

# Evaluation of wild animals browsing preferences in forage resources

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## Abstract

Excessive presence of wild ungulates can produce negative effects on herbaceous crops or woody species, and to face this problem, habitat improvements are often performed to recreate suitable environments for a given animal species and to attract animals far from cultivated crops. A common example of these interventions is represented by grassland restoration and to evaluate the real animal preferences on restored forage resources a proper trial was established in a hilly area of Tuscany (central Italy), inside the historical Park of Pratolino, near Florence. The trial compared six different forage species or mixtures sown in plots: vegetal material was represented by two pure stands (*Onobrychis viciifolia* and *Medicago sativa*) and four mixtures differing in number and kind of used species. Plots were utilised only by wild animals occurring in the area. Data collection consisted of botanical samples in each plot in different periods to obtain the percent presence of each species. At the same time, a visual estimation of animal intake on all occurring species was performed to obtain the browsing ratio of single species and overall defoliation rate for each species/mixture. Moreover, six camera traps were placed on the boundary of the experimental site to record videos of wild animals browsing in the area for identification of animals actually occurring on different plots and for com-

parison of these results with botanical data. Vegetation surveys permitted a proper evaluation of animals intake and of their feeding preferences. In general, sown species performed a major role in animal browsing, even if in some periods also a few native species (such as *Plantago lanceolata* or *Cichorium intybus*) were utilised in a strong way, depending on vegetation context and existing biomass. Camera traps results permitted the identification of browsing animal species (mainly represented by roe deer) and plots frequentation resulted to be highly related to animal intake found by botanical relevés.

## Introduction

Management of agroforestry resources is sometimes difficult in many rural areas due to the high presence of wild animals (Fratini *et al.*, 2016), as their excessive presence can produce negative effects on agriculture or forest products (Innocenti *et al.*, 2015; Kamler and Homolka, 2016). Damage is caused on different kinds of crops, such as annual herbaceous crops or vineyards (Calenge *et al.*, 2004; Bleier *et al.*, 2016) or on forests, especially taking into account the difficulty of trees regeneration or growth (Gill and Beardall, 2001; Côté *et al.*, 2004). To face this situation, habitat improvements are often performed to recreate suitable environments for animal species and to reduce damage in cultivated crops or natural resources (Ponzetta *et al.*, 2010). A common example of these interventions is represented by grassland restoration (Genghini and Capizzi, 2005), performed as a consequence of changed technical and economic conditions in many hilly and mountainous areas (Giustini *et al.*, 2007) that produced the decline of extensive grazing activity or pastoral practices (Argenti *et al.*, 2011), with remarkable effects on productivity, forage quality e diversity of herbaceous coenoses (Targetti *et al.*, 2013; Freschi *et al.*, 2015; Pittarello *et al.*, 2016). Grassland restoration is performed by clearing shrubs and trees encroaching pastures or meadows once highly utilised and this operation is often followed by a sowing of a proper forage mixture apt to local environmental conditions (Di Tomaso *et al.*, 2010). Aims of this technique are to recreate areas useful for wild animals feeding (Cervasio *et al.*, 2016) and to recover other important ecosystem services related to open areas, such as landscape heterogeneity or ecological diversity (Laiolo *et al.*, 2004; McAllister *et al.*, 2014; Rossetti *et al.*, 2015). Open areas can be maintained for a long time only utilising proper restoration strategies and maintenance techniques (Alday *et al.*, 2012). Thus, it is of a great importance to propose methods and parameters to monitor effects of restoration and evolution along time (Cervasio *et al.*, 2016). This is particularly true when target animals are wild species that can have a very different feeding behaviour from domestic ones (Gonzalez-Hernandez and Silva-Pando, 1996; Vavra and Ganskopp, 1998). For these reasons

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it is necessary to investigate wild animals browsing activity that can affect vegetation evolution in a remarkable way (Höft *et al.*, 2010) and this is important also for conservation purposes (Nagaike, 2012). Methods to analyse animals feeding selection are mainly derived from direct observation of animal grazing or from assessment of damage or intake on single species (Iussig *et al.*, 2015). An interesting information can be also derived from new technologies used in wild animals assessment, such as those represented by camera traps (Sorbeti *et al.*, 2012). Main objectives of the present research are the following: i) to assess wild animals feeding preferences on sown forage resources; ii) to evaluate different methods for monitoring of animal intake (vegetation survey and camera traps).

## Materials and methods

The research was carried out inside the *Parco Mediceo di Pratolino*, a historical park of about 155 ha, mainly composed by woods and by nearly 30 ha of open grassland areas, located approximately 15 km north from Florence (Tuscany, central Italy). The area is situated at an altitude of 415 m a.s.l. with an average annual temperature of 14.6°C and an average rainfall of 912 mm, and it is characterised mainly by presence of clay soil. The whole area is completely fenced and no domestic animal is present, thus the browsing data obtained by the study can be attributed to the wild animals present inside the park.

The trial was established on April 16<sup>th</sup> 2015 by sowing of six different forage single species or mixtures in plots (5x3.5 m wide) arranged in a completely randomised block design with three repli-

cations. Tested vegetal material included two pure stands, such as sainfoin (*Onobrychis viciifolia*, number 1) and lucerne (*Medicago sativa*, number 2) and four different forage mixtures represented by commercial or specific mixtures for faunistic purposes (numbers from 3 to 6). Mixtures comprised mainly legumes and grasses usually utilised for grassland establishment but in some cases also other herbaceous species, generally not commonly employed for these aims, are present (Table 1). Analysis of plots was performed since their complete establishment until summer 2016 in order to have a complete year of evaluation. Assessment comprised both botanical analysis (by means of five samplings in different dates, in order to investigate variations among different seasons) and animal presence in the experimental area. Botanical composition was assessed by means of a vertical point-quadrat transect 5 m long placed on the diagonal of each plot, according to Daget and Poissonet method (1971). Along each transect, at every 20 cm interval, each species touching a steel needle was recorded and in this way specific frequency (SF<sub>i</sub>) of a given species was obtained, *i.e.* the number of the occurrences of that species along the line (Iussig *et al.*, 2015). After that, species relative abundance (SRA<sub>i</sub>) was calculated for a given species by the following formula (Argenti and Lombardi, 2012):

$$SRA_i = \frac{SF_i}{\sum SF_i} \times 100$$

in order to obtain the percentage presence of each species inside the plots (Probo *et al.*, 2013).

**Table 1. Vegetal material tested in the trial: pure stands (n. 1 and 2) and mixtures with different species in their composition (n. from 3 to 6).**

Species	Pure stand/mixtures					
	1 Sainfoin	2 Lucerne	3 Commercial mixture	4 Specific wildlife mixture	5 Specific roe deer mixture	6 Pollinator mixture
<i>Onobrychis viciifolia</i>	X		X	X	X	X
<i>Medicago sativa</i>		X	X	X	X	X
<i>Festuca arundinacea</i>			X			
<i>Dactylis glomerata</i>			X			
<i>Lolium perenne</i>			X		X	
<i>Lotus corniculatus</i>			X		X	X
<i>Secale cereale</i>				X	X	
<i>Lolium multiflorum</i>				X	X	
<i>Trifolium pratense</i>				X	X	X
<i>Trifolium repens</i>				X	X	X
<i>Fagopyrum esculentum</i>				X		
<i>Vicia villosa</i>				X		
<i>Lupinus angustifolius</i>				X		
<i>Pisum sativum</i>				X		
<i>Ornithopus compressus</i>				X		
<i>Brassica napus</i>				X		X
<i>Trifolium alexandrinum</i>					X	
<i>Raphanus sativus</i>					X	
<i>Hedysarum coronarium</i>						X

Botanical relevés were utilised to compute pastoral value (PV; Daget and Poissonet, 1972) using the following equation:

$$PV = \frac{\sum (SRA_i \times SI_i)}{5} \times 100$$

where specific index ( $SI_i$ ) is a synthetic index (ranging from 0 to 5) used to summarise the forage value of each species (Cavallero *et al.*, 2002; Bagella *et al.*, 2013). In this way pastoral value ranges from 0 to 100 and this parameter is commonly used to express the overall forage potentiality of the pasture vegetation (Cavallero *et al.*, 2007).

Data of animal utilisation was performed by means of visual judgment of browsing activity estimated on each species recorded along the botanical transect, following the method already used in similar research addressing wild animals feeding preferences (Argenti *et al.*, 2012). Animal intake estimation on encountered plants used different scores according to the following scale:

- 0=no sign of animal intake
- 1=reduced sign of browsing
- 2=moderate presence of browsing or utilisation
- 3=high percentage of utilisation

and results permitted to quantify to which extent a single species was utilised by animals grazing. In particular, obtained data was elaborated to compute:

- contribution to defoliation rate (CDR<sub>i</sub>), as percentage contribution for a given species to total observed browsing, represented by the ratio between the sum of scores for a single species and total scores of all species encountered along a transect;
- utilisation rate (UR), as percentage of observed browsing respect to the potential for each plot (pure stand or mixture), represented by the ratio between sum of all scores along a transect and maximum potential total score (*i.e.* total number of contacts of all species along a transect x 3).

According to Orth *et al.* (1988), the CDR of each species was then correlated to its relative abundance, and in this way the CDR<sub>i</sub>/SRA<sub>i</sub> ratio is used to define if a species is actively searched (CDR<sub>i</sub>/SRA<sub>i</sub> >1) or refused (CDR<sub>i</sub>/SRA<sub>i</sub> <1) by animals, considering that if this ratio is equal to 1 the species is utilised proportionally to its occurrence in the canopy.

Moreover, to have a proper evaluation of number and species of wild animals actually frequenting the experimental plots, six camera traps were placed just after the sowing on the boundary of experimental site and oriented towards the plots to record videos of occurring wild animals (Newey *et al.*, 2015). Camera traps were set to start automatically when an animal entered its reference area and to record videos 30s long. These tools were checked regularly, normally every 15-20 days, to download recorded files for the whole duration of the trial, until summer 2016. Analysis of obtained videos permitted to recognise animal species frequenting the area and to identify plots utilised by the animals in each event

of grazing. Data of video-trapping was then compared to that obtained by vegetation analysis in order to evaluate the correspondence between the two methods. Results were analysed by means of GLM procedure performed to test the effect of pure stands/mixtures, date of sampling and their interaction. Software used was IBM SPSS Statistics, release 23 (2015).

## Results and discussion

Table 2 reports the results of ANOVA performed on tested variables coming from botanical analyses. Date of sampling was the factor that affected in the most remarkable way results of animal browsing, as vegetal material influenced only two parameters, while interaction of these variables assumed a really reduced meaning. The variation of selection by animal along the vegetative season was clearly pointed out in previous studies (Moser *et al.*, 2008; Freschi *et al.*, 2016) and this could be due to modification in palatability of herbaceous species according to their different stage of development (Prache *et al.*, 1996), but it could also be influenced by forage biomass presence or plants reaction to utilisation, that can change along growing season (Dumont, 1995). Thus we can say that animal selection is narrowly related to the vegetation context in which a species grows (Orth *et al.*, 1998). The reduced importance of pastoral value to explain wild animals browsing in forage resources was already pointed out by Ponzetta *et al.* (2010) and it is mainly due to specific indexes that are generally studied for domestic stocks. For these reasons, it was suggested to propose a list of specific indexes especially focused on wild animal intake to have a proper assessment of pastoral value for faunistic purposes (Argenti *et al.*, 2012). Evolution of contribution of sown species to defoliation rate (CDR) along time for the tested vegetal material shows that the choice of introduced species is very important in determining animal selection. However, this parameter tends to decrease along the time span of the trial, and at the end of period of observation CDR of sown species is roughly about a 50-60% for all tested treatments (Figure 1). This is due to the invasion of the

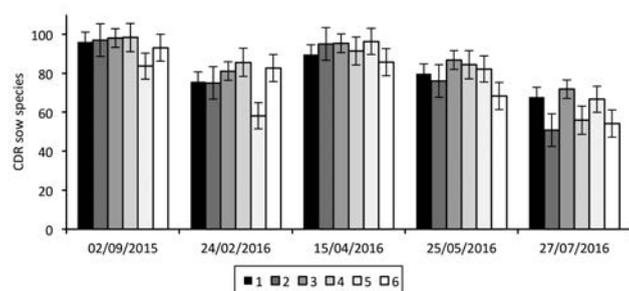


Figure 1. Evolution of contribution to defoliation rate of sown species for tested species/mixtures in different dates of sampling.

Table 2. Results of analysis of variance for tested parameters deriving from botanical transects.

Source of variation	CDR sown species	CDR native species	CDR/SRA sown species	CDR/SRA native species	UR plots species	% of browsed species	PV
Pure stand/mixture	ns	ns	**	ns	ns	**	ns
Date of sampling	**	**	**	**	**	**	ns
Interaction	ns	ns	*	ns	ns	ns	ns

CDR, contribution to defoliation rate; SRA, species relative abundance; UR, utilisation rate; PV, pastoral value. \*P<0.05; \*\* P<0.01; ns, not significant.

experimental plots by other species with a natural and continuous process of renaturalisation which can be considered anyway of high ecological importance (Wilsey and Martin, 2015). This evolution can not be considered completely negative because the utilisation of native species by wild animals can be performed also at a remarkable level and they can adapt, in particular situations, to browse also species of reduced forage quality (Cervasio *et al.*, 2016).

A proper evaluation of animal selection for sown and native species in general is provided in Figure 2. CDR/SRA ratio for sown species is always higher than 1, *i.e.* the proposed threshold to discriminate searched or refused species (Orth *et al.*, 1998). In some cases, values of this parameter are remarkably higher than 1 for sown species in each pure stand or mixture (Figure 2A), indicating the great appreciation of animals that utilised the plots for these typologies of resources. On the other hand, species deriving from recolonisation (Figure 2B) present generally values of CDR/SRA ratio lower than 1, but with a general tendency to increase in period of reduced forage production (winter, summer). This seems to indicate that animals can adapt their feeding behaviour, intensifying their browsing on these species in period of reduced forage availability, such as at the end of the period of trial (July) when the ratio in some plots is between 0.5 and 1. Results are in line with previous researches performed utilising the same methodology in mountain environment (Cervasio *et al.*, 2009) that report high changes in wild animal intake on grassland among different periods. In this way wildlife can show an opportunistic behaviour in relation to forage availability (Freschi *et al.*, 2017).

Analysis of feeding preferences at single species level, permitted to point out that, among sown species, *Onobrychis viciifolia* and *Medicago sativa* were those that produced best scores for CDR/SRA ratio, confirming a high variation among different periods of the year, with values remarkably higher than 1 as average of all treatments in each date of sampling (Table 3). Among grasses, that were less present in the original composition of mixtures, *Dactylis glomerata* was the most appreciate by animals when occurring on the plots. Only a couple of autochthonous plants (*Cichorium intybus* and *Plantago lanceolata*) presented in different periods of data collection average values higher than 1, as the major part of native species sometimes were not highly utilised by animals occurring on the plots. Even if it is difficult to compare obtained data with those from other studies, as previous researches investigated mainly effect of wild animals on forests than on open areas (Faison *et al.*, 2016), the importance of grassland for wild animals browsing in comparison to closed forest was already pointed out by Kuijper *et al.* (2009). As a general consideration,

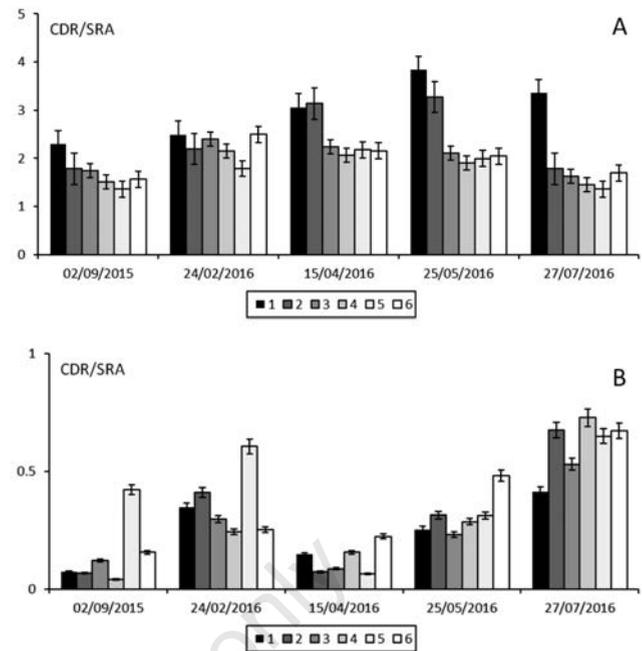


Figure 2. Values of contribution to defoliation rate/species relative abundance ratio for sown (A) and native (B) species for tested species/mixtures in different dates of sampling.

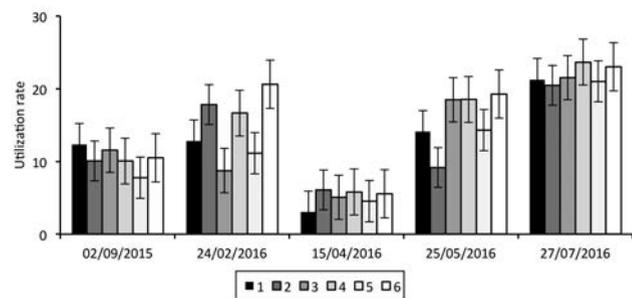


Figure 3. Evolution of utilisation rate for tested species/mixtures in different dates of sampling.

Table 3. Contribution to defoliation rate/species relative abundance ratio for main sown and native species in different dates of sampling (average from all species/mixtures treatments).

CDR/SRA	Dates					
	2/9/15	24/2/16	15/4/16	25/5/16	27/7/16	
<b>Sown species</b>						
<i>Onobrychis viciifolia</i>	2.87	2.31	1.54	3.54	3.06	
<i>Medicago sativa</i>	1.42	2.73	4.41	2.07	1.47	
<i>Dactylis glomerata</i>	2.65	-	-	-	1.96	
<b>Native species</b>						
<i>Cichorium intybus</i>	1.03	-	-	-	1.72	
<i>Daucus carota</i>	-	-	-	0.08	0.30	
<i>Picris hieracioides</i>	-	-	0.27	0.36	0.88	
<i>Plantago lanceolata</i>	0.49	1.69	0.39	0.82	0.49	
<i>Sanguisorba minor</i>	0.12	0.45	-	0.66	0.32	

CDR/SRA, contribution to defoliation rate/species relative abundance ratio.

taking into account differences in studied environments, data reported in this work is consistent with that found by Argenti *et al.* (2012), that reported high CDR/SRA ratio in some periods also for some herbaceous species considered of no forage interest. Obtained data confirmed also what found for some herbaceous species by Freschi *et al.* (2014) that investigated faecal pellets content in hare in an area of south Italy.

Percentage of utilisation derived from botanical analysis (UR) is highly dependent on period of sampling, with no significant differences among species and mixtures investigated in the trial (Figure 3). After the period of establishment, the utilisation rate is really lower in period of great forage production (such as spring), while it increased remarkably during summer, thus indicating the possibility for wild animals to have a strong intake on herbaceous resources in period of reduced biomass availability. The same trend throughout the period of observation was found for percentage of browsed species (Figure 4), *i.e.* the proportion of species that presented some sign of browsing on the total number of species occurring in each plot. In this case also the effect of interaction between vegetal material and date of sampling resulted significant, with higher values for more complex mixtures, and in some situations, during last date of data collection, more than 50% of the present species (sown or autochthonous) were utilised by animals. This feeding behaviour is due mainly to high adaptability of wild animals to utilise also species considered of reduced quality, and in this way selectivity can be considered one of the most important factors affecting animal preferences (Rook *et al.*, 2004). Wild animals in our trial showed performances similar to what described by Orth *et al.* (1998), by Moser *et al.* (2008) or by Freschi *et al.* (2014), concerning variability of animal utilisation according to seasonal changes in food resources availability, or by Boulanger *et al.* (2015) that reported high browsing activity performed by wild ungulates on species of no quality or even toxic. Concerning level of utilisation, data of percentage of browsing is consistent with those of Ponzetta *et al.* (2010) and Iussig *et al.* (2015).

Analysis of recorded videos permitted clearly to point out that roe deer (*Capreolus capreolus*) was absolutely the main user of the experimental area, as roughly 95% of the videos recorded represented individuals of this species browsing in the plots, while the resting 5% was represented by wild boar (*Sus scrofa*), pheasant (*Phasianus colchicus*) and hare (*Lepus europaeus*). The remarkable presence of roe deer in the plots can explain the reduced number of herbaceous species with a relevant utilisation in our trial, as this animal has a selective behaviour, and this confirms the findings of Freschi *et al.* (2017) who reported that a great amount of roe deer diet was composed by a reduced number of preferred vegetal species.

From the beginning of the trial to the last date of sampling, 1849 videos of animal browsing in different plots were recorded by camera traps and it was possible to properly detect in which plot animals were utilising the canopy (Table 4). Pure stand of sainfoin was the kind of vegetation type more frequented by animals as plots of mixtures 4 and 5 were those in which animals were less recorded by camera traps. Correspondence among browsing data found through botanical analysis and camera traps is represented by the existence of a significant regression between total browsing scores and number of videos recorded in each plots belonging to different species and mixtures (Figure 5). In this way both methods proved to be interesting for future assessment of utilisation activity of wild animals, especially ungulates (Kuijper *et al.*, 2009), and they could be useful tools for territorial management purposes and to examine evolution of plant communities under the determinant

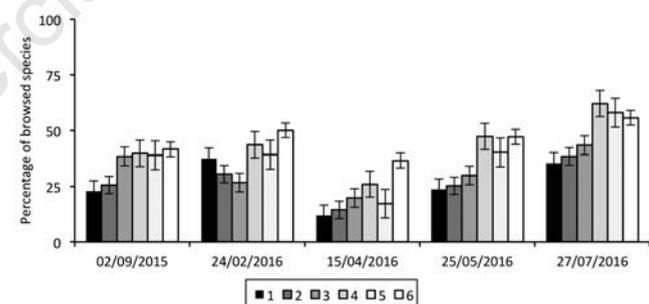
driver represented by wild animals population dynamic (Boulanger *et al.*, 2015).

## Conclusions

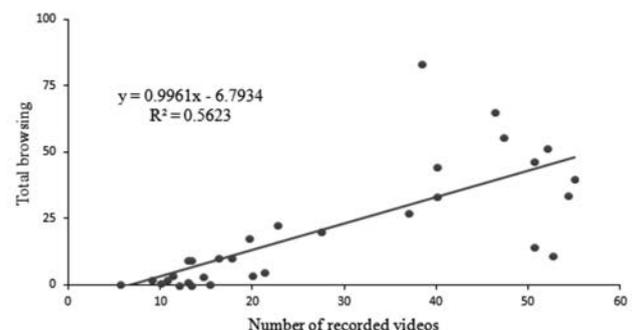
Methods employed in the research demonstrated to be able to assess in a proper way feeding preferences of wild animals, confirming results coming from previous experiments conducted in different environments. Assessment of browsing activity integrated

**Table 4. Number and percentage of recorded videos for different species/mixtures during the trial period.**

Species/mixture	Videos	
	N	%
1	481	26.1
2	276	14.9
3	367	19.8
4	203	11.0
5	176	9.5
6	346	18.7
Total	1849	100



**Figure 4. Evolution of percentage of browsed species for tested species/mixtures in different dates of sampling.**



**Figure 5. Regression between number of videos recorded in each species/mixtures and the correspondent total browsing obtained by botanical relevés.**

in normal botanical transect permitted an efficient evaluation of animal intake without a remarkable increasing in time due to data collection, thus it is conceivable to replicate this kind of analysis in next researches. Camera traps produced interesting data about animals behaviour and their use could be developed in further studies devoted to evaluate use of resources performed by wild animals or to analyse time spent in different activities.

Results on browsing on single species could be useful in the future to formulate specific mixtures studied for particular species of wild animals to be utilised in peculiar periods, *i.e.* to reduce damage on crops in a given physiological stage.

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