations of conservation concern. But relevant data can be obtained only from long-term population monitoring, epidemic and case-surveillance patterns, genetic analyses of rapidly evolving pathogens, serological surveys, and intervention studies. In any event, rescue, therapy and euthanasia have little relevance to conservation (Macdonald & Laurenson 2006), while epidemiological research contributes to wildlife conservation policy in terms of management of endangered populations and integration of wildlife conservation with public health interventions. Long term, integrative and cross-species research is essential to form correct and effective conservation policies for disease control and optimization of ecosystem health (Cleaveland et al. 2007).

Unfortunately, there are few studies about the role of infectious diseases on the regulation of wildlife populations, as the pathogen-host dynamic is the result of the interaction between complex ethological, physiological and genetic mechanisms (East et al. 2011).

In literature there are few empirical studies that demonstrate that parasites may regulate host population densities. Gulland et al. (1993) studied the fluctuation of an unmanaged population of Soay sheep living on Hirta, Scotland, correlating variations in density with the infestation of gastrointestinal nematodes. They showed that sheep, experimentally relieved of their gastrointestinal nematodes (predominantly *Teladorsagia spp*.), survived in a population crash better than matched controls, highlighting that nematode parasites influence sheep survival during a population crash. From 1995, Rossi et al. (2007) investigated the sarcoptic mange in Alpine chamois (*Rupicapra rupicapra*) of the Dolomite Alps (Italy). The sarcoptic mange interested four meta-populations of Dolomite chamois following the outbreak of the disease in Austria. Since then, monitoring of the spatial and temporal progress of the outbreak was carried out, showing that the demographic decline of the four meta-populations ranged between 49 and 77% (mean=62.5±13.5 se). A study on the interaction between parasite and host population dynamics was conducted by Albon et al. (2002) about the effects of abomasal parasites (predominantly Ostertagia gruheneri) on the dynamic of a reindeer population. The Authors found that anthelminthic treatment in April–May increased the probability of a reindeer having a calf in the next year, compared with untreated controls. However, treatment did not influence the survival of the reindeer over the winter.

Over time, the studies about the role of infectious diseases as factors limiting the growth of wildlife populations increased significantly. Great attention was focused on those diseases that cause major die-offs (e.g. rinderpest, Prins & Weyerhaeuser 1987). However, the effects of diseases causing low annual mortality rates and decreasing of reproduction rates were still little known. As a consequence, the role of chronic infectious diseases in conservation of wildlife populations is often underestimated. For example, some chronic diseases, like bovine tuberculosis (*Mycobacterium bovis*) and brucellosis (*Brucella abortus*) surely played an important role in conservation of wood bison (*Bison bison athabascae* L.) in Wood Buffalo National Park, Canada (Carbyn et al. 1993, Carbyn et al. 1998, Geremia et al. 2008). Joly e Messier (2005) found that bison positive for both diseases (tuberculosis and brucellosis) were less likely to be pregnant or to survive during the winter than bison positive for one or neither disease. Further, bison that were tuberculosis-positive had a lower pregnancy rate. However, these Authors concluded that demonstrating a negative effect of diseases on survival and reproduction is a necessary, but not sufficient, evidence to explain the role of diseases in decline of bison population.

The outbreaks of infectious disease that recently affected Pyrenean chamois (*Rupicapra pyrenaica* pyrenaica) populations were investigated by Pioz et al. (2007). A pestivirus was hypothesized to be the cause of this disease and this virus can cross the species barrier and be transmitted to or from wildlife. Using an epidemiological survey, conducted from 1995 to 2004 at Orlù (France), the Authors characterized the virus and analyzed its transmission. They found that pestivirus incidence and sero-prevalence varied seasonally and according to number of individuals younger than 2 years old. This evidence showed that viral transmission was dependent on the age-structure of host population. But, even in this case, the Authors concluded that further investigation was needed to estimate the impact of pestivirus on host population dynamics.

2. EFFECTS ON FECUNDITY AND KID/JUVENILE SURVIVAL

Pathogen effects were analyzed by some authors in long term surveys on wild populations, especially towards the costs of reproduction and female survival. The interaction between individual differences, parasites, body mass and primiparity and the cost of reproduction was well documented in North American Mountain goat (Festa-Bianchet & Côté 2008). Pellettier et al. (2005) investigated the correlation between the fecal count of lungworm larvae (LPG) and the reproductive effort in the Bighorn sheep. Overall, they found that LPG varies seasonally, peaking in females prior to lambing and in males during the rut. Age had no effect on LPG for either sex. During the autumn, we found no effect of age or mass on LPG for sheep one year and older. Lamb body size or sex did not affect LPG. Females that weaned a lamb had higher counts than females that did not produce a lamb or females whose lamb died during the summer.

Nevertheless few studies investigated the effect of macro – and micro-parasitis on fecundity in European and Alpine ungulates. Pioz et al. (2008) studied three bacterial diseases caused by Salmonella enterica serovar Abortus-ovis, *Chlamydophila abortus* and *Coxiella burnetii* which are responsible of reproductive failure in sheep, goat and cattle. They investigated the influence of these diseases on Alpine chamois (*Rupicapra rupicapra*) population dynamics with long-term studies on demography and epidemiology, in Les Bauges Reserve, France. A generalized linear model was used to analyze the reproductive success of chamois according to population density, weather conditions and the prevalence of antibodies against these bacteria in female chamois. This approach showed the confounding effect of weather and parasitism on fecundity. After accounting for density, the prevalence of antibodies against the three bacteria explained 36% of the annual variation in reproductive success, and weather conditions explained an additional 31%. The Authors found that female chamois more likely failed in their reproduction when prevalence of the three bacteria was high, in addition, prevalences against *Salmonella* and *Coxiella* were high after a cold and snowy winter or a snowy spring. This study, for the first time, proved that infection by microparasites, although they entailed no visible sign, could significantly reduce fecundity once density and weather conditions had been accounted for (Pioz et al. 2008).

3. THE EXAMPLE OF ALPINE CHAMOIS POPULATION IN THE GRAN PARADISO NATIONAL PARK (GPNP)

As concerned the protected populations of Alpine chamois in the Gran Paradiso National Park (Italy), censuses, carried out since the 1960 to nowadays, showed an increasing trend of about 73 chamois per year ($R2=0.69$, $p<0.0001$, $+73.04\pm6.62$ chamois/year). Recent researches on population dynamics emphasized the need to measure the interactions between extrinsic factors –e.g. climate – and other sources of variation, such as density-dependent, food limitation and demographic structure, to better understand the mechanisms underlying wildlife numerical fluctuations (Gaillard et al. 2000, Coulson et al. 2001). Imperio et al. (in prep.) investigated the effects of intrinsic and extrinsic factors on the demographic parameters of the Alpine chamois in the GPNP. They expected that severe snow depth should strongly affect the growth rate of chamois population, through a negative impact on demographic parameters, such as survival and fecundity (Jonas et al. 2008, Gonzalez & Crampe 2001, Willisch et al. 2013). Because extreme age-classes are expected to be particularly sensitive to unfavorable environmental conditions (Solberg et al. 2001), kid winter survival should represent one of the main drivers of the mountain ungulates numerical fluctuations. Milder spring-summer weather conditions, possibly through to a shift in plant phenology and the consequent decreasing of body mass, may as well cause a reduction of survival and fecundity rates (Loison & Langvatn 1998, Rughetti & Festa-Bianchet, 2012). As climate changes can drive the oscillations of wild populations, Imperio et al. (in prep.), according to the PROTHEUS climate model and the results of empirical model for growth rate, showed that the projection of chamois population in GPNP will have a significant decreasing trend, with a lost of about 30 animal/year from 2013 to 2050 ($R2=0.37$, $p<0.0001$, -30.98 ± 6.66 chamois per year). This trend is thought to be more linked to changes in kid-juvenile survival, caused by modification in food availability, rather than that of adults, due to snow and severe winter conditions. But, each environmental stressor may activate the effects of pathogens, influencing the host survival. This is the reason why it is very important to control wild populations also from the point of view of the health status. In GPNP, from 1995 to 2012, 66 serum samples of Alpine chamois were analyzed for the following pathogens: *Micobacterium paratubercolosys*, *Mycoplasma agalatie*, *Neospora sp*., *Toxoplasma sp*., *Brucella abortus/melitensis/ovis*, *Leptospira sp*., *Salmonella abortus ovis/equi*, *Besnoita sp*., BVD, CAEV, IBR, BT. To date, all the tests were negative and the prevalence was almost zero. This lack of effect, or lack of knowledge, did not allow to model the population dynamics over time, taking also into account the effects of the diseases, linked to environmental changes.

4. CONCLUSIONS

Many limitations make the investigations regarding the role of infectious diseases on wildlife population dynamics very difficult, first, the need of long term series of censuses with good reliability of density, estimation of reproductive success and mortality rate. But we also need regular samplings of blood/serum, serological tests of good sensitivity and specificity, implementation of statistical models, identification of the real causes of mortality and identification of the primary etiological agent. These data collections are not so easy to store over time, because these animals are difficult to capture and to find intact after death, especially in high mountain habitats, with high incidence of scavengers and predators. Finally as suggested by Macdonald and Laurenson (2006), we need an inter-disciplinary approach to this problem, overcoming the false dichotomy that the control of wildlife diseases is the veterinarians' domain, while conservation is the domain of biologists.

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DISEASES AFFECTING PYRENEAN CHAMOIS (*Rupicapra pyrenaica pyrenaica*) POPULATIONS IN CATALONIA

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In Catalonia (north-eastern Spain), Pyrenean chamois (*Rupicapra pyrenaica pyrenaica*) populations are found in the northern part, corresponding to the Pyrenees. Although not exclusively, most of the population is found within different protected areas, namely the National Park of Aigüestortes and Llac de Sant Maurici (NPALSM), and five National Game Reserves (NGR), where chamois can be hunted under a strict management plan (Figure 1).

1-NGR of Cadí-Moixeró
2-NGR of Alt Pallars-Aran
3-NGR of Freser-Setcases
4-NGR of Cerdanya-Alt Urgell

Figure 1. National Game Reserves with Pyrenean chamois populations in Catalonia.

By 2000, the chamois population in the Catalonian Pyrenees was censed around 13 000 individuals, distributed as shown in Table 1 (Padrós et al. 2004).

Area	Abbreviation	Census
National Park of Aigüestortes i Llac de Sant Maurici	NPASLM	2950
NGR of Cadí-Moixeró	NGRCM	2320
NGR of Cerdanya-Alt Urgell	NGRCAU	339
NGR of Alt Pallars-Aran	NGRAPA	4832
NGR of Freser-Setcases	NGRFS	2634
TOTAL		**13 075**

Table 1. Pyrenean chamois census in Catalonia in 2000 (Padrós et al. 2004).

However, in the 2011 spring census, the chamois populations in the NGR of Catalonia had declined to 9238, mainly due to pestivirus-induced mortality (see below), although the trend was variable among the different NGR (for example, population in the NGRFS increased up to 3162 in spring 2011) (López-Martín et al. 2013). Apart from pestivirus, several other diseases have affected or are circulating within the chamois populations in Catalonia.

Pestivirus

In 2001, a new pestivirus infection causing mortality was identified in the NGRAPA (Hurtado et al. 2004, Marco et al. 2007). This disease spread and caused mortality in the NGRCAU and NGRCM, as well as in the Val d'Aran region, in 2005-2007. In 2009-2010, a new mortality outbreak was registered in the NGRAPA. In Andorra the pestivirus was detected for the first time in 2010 (Marco et al. 2008, 2009 and 2011). However, pestivirus mortality has not been registered in the NGRFS or in the *Réserve nationale de chasse et de faune sauvage d'Orlu*, in France, although pestivirus RNA has been found in both areas in 2004 and 2007, respectively. Table 2 shows the outbreak years and the mortality (estimated indirectly as the difference between censuses in two consecutive years) found for each NGR.

Year	Area	Mortality
2001-2002	NGR of Alt Pallars-Aran	42%
2005	NGR of Cerdanya-Alt Urgell	86%
2005-2007	NGR of Cadí-Moixeró	63%
	Val d'Aran	-
2009-2010	NGR of Alt Pallars-Aran	-
2010	Andorra	41%

Table 2. Outbreaks and chamois mortality in the NGR of Catalonia and Andorra.

Pestivirus infection in the Pyrenean chamois is characterized by cachexia, hair loss with skin hyperpigmentation, behavioural disorders associated to brain lesions (encephalitis), and immunosuppression. Finally, death in many cases is precipitated by processes depending on the diseases present in the area (pneumonia in NGRCAU and NGRCM, blood parasites in NGRAPA and Val d'Aran).

Retrospective serological studies have shown that the prevalence of antibodies against pestiviruses was low previously to each outbreak in the affected NGR, whereas in the NGRFS, where pestivirus-related mortality has not been registered, this prevalence has been consistently over 40%. On the other hand, the NGRFS has also a higher genetic variability for the MHC complex genes than the other affected NGR. Therefore, a combination of population immunity, genetic variability, and ecological factors such as chamois movement, population density and aggregation, may explain the different success of chamois pestivirus to cause a mortality outbreak in the different NGR in Catalonia.

Infectious keratoconjunctivitis

Infectious keratoconjunctivitis (IKC) is a disease affecting both domestic ruminants and wild *Caprinae* species, including chamois (*Rupicapra* spp.). In the Pyrenees, signs of IKC have been reported since 1952. The first IKC outbreak in the Pyrenees was reported in the Central French Pyrenees in 1980, spreading through the whole mountain system (Catusse 1982). Several IKC outbreaks have been reported since, and IKC has become endemic in the chamois population in the Pyrenees (Marco et al. 1992, Viñas et al. 1992, Arnal et al. 2013).

Several pathogens have been identified in IKC-affected chamois, including *Mycoplasma conjunctivae*, *Chlamydophila psittaci*, and *Moraxella* (*Branhamella*) *ovis*, apart from other secondary infectious agents. *M. conjunctivae* seems to be the main causative agent involved, although some studies suggest that *M. conjunctivae* strain and host susceptibility may be determinant factors in causing disease and consequently spreading in a chamois population (Egwu et al. 1989, Dagnall 1994, Marco et al. 2009b). Interspecific transmission and shared *M. conjunctivae* strains between wild and domestic ruminants has been reported, and domestic sheep may act as a reservoir species (Belloy et al. 2004, Fernández-Aguilar et al. 2013), although this may vary depending on the epidemiological situation.

Clinical signs include eye redness, lachrymation, and corneal opacity, and consequences range from transient blindness to complete eye loss in case of cornea perforation. In most of the cases the chamois recovers naturally, and hair loss can be observed below the eye as a consequence of lachrymation. IKC is transmitted by flies, and it is therefore a seasonal disease, affecting chamois mainly in summer. Morbidity is high, affecting 50-90% of the chamois, but mortality is relatively low (5-20%), mainly related to traumatic injuries during the transient blindness period or starvation when blindness is irreversible due to eye loss (Costa 1986, Gauthier 1991).

Table 3 summarizes the most important outbreaks reported in the chamois population of the Pyrenees.

AREA	DATE	POPULATION AFFECTED	MORBILITY	MORTALITY	REFERENCE
France, Val d'Aran, NGRAPA	1980-1983	All the population in the area	Unknown	Unknown	Candoussau-Luquet, 1987
NPASLM	1990	900 chamois	50-60%	10%	Marco et al., 1992
NGRCM	1991	400 chamois	40-50%	10%	Viñas et al., 1992
NPASLM	1993	150 chamois	40-50%	5-10%	
NGRFS	1995	3600 chamois	40-90%	1-3%	
Aragón, Navarra	2006-2008	471 chamois found dead; around 2000 population decline	Not reported	12.5%	Arnal et al. 2013

Table 3. Infectious keratoconjunctivitis outbreaks reported in Pyrenean chamois.

Pneumonia

Bronchopneumonia is a common finding in Pyrenean chamois, mainly in winter. Depending on the severity of the climatology, it may cause up to a 30-40% of mortality, affecting mainly kids and yearlings and therefore having an effect on population recruitment. Several pathogens could participate in the pathogenesis of chamois pneumonia, including viruses (respiratory syncytial virus, bovine herpesvirus, parainfluenza virus-3) and bacteria (*Mannheimia haemolytica*, *Pasteurella multocida*, *Mycoplasma ovipneumoniae*). However, the relationship between these agents and the severity of the pneumonia depends on the strain, environmental factors and individual susceptibility. As compared to pestivirus and IKC, further research is needed in order to understand both the pathogenesis and the population effects of this complex disease.

Other diseases

Other pathogens have been detected in the chamois population of the Catalonian Pyrenees, with none or unknown population effects.

Fascioliasis

Fasciola hepatica is a fluke which parasites the liver of ruminants. It is transmitted by freshwater snails, which act as intermediate hosts. This disease has been detected in the NGRFS close to mountain streams in areas where domestic sheep and cattle graze.

Toxoplasma

Toxoplasma gondii is a protozoan parasite of felines, which uses other warm blood animals as intermediate hosts. In the intermediate hosts, the tachyzoites parasite neural and muscle tissues, causing behavioural disorders and depression which can lead to death. In the NGRCM, a parasite morphologically similar to *T. gondii* have been found in several chamois showing neurological signs, but further molecular characterization and serological studies are needed to fully identify the parasite and its cycle, including the definitive host (most probably a carnivore).

Coenurosis

Coenurosis is a disease caused by *Coenurus cerebralis*, the larval phase of *Taenia multiceps*, a tapeworm of dogs and wild carnivores. The coenurus is a large (up to 5 cm of diameter) cyst full of liquid and floating scolices, usually localized in the brain or spinal cord and therefore causing neurological clinical signs. In the Catalonian Pyrenees, chamois with coenurosis showing neurological signs and poor body condition are sporadically found.

Contagious ecthyma

Contagious ecthyma is an infectious dermatitis caused by a parapoxvirus which affects primarily the lips of young animals, although it may occasionally affect the oral cavity and also feet. This is an occasional finding in chamois in the Catalonian Pyrenees.

Dermatophytosis

Dermatophytosis caused by the fungus *Trichophyton mentagrophytes* has also been identified as the cause of skin lesions and death in some chamois from the Catalonian Pyrenees.

Jaw osteomyelitis

Jaw osteomyelitis, with teeth loss and bone deformation, has been found in some chamois. Normally, this disease is due to an infection of the tooth root, leading to the formation of an abscess within the jaw. The chamois may lose weight and finally die because of starvation after chronic poor body condition. The incidence of this phenomenon, as well as whether it is related to diet quality or not, is unknown.

Abscesses

Abscesses after penetrating wounds or infected lesions are an incidental finding in chamois necropsies, sometimes unrelated to the cause of death. Pyogenic bacteria such as *Trueperella* (formerly *Arcanobacterium*) *pyogenes* have been found, and a new bacterium (*Streptococcus rupicaprae*) has been described according to biochemical and molecular genetic studies. The clinical signs caused by this abscesses depend on its localization, but the effects on chamois population are considered negligible up to date.

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SEASONAL HABITAT DISPLACEMENT OF CHAMOIS BY RED DEER IN THE SWISS NATIONAL PARK?

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INTRODUCTION

An increase in red deer numbers in many parts of Europe over recent decades have regionally led to concerns of increasing potential for interspecific competition with sympatric ungulate species.
In the Swiss National Park, red deer, chamois and ibex locally co-occur at high densities during summer. During the winter however, red deer are largely absent from the Park, migrating to lower altitudes in the autumn and returning to the Park in late spring.
The absence of hunting and natural mammalian predators, as well as minimal disturbance by humans (visitors are obliged to keep to footpaths), make the area ideally suited to studying interspecific interactions between the three ungulate species under natural conditions. We investigated overlap in diet and habitat use, tested for displacement of the two bovid species by red deer, and looked for direct signs of competition with respect to population sizes and body condition.

METHODS

Two ungulate monitoring areas exist in the Swiss National Park: Val Trupchun with densities of up to 29 red deer, 18 ibex and 9 chamois per km² in summer, and Il Fuorn, with lower densities of up to 11 red deer, 13 chamois and 1 ibex per km².

Diet: based on dung samples collected in February, May, August and November in 2008. Plants found in samples were grouped into *Cyperaceae*, *Poaceae*, herbs, *Ericaceae* and conifer fragments. A correspondence analysis was then conducted on the frequency of each group per sample, followed by Anova.

Population trends: based on yearly ungulate censuses 1990 – 2013. Spearman correlations were conducted between the logarithm of population changes for each species pair.

Body condition: based on horn growth of male and female chamois kids and yearlings born in 1990 or later. Spearman correlations were conducted between the horn growth of young chamois and census sizes of all three species in corresponding years.

Habitat overlap: based on regular mapping of the spatial distribution of ungulates during one morning in August 1997 to 2013. The analysis was based on the following environmental parameters: altitude, slope, terrain ruggedness, solar radiation and NDVI. Only sightings of animals on meadows were considered. Data were analysed using a PCA and GLM.

Habitat displacement: based on the same data as above, but also including January surveys. Explanatory variables were also the same as above, but NDVI was replaced by the nominal variable habitat type. The influence of red deer density on the distribution of male and female chamois and ibex in summer and winter along the first two axes of the ordination was investigated with GLMM's.

RESULTS

Diet: Overall, the variation in the proportion of different plant groups in the diet of chamois, ibex and red deer was higher for the same species between seasons than between species within the same season. There was no difference in diet composition between the three species during either spring or summer, only between chamois and ibex during autumn, and between red deer and the two bovids in winter.
Population trends: No significant correlation was detected between the change in population size of red deer and that of chamois in Val Trupchun. In Il Fuorn, a positive correlation was detected between the change in total red deer abundance from year t to t+1 and the number of chamois kids the following year ($r=0.89$, $p<0.001$).
Body condition: In Val Trupchun, horn growth of young male chamois showed a significant intermediate positive correlation with the average overall number of ibex ($r=0.69$, $p<0.001$), but a negative correlation with the average total number of red deer ($r=-0.57$, $p= 0.002$). The horn growth of young female chamois was significantly negatively correlated only with the average number of male red deer ($r =-0.64$, $p<0.001$). In Il Fourn, no significant correlation was found

between the horn growth in young chamois and the census size of any of the three species.
Habitat overlap: There was extensive habitat overlap between chamois and red deer in Val Trupchun. In Il Fuorn, this only applied to male chamois and red deer. Females of the two species could be separated better, especially along the axis that was determined by altitude, slope and NDVI. The GLM confirmed this result: the model for female chamois and red deer in Val Trupchun explained only 33% of the deviance, while the model for Il Fuorn explained 43%.
Habitat displacement: The summer and winter habitats of both chamois and ibex showed little overlap and were differentiated mainly along the first axis of the ordination, determined predominantly by forest, altitude and solar radiation. Differentiation between the two species was lower within the same season, and was accounted for mainly by the second axis, which was determined predominantly by the habitat types forest vs. rock. Red deer density had an influence on the habitat use of both chamois and ibex, during summer and winter. This suggests habitat displacement with increasing red deer numbers, including a lagged effect.

DISCUSSION

While the reduced degree of habitat overlap between chamois and red deer females in Il Fuorn (intermediate red deer density) by comparison to Val Trupchun (high red deer density) could be interpreted as reduced potential for competition, this may also be related to differences in habitat quality between the two study areas, with Val Trupchun being the more productive habitat and therefore allowing higher interspecific overlap. However, evidence for interspecific competition with increasing densities of red deer comes from two lines of evidence:

1) the negative correlation between red deer density and the horn growth of young chamois in Val Trupchun (and the lack thereof in the lower density area of Il Fuorn), and
2) the influence of red deer density on habitat use of both chamois and ibex in the high density area of Val Truphun, i.e. habitat displacement.

The fact that this influence of red deer density on habitat use of the two bovid species extends into the winter when red deer are absent from the Park suggests that trampling damage may play a role, which still shows effects even after red deer have migrated out of the Park in autumn.

GENETIC VARIABILITY AT NEUTRAL AND ADAPTIVE MARKERS IN THE ENDANGERED TATRIC CHAMOIS SUBSPECIES

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Chamois (Family *Bovidae*, genus *Rupicapra*) are mountain ungulates distributed over the Southern and Central Europe mountainous areas, the Balkans and the Near East (Turkey and Caucasus). The current taxonomy indicates the presence of two species: the Alpine chamois (*R. rupicapra*) with seven subspecies based on local geographical distribution (*rupicapra*, *cartusiana*, *tatrica*, *carpatica*, *balcanica*, *asiatica* and *caucasica*) and the Pyrenean chamois (*R. pyrenaica*) with three discontinuous subspecies (*pyrenaica, parva* and *ornata*) (Lovari & Scala 1980, Nascetti et al. 1985, Masini & Lovari 1988, Hammer et al. 1995, Pérez et al. 2002). Recent evidence by Rodriguez et al. (2009, 2010) and by Pérez et al. (2011) suggest to revisit the taxonomy of the genus, partly because of the marked differences between Appennine chamois *R. p. ornata* and the other subspecies.

Several taxa of the genus are included in the red list by the IUCN, including the Tatra chamois (*Rupicapra rupicapra tatrica* Blahout 1971), a glacial relict and a rare endemic subspecies, which has been classified as a threatened species also by the EMA (European Mammal Assessment) (Aulagnier et al. 2008). Tatra chamois have been recognized as a separate subspecies mainly based on morphological features (Blahout 1972). There is only one native autochthonous population in the High, Western and Eastern Tatra Mountains; two significant bottlenecks with a decline from 1000-1500 to 200-300 animals have been reported (Jurdikova 2000). A second small group has been introduced in the Low Tatra around the 1970s (Radúch & Karč 1983) to establish a "reserve population". Up to now, the population of Tatra chamois in Low Tatra is represented by almost 100 individuals (Zemanová et al. 2011). Moreover, individuals from *rupicapra* subspecies have been introduced mostly for hunting purposes from Bohemia and Moravia into Slovak Paradise and Great Fatra Mountains in Slovak Republic around 1964-1968, before the definition of tatrica as separated subspecies to *rupicapra* (Zemanová et al. 2011). A Conservation Action Plan with a wide-range scale of activities aimed at the protection of Tatra chamois started In 2001 (Koreň et al. 2001).

Since chamois live at moderately high altitudes (1000 to 3500 m) and are well adapted for life in open rocky terrains and boreal alpine meadows, valleys and lowlands separating the mountain peaks and ranges represent significant migration barriers (Lomolino & Davis 1997, Crestanello et al. 2009). Consequently, the long-term isolation of small populations significantly restricted the gene flow as well as colonization rates between populations, especially in fragile habitats where anthropogenic factors, climate change, pollution, predators and infections could threat their health status (Crestanello et al. 2009, Štefančíková et al. 2011). Considering these limitations, however, the Slovak Paradise and Great Fatra areas are geographically close to Low Tatra and chamois may occasionally descend during the winter to lower altitudes, representing a potential risk of hybridization between two distinct subspecies.

The study here presented is aimed to infer the amount of genetic variability in specimens of Tatra chamois, using information from three genomic regions: one adaptive marker (the exon2 of the DRB1 gene of the Major Histocompatibility Complex of class II) and two neutral markers (mitochondrial cytochrome b and partial control region D-Loop).

Tissue samples (muscle, liver, kidney, skin, lungs) have been collected between 1997 and 2010 from 70 individuals of the native endemic *Rupicapra rupicapra tatrica* from the High Tatras mountains. Results obtained by sequences analyses of adaptive marker (DRB1 exon2) highlighted a quite low level of genetic diversity and a high homozygosity; out of the haplotypes observed, three were previously described (RuruDRB*01, 15, 28) and seven newly identified haplotypes were designated as RuruDRB*41-47. The most frequent allele was RuruDRB*28, previously reported by Mona et al. (2008) with a low frequency in three populations from the eastern Alps. Most of the variability observed was linked to PBR (peptide binding region). Regarding mitochondrial markers, genetic variability at cytb was lower compared to amount of variability at D-loop, as expected. Cytb analysis described a quite homogenized situation, where no clear differentiation was reported among samples from High Tatras here analysed, from High and Low Tatras and from Alpine chamois specimens introduced in Slovak Paradise (Crestanello et al. 2009). This result was expected since a high structural and functional conservation was often associated to cytochrome b molecule. D-loop results describe a very high variation, with a frequent haplotype shared by "pure" tatric chamois from High and Low Tatra, and no shared alleles with introduced individuals from other localities (Great Fatra and Slovak Paradise). The pairwise comparison among populations (Fst) reported similarity between the specimens analysed here with specimens from High Tatras analysed in Crestanello et al. (2009) and a very high divergence between specimens from Low Tatra and those from Great Fatra and Slovak Paradise.

Given the endangered status of the species, the trend in genetic variation in Tatra chamois population should be systematically observed, also in relationship to MHC variation as an indicator of the ability to respond to potential epidemic events. In fact, parasitic disease due to lung nematodes has contributed considerably to the morbidity of chamois in the Slovak National Park (Štefancikova et al. 2010). The differences in haplotype composition observed represent a strong basis to monitor the potential interbreeding with introduced alpine chamois.

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POSTER ABSTRACTS

GROUP DYNAMICS AND LOCAL POPULATION DENSITY OF APENNINE CHAMOIS AT THE ABRUZZO, LAZIO E MOLISE NATIONAL PARK: TREND AND SPATIAL VARIATION

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ABSTRACT

The social organization of a species may be influenced by various factors. As a general rule, in ruminants number, size and composition of groups should vary according to population density. Recent studies on the Apennine Chamois (*Rupicapra pyrenaica ornata*) at the Abruzzo, Lazio e Molise National Park (hereafter abbreviated as PNALM) showed that this population may be subjected to density-dependent processes. Over the last 8 years, population size has generally decreased, so we expect corresponding changes in social structure, particularly in group number and mean group size. To test this hypothesis we analyzed the detailed summer data on group size and composition collected in 2008-2013 and those collected in1995-1996 when the population trend was opposite. The study area was the Val di Rose, which hosts one of the most representative herds occurring in the PNALM. Field methods were based on ground counts: systematic and standardized repeated visual scans were performed by 1-2 trained operators along the same routes. During scans, number, size, composition and location of chamois groups were recorded. A group was defined as one or more individuals close to each other and located at least 50 meters from other individuals. Group size classes were defined as follows: 1, 2-5, 6-10, 11-20, 21-40, >40 individuals. Sex and age class of each individual were noted to study group composition and population structure. Local population density was calculated as the number of individuals seen in each scan session in the 100% MCP area based on the locations of all the chamois groups sighted during the repeated counts. Raw data were log-transformed.

Local population density in Val di Rose changed across years ($F = 4.1$, $df = 7;82$, $P < 0.001$) with a decreasing trend (Spearman, $r = -0.45$, $P < 0.05$), dropping from 83.4 to 21.7 heads/km^2. Mean group size ($F = 10.8$, $df = 7;82$, $P < 0.001$) and group number (Kruskall-Wallis, $df = 7$, $H = 21.8$, $P < 0.01$) changed as well, the former decreased (Spearman, $r = -0.66$, $P < 0.001$), the latter increased (Spearman, $r = 0.27$, $P < 0.05$). We found a positive correlation between local population density and both mean group size (Pearson, $r = 0.43$, $P < 0.001$) and group number (Spearman, $r = 0.27$, $P < 0.05$). Population density accounted for 18.4% and 14.1%, respectively, of their variation (GLM, $P < 0.001$).

We found a strong concordance in group frequency distribution across the years (Kendall Concordance Coefficient, $W = 0.91$). Singleton class and 2-5 class were always the most frequent, but the former was the most frequent in 2008-2013, whereas the latter was most frequent in 1995-1996. Moreover, the class > 40 had never been recorded for the last 6 years, when in fact the number of medium-large groups (i.e. > 20 individuals) was found to decrease (Spearman, $r = -0.81$, $N = 8$, $P < 0.01$) and the number of small groups (1-5 individuals) increased (Spearman, $r = 0.78$, $N = 8$, $P < 0.05$). These results do not change much if we take into account the possible bias due to the number of one-male groups that, for any reason, may have been sighted more frequently in one year than in another (one-male groups represent on average 54.5±14.1% of all singleton groups and their proportion showed a clear positive trend in 2008-2013: the reason of such a result still awaits an explanation). We also found that the number of groups >20 was positively correlated with population density (Spearman, $r = 0.29$, $P < 0.05$) and negatively correlated with female group number (Spearman, $r = -0.42$, $P < 0.001$). On the other hand, female group number was negatively correlated with mean group size (Spearman $r = -0.40$, $P < 0.001$) and explained the 22.8% of its variation (GLM, $P < 0.001$).

These results outline the complex relationship between social structure and population density and are consistent with what generally reported in literature. Overall, our results support the hypothesis that the population density decrease was related to an increase in small groups and a decrease in medium-large groups, in other words to a more scattered distribution of chamois in the area, concerning both female and one-male group dynamics.

However, Val di Rose does not seem to be representative of the whole PNALM, since the analysis of data collected in 2010-2013 in five areas, including Val di Rose, suggest that a certain spatial variability exists. These samples are too small to perform statistically reliable tests on trends, nevertheless each year the frequency distribution of group size showed quite a low concordance among herds (Kendall Concordance, $0.54 \leq U \leq 0.70$). Thus, although probably occurring throughout the PNALM, density-dependent processes might differ from place to place and/or each herd might respond differently in relation to local conditions. To better assess species' population dynamics and conservation status it is important to continue monitoring social organization in this species.

THE USE OF BLOCK COUNTS, MARK-RESIGHT AND DISTANCE SAMPLING TO ESTIMATE POPULATION SIZE OF ALPINE CHAMOIS

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ABSTRACT

Population size estimates may represent indispensable tools for many research programs and for conservation or management issues. Mountain ungulates living in open areas are often surveyed through ground counts that, however, neglect detectability and normally underestimate population size. While the use of sample counts is desirable, few studies have concurrently compared different probabilistic approaches to estimate population size in this taxon. Here, we compare the size estimates of a male population of the mountain-dwelling Alpine chamois *Rupicapra rupicapra* using mark-resight and line transect sampling methods, while block counts were used to obtain the minimum number of males alive in the study area. Surveys were conducted within the Gran Paradiso National Park (Italy), in August-September 2013. Surveys were performed independently using block counts along purposely selected paths and vantage points, mark-resight over 5 consecutive resightings from vantage points and paths, and line transect sampling along 12 transects repeated 8 times. Block counts yielded a minimum number of males alive in the population of N=72 individuals. This value was greater than the upper bound of the 95% confidence interval achieved using line transect sampling (N=54, SE=14%, 95% CI: 40-71) while mark-resight yielded a more realistic result of N=93 individuals (SE=18%, 95% CI: 63-137). Our results suggest that line transect sampling is performed poorly in the Alpine environment, leading to underestimates of population size, likely due to violations of some assumptions imposed by the rugged nature of the terrain. The mark-resight yielded lower precision, possibly due to the limited number of marked individuals and resighting occasions, but it is likely to provide robustness and accurate estimates when marks are evenly distributed among animals.

LAUNCH OF NEW POPULATION OF APENNINE CHAMOIS IN SIRENTE VELINO NATURAL PARK: FIRST DATA

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ABSTRACT

The launch of a new fifth population of Apennine Chamois (*Rupicapra pyrenaica ornata*) in Sirente Velino Natural Park was developed within the framework of the LIFE project COORNATA (LIFE09 NAT/IT/00183). In the period July-October 2013 the first 7 females captured in the wild and 3 males taken from captive-breeding enclosures were all released. All the animals were marked with ear tags and fitted with radio-collars GPS/VHF (Vectronic, Followit).

Here we present the first data obtained from the monitoring program (radio-telemetry and direct observations) of the animals during the first months of release. An individual died in the first 10 days from its release. All the other animals frequented the mountain ridge of Monte Sirente, mostly above the timberline (1600-2300 m above sea level), with an exclusive use of the higher quotes (above 2200 m) during summer and autumn seasons and lower altitudes mainly used during winter period. The MCPs (Minimum Convex Polygons) calculated for 2 months periods for each animals show that most of them occupied a maximum home range during summer (Mean ± S.E. = 594.441 ± 106.838 ha), early after the release, and a smaller one during late winter (Mean ± S.E. = 93.419 ± 30.643 ha). The females have been seen in association between themselves or with the only one adult male, while the two young males were more isolated and associated each other.

MONITORING OF A REINTRODUCED POPULATION OF CANTABRIAN CHAMOIS IN THE ARAMO MOUNTAIN RANGE (NORTH OF SPAIN)

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ABSTRACT

Between 2007 and 2012, 75 Cantabrian chamois were released in the Aramo mountain range, a calcareous massif close to the chamois core area in the Cantabrian mountain range. This location saw the extinction of this species in the beginning of the XXth century by overhunting, but the habitat quality still remains suitable.

The source population came from Somiedo Natural Park where chamois are abundant (<2800 individuals). In this protected area 100 animals were captured with vertical nets of 300-500 m long, requiring 7-10 handlers who were placed every 50 m close to the nets, 6-8 beaters and 3-5 blockers stop animals from escaping. The mean success was 2.4 captures per day of field work. When big catches occurred (>6 individuals) the exceeding animals were released to avoid stress deaths (eight individuals were released). Seventeen specimens died (four during capture and thirteen shortly after their release) and nine moved to other areas. The founding population compiled 24 males and 42 females.

Chamois were released in three separate (3-4 km) areas with ear tags (all), encoded colour collars (>2 years old specimens) and radio-tracking emitters (7 VHF and 9 GPS/GSM). Monitoring was implemented by receiving 1500-8500 radio-tracking fixes a year and visiting field sites 3-4 days per week.

The mean natality rate observed was 0.22 (similar to other Cantabrian populations), the mean mortality + emigration was 0.12 (slightly lower than other expanding populations and even lower than stable populations) and the annual increase rate of the new rising population, considering only not released animals, was very high $\lambda = 1.46$, but smoothed in the last years ($\lambda = 1.2$).

POST-RELEASE DISPERSAL DIFFERS BETWEEN WILD CAUGHT AND CAPTIVE FOUNDERS OF APENNINE CHAMOIS RELEASED INTO NEW AREAS

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ABSTRACT

From 2008-2010, 16 Apennine chamois *Rupicapra pyrenaica ornata* (10 females, 6 males) were released into the Monti Sibillini National Park. Founders caught in the wild (N=8 ind.) and those from large enclosures (N=8 ind.) differed for movement frequency (interfix distance/hour) and distance covered (from the release site) in the first 5 months ca. from release, significantly greater in wild-caught individuals; males moved significantly more than females; wild-caught individuals shifted their home ranges significantly more often than those reared in large enclosures; no age or sex differences were found. In the case of the Apennine chamois, no previous information is available on its post-release behaviour or the factors determining the success of conservation actions. Thus, our results are important on the implementation of further releases: we recommend a mixed strategy of selection of founders to prevent large movements in the initial stages of release, but at the same time fair opportunities should be provided to avoid inbreeding depression.

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RED DEER AND APENNINE CHAMOIS: A DIFFICULT COEXISTENCE?

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ABSTRACT

Information is scarce on mechanisms of interspecific competition between wild ungulates. In Abruzzo, Lazio e Molise National Park (PNALM, Apennine, Italy), we analyzed the effects of ecological overlap between red deer *Cervus elaphus* and Apennine chamois *Rupicapra pyrenaica ornata* ("vulnerable", IUCN) on both the quality of grassland and the foraging efficiency of chamois. In the last decade, a c. 50% decline in the abundance of Apennine chamois has been recorded in the core area of their local distribution range, in PNALM, whereas numbers of red deer (reintroduced in 1972-1987) have greatly increased.

In study area A, we assessed diet overlap between deer and chamois, as well as the effects of grassland use by the former on foraging behavior of the latter. The composition of grassland was compared to that recorded when the former was absent. In summer-autumn 2010-2011, we found: (i) a great diet (>90%) overlap between deer and chamois; (ii) a significant increase of unpalatable plant species and a decreasing trend of nutritious, most grazed species by chamois, in respect to 1982-1984 (deer absent); (iii) a significantly reduced feeding intensity (bite rate) of adult female chamois in patches used also by deer, compared to areas without deer.

In summer-autumn 2012-2013, we compared the quality of grassland and the foraging efficiency of adult female chamois across three sites with different densities of red deer (Area A: great density; Area B: intermediate density; Area C: deer absent). In Area A, alteration of grassland through trampling was the highest and female chamois showed the highest search effort for food (step rate) and the lowest feeding intensity. Deer were the main factor influencing seasonal increase of trampling.

Winter survival of offspring of mountain ungulates depends on availability of high-quality forage in the warm season. Our results suggest a local negative effect of red deer on availability of nutritious plants in summer-autumn, because of grazing and trampling, in turn affecting winter survival of kids.

TAKE-HOME MESSAGE: the reintroduction of a non-threatened species – potentially competing with a threatened one – may not be always advisable.

ACKNOWLEDGEMENTS: PNALM Agency (integrated by LIFE 09NAT/IT/000183 COORNATA, for some diet analyses) and Italian Ministry of University and Research (PRIN project n. 2010P7LFW4), for financial support; G. Rossi, D. Febbo; PNALM personnel; A. Saddi.

OBSERVATION OF THE LONGEVITY OF THE INDIVIDUALS OF APENNINE CHAMOIS *(Rupicapra pyrenaica ornata)* THAT WERE RELEASED FOR THE REINTRODUCTION IN THE GRAN SASSO-LAGA NATIONAL PARK AND THE SURVIVAL IN THE FIRST YEAR OF LIFE OF THE KIDS FROM 1995 TO 2008

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ABSTRACT

The reintroduction of the Apennine Chamois in the Gran Sasso e Monti della Laga National Park was realized through the release of a group of 26 chamois from 1992 to 1994 (Global Re-introduction perspectives; IUCN 2010) and afterwards during the Life Project "Conservation of *Rupicapra pyrenaica ornata*" of another group of 9 chamois from 1999 to 2001 amounting to 35 chamois. All the individuals were equipped with ear tags and 17 of them also with WHF radio-collars.
In 1995 the period of the formation of stable herds began and the individuals have been monitored throughout the whole year.
We here report the data related to the longevity and the reproduction of 23 of the 35 released individuals (65,71%) that have been present from 1995 until today out of a population that counted around 25 individuals in 1995, around 380 individuals in 2008 and around 450 individuals in 2012.
We documented the survival of 9 females, one of them survived for 20 years, one for 19 years and one for 18 years.
The average lifespan calculated on all the marked females that are part of the present study is 13.7 years excluding one 15-year-old individual that is still alive. We also documented the survival of 13 males, two of them survived 15 years, two 14 years, one 13 years, with an average lifespan of 9.4 years.
The assumption of a highly significant relation between longevity and age of release was verified by Spearman's rank correlation coefficient r=0.732 ($p<0.05$) ($p>0.01$).
The longevity of the 10 females is significantly higher than the one of the 13 males (U=25,5; $P<0.05$,Mann-Whitney U-Test).
An average death rate of 10.6% per year has been calculated using a contingency table between the expected population (population without any phenomenon of emigration or immigration) knowing the annual "recruitment" (kids observed in July) and the population at the end of the year (estimated on the basis of the comparison between data obtained by monitoring in spring and the results of the block counts performed in autumn in the period 2000/2008).
In the first year the survival rate (number of yearlings re-counted the year after they were born) calculated during that period was 84.92 %.
We documented the reproduction of three individuals at the age of 16, 15 and 12 years.
We notice how the longevity of the Apennine chamois population in the PNGSL, under conditions of maximum potentiality for the species, is a decisive factor of the reproductive success.
We reaffirm the importance of long-term monitoring as an indispensable instrument for the understanding of the factors that contribute to the success of reintroduction.

ATYPICAL COLORATION IN A SOUTH WESTERN ALPS CHAMOIS

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ABSTRACT

In the *Rupicapra* genus is remarkable how the color pattern is common among the species and subspecies with the known differences in winter and summer appearance. Variation in color and lengths of hairs are recognized as adaptation to seasonal changes as well in many other ungulates.

Here we present a case of leucism in *Rupicapra rupicapra* living in the southern slope of the Marittime Alps, at the top of Imperia Province.

Leucism is a phenotype with defects in pigment cell presence in the skin and hairs, or feathers during the development. In these individuals the results of this illness are a partial or total lack of color on the body surface. The cases differ from albino where no melanin is present at all as quoted by the red eyes in contrast with commonly colored iris in the leucistic specimens.

The specimen lives within its familiar group of 3-4 chamois where we first sighted it in 2011. It's the only one of the group with a color variation. During the winter the group moves to a lower altitude with the other chamois of the area and no negative or particular interactions were noted.

After a short period of thinness during last winter, it has now fully recovered and moved to the tops of the pastures.

All our observations have not shown any negative impact of the leucist coloration and future observation will try to study the interactions of the specimen in the groups.

A TARGET THAT IS TOO BIG:
IMMATURE GOLDEN EAGLES ATTACKS TO ADULT CHAMOIS

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ABSTRACT

The golden eagle *Aquila chrysaetos* is one of the most important predators for chamois *Rupicapra* spp. in Alps and Pyrenees, as quoted by numerous authors. Golden eagles can lift up to 5-6 kg if they have favorable winds and so direct predation is manly devoted to yearlings and adults are consumed as carrions.
Chamois are able to engage defensive behavior especially to protect their young. Mothers defending offspring against eagles are known in both species and, as examples, in *Ovis canadensis*, *Ovis gmelini*, as well as in other ungulates
During research on the populations of the chamois inhabitants the southern slope of Marittime Alps, two cases were collected of a direct attack to adults chamois.
The first sequence was shot on the 12/11/2011 when a young eagle tried to attack an isolated adult that simply ignored the bird.
In the second case, at 02/11/2013, the chamois responded to the attack with a defensive posture and jumps showing horns to the flying bird that abandoned the fight.
We suppose that during the first part of its life the eagle will have to try to find way to refine its attack sequences and identify suitable targets. Also its behavior to trail big prey into gorges and later scavenge on them can be considered and the sequences taken in photos can be parts of the training for the young eagle.

HEY, DO YOU WANT TO TASTE? USE OF BAITED BOX TRAP BY APENNINE CHAMOIS

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ABSTRACT

In the Gran Sasso e Monti della Laga National Park, for the first time after their reintroduction, live captures of free ranging Apennine chamois (*Rupicapra pyrenaica ornata*) were performed, developing and testing new capture methods, in the frame of the LIFE project: "Coornata: development of coordinated protection measures for Apennine Chamois (LIFE09 NAT/IT/000183)". A box trap partially constructed of wood was built into a natural cave, it measures about 1.5 m x 3.0 m x 2.0 m. We installed the trap in Monte Coppe, in areas of observed high chamois use.

The trap was built in October 2010, baited with salt, concentrated vegetable attractants and fruits. Entrance in the trap and utilization of salt lick was monitored through photos and videos acquired by camera trapping.

We observed a progressive increase in the number of visits to the box trap within the study period: in 2010 we recorded 2 visits in 3 months, in the whole year 2011 11 visits, 31 in 2012, 48 in 2013 and 20 in 2014 (in January-March). Chamois spent a minimum of 1 minute inside the trap to a maximum of 11 hours inside or in the immediate neighbouring surroundings of the trap. As for the number of visits, we observed a progressive increase in the mean time interval spent by chamois inside the box trap (or in the proximity) throughout the study period: from 29 minutes in 2011 to 134 minutes in 2013. The trap was visited more frequently in autumn (50 times), spring (34) and winter (23), while we detected, in the whole study period, only 5 occasions in summer, as expected since the Monte Coppe area is mainly a wintering area.

Chamois entered inside the trap more frequently during daylight, although we recorded entrances within all time slots.

We recorded the presence of all age and sex classes in the box-trap, even if yearlings and young males were the most represented category. We recorded the presence of kid only in 1 occasion. In most occasions (66) only a single animal at a time visited the trap, in 31 occasions 2 animals entered together, and we recorded a maximum of 6 chamois inside the trap.

We captured and ear tagged 3 chamois in june-july 2011. Only 2 marked animals (1 male and 1 female) were camera trapped inside the box trap in the study period, both re-entered the trap exactly one year after being trapped. While the female entered again only in 1 occasion, the male entered 4 times, once, 3 years after being captured.

CHAMOIS OF MOUNT GENEROSO NEAR TO EXTINCTION

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ABSTRACT

Mount Generoso is situated on the border between Switzerland and Italy. It is a mountainous group delimited by the Lake of Como, the Lake of Lugano and the Motorway Como-Chiasso-Bellinzona.
Eight thousand hectares of about sixteen thousand of Alpine District of hunting are occupied by chamois.
During 1970 few individuals were set free in Switzerland but, because of the mountain's position, it is clear that there is possibility of interchange with populations of contiguous ungulates.
After a period of great expanction (about 600/700 individuals were censused between Switzerland and Italy), around 1990 and 2000 we started to observe phenomenous of reduction of birth, about the 20-30% of females had the kid, a lot of chamois showed broken horns, a lot of them were lames/limpings, every animal is thinner and debilitated, also during the arrival of red deer and wild boar.
With the first samples started in 2011 situation seems to be really warning:

- almost every subject (99%) showed heavy alterations of dental tables;
- abnormal growth of the hoofs;
- body weight really under the average.

From the tests: haematological/sierological, for infective illnesses, bacteriological, histological and the tests of water there are no apparent causes that can justify this phenomena, while genetic tests show a low biodiversity and risk of extinction in near thew future, cause of the blood relationship.
Probably these pathological manifestations are due to the weakening of specie for the blood relationship; so the very low biodiversity arranges to a limited resistance to pathogens, reduction/decrease of fertility, decrease of survival level and finally the probability of extinction.
To resolve the problem we think to program for the year 2015 the introduction of new subjects which can bring a new genetic heritage.

MASS MORTALITY BY LIGHTENING IN APENNINE CHAMOIS *(Rupicapra pyrenaica ornata)*: A CASE REPORT FROM THE ABRUZZO, LAZIO E MOLISE NATIONAL PARK, ITALY

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ABSTRACT

Apennine chamois (*Rupicapra pyrenaica ornata*) is an endemic and endangered subspecies living in Central Apennines (Italy). According to recent estimates, the entire population of Abruzzo chamois consists of about 1700 subjects, and 400 chamois live in the Abruzzo Lazio e Molise National Park (PNALM).

On April 22th 2014, ten chamois were found dead in locality Monte Sterpi d'Alto (Civitella Alfedena, PNALM), at an altitude of 1960 m above the sea level. Chamois carcasses – three males and seven females, aged between one and nine years – laid in a very limited area of approximately 550 m². After in field investigation, animal identification and primary inspection, the carcasses were referred to the Istituto Zooprofilattico Sperimentale Abruzzo e Molise for necropsy and laboratory diagnostic investigations.

Field observations and detailed necropsy pointed out scorched streaks on the skin surface, severe in two chamois and less pronounced in other three. Such skin lesions were hairless and dark grey in color. Main streaks started from the head, close to the eye, and proceeded along the neck, the upper chest and abdomen. In addition, minor streaks branched and ran along the hind and fore legs. Subcutaneous oedema and petechiae, pulmonary oedema, foci of parasitic bronchopneumonia, and congestion of the small intestine were additional consistent findings. Laboratory investigations yielded inconclusive diagnostic results. On the basis of what above, the diagnosis of death due a lightning strike was made.

In veterinary medicine, lightning strikes are mainly reported in domesticated animals housed outdoor, whereas it seems a rather uncommon and likely underestimated cause of death in wild animals. Reasonably, wild animals are often exposed to lightening, but their carcasses are uncommonly found. In the present report, characteristic skin lesions were observed in five chamois, as result of current flow through the body of animals after an atmospheric flash. We suppose that indirect spreading of current killed the remaining five chamois, which were found dead in the same site with no evidence of scorched streaks. Monitoring the health status of endangered wild species is crucial for their preservation. Necropsy findings were decisive in order to solve the present diagnostic query. The same pathological findings remark that lightening should be always considered as differential diagnosis in the course of mass mortality event affecting wild animals.

LAZY GLUTTON MALES, WISE PICKY FEMALES: THE FORAGING BEHAVIOUR OF APENNINE CHAMOIS

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ABSTRACT

Foraging behavior is influenced by availability of food resources, as well as individual characteristics, and can differ between sexes, leading to different patterns of food/habitat selection. In dimorphic ungulates, females are usually more selective foragers; showing greater bite rates and spending more time foraging than males. In an area of Abruzzo, Lazio e Molise National Park (central Apennines), we evaluated the gender differences in foraging behaviour in Apennine chamois *Rupicapra pyrenaica ornata*, during the warm season, before the rut (July-early November, 2010-2012). Both sexes selected nutritious vegetation patches and spent a comparable amount of time feeding. However, males had a significantly greater feeding intensity (bite rate) and a lower search effort for feeding (step rate), as well as they spent more time lying down than females. Females selected foraging sites closer to refuge areas than males.
In chamois, sexual size dimorphism is seasonal, being negligible in winter-spring, but increasing to 30-40% in autumn. Our results suggest that males enhance their energy and mass gain by increasing their food intake rate during the warm season, to face the costs of the mating season (November). Conversely, females seem to prioritize a fine-scale selection of vegetation and the protection of offspring. A great food intake rate of males in the warm season could have developed as a behavioral adaptation leading herbivores to the evolutionary transition from year round monomorphism to permanent dimorphism, through seasonal-dimorphism.

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PHYSIOLOGICAL RESPONSE TO ETHO-ECOLOGICAL STRESSORS IN MALE ALPINE CHAMOIS: TIMESCALE MATTERS!

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ABSTRACT

From a life history perspective, glucocorticoids secreted by the neuroendocrine system, integrating different sources of stress through an adaptive feedback mechanism, may have important consequences on individual fitness. Although stress responses have been the object of several investigations, few studies have explored the role of proximate mechanisms responsible for the potential trade-offs between physiological stress and life history traits integrating social and environmental stressors. In 2011 and 2012 we collected data on faecal cortisol metabolites (FCM) in a marked male population of Alpine chamois, within the Gran Paradiso National Park (Italy). Using a model selection approach we analysed the effect of potential etho-ecological stressors such as age, social status (territorial vs. non-territorial males), minimum temperature, snow depth and precipitation on FCM variation. To correctly interpret environmentally – and socially-induced stress responses, we conducted model selections over multiple temporal scales defined a priori: year, cold months, spring, warm months, mating season. Over the year, FCM levels showed a negative relationship with minimum temperature, but altogether climatic stressors had negligible effects on glucocorticoid secretion, possibly owing to good adaptations of chamois to severe weather conditions. Age was negatively related to FCM during the rut, possibly due to greater experience of older males in agonistic contests. Social status was an important determinant of FCM excretion: while both the 'stress of subordination' and the 'stress of domination' hypotheses received some support in spring and during the mating season, respectively, previous data suggest that only the latter may have detrimental fitness consequences on male chamois.

CHAMOIS *(Rupicapra spp.)* AS A MODEL FOR RESEARCH ON DISEASE ECOLOGY AND HOST-PARASITE INTERACTIONS

F. Obber[1*] and The Chamois PRIN Consortium[2]

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ABSTRACT

Background: management of disease in wild populations needs, besides adequate surveillance protocols and diagnostic tools, a continuous improvement of the knowledge about the ecology of the involved pathogen/s and the host-pathogens/s relationships, including host and disease dynamics. The MIUR-PRIN project n° 2010P7LFW4 has the general objectives to investigate the above issues in a host-parasite model represented by different species and subspecies of chamois (*Rupicapra spp.*) and a wide array of infecting/competing organisms (viruses, protozoans, helminths and arthropods, as well as other wild ruminants).

Aim of the study: the project is currently ongoing and it is expected to obtain data on:

1. the patterns of selected macroparasite (mites and gastrointestinal helminthes) and microparasite (pestivirus and Respiratory Syncytial Virus) infections;
2. the patterns of genomic variability in chamois populations;
3. the host's immunocompetence and the pathogenesis of the parasitic-induced lesions;
4. the protozoan parasite communities in chamois populations;
5. the relationships between epizootiological, genetic and immune evidences with demographic and ecological factors.

Materials and methods: the project has foreseen the collection of feces, spleen, lung, blood and skin samples from:

1. Alpine chamois of different populations from Eastern and Central Alps;
2. Apennine chamois from the Abruzzo National Park and the Majella and Gran Sasso Parks;
3. Pyrenean chamois;
4. Tatra chamois from Tatra Mountains.

Preliminary results: quantitative PCR assays, aimed to quantify *Sarcoptes* infections is currently under optimization. Morphological and molecular identification of adult helminths, with likely *Haemonchus contortus* as the dominant species, and eggs are presently ongoing. First serological tests for Respiratory Syncytial Virus and pestivirus, showed low seroprevalence in Central Alps. The genetic variation in chamois population is actually under study by DNA sequencing of the MHC class I and class II genes and mitochondrial regions (D-loop and cytB). DNA extraction and PCR amplification have been completed for samples from Central Alps. Preliminary immunohistochemical investigations on the immunological status of examined subjects allowed to localize CD3+, CD4+, CD79a+, CD21+ and Foxp3+ lymphocyte subsets and CD68+ and Cd11b macrophagic cells. The first data on protozoans showed a high positivity (85%) to *Eimeria spp*. and the first record of potentially zoonotic *Giardia duodenalis* in chamois (assemblage A). This data has been also confirmed by preliminary tests for coproantigens. Then, molecular characterization and phylogenetic studies will be performed on the detected pathogens. Demographic and ecological studies will be conducted by evaluating diet overlap between Apennine chamois and red deer, comparing foraging behavior and analyzing behavioural interactions.

It is interesting to point out that the field work of this project takes advantage from different networks implemented for wildlife disease research and surveillance (e.g. RC IZSVe 08-12 for North-Eastern Italian Alps), thus integrating different knowledge and expertise.

SANITARY MONITORING OF THE ALPINE CHAMOIS *(Rupicapra rupicapra)* IN THE PROVINCE OF IMPERIA, ITALY (2002-2012)

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ABSTRACT

In recent years, the alpine chamois (*Rupicapra rupicapra*) population of the Province of Imperia, NW Italy, underwent sanitary monitoring, by the Istituto Zooprofilattico Sperimentale del Piemonte, Liguria e Valle d'Aosta (IZSPLV), in collaboration with the local Game Management Unit "Comprensorio Alpino", the Provincial Administration, and the National Forestry Service (CFS). The monitoring plan was set up to investigate the effects of coexistence between the free-range livestock and wildlife in the area, at the provincial and regional scale. Alpine chamois in the Ligurian Alps represent the westernmost and southernmost population of this species in the Alps, demographically distinct from the others and of particular interest from an ecological point of view, as its habitat is influenced by the Mediterranean climate. During the hunting seasons, all hunted chamois underwent viscera examination, as well as organs and tissue sampling for chemical, bacteriological and virological analysis. Hunters were also requested to take a blood sample from each carcass, for serological investigations. Chamois found dead in the Imperia province were also delivered to IZSPLV either by the Provincial Police or the National Forestry Service personnel. The latest census of the local chamois population, whose demographic parameters (age, sex, annual recruitment, and mortality rate) appeared to be constant throughout the years, took place in April 2014, resulting in 845 individuals. Our study refers to the results of the sanitary monitoring in the period 2002-2012, based on descriptive epidemiology (distribution of pathologies according to place, time and features of the affected individuals). A dedicated database was set up based on sampling data and on the results of the analysis performed at IZSPLV. The impact of the main investigated diseases, i.e. brucellosis, pseudotuberculosis, paratuberculosis, keratoconjunctivitis by *Mycoplasma conjunctivae*, bluetongue, parasitic pneumonia, and cysticercosis, and heavy metals (including Pb, As, Cd, and Cr) on the chamois population was evaluated. In the case of those pathologies that were never found, the maximum expected prevalence – according to the amount of negative samples obtained – was estimated. Results obtained during this study allowed to redefine priorities in sanitary monitoring, and to determine which infectious diseases are circulating within the local chamois population and may have an impact on human and/or domestic animals health, or on the conservation and management of the chamois population.

ACTIVE AND PASSIVE HEALTH SURVEILLANCE IN A PYRENEAN CHAMOIS POPULATION

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ABSTRACT

Pyrenean chamois health surveillance has been made in the Hunting Reserves (HRs) of the Aragonese Pyrenees in a 14 year period, 2000-2013. Four hundred and nine chamois ill or found dead have been analysed, in addition to 118 hunted animals and 2601 samples of hunted chamois. The aim of the study was to establish the status of the epidemic processes with a serious impact on this species, including pestivirus disease, infectious keratoconjunctivitis, zoonoses such as brucellosis and tuberculosis; as well as pathological processes in ill or dead chamois found on the mountains.

The study of pestivirus disease was conducted in 2426 chamois from Aragon (385 ill-dead and 2041 hunted). In the Aragonese Pyrenees, neither infected chamois nor clinical signs were detected between 2001 to July 2011 (n=1656). After the first detection in Aragon in 2011 the virus was confirmed by Ag-ELISA in 97 out 770 studied animals. Serological studies against pestivirus (n=2373) showed a higher proportion of seropositive animals in the affected HR.

An outbreak of infectious keratoconjunctivitis (IKC) in chamois population in Aragon and Navarre was detected in the spring of 2006 until late 2008. One hundred and nine affected animals were collected, mostly during 2007 in Viñamala's HR and in 2008 in Los Valles' and Benasque's HRs. The process was seasonal, beginning in spring-summer and ending in winter, except in Benasque's HR where it went on until the following winter. *M. conjunctivae* was the main causal agent identified by rt-PCR in IKC affected chamois. It was identified in 89.42% of animals tested (n=104). A 4.21% (8/190) of hunted chamois, sampled during 2006 to 2009, without eye damage, were carriers of *M. conjunctivae.*

A 0.5% (13/2703) of Pyrenean chamois was seropositive against brucellosis, being negative to bacterial culture. The necropsy of 409 ill-dead chamois revealed a 28.6% (117) with IKC, a 19.3% (79) with pestivirus disease, a 6.3% (26) with non-parasitic bronchopneumonia, 7% (29) with traumatisms, 1.5% (6) with digestive processes, 1.7% (7) with other diseases and 35.4% (145) with inconclusive processes, being most of them incomplete animals.

Hunted animals (n=118) showed verminous pneumonia by small strongyles; visceral cysticercosis; coccidia and nematodes (*Ostertagia spp*. and *Haemonchus spp*.) in the abomasum. The presence of areas with chronic catarrhal pneumonia in apical lobes was frequent.

No suspicious lesions compatible with either tuberculosis (n =301) or mange (n =299) were found in the Pyrenean chamois studied.

* The study was funded by Aragon Government.

BASELINE FOR THE SURVEILLANCE IN HEAVY METAL CONCENTRATION IN *Rupicapra rupicapra* IN SOUTH-WESTERN ALPS

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ABSTRACT

Alpine Chamois *Rupicapra rupicapra* represent an important faunistic value for both conservation and hunting purposes in the alpine environments. Ungulates can be considered an important bioindicator of pollution due to the fact that they are large herbivores and in that guild can magnify the presence of contaminants such as heavy metal from the forage.
Heavy metal can be dangerous to organisms in low quantities for their potential role not only as a toxic substance for the tissues but also for their power to disrupt the immune system and enforce the risk for infections or parasitism. The alpine environment can provide some natural concentration of metals due to the rocks composition mediated by the forage, but the main flux can be related to the local or general diffusion of pollution
There is no information about heavy metal concentration in tissues of this species. Information about their presence levels can be important as the meats of these animals are consumed, as well as the need to understand a possible role concerning the health of the chamois populations.
Here we report about the concentration of Pb, Cd, Cr, Se, Hg, As, Ni, Co, Cu and Fe in the kidneys of 15 chamois sampled in 2007 in hunting grounds located in the Alpine area of Imperia Province, in the southwestern Alps.
The sample derived from specimens sent to local Veterinary Authorities in order to have a heath check before their meat was to be consumed. Ten grams of kidney tissue were first of all mineralized by microwave technique and later analyzed by IOCP plasma spectrophotometric techniques.
The results show that Nickel was always under the possible quantification limit and Pb was found, at low levels and only in 4 specimens, this was mostly likely due to the use of bullets during hunting.
Cd, Cr, Se, Co, Cu and Fe were found above over the detection level in all the 15 specimens. Hg was detected in 14 specimens and As in 13. No correlations were found to sex or age of the samples or the presences of infections or other health problems.
The concentration in ng/g in the fresh tissue are:
AS with a media of 33.306 (1.00-68.00) with St.Dev. 21.464;
Cd with a media of 480.349 (48.00-1506.00) with St.Dev. 437,875;
Co with a media of 36.933 (18.00-59.00) with St.Dev. 12.151:
Cr with a media of 72.133 (59.00-90.00) with St.Dev. 9.289;
Cu with a media of 3643,867 (2641.00-4227.00) with St.Dev. 448.511;
Fe with a media of 2334.40 (1343.00-5101.00) with St.Dev. 889.247;
Hg with a media of 16.071 (5.00-37.00) with St.Dev. 7.917;
Se with a media of 659.367 (389.00-842.00) with St.Dev. 121.203.
All the concentrations reported are extremely low and demonstrate a very healthy environment but the individual variations can underline the ability of chamois to be a good potential bioindicator for any contaminations in the system.

GASTRO-INTESTINAL PARASITES IN TATRA CHAMOIS
(Rupicapra rupicapra tatrica)

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ABSTRACT

Tatra chamois (*Rupicapra rupicapra* tatrica) is a significant representative of the Tatra endemic fauna. The numbers and health status of these animals are affected by different critical factors – climatic conditions, industrial pollution of the environment, individual anthropogenic impacts etc. In terms of health hazards, parasitic infections play an important role that can lead to significant depletion of the entire population. The aim of our work was to study the occurrence of gastrointestinal parasites of Tatra chamois in current environmental and climatic conditions.

During the pilot phase in 2013, in total 179 chamois faecal samples from the Slovak side of the Tatras and 33 samples collected in Polish part of the mountains and for comparison also 15 samples from geographically separated area of Slovak side of the Western Tatras were examined using standard coprological methods.

The results revealed the overall prevalence of gastrointestinal parasites in chamois of the Slovak part of the High Tatras reaching 58.5 %. Most frequent were protozoa – *Eimeria spp*. (41.5 %), helminths were represented by Moniezia spp. tapeworms (29.3 %); eggs of family *Trichostrongylidae* were found in 9.1 % of examined samples. Sporadically the eggs of the genera *Nematodirus* and *Capillaria* were detected. The chamois living on the Polish side of the Tatras were infected by *Eimeria spp*. (21.2 %), *Moniezia spp*. (15.2 %) and *Trichostrongylidae* (9.1 %). Examination of 15 chamois faecal samples from the Western Tatras showed significantly lower occurrence of intestinal parasites with Eimeria spp. oocysts detected in one sample and strongylid eggs present in a single specimen. The initial research on gastrointestinal parasites of the Tatra chamois introduced one disputable finding – a relatively high prevalence of the genus Moniezia. In the Slovak part of the High Tatras, nearly 30 % of samples were positive for tapeworm eggs, that is significantly more in comparison with other European studies. These differences may be related to the presence of suitable intermediate hosts (*Oribatida mites*) in the environment, which is evidently closely linked to the climate and microclimate conditions. Further intensive research on parasite composition and distribution in Tatra chamois is needed in broader temporal, ecological and zoological contexts.

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PREVALENCE OF GASTROINTESTINAL PARASITES IN FREE RANGE SHEEP AND CATTLE SYMPATRIC TO APENNINE CHAMOIS

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ABSTRACT

Parasite infestation is one of the most common problems affecting cattle sheep and goats of all ages and breed.
Internal parasites interfere with nutrition, growth and the production.
This study was conducted to examine the gastrointestinal parasites in 892 faecals samples of cattle, sheep and goat. Fresh faecal samples were collected from cattle and sheep of different ages and breeds from july 2011 to april 2014 in the territory of four protected area in Central Apennine in Italy: “Abruzzo, Lazio e Molise National Park”, “Gran Sasso e Monti della Laga National Park”, “Monti Sibillini National Park” and “Sirente Velino Natural Park”, where the populations of Appennine Chamois (*Rupicapra pyrenaica ornata*) are expanding and increasingly in contact with livestock. These faecal samples were processed by standard flotation method to identify endoparasite species.
A total of 6052 cattle, 10.684 sheep and 3126 goats, including improved young, improved adult, native young and native adult were collected using simple circular random sampling method.
Samples were collected just after defecation. Faecal samples were placed into a vial placed into a cool box and transported for the laboratory examination.
In cattle (313 faecal samples) microscopic examination revealed that about 161 samples (51.4%) were infected with gastrointestinal parasites. Among parasitic infectioned samples, helminth (45.4 %) and protozoa (26.8%) were examined. Strongyle (gastrointestinal) was the most common parasite in faecal samples of all cattle sampled (44.4%, n. 139).
In sheep and goats (579 faecals samples) microscopic examination revealed that about 538 samples (92.9%) were infected with gastrointestinal parasites. Among parasitic infectioned samples, helminth (85.3%) and protozoa (74.1%) were examined.
The results of this study revealed the prevalence of various internal parasites in cattle, sheep and goat in the areas of presence of Apennine chamois.
This approach will initiate proper control strategies to minimize parasitic infections.

PREVALENCE OF COXIELLA, TOXOPLASMA AND SALMONELLA IN THE OVINE AND CAPRINE FARMS OF SIRENTE VELINO NATURAL PARK: CONSIDERATIONS AND THE POSSIBILITY OF A HOLISTIC APPROACH TO DISEASES COMMON TO DOMESTIC AND WILD ANIMALS AND HUMANS

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ABSTRACT

Within the European Project LIFE Coornata for the protection of Apennine chamois, a monitoring of the state of health of domestic livestock was undertaken, particularly sheeps and goats grazing in the Sirente Velino Natural Park area. Starting from July 2012, all the farms falling in this area were subjected to serological, parasitological and necropsy survey, associated with bacterial and viral research, in order to investigate the presence of zoonotic pathogens and not interesting animals and wild livestock. This poster focuses on some agents of zoonoses which pose a major health risk that concerns domestic, wild animal and humans alike. In addition to highlighting the possible critical points in the fields of public health and wildlife matters, the poster analyzes the possibility of a synergistic action between the different territorial sanitary entities against these diseases in view of the “One World-One Medicine-One Health”.
Although these diseases represent important zoonoses, there are no national prevention plans and therefore they are not monitored by the Veterinary Services of the local health authorities (ASSLL).

SEROSURVEY FOR SELECTED PATHOGENS IN SHEEP AND CATTLE IN THE AREAS OF PRESENCE OF THE APENNINE CHAMOIS

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ABSTRACT

Background.
From 2011 to 2014, during the Life Coornata Project, in the activities related to the action C.6, antibody seroprevalence in n. 2998 cattle and n. 14.668 sheep and goats was investigated in five protected area in Central Apennine in Italy: Abruzzo, Lazio e Molise National Park", "Majella National Park", "Gran Sasso e Monti della Laga National Park", "Monti Sibillini National Park" and "Sirente Velino Natural Park", where the populations of Appennine Chamois (*Rupicapra pyrenaica ornata*) are expanding and increasingly in contact with livestock.

Materials and Methods.
We investigated antibody seroprevalence against: *Neospora caninum* (n. 595 sera samples), *Chlamydia psittaci* ovis (n. 4095), *Coxiella burnetii* (n. 1596), *Salmonella abortus ovis* (n. 3.889), *Toxoplasma* (n. 1722), *Border disease* (n. 2544), *Mycoplasma agalactiae* (n. 2071), *Mycobacterium paratuberculosis* (n. 1893), *Borrelia spp*. (n. 487), Contagious Ecthyma (n. 145), Bovine Viral Diarrhea (n. 715), Infectious bovine rhinotracheitis (n. 245), Parainfluenza virus type 3 (n. 67), *Anaplasma phagocitophila* (n. 44), and *Leptospira spp*. (n. 31).

Results.
In cattle serological positivity were observed as follows: *Coxiella burnetii* (0.2%), *Salmonella abortus ovis* (0.07%), *Mycobacterium paratuberculosis* (3.8%), *Neospora caninum* (18.8%), Bovine Viral Diarrhea (43.5%), Infectious bovine rhinotracheitis (25.3%), *Chlamydia psittaci ovis* (19.4%), *Toxoplasma* (29%), Parainfluenza virus type 3 (88%), Borrelia (0.9%) and Border disease (64.6%).

While in sheep and goats, serological positivity were observed as follows: *Neospora caninum* (54.2%), *Chlamydia psittaci ovis* (47.8%), *Coxiella burnetii* (7.9%), *Salmonella abortus ovis* (4.1%), *Toxoplasma* (45.5%), Border disease (52.1%), *Mycoplasma agalactiae* (1.3%), *Mycobacterium paratuberculosis* (7.6%), *Borrelia* spp. (0.6%), Contagious Ecthyma (15.6%).

Conclusion.
To our knowledge, this is the first study reporting prevalence and risk factors associated with certain infectious agents in the areas of presence of Apennine chamois. Moreover, our results suggest furthering our studies in deep epidemiology of some diseases in the areas of presence and spread of Apennine chamois, not only throughout a serological monitoring but also by researches directed to the agents in particular in ewes and cows after parturition and/or abortion.

RETROSPECTIVE SEROLOGICAL INVESTIGATION ON SOME THREATENING INFECTIOUS AGENTS IN APENNINE CHAMOIS *(Rupicapra pyrenaica ornata)*

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ABSTRACT

Apennine chamois (*Rupicapra pyrenaica ornata*) is a geographically isolated subspecies of Pyrenean chamois, currently living only in limited areas of Central Italy, and included in the red list of the International Union for Conservation of Nature. For these reasons an extension of the territory for this species of chamois is needed to increase the population and translocations for reintroduction programmes are planned. However, this practice could be responsible for introduction of infectious diseases inside the populations.

A serological retrospective survey on 120 Apennine chamois, captured for their routine marking or reintroduction operations from 1990 to 2008 at the Abruzzo, Lazio e Molise National Park (PNALM), was performed to detect antibodies against pestiviruses, Bovine Parainfluenza 3 virus (PI-3), Bluetongue virus (BTV), Bovine herpesvirus type 1 (BHV-1), *Brucella spp*., *Chlamydophila spp*., *Coxiella burnetti* and *Leptospira spp* and results were reported.

Serums were negative for PI-3, BTV, BHV-1, *Brucella spp*., *Chlamydophila spp*., *Coxiella burnetti* and *Leptospira spp*., while 8 animals were positive for pestiviruses antibodies.

Better planning with regards to sampling and a specific surveillance program for infectious diseases are needed, especially in a small and limited population, like Apennine chamois, in which reintroduction programmes are considered a strategy of wildlife conservation and other risk factors, like the sharing of grazing with wild and domestic animals, exist.

SURVEILLANCE AND RESEARCH ON SARCOPTIC MANGE OF CHAMOIS IN THE NORTH-EASTERN ITALIAN ALPS

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ABSTRACT

Sarcoptic mange is one of the most severe diseases of wild *Caprinae* populations in Europe, raising concern about wildlife management and conservation. Since 1995, an epidemic of sarcoptic mange has been affecting the chamois (*Rupicapra r. rupicapra*) population of the dolomitic area, in the North Eastern Italian Alps, involving also sympatric ibex (*Capra ibex*) populations. During its spread, the disease affected also protected areas, as in 2007 for "Paneveggio-Pale di San Martino Natural Park (PNPPSM)". The present work summarizes the results of surveillance and field epidemiology on this disease in Alpine chamois in the Belluno and Trento provinces of North Eastern Italian Alps, including the PNPPSM.

Namely:
– we propose an explorative approach, implemented by time series analysis and geographic information system (GIS), exploring the mange epidemic in chamois and providing a definition of epidemic front which involves epidemic peaks instead of index cases;
– we use the same approach to evaluate the front spreading speed, using the mountain massif as the main epidemiological unit;
– we analyze the sensitivity of different levels of surveillance on the disease in the field and the possible sources of bias in estimating the disease impact in chamois populations in a protected area (PNPPSM), allowing an estimate of the effective impact of mange versus other mortality causes.

Our results strengthen the conclusions of previous studies on sarcoptic mange epidemiology. The mange front appears to spread in a south westward direction with an estimated mean of 3.8 km/year. Regarding clinical cases, time series analysis confirmed previous studies, showing the main incidence of the disease during late winter/early spring.
An analysis of mortality data in the PNPPSM showed an evident contribution of other mortality causes, namely starvation and winter mortality, to the main mortality peak of sarcoptic mange. This situation could have been determinant, amplifying the impact of the mange peak and leading the chamois density to values close to the estimated threshold density for the transmission of *Sarcoptes scabiei* in some areas.

THE EFFECTS OF PULMONARY DEFICIENCIES ON A VULNERABLE APENNINE CHAMOIS POPULATION REQUIRE A CAUTIONARY IMMOBILIZATION PROTOCOL

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ABSTRACT

The Apennine chamois (*Rupicapra pyrenaica ornata*) is an endemic subspecies which survives in some massifs of Central Italy. Although its IUCN conservation status has been down-ranked from Endangered to Vulnerable, this chamois still faces major threats such as those associated with its limited population size and limited number of subpopulations, low genetic variation, and competition with other ungulates. Because the Apennine chamois found in the Abruzzo, Lazio and Molise National Park (Central Italy) – hereafter abbreviated as PNALM – constitutes the last remaining autochthonous population, it has an especially high conservation value.

Since 2005-2006, the PNALM population size has shown a negative trend and a decrease in growth rate, mostly due to the high winter mortality of kids in the first year. This population may be subjected to density-dependent processes caused by several factors (e.g. high intraspecific local-density, reduced carrying capacity due to changes in production and species diversity, and to interspecific competition for grazing pastures). One of the effects of these conditions is the high level of parasites recently found to affect this population. Parasitological analysis of 405 droppings collected in 2011 and 2012 revealed a 68.4% occurrence of bruncopulmonar strongyles, 62.5% gastrointestinal parasites and 88.9% coccids. Larvae/oocists/eggs counts in faeces showed a highly skewed distribution in the population and unusually high peaks of intensity. Both prevalence and intensity were significantly higher than those of two other Apennine chamois populations (Majella and Gran Sasso National Parks), where chamois density is likely to be much lower. The occurrence of strongyles and coccids at PNALM was also significantly higher than that recorded 15 years ago.

In addition, after over twenty years during which no mortality was recorded, in 2006 two individuals died on the same day during translocation from PNALM to the Monti Sibillini National Park, as part of a reintroduction project to the latter area. In 2008 and 2009 another two individuals captured in PNALM, apparently in excellent body conditions, died during anesthesia. Moreover, the post mortem examinations of 17 chamois retrieved between 2010 and 2013, including 3 juveniles, highlighted for most of them (84.2%) a poor pulmonary condition caused by high infestations of bruncopulmonar strongyles. These clinical conditions, broadly occurring in the population, represent a potential risk in case of immobilization and manipulation and cannot be predicted from a visual assessment of the subject's external conditions.

Within the project LIFE09 NAT/IT/000183 "Coornata", we evaluated which of two anesthesia protocols usually applied by PNALM staff is more appropriate to reduce the risks for the animals. For the purpose of our study, and in accordance with the aforementioned findings, we distinguished between two periods: 1990-2005 and 2006-2013. Each of the two protocols was applied both before and after 2006.

A total of 104 chamois immobilizations have been carried out since 1990, 83 using Xilazine-Ketamine (XK) and 21 using Medetomidine-Ketamine (MK). Before 2006, XK was used 57 times and MK 11; since 2006, XK was used 26 times and MK 10 times. The parameters considered were the following: induction time (IT, in minutes), i.e. the period from darting to complete immobilization (head down); recovery time (RT, in minutes), i.e. the period from induction of the antidote (Atipamezole) to standing; age, sex and weight of the animal; dosage (mg) of first drug injection; heart rate (HR), respiratory rate (RR) and the first rectal temperature (T) recorded after recovery.

We found no correlation between induction time and injection site (chamois were immobilized by intramuscular injection into the rump, hip or thigh) in any of all the possible comparisons. There was also no correlation with body weight, sex, age and first dosage, so all data were treated together. None of the mortality events occurred (3 for each protocol) was related to a specific anesthesiological aspect. Prior to 2006 we found no significant difference for IT between the two protocols. Following 2006, we did find a strong difference as IT (±s.d.) for MK was significantly much shorter than it was for XK: 4.9 ± 1.9 vs. 12.9 ± 10.3 (Mann-Whitney, $U = 124.5$, $P < 0.05$). IT differed significantly between the two periods for both protocols, but with an opposite trend: it decreased for MK (before 2006: 6.8 ± 1.4; Mann-Whitney, $U = 19$, $P < 0.05$) maintaining the same dosage, whereas it increased with XK (before 2006: 7.0 ± 3.0; Mann-Whitney, $U = 144$, $P < 0.05$) despite a 100% increase of Xilazine dosage. This quite odd result awaits an explanation and it might be due to a different anesthetic action on receptors in relation to a changed stress condition of the subject. On the other hand, we found no difference between the two protocols for RT (Mann-Whitney, P = n.s.). Mean HR was 55.9 ± 15.0 for XK and 51.2 ± 8.4 for MK, mean RR was 66.3 ± 23.4 for XK and 69.9 ± 18.8 for MK, both in accordance with previous results in the same area. HR and T did not correlate with the time since immobilization for both the protocols; RR showed a significant negative correlation for both protocols, but the relationship for MK was stronger ($r = -0.47$ vs. $r = -0.28$, $P < 0.05$). A less variable decreasing RR is usually associated with a deep anesthesia and consequent decreasing stress level or adaptation to stress.

According to our results, MK protocol yields a minor induction time, thus allowing a quicker immobilization. It would also allow the measures required to be started sooner, thus minimizing the sanitary problems that may occur during the anesthesia. Moreover, MK protocol seems to be more effective to obtain a deeper anesthesia because of the higher regularity of some anesthesiological parameters (RR in particular).

SPATIAL AND TEMPORAL PHYLOGENY OF BORDER DISEASE VIRUS IN PYRENEAN CHAMOIS

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ABSTRACT

Border disease virus (BDV) (Genus *Pestivirus*, Family *Flaviviridae*) affects a wide range of ruminants worldwide, mainly domestic sheep and goat. Since 2001 several outbreaks of disease associated to BDV infection have been described in Pyrenean chamois (*Rupicapra pyrenaica* pyrenaica) in Spain, France and Andorra. These outbreaks have decimated several Pyrenean chamois populations, with mortalities ranging from 40% to 85%. The infection has become endemic in the Central and Eastern Pyrenees. After the severe BDV outbreaks, different epidemiological scenarios have appeared in the Pyrenees, some of which are having a negative impact on host population dynamics. The aim of this study was to clarify the origin and dispersion of the Pyrenean chamois BDV genetic variant by reconstructing the spatial and temporal dynamics of BDV 5' UTR sequences of Pyrenean chamois, 10 novel sequences and 41 retrieved from public databases. Sheep BDV sequences (n=43) from Spain and France were also retrieved. A phylogenetic analysis was performed using a Bayesian Markov chain Monte Carlo (MCMC) method implemented in the BEAST v.1.74 package. The maximum clade credibility tree summarizing all of the trees obtained during the MCMC search showed a main clade supported by posterior probabilities of 1, corresponding to the Pyrenean chamois phylogenetic group. The chamois clade originated from sheep BDV and the time of the most recent common ancestor estimates for the chamois clade was 19 years ago, thus indicating its relatively recent emergence (mean estimate 1992). There were also some highly significant subclades among chamois sequences clustering three geographical areas in Pyrenees: Eastern area (Freser); Central area (Cadì, Cerdanya-Alt Urgell, Orlu) and Western area (Val d'Aran, Pallars Sobira, Aragon and Andorra). Our data suggest that Pyrenean chamois phylogenetic group originated from sheep BDV genotype 4, generating a founder effect due to intra-species spread and spatial dispersion, still going on such as Western direction.

LIFE COORNATA PROJECT RESULTS

THE GENUS *Rupicapra*: AN OVERVIEW

SESSION I – STATUS AND ECOLOGY OF CHAMOIS SUBSPECIES

SESSION II
THE ROLE OF REINTRODUCTIONS IN CHAMOIS CONSERVATION

SESSION III – THREATS AND CONSERVATION

Official Endorsement

Caprinae
Specialist Group

Reintroduction
Specialist Group

Partnership

Coordinating
Beneficiary

Associated Beneficiaries