ANALYSIS OF FOOD HABIT OF CHAMOIS USING GIS

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Abstract
The study aims to define the impact produced by this wild ungulate on the vegetation and the attractiveness of some vegetal species. The investigated area, 110 ha at an height between 1695 m and 2150 m a.s.l., is located within the Natural Park "Paneveggio - Pale di San Martino". On the basis of the results of the data elaboration concerning the alimentary habits of the chamois, 6 vegetation species have been chosen because of their being appetizing for the ungulate during the whole year (*Rhododendrum ferrugineum*, *Calamagrostis villosa* and *Vaccinium myrtillus*) or during some periods (*Nardus stricta* in autumn) or because generally not used (*Deschampsia caespitosa* and *Festuca varia*). The abundance percentage of these species has been calculated with geostatical methods (regularized spline with tension), using GIS GRASS, beginning from the data of the survey (88 points localised with GPS). The maps of the single species obtained with such a method have been compared using the preference index of Jacobs (1974), with the locations (about 5000) of the ungulate indicated as a total and also divided for season, in order to understand if chamois look for or avoid the different species. These locations were carried out from December 1998 till November 1999 in a parallel study with radiocollars on nineteen females (ages 1-13 years) tagged with plastic ear-tags. Radio and visual locations were made throughout the year, 5-6 times a week for each animal. For each species, according to the distribution of abundance, categories with different range have been identified, so that each category includes at least 4 % of the whole study area.

Introduction
Various methods of investigating feeding selection of chamois have been proposed, and their advantages and disadvantages are reviewed by Perle and Hamr (1985). The method used in this study, based on field observations, is time consuming but it allows the investigator to obtain good indications of plant species used or avoided in areas inhabited by chamois (Dunant, 1977).
Although the individual plant species selected by the ungulate are well-known, precise information on plant communities within chamois habitat are lacking. Most authors use broad, generic definitions for vegetation type (e.g., grassland, meadows, forest zone, etc.) found in chamois habitat (Homolka and Matous, 1999, Durand, 2000). Studies on habitat selection for food are usually based on overlapping maps of chamois home range with these generic type vegetation maps. In this study we analysed plant selection based on the overlap of abundance maps of single plant species and female chamois localizations. Maps of single species and not vegetation maps were used, so that the resulting data are more clearly linked with active searching of specific plant species.

Study area
The study area is located in the Natural Park of "Paneveggio e Pale di San Martino" (11°40' - 12°00' E; 46°10' - 46°30' N), situated in the eastern part of Trentino-Alto Adige, North Italy. This area (110.6 ha; 1695-2149 m a.s.l.) was selected to coincide with a parallel study with radiocollared female chamois (Fasoli et al., 2001). The sex ratio of the population is clearly biased towards females (0.38 male:female). The climate is continental pre-alpine (Gafta and Pedrotti, 1998).

The average annual temperature is 2.7 °C and the annual rainfall 1100 mm. During the two years of study the temperature was above average, particularly in the year 2000 (4.1 °C), with spring and summer much warmer than the average (Figure 1). Rainfall values are generally lower in summer and higher in autumn. In 1999, rain was abundant in September and October, while in 2000 it was concentrated in the month of November, with very high values (400 mm vs. the 40-year average of 85 mm, Figure 1).

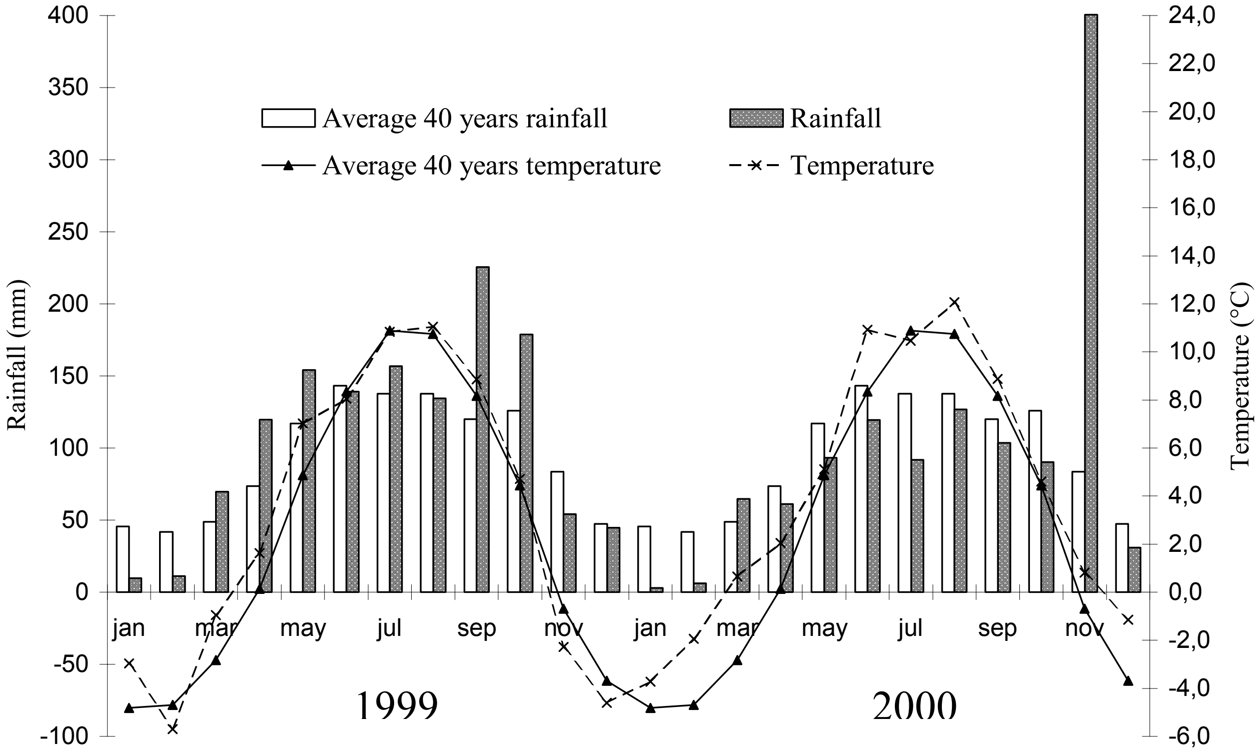

Figure 1 – Climate of study area

Methods

88 floristic surveys were carried out during the years 1999-2001, following a modification of the method proposed by Braun-Blanquet (Westoff and van der Mareel, 1978), where the percentage abundance of each species was noted for each relevé. The area of each survey was 100 m². In the case of forest surveys, the vegetation cover was divided in three strata: herbaceous, shrub-like and arboreous. The survey locations were recorded using a GPS (Trimble Geoexplorer 3), with differential correction of points, using the base station at Trento. 203 plant species were found and classified. In order to identify the species most appetising to the chamois, 66 direct observations of feeding by chamois were carried out. Based on these results, six species were identified because of their strongly positive selection by chamois during the whole year (*Rhododendrum ferrugineum, Calamagrostis villosa* and *Vaccinium myrtillus*), during some periods (*Nardus stricta* in autumn), or rarely (*Deschampsia caespitosa* and *Festuca varia*). The percentage abundance of these species was calculated using the geostatical method of regularized smoothing spline. This is a radial basis function method for interpolation from scattered data, similar to a flexible curvilinear function, and was used to produce a curve to join a series of points. The GIS GRASS module s.surf.rst was used with the tension parameter set to 40 and the smooth parameter set to 0.2. The minimum number of points for interpolation was fixed to 10, and the distance under which two points were considered too close was set to 5 metres. An example of a single species map can be seen in figure 2 where the distribution of *Festuca varia* is reported.

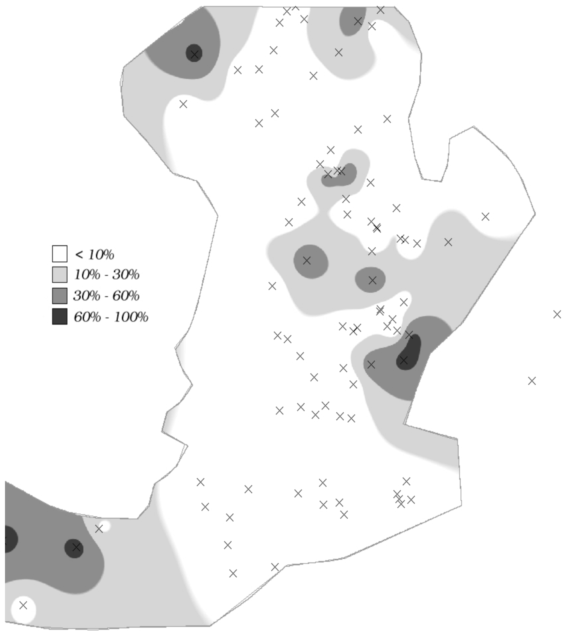

Figure 2 – Distribution of Festuca varia

A three steps procedure was followed to find the relationship between plant species and chamois movements. The first step was the overlapping of chamois localizations onto single species distribution maps. To localize chamois were used all the 5000 localization data obtained from the telemetry study, which were then divided by season, in order to determine whether chamois search for or avoid different species. The calculation of the used portion of each single species (P_u) was obtained using GIS GRASS modules r.mask and r.report. The second step was the computation of the percentage covered by different abundance categories of each single vegetal species (P_d). The third step was the selection of the areas by the preference index of Jacobs (1974), which correspond to the following formula:

$$I = \frac{P_u - P_d}{(P_u + P_d) + 2P_u P_d} \qquad [1]$$

where Pu is the used portion and Pd is the available portion. The index I varies between –1 and +1. A positive value indicates that the species is grazed more than the availability while a negative value indicates an underutilisation. A value equal to zero means that the species is utilized as much as available (coincident proportion). This three steps procedure takes to subdivide into three categories the species: environments chosen by the female chamois, indifferent environments, and environments avoided.

In the first category *Rhododendrum ferrugineum* and *Festuca varia* are included. Rhododendron cover is less than 7% over 63% of the study area and covers more than 18% in just 10% of the study area. During the entire year the chamois actively choose the areas where rhododendron is present more than 18% and avoid those areas where this species is low in abundance. Such selection is more obvious in summer. In summer and in autumn the ungulates were often located in areas where rhododendron cover is 14-18%, which they usually avoid in the other months (Figure 3).

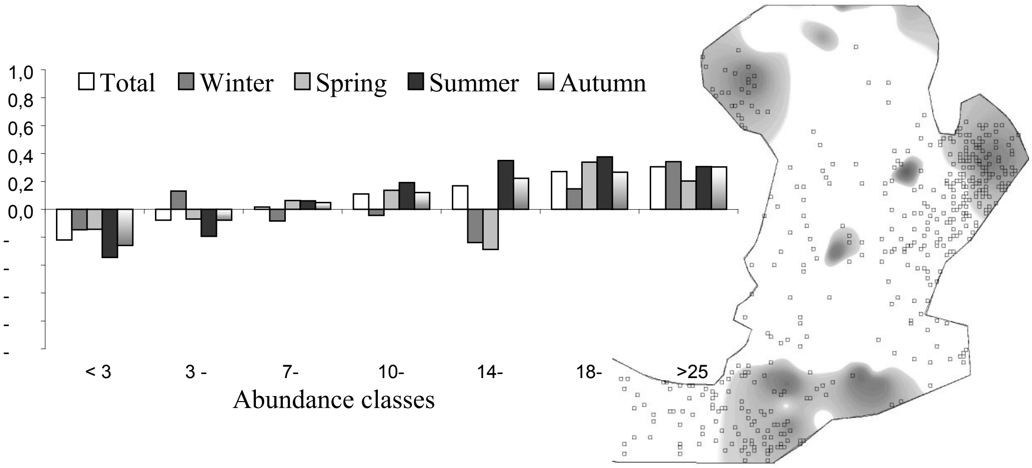

Figure 3 – Jacobs index for Rhododendrum ferrugineum and summer localizations of chamois overlaid on rhododendron map.

The selection of areas dominated by *Festuca varia* is almost certainly not correlated with the feeding on these grasses, since they constitute a minor component of the diet (grazing was only observed in two of these sites). In the study area F. varia coverage is 20%, with 18% being high abundance areas. During most of the year, but particularly in spring, chamois choose, areas with an abundance of fescue. These areas are probably selected because chamois prefer, steep and sunny slopes (von Elsener-Schack, 1985) which happen to be favourable habitats for variegated fescue.
The indifferent environments category includes *Nardus stricta* and *Calamagrostis villosa*. Mat grass is distributed across the study area representing the characteristic species of many botanical associations. In 32% of the area the species has coverings greater than 20% and only in some small areas it occurs with low abundance. The female chamois avoids the zones with a low presence of these grasses, in the winter and spring months overall it uses areas with intermediate abundance of mat-grass (Figure 4).

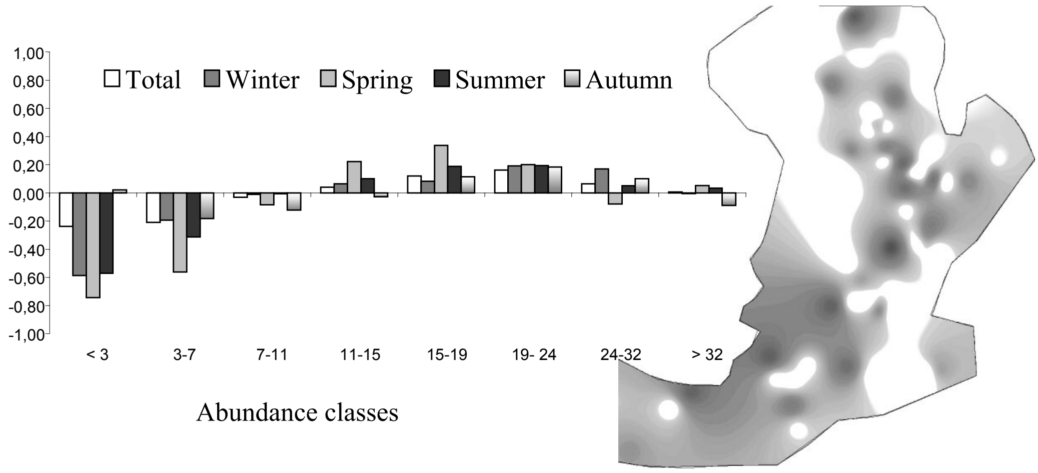

Figure 4 – Jacobs index for Nardus stricta and nardus map.

This selection is not correlated with a true searching of the species, but derives from the fact that the zones with a low concentration of mat-grass are located inside *Pino mugo* associations where the ungulate rarely passes or stops. From the observations of grazing it has emerged that the ungulate used the mat-grass in autumn, but this result was not confirmed by the present analysis.
Calamagrostis villosa, is a typical species of the larch forest and its distribution is highly correlated with that of larch. Therefore, this species is present in most of the area (in 73% of the territory the

abundance is less than 6%) and concentrated in quite precise zones. The chamois avoids the areas with a high presence of these grasses, which correspond to the denser part of larch forest, especially in the summer months when the ungulate moves to higher altitude habitat. A reasonable utilisation of the areas with 6-10% reed-bent grass in spring is probably connected with the shelter given by the larch forest to the females with yearlings.

Environments avoided include *Vaccinium myrtillus* and *Deschampsia caespitosa*. *Vaccinium myrtillus* is rare throughout the study area and entirely absent in one half. The species is present in only about 20% of the territory with an abundance higher than 5%. From the analysis of the grazing data it emerged that this species was frequently used by the chamois. For this reason we have tried to verify if the ungulate actively searches for these plant species. The indications are that areas with a greater presence of shrubs are avoided (Figure 5), while a preference is shown for those with low presence of the dwarf bilberry. Such selection is much more obvious in spring, when the chamois searches for different food sources, such as herbaceous plant shoots. The grazing of this shrub is limited to cases in which there are no other more appetising species available.

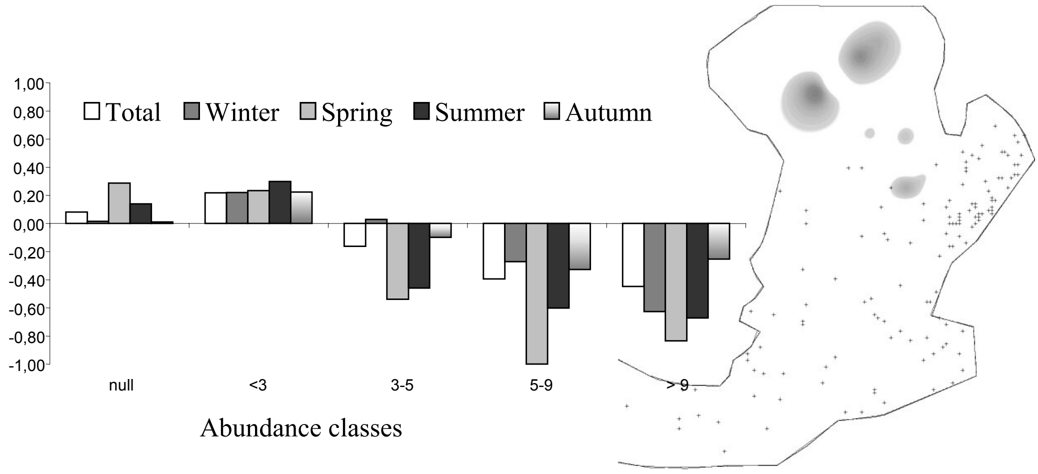

Figure 5 – Jacobs index for Vaccinium myrtillus and spring localizations of chamois overlaid on bilberry map.

Deschampsia caespitosa occupies precisely defined areas in the degraded zone of mat-grass association. The grasses form dense tufts which are not appetising for any animal. However, the young shoots and other growth is palatable. In 16% of the area it is present in considerable abundance (>15%), while it is absent in 20% of the surveys. For this species we found an excellent correspondence with chamois localization data. However, chamois avoid areas with high Deschampsia abundance and it is instead located in those areas where the species is present in low abundance. This avoidance occurs throughout the year, but is less obvious in spring perhaps because the ungulate is forced into such associations by the search for palatable species and for young grasses.

Conclusion

A specific factor of this work is the utilization of statistic modules of a GIS to define the vegetal species selected by the ungulate. This definition is also confirmed by the in field observation of chamois grazing. The chamois in the study area present a selector behaviour especially in spring and summer while in autumn and winter months they use particularly shrubs. The adopted system of analysis presents some problems, first because the chamois are not very selective for plant species (Ferrari and Rossi, 1985) and therefore it rarely moves to search for food. A second problem concerns the dataset used, that included all the localisation of the chamois without distinguishing those in which the animal actually grazed. A successive analysis of the data using only such observations would be useful. Despite these negative aspects we maintain that this methodology is suitable for obtaining clearer information on the feeding selection of chamois.

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