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Original Investigation

Effects of livestock and non-native mouflon on use of high-elevation pastures by Alpine chamois

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ABSTRACT

Interspecific interference among livestock, native and non-native large herbivores is a key management and conservation issue, and little is known about its dynamics and implications. We investigated whether native Alpine chamois (*Rupicapra r. rupicapra*) modify their spatial distribution when non-native mouflon *Ovis orientalis musimon* and livestock (domestic sheep *Ovis aries*, and domestic goats *Capra hircus*) inhabit the same areas in the Alpine meadows of Italian Eastern Alps. We walked 5 hiking trails (5.0 ± 0.1 km) at dawn, twice a month during summers 2007 and 2008. During these surveys, we located each group of free-ranging ungulates (chamois, mouflon, and livestock). We also estimated the quality of meadows, finding that forage availability increased linearly as the distance from rocks (i.e., chamois refuges) increased. We predicted that the linear distance between chamois groups and rocks would depend on the co-presence of livestock and mouflon groups. Our results showed that chamois were more likely to be observed in areas with low food availability, but safer (i.e., closer to the rocks), whenever the nearest livestock group was larger and closer, especially if the shepherd's dog was present. Avoidance of the best feeding patches by the wild species is presumably due to spatial interference (e.g. visual and acoustic disturbance) and/or predation risk perception caused by the presence of shepherd's dogs. Similarly, the larger was the nearest group of mouflon, the closer to rocks was located the chamois group. Interestingly, mouflon group vicinity induced chamois to move closer to rocks only if mouflon rams were within the group. This suggests that physical displacement of the smaller species (i.e. chamois) is likely to occur to avoid direct disturbance of larger mouflon rams. Our study clearly showed how a native herbivorous species adjusts its spatial distribution and decreases the likelihood of using areas with higher food availability when livestock and/or a non-native species co-occur.

Introduction

Animals are expected to adjust their spatial use depending on resource requirements (MacArthur, 1972). Spatial use, however, can be influenced by interspecific interference (Putman, 1996), predation risk (Mysterud et al., 1999) and anthropogenic factors (Herrero et al., 1996). Interspecific interactions may lead to lower density or even to the complete displacement of one competitor from its preferred habitats (Gordon and Illius, 1989; Forsyth and Hickling, 1998; Latham, 1999). In regards to large herbivores, the study of interspecific interactions is particularly important if native ungulates coexist with non-native species or free-ranging livestock (Vázquez, 2002; La Morgia and Bassano, 2009). While native sympatric species commonly show a low degree of interaction, as a consequence of niche differentiation (Hartnett et al., 1997), the introduction of non-native wildlife species may drastically unbalance the structure of the herbivore community (Vázquez, 2002). The co-presence of domestic ungulates along with non-native ungulates leads to further complications, with obvious concerns for the conservation of native ungulates, possibly endangered by such cumulative effects.

Previous studies on the interaction between wildlife and livestock suggest that spatial segregation is likely to occur because of direct competition (e.g. Coe et al., 2001; Kie, 1996). Other studies clearly showed that diet overlap occurs between wild and domestic ruminants (e.g., Mysterud, 2000; Mussa et al., 2003). Free-ranging cattle (*Bos taurus*), domestic sheep (*Ovis aries*) and domestic goats (*Capra hircus*) within summer grazing areas can affect the spatial distribution of wild ungulates and modify their activity budgets

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and diet (Kie et al., 1991; Kie, 1996; Mattiello et al., 2002; Brown et al., 2010). Moreover, livestock, being often locally abundant and artificially kept at high densities by supplementary feeding, are potentially competitors for wild ungulates (Latham, 1999). In addition, the need to minimize endoparasite uptake from faeces may also play a role in driving spatial behaviour of wild ungulates (Fankhauser et al., 2008). The contest for space and food among competitors could have negative consequences on the population dynamics of native species (Forsyth and Hickling, 1998; Forsyth, 2000; Mishra et al., 2004), particularly in mountainous areas where ungulates face seasonal nutritional bottlenecks. For example, in autumn adult males of Alpine chamois (*Rupicapra r. rupicapra*) trade feeding activities for mating ones and fat reserves decline fast (Forsyth et al., 2005; Willisch and Ingold, 2007; Garel et al., 2011). Afterwards, winter rigours exert severe constraints on the survival of both male and female chamois (Bocci et al., 2010). Females, in particular, which have depleted fat reserves during harsh winters, may face high energetic demands for birth and lactation in spring (Oftedal, 1984). Thus, summer may be considered the most important season for food intake and consequent body growth, and the presence of livestock and non-native ungulates may affect the achievement of a good condition.

In regard to the alpine environment, it is still unknown whether Alpine chamois could have limited access to the best foraging sites as a consequence of the co-presence of non-native mouflon (*Ovis orientalis musimon*) and free-ranging livestock. The introduction of mouflon in the Alps began in 1962 and the Alpine population in Italy is now around 5500 individuals (in all the Alps about 16,500 individuals – Carnevali et al., 2009; Apollonio et al., 2010). So far, the effects of these introductions have been poorly investigated. Studies conducted in the Pyrenees suggested that Pyrenean chamois (*Rupicapra p. pyrenaica*) were displaced by the presence of non-native mouflon (Gonzalez, 1984, 1986). Similarly, a marked spatial segregation was recorded between Pyrenean chamois and livestock in Spain and France (Berdoucou, 1986; García-González et al., 1990) and between Cantabrian chamois (*Rupicapra pyrenaica parva*) and livestock in Spain (Rebollo et al., 1993). The present study investigates the interference of livestock and non-native mouflon on the spatial distribution of native Alpine chamois. We predicted that the access by Alpine chamois to the best summer foraging sites could be negatively affected by the presence of mouflon and livestock. We also predicted that the presence of shepherd's dogs guarding livestock could further enhance physical displacement, as a response to direct harassment and predation risk perception.

Material and methods

Study area

The study was conducted in a 45.5 km^2 wide area of the Southern slope of the Brenta Massif (46°05′ N; 10°50′ E), Trento Province, Central-Eastern Alps, Italy (Fig. 1). Elevation ranged from 950 to 2850 m a.s.l. (mean elevation 2005 m a.s.l). Observations were carried out in grassland meadows above the tree line (2000 m a.s.l., 12% rocks and 88% meadows), where blue moor grass (*Sesleria albicans*) and carnation grass (*Carex firma*) were dominant (Adamello Brenta Nature Park – official data). The extension of all meadow patches ($n = 69$) was 40.04 km^2, the mean patch size was 1.86 (SE, ±0.23) km^2 and the mean distance between near patches was 87 (SE, ±63) m. These areas were commonly used in summer by Alpine chamois (12 animals/km^2, estimated by block count censuses in early summer; Fig. 2), mouflon (introduced by hunting associations in the 1970s, 4.5 animals/km^2, estimated by block count censuses in early summer; Fig. 2), and large flocks of domestic sheep and domestic goats (variable number from year to

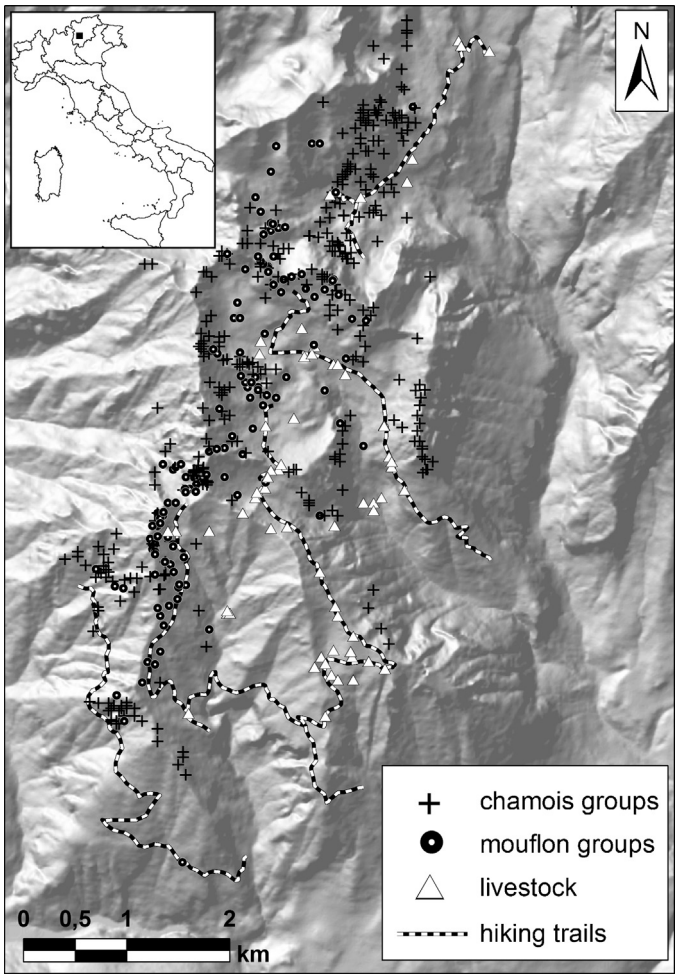

Fig. 1. Digital elevation model of the 45.50 km^2 wide study site of the Brenta Massif (46°05′ N; 10°50′ E), Eastern Italian Alps. Locations of ungulate groups (chamois, mouflon, livestock) observed from 5 hiking trails walked during summers 2007–2008 were reported on the map.

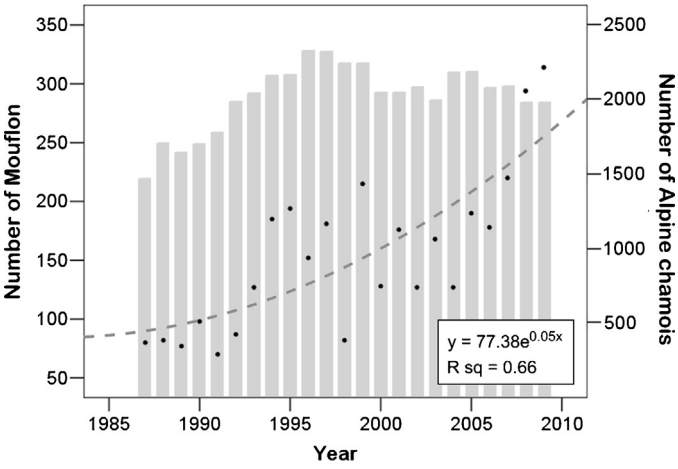

Fig. 2. Increase of mouflon population estimates (black dots, dotted regression line, regression equation and R^2) recorded from 1987 to 2009 for the 45.50 km^2 wide study site of the Brenta Massif, Eastern Italian Alps. Background grey bars represent Alpine chamois population estimates for the same period in the SE sector of the Brenta Massif. Population estimates were obtained with block count census for both species (Trento Province – official data).