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SPATIAL SEGREGATION AND SUMMER HABITAT USE BY ALPINE CHAMOIS (*RUPICAPRA RUPICAPRA*) AND MOUFLON (*OVIS ORIENTALIS MUSIMON*) IN THE DOLOMITI BELLUNESI NATIONAL PARK, ITALY

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ABSTRACT.– Studies were undertaken on the spatial overlap and habitat selection of the introduced Mouflon and the autochthon Chamois population in the Dolomiti Bellunesi National Park (Eastern Italian Alps). Mouflon distribution within the Park showed a marked seasonal shift from winter (December-May) range (400-800 m a. s. l.) to the summer (June-November) range (1600-1800 m a. s. l.). Consequently, significant overlap with Chamois occurred only in summer. Therefore, spatial overlap and habitat selection were studied in more detail in the summer range of Mouflon. The results showed that the areas most intensively used by the two species were distinct. Both species avoided areas with rock outcrops and dense forests, Mouflon used Pinus mugo *stands and scree much more than Chamois, and conversely Chamois used more alpine pastures and* Larix decidua *stands. The results therefore indicate that Chamois and Mouflon segregate spatially and use different resources.*

RÉSUMÉ.– Nous avons étudié la superposition spatiale et la sélection de l'habitat des populations de mouflons introduits et de chamois autochtones du Parc National des Dolomites Bellunesi (Alpes italiennes orientales). La distribution du mouflon dans le parc change clairement d'une saison à l'autre (en hiver : décembre-mai, entre 400-800 m d'altitude ; en été : juin-novembre, entre 1600-1800 m d'altitude). Par conséquent, la population se superpose avec celle du chamois seulement en été. Nous avons alors étudié la distribution estivale du mouflon à une échelle plus fine. Nous avons pu montrer que les territoires les plus utilisés par chacune des deux espèces étaient séparés. Les deux espèces évitaient les terrains avec des escarpements ou blocs rocheux et les forêts denses, toutefois le mouflon utilisait les bosquets de Pinus mugo *et les éboulis beaucoup plus fréquemment que le chamois; ce dernier au contraire cherchait plus les pâturages alpins et les forêts de* Larix decidua. *En conclusion, nous observons une ségrégation spatiale des populations de chamois et de mouflons, de plus, elles utilisaient des ressources différentes.*

RESUMEN.– En el Parque Nacional "Dolomiti Bellunesi" (Este de los Alpes italianos) se estudió el solapamiento espacial y la selección de hábitat entre el muflón (introducido) y la población autóctona de rebeco. La distribución del muflón en el Parque mostró una marcada estacionalidad: con un rango de 400 a 800 m de diciembre a mayo y de 1600 a 1800 de junio a noviembre. Solo existe solapamiento significativo con los rebecos en verano, por lo que el estudio en profundidad de la selección y solapamiento de hábitat del muflón se realizó durante esos meses. Los resultados mostraron una segregación entre las áreas más intensivamente usadas por las dos especies. Aunque ambas especies evitan zonas de afloramientos rocosos y bosque denso, el muflón usa las pedrizas y bosquetes de Pinus mugo *más intensamente que el rebeco. Inversamente, el rebeco usa más pastos alpinos y bosquetes de* Larix decidua. *Por lo tanto, el rebeco y el muflón se segregan espacialmente y usan distintos recursos.*

Key-words: Chamois, Mouflon, spatial segregation, habitat use, Italian Alps.

1. Introduction

Mouflon *Ovis orientalis musimon* has been recently introduced in various areas throughout the Alps, mainly for hunting purposes (CUGNASSE & HOUSSIN, 1993; PEDROTTI *et al.*, 2001). Spatial overlap with Alpine chamois *Rupicapra rupicapra* may occur, and the possibility of interspecific spatial and trophic competition has been suggested (PFEFFER & SETTIMO, 1973). When the Dolomiti Bellunesi National Park (DBNP) was established in 1992, in the area there was an introduced nucleus of Mouflon. Therefore, a major objective of the monitoring of ungulates within the park was to assess the potential for competition between Mouflon and the autochthon Chamois. The objectives of the study were (1) to investigate the spatial overlap and (2) the summer habitat use of the two species. To this purpose, first we assess the seasonal distribution of mouflon and then we analyse, within the area of potential seasonal overlap, the distribution of the two species at a finer scale; comparisons of habitat use between the two species are also presented to support inferences from spatial overlap analysis.

2. Methods

Study area

The Dolomiti Bellunesi National Park (32 km^2) lies at the southern edge of the Alpine region, in the Eastern Italian Alps. The area is mountainous,

with steep slopes that rise from the bottom of the surrounding valleys (400-600 m a. s. l.) to the high plateaux (1800-2200 m a. s. l.) and Dolomite peaks (up to 2500 m) in the central part of the Park. Slopes are extensively covered by forests (mostly, with increasing elevation, *Ostrya carpinifolia*, *Fagus sylvatica* and *Picea abies*), while the high plateaux maintain large areas of alpine pastures, interspersed with rock outcrops, scree, larch *Larix decidua* and *Pinus mugo* stands. Annual average precipitation is >1500 mm and snow usually covers the high plateaux from November-December to May. At the lowest elevations, snow cover may last occasionally for a few days in winter. The chamois is widespread, although with variable densities, through the study area. Due to barriers (the valleys surrounding the park), exchange of individuals with surrounding areas is limited. The mouflon was introduced in the early 70's, and it is completely isolated from other populations. The maximum estimated size of the nucleus is close to 300 head, with an annual average increase (1995-2001) of approximately 3-4% (RAMANZIN, unpublished data).

Seasonal distribution

Data on mouflon distribution were obtained from the "species distribution monitoring project" of the park (RAMANZIN & APOLLONIO, 1998). According to this project, the forest service personnel recorded location, elevation (m a. s. l.) and number of individuals of each group of chamois and mouflon observed through the park during their field duties. The trails and routes used are well distributed across the different areas (and habitats) of the park and, though sampling effort could not be standardised for all the habitats, we assume that data collected can produce an estimate of spatial distribution of Mouflon and be used to compare seasonal use of different elevations by the two species.

The scale of analysis of Mouflon distribution was based on a 100 ha grid (UTM, fuse 33); Grid cells where Mouflon was detected were separated for summer (June-November), winter (January-April), and an "intermediate" period (December and May).

Within the total grid cells used by Mouflon, elevation data of each sighting of both species were pooled bimonthly in 4 elevation classes (<900 m, 900-1300 m, 1300-1700 m, >1700 m); bimonthly proportional distributions of Chamois and Mouflon within the elevation classes were compared with the χ^2 test. Data used were collected from 1997 to 1999, for a total of 5336 groups of chamois and 2390 groups of mouflon.

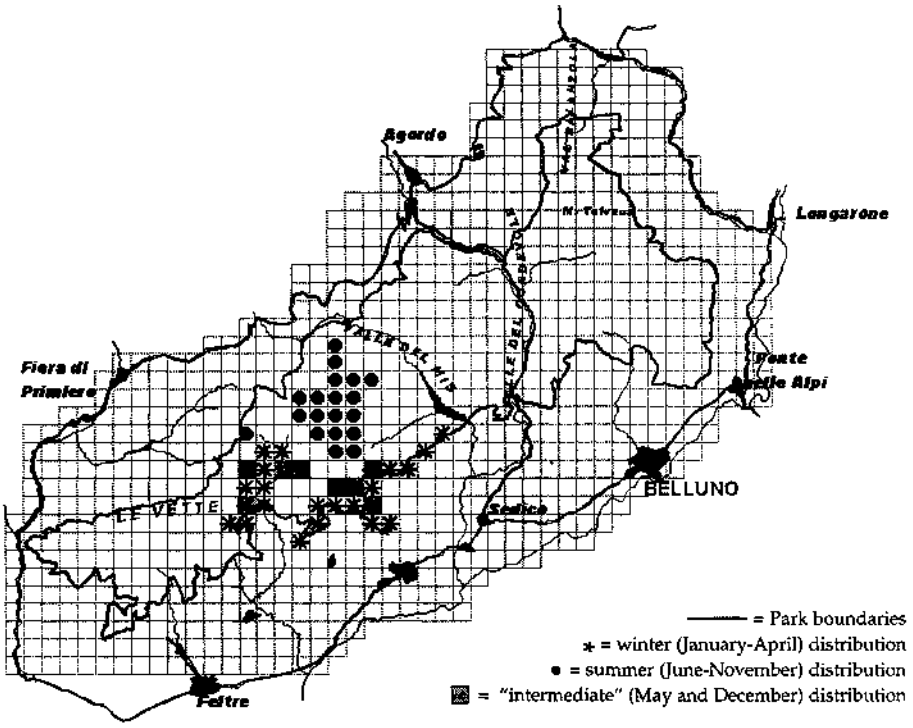

Figure 1. Study area and distribution of mouflon within the park.

Summer spatial overlap and habitat use

Based on the results of the seasonal distribution estimation, a study area (size: 2425 ha; elevation range: 1700-2300 m) covering the summer distribution of mouflon was identified (Figure 2). Eight transects (average length: 3.9 km, minimum: 1.1 km; maximum: 7.4, total: 28.6 km) were chosen in order to sample the various land cover types of the area (Figure 2). Six habitat types were mapped, taking into account the degree of openness and vegetation type: rock outcrops, scree, alpine pastures, *Pinus mugo* stands, *Larix decidua* stands and *Picea abies* and *Fagus sativa* stands. These habitat types are easily discernible from visual observation. To facilitate location and recording of observations, a 250 x 250 m grid (UTM fuse 33) covering the area was printed over maps (1:5.000) of the transects used for field surveys. During June-November 1997-1999 the transects were walked approximately 3 times each month (298 in total), at different hours of the day. A total of 824 groups of

chamois and 487 groups of mouflon were observed. Number of animals observed, habitat type and location within the grid (expressed as the UTM coordinates of the cell center) were recorded for each group. Because the individuals within a group are not independent, each sighting of a group was considered as a single observation for subsequent analysis. To standardise sampling effort, numbers of observations/cell from each transect were divided by the number of the transect's replications within periods (May-June, July-August, September-November).

Figure 2. Study area within the summer distribution of mouflon. The grid coverage, habitat types and transects (lines with different styles) are shown.

A simple estimation of spatial overlap between chamois and mouflon was obtained as the number of cells containing both species in the total number of cells occupied. A spatial estimate of areas with different intensities of use by the two species was obtained with the Animal Movement ArcView extension (HOOGE & EICHENLAUB, 1997), using the Kernel option (WORTON, 1989)

with 95%, 80% and 60% probabilities for each species, year and period, respectively. Using a probability contours approach, instead than a comparison of locations number/cell, allowed for a spatially based comparison. Spatial overlaps of areas with different intensities of use by chamois and mouflon were estimated as the percent area overlaps of the probability contours. Areas (ha) and percent overlaps of probability distributions were analysed through a one-way analysis of variance (ANOVA; SAS, 1989).

To investigate habitat use all the observations of each species were pooled across years and periods. The number of groups of mouflon observed in each habitat type was compared (χ^2 test) with an expected number calculated on the basis of the proportional distribution of chamois groups in each habitat type.

3. Results

Seasonal distribution

Mouflon used two distinct seasonal ranges (Figure 1). In summer, the mouflons concentrated within a high elevation area at the centre of the park, while in winter and early spring they moved to lower elevations spreading along the slopes and the bottoms of the valleys. From January to April, the elevation ranges used differed greatly between the two species (January-February: d.f. = 3, $\chi^2 = 1685.8$, $P < 0.001$; March-April: d.f. = 3, $\chi^2 = 6587.9$, $P < 0.001$), with approximately 80% of mouflon sightings occurring below 1300 m and, conversely, 80% of chamois sightings above 1300 m (Table 1). In the other periods, there were no differences in the estimated use of elevation classes (May-June: d.f. = 3, $\chi^2 = 2.25$, $P > 0.05$; July-August: d.f. = 3, $\chi^2 = 3.25$, $P > 0.05$; September-October: d.f. = 3, $\chi^2 = 3.15$, $P > 0.05$; November-December: d.f. = 3, $\chi^2 = 0.73$, $P > 0.05$) and both species strongly selected high elevations, with approximately 90% of observations above 1700 m.

Table 1: Bimonthly distribution (% of total observations) of chamois and mouflon in the different elevation classes.

	Chamois						*Mouflon*					
	Jan-Feb	*Mar-Apr*	*May-June*	*Jul-Aug*	*Sept-Oct*	*Nov-Dec*	*Jan-Feb*	*Mar-Apr*	*May-June*	*Jul-Aug*	*Sept-Oct*	*Nov-Dec*
<900	1.0	0.9	1.3	1.3	1.4	3.6	41.2	78.5	0.6	0.0	0.0	3.4
900-1300	21.8	4.9	0.3	0.4	0.8	5.6	42.1	6.7	0.9	0.0	0.4	6.1
1300-1700	32.2	8.8	5.6	6.0	5.0	10.2	16.7	1.0	8.0	9.1	2.4	7.7
>1700	45.0	85.4	92.8	92.3	92.8	80.6	0.0	13.8	90.5	90.9	97.2	82.8
Observations	400	759	863	1213	1532	638	102	209	801	549	468	261

Summer distribution and spatial overlap

Chamois were detected in 153 cells and mouflon in 106 cells of the 388 sampled. This leads to an estimated total range of 938 ha and 663 ha, respectively. Both species were observed in 86 of the 170 cells occupied by at least one species (51% overlap).

The estimated surfaces of probability contours were significantly influenced (see Table 2 for statistics) by probability contours (as obvious), species and period. The surface of the 60% probability distribution for both species averaged approximately 15-20% of that estimated with the 95% probability (Table 3). This implies a three-fourfold increase in locations/surface, i.e. in intensity of use. Mouflon used smaller areas than chamois (Table 3). On average, distribution estimates were smaller in May-June and especially in October-November than in July-August (Table 3), but this was mainly due to the changes of mouflon distribution (the interaction species by period was very close to statistical significance; see Table 2 for statistics).

Table 2. Analysis of variance of the estimated area (ha) and overlap (% of area) of the probability distributions of the two species in the summer range of mouflon.

	Area (ha) of probability distributions				*Distribution overlap (%)*		
	D.F.	*Mean Square*	*F*	*P*	*Mean Square*	*F*	*P*
Intensity of use (IU)	2	787756	67.6	<0.001	3503.01	18.7	<0.001
Period (P)	2	120673	10.4	<0.001	1496.13	8.0	<0.01
Species (SP)	1	116091	10.0	<0.01	450.05	2.4	0.129
P by IU	4	20732	1.8	0.156	178.64	0.8	0.444
P by SP	2	29388	2.2	0.095	106.03	0.6	0.572
SP by IU	2	35617	3.1	0.060	190.63	1.0	0.371
Error	36	11659			186.71		

In accord with the above presented cell-based comparison, there was a partial spatial overlap (varying from 34 to 48%) between the two species for the 95% probability distributions (Table 3), but with increasing intensity of use spatial overlap declined to less than 10%. Spatial overlap was lower in september-November than in the other periods.

Table 3. Effect (least square mean) of intensity of use (probability contours), species of use and period on estimated range area (ha) and overlap (% area) of chamois and mouflon in the summer range.

	Intensity of use (probability contours)						*Period*					
	Chamois			*Mouflon*			*Chamois*			*Mouflon*		
	95	80	60	95	80	60	*May-June*	*July-Aug*	*Sept-Nov*	*May-June*	*Jul-Aug*	*Sept-Nov*
Area (ha)	672	288	157	466	259	93	306	428	385	196	413	209
Overlap (% of area)	47.6	24.2	12.4	33.6	23.3	8.6	32.9	32.7	18.7	22.6	32.2	10.7

Summer habitat use

Comparisons between the habitat types should be taken with caution because of unequal visibility within different habitats. Therefore, no estimates of habitat selection were attempted. Instead, since visibility of both species can be assumed to be similar within a given habitat, we compared habitat use between chamois and mouflon. Use of the different habitats differed significantly between the two species (d. f. = 5, $\chi^2 = 79.6$, $P < 0.001$). Both chamois and mouflon were seldom observed in rock outcrops and almost never detected in *Picea abies* and *Fagus sylvatica* forests (Figure 3). Mouflon used *Pinus mugo* stands and scree much more than chamois, which conversely used alpine pastures and *Larix decidua* stands remarkably more than mouflon.

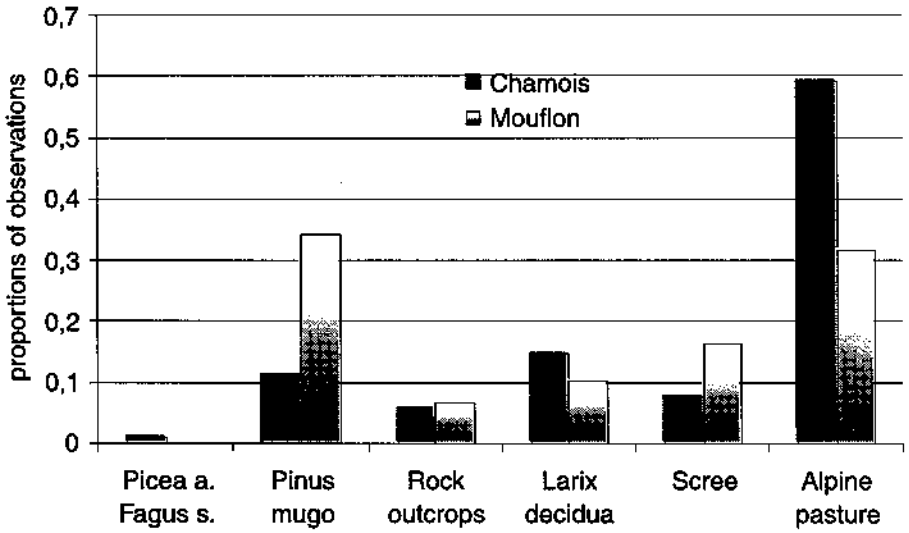

Figure 3. Habitat use of chamois and mouflon within the summer range of mouflon.

4. Discussion

Seasonal distribution

The marked seasonal elevation shifts shown by mouflon in this study agree with what reported by PFEFFER & GENEST (1969) and PFEFFER & SETTIMO (1973). The reason why mouflon migrate from the high plateaux to the lower slopes and valleys bottoms during winter is most probably linked

to thick snow avoidance. We have observed, in coincidence with early snowfalls, sudden collective displacements towards lower elevations. According to Office National de la Chasse (1993), the species is poorly adapted to snow, so that locomotion and feeding become very difficult when the snow depth exceeds 30-50 cm. Other reasons for choosing lower elevations during winter might be the availability of better quality browse from deciduous, rather than coniferous, shrubs and trees, and the earlier start of vegetation growth in late winter and spring. In addition, parturition starts in March and peaks in April; in this period females may find better climatic conditions and food offer at lower elevations.

In any case, it is clear that in late winter and early spring mouflon and chamois are spatially segregated. Therefore, spatial overlap and habitat use were investigated in the summer range of mouflon.

Distribution, spatial overlap and habitat use during summer

The smaller estimated distributions of mouflon at the beginning and ending of summer can be explained by different factors. In May-June, the migration to the summer range is not completed, and migration to winter ranges may start in late October; therefore the areas used in these periods might be smaller. In addition, the September-November period coincides with the rut season of mouflon, and the contraction of distribution could be explained by a concentration of both sexes in the same areas.

The analysis of the seasonal distribution of mouflon within the DBNP was based on a 1 x 1 km grid and estimated an area of spatial overlap with chamois during summer (may-november). Within this summer range of mouflon, a finer scale of analysis (250 x 250 m grid) and a spatial density approach showed that, although overlapping at the 1 x 1 Km scale, chamois and mouflon were spatially separated when areas of increasing intensity of use by the two species were compared. During September-November, when the surface of estimated distribution of mouflon decreased, this segregation increased. Therefore, there was evidence of a tendency for spatial segregation between chamois and mouflon. This finding seems consistent with the hypothesis of mutual avoidance between the two species, that has been forwarded by PFEFFER & SETTIMO (1973) and GONZALEZ (1985), but the interpretation of this result remains speculative because no direct inferences can be supported by our data.

A spatial segregation could arise from mutual avoidance, but also from different preferences amongst the available resources. Although we did not address differences in habitat preferences, our results indicate that mouflon

and chamois are able to use different resources. Chamois concentrated on alpine pastures (60% of total use) that were less used by mouflon (30% of total use); chamois were seldom detected in *Pinus mugo* stands (10% of total use), that were apparently an important resource for mouflon (35% of total use). It is also interesting that both species seem to avoid rock outcrops and dense forests (although the use of this latter may be underestimated due to lower visibility, values are so low that the indication of avoidance is clear). Similar results have been reported for mouflon by CRANSAC & HEWISON (1997).

In conclusion, the results obtained in this study indicate that in the DBNP the habitat requirements of chamois and mouflon differ during winter, and this leads to spatial segregation. Spatial overlap might occur in summer, but also in this period the areas most intensively used by mouflon remain separated from those most intensively used by chamois. In addition, habitats used differ between the two species. Therefore, spatial segregation could be due to a different selection of resources, and not, or at least not only, to mutual avoidance. Although the occurrence of interspecific competition in ungulates communities is very difficult to demonstrate (PUTMAN, 1996), the knowledge of spatial overlap and resource use is in fact essential for interpreting possible long term changes of the two species, and clearly to suggest mechanisms for interpreting the possible outcome of competition.

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