



Seasonal preferences in diet selection of semi-free ranging European bison (*Bison bonasus*)

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Abstract The largest herbivorous animal in Europe, the European bison, is in spite of all conservation efforts still listed as vulnerable and a protected species. Detailed information about the ecology of this animal is needed for successful restocking and completion of reintroduction programs. Because of the scarcity of quantitative data on the seasonal changes in diet composition of European bison, we focused in our study on seasonal differences in proportions of preferred plant species in the diet of semi-free living European bison in a spacious habitat hosting a broad range of vegetation forms. In the former military area “Döberitzer Heide” close to Berlin, Germany, no additional fodder is supplemented. The animals were observed over a period of one year and preferred plant species were noted. European bison showed seasonal preferences in diet selection and composition. During summer, the diet was highly mixed and consisted of herbs, foliage and sedges. Tree bark and branches became a notable dietary component in winter. This study aimed to provide sound knowledge necessary for proper management and the selection of suitable habitats for this species and its results suggest that in the annual cycle, the European bison need access to diverse habitats.

Keywords: ungulate, herbivore, fodder, habitat, preferences

Introduction

Differences in food specialization and seasonal changes in food preferences are a well known phenomenon for a large number of herbivorous mammals (Larter *et al.* 1991; Coppedge *et al.* 1998; Abaturov *et al.* 2003; Clauss 2008; 2013; Kazmin *et al.* 2013; Abaturov *et al.* 2015). In former times, the European bison (*Bison bonasus*) was distributed throughout different parts of western, central and south eastern Europe as well as the Caucasus (Karbowski *et al.* 2014). At the beginning of the 20th century, the last free-living animal was killed (Karbowski *et al.* 2014), and just 54 animals living in captivity survived (Ramos *et al.* 2016). Due to intense breeding efforts, the current population could be built up. However, the European bison is still at risk and more information about its biology is needed to protect this species successfully



(Ramos *et al.* 2016). Thus, the European Bison Center underlined the need for studies about the ecology of this species (Pucek *et al.* 2004). The effectiveness of conservation as well as the selection of suitable habitats for reintroduction depend on the soundness of knowledge (Kerley *et al.* 2012; Ramos *et al.* 2016). Different studies about the habitat and diet selection of bison (*Bison bison*) and plains bison (*Bison bison bison*) have been carried out (Larter and Gates 1991), but only a few studies on food preferences of European bison (*Bison bonasus*) exist (Ramos *et al.* 2016). Traditionally, the habitat of this species is considered to be the forest, but several studies suggest that the European bison historically lived in open grasslands or mixed habitats (Mendoza and Palmqvist 2008; Kowalczyk *et al.* 2011; Kerley *et al.* 2012). The study of Bocherens *et al.* (2015) about isotopic variation of skeletal remains of Early Holocene European bison, aurochs (*Bos primigenius*), moose (*Alces alces*) and reindeer (*Rangifer tarandus*) indicated significant differences in diet of European bison in comparison with the other ungulates, and pointed at its diet being intermediate between pure grazers and browsers. Likewise, the diet of European bison is described as mixed, consisting of grass, leaves and shrubs (Gębczyńska *et al.* 1991; Bocherens *et al.* 2015). Habitat selection is influenced by feeding behavior as well as strategies to reduce predation risk, competition and harsh weather conditions (Ripple and Beschta 2004). For the European bison, different reintroduction programs exist, but the knowledge of natural feeding behavior, suitable habitats and exploration behavior is limited (Hirzel *et al.* 2004; Kerley *et al.* 2012; Bocherens *et al.* 2015; Schmitz *et al.* 2015). So far, forest habitats were chosen for reintroduction of European bison, but hay supplementation is needed to avoid its expansion into open habitats or farm crops (Kraśńska and Kraśński 2007; Cromsigt *et al.* 2012; Kamińska and Kowalczyk 2012; Kerly *et al.* 2012; Kowalczyk *et al.* 2013). Some studies about habitat use and diet of European bison have been carried out, but observation periods were mostly short or fodder uptake influenced by supplemental feeding (Kowalczyk *et al.* 1976; Kerley *et al.* 2012; Shakun 2012; Bergmann *et al.* 2015; Ramos *et al.* 2016; Schmitz *et al.* 2015). Furthermore, most studies on the diet originate from the Białowieża forest, where the species was first reintroduced (Pucek 2004). The supplementation of fodder influences natural behavior and increases the risk of diseases like helminth invasion resulting from constant use of the same area (Treboganova 2010; Kowalczyk *et al.* 2011; Kołodziej-Sobocińska *et al.* 2016). There is a need of studies on diet selection of European bison in a variety of habitats and in the absence of supplemented forage (Kerley *et al.* 2011). The aim of our study was therefore to identify seasonal diet preferences of European bison in heterogeneous habitats under free-choice conditions without the supplementation of fodder.

Materials and methods

Study area

The study was carried out at the reserve Döberitzer Heide. The area was in military use for more than 100 years until 1992. Nowadays, it is a nature reserve and also part of the network “Natura 2000”. It is located very close to Berlin (52°30'43.7" N, 13°01'43.5" E) and has a temperate seasonal climate. In 2010, a fenced core area of about 1860 ha was established in the middle of the nature reserve by the Heinz Sielmann Foundation and European bison and Przewalski's horse were introduced there. Additionally, there are red deer, roe deer, fallow deer and wild boar. The fenced area comprises different habitat types like deciduous forest, pine forest, meadow, wet meadow and dry grassland. Water is offered by five solar-powered watering troughs. There is no supplementation of hay or any other kind of fodder during the year.

Study subjects

The first European bison were introduced to the core area of the Döberitzer Heide in 2010/2011. Presently, there are approximately 60 individuals in this area. The gender ratio is nearly equable. The age ranges from newborn calves to ten-years-old individuals. The animals are living in variable herds with changing numbers.

Data collection

The study was carried out by direct observations of the animals over one year. The bison were observed for two days every week for an average of eight hours. The observer was sitting in a car approximately 50–100 m away from the animals to minimize disturbances. For every observation, the type of habitat and the eaten plants were noted. In four time periods, samples of the preferred species were collected after observing animals and visually checking for marks of grazing on the species: 01.07.-31.08.2016, 01.10.-30.11.2016, 01.01.-28.02.2017 and 01.04.-31.05.2017. All plant species were classified in groups from 1 (always eaten) to 3 (rarely eaten) which are reflecting feeding preferences.

Statistical analyses

The hierarchical classification of the plant preferences (1–3) was done as shown in Table 1. Field surveys are named as observation events. In Category 1 plant species were consumed to 95–100% in the observation events. That means a high preference for this plant species by observed European bison.

Table 1. Percentage occurrence of a single plant species observed as a food source in the field surveys.

Percentage occurrence of eaten plant species in observation events	Description	Category
95–100%	highest food preference	1
50–95%	high to moderate preference	2
5–50%	moderate to seldom preference	3

The single plant species were grouped into “functional groups” of forage plants not only according to their botanical affiliation but also regarding the plant parts contributing to the mammal’s diet. The latter aspect gains in importance in case of shrubs and trees as potential food source. Thus, the functional groups “bark”, “twig” and “foliage” refer to woody plants, whereas Cryptophytics and Hemicryptophytics, which offer with their vegetative sprouts a more homogeneous food source, were categorized as gramineae or dicots (“grass”, “herbs”). Sedges, bulrushes and rushes were classified in a separate group because of their physiological differences to the true grass family. Furthermore, we distinguished between “twigs”, often with buds, and “sprouts”, which comprise a mixture of young, mostly not yet lignified branches and leaves.

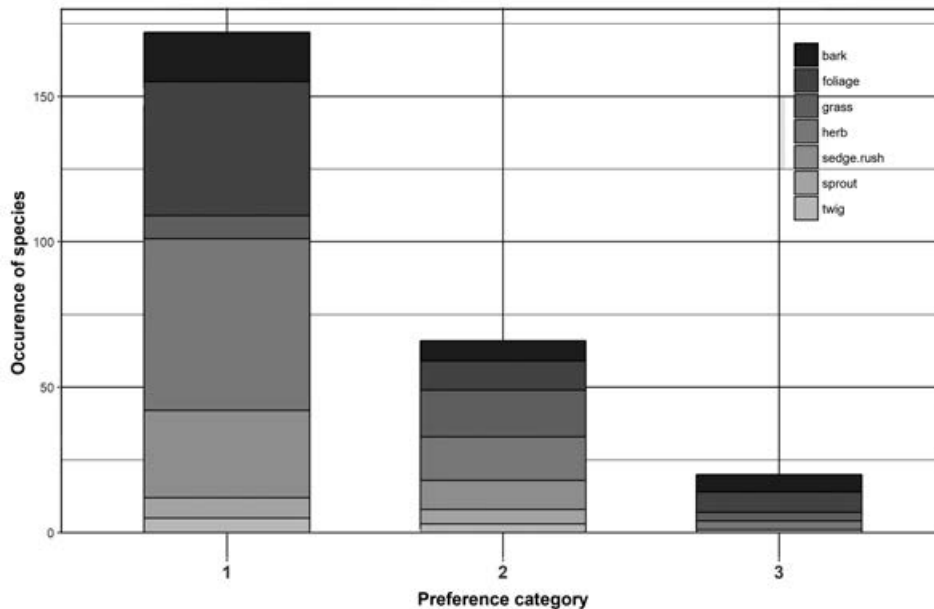


Figure 1. Abundance of functional groups in the three grazing preference categories (1 = highest preference; 3 = rarely eaten) based on a year-round field survey. Number of plant species within the functional groups is represented on the vertical axis.

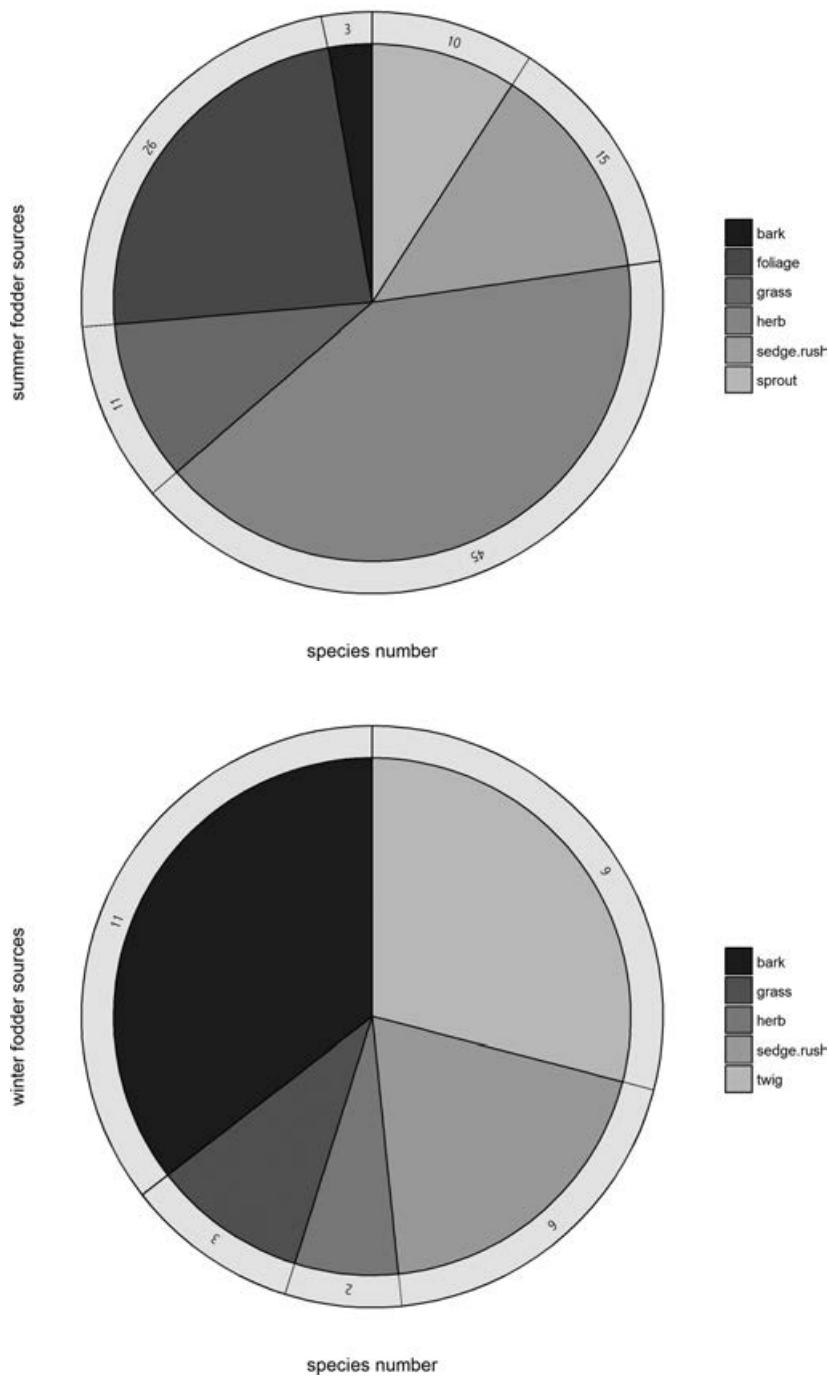


Figure 2. Proportions of functional groups of plants in European bison diet in summer (above) and winter (below). Numbers on the chart represent number of plant species.

Contingency tables were applied to analyse abundance frequencies of representatives of the single functional groups within the respective preference categories. Chi-square-test after Pearson was used to examine dependencies of the preference categories on plant functional groups. All analyses were done using scripts written in the statistical computing environment of R (R Development Core Team, 2017).

Results

The preferences in diet of the European bison were not independent from the botanical nature of foraged plants (Figure 1). The Chi-square-test showed a significant dependency of the preference categories on plant functional groups ($p < 0,001$). Plants within one functional group were variously preferred. Each functional group was represented in all three preference categories. Within the three preference categories, functional groups consisted of different numbers of plant species.

The preferences towards particular plant species in the diet of the European bison varied seasonally. The summer diet was most diverse and drastically different from that of winter (Figure 2). In summer, the diet consisted mainly of herbs, foliage, sedge and rush. During winter, the diet was dominated by bark and twigs.

Discussion

The diet of the European bison in the reserve Döberitzer Heide consisted of a large number of different plant species. Previous studies concluded that the diet of European bison is composed of forbs, grass, shrubs and tree bark (Borowski and Kossak 1972; Caboń-Raczyńska *et al.* 1987; Gębczyńska *et al.* 1991; Krasińska and Krasiński 2007). Additionally, in this study the European bison showed a high preference for foliage and sedges. The composition of the diet varied seasonally. In spring and early summer, fresh shoots of herbs, grass and sedges as well as foliage were preferred. Fresh shoots are generally favoured by different herbivores – as well as by the observed animals in this study – because they are mostly richer in protein than older ones. Due to the lower level of crude fibre, the digestibility is higher. A preference for fresh shoots was also observed for American bison (Bergmann *et al.* 2015).

The high variation in feeding preferences of European bison over the year may have allowed them to minimise competition with other giant mammals like aurochs that lived at the same time period, and in quite similar habitats. The use of different food sources within similar habitats is known for other herbivores (Feranec 2007; Feranec *et al.* 2009; Pushkina *et al.* 2014). Additionally, forest expansion in the post glacial period increased the availability of browse (Kerley *et al.* 2012; Bocherens *et al.* 2015). The observed high preference for tree bark during winter in our study could be a consequence of low availability of alternative dry fodder in this period. The consumption of browse was found to decline significantly when hay is sup-

plemented (Kowalczyk *et al.* 2011). However, all consequences of supplementing fodder are not well known yet. It may increase the transmission of pathogens and parasites as well as influence natural behaviour like formation of group sizes (Radwan *et al.* 2010; Treboganova 2010; Kowalczyk *et al.* 2011; Kołodziej-Sobocińska *et al.* 2016). Typically, wild ungulates have to survive under conditions with low food availability in winter time. Therefore, different adaptations like lower metabolic rate, changes in foraging behaviour as well as reduced food intake and increased gut passage time occur (Arnold *et al.* 2004; Parker *et al.* 2009). The ability of European bison to digest lignin-rich fodder has already been described by Gębczyńska *et al.* (1974) and Kowalczyk *et al.* (1976). In comparison with cattle, the European bison can utilize fodder in a more efficient way concerning the digestibility of energy and nutrients (Gębczyńska *et al.* 1974). This ability can be a specific adaptation to the environment the European bison was forced into due to forest expansion and human pressure (Pucek *et al.* 2004; Bocherens *et al.* 2015). The pre-refugee ecology of the European bison is required to be taken into account in conservation management and reintroduction programmes. As our study shows, the diet of the European bison can be quite diverse and differs a lot between the seasons. In forest habitats, the species needs access to open areas like river valleys or meadows (Bocherens *et al.* 2015). Krasińska and Krasiński (2007) summarized that all free-ranging populations of European bison were reintroduced into forest habitats and more than half of them have expanded their range to have access to open habitats. As a result, most free-ranging populations are fed with artificial forage (Kerley *et al.* 2012). In ancestral bison, no evidence for forest specialisation was found (McDonald 1981). Furthermore, the cranio-dental morphology of the European bison is typical for grazing species, so that forest habitats are not compatible with its feeding morphology (Hofmann 1989; Kerley *et al.* 2012). This is emphasized also by the results of this study.

Conclusions

The study aims to help to improve the strategies for the conservation of this threatened species. Seasonal preferences of European bison towards plant species contributing to its diet items are highly changeable. European bison needs an access to open habitats to satisfy its requirements. Forest is possibly a marginal or suboptimal habitat for European bison and reintroduction limited to those habitats may limit conservation success.

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Preferencje sezonowe pokarmowe żubrów utrzymywanych w hodowli półwolnej

Streszczenie: Największy roślinożerca Europy, żubr, wciąż jest według zasad ochrony gatunków traktowany jako zagrożony i jest on chroniony. Szczegółowe informacje o ekologii tego gatunku są potrzebne dla wzbogacania istniejących stad jak i reintrodukcji. Z powodu skromności naszych danych o sezonowych zmianach składu diety żubra, postanowiliśmy skoncentrować się w naszych badaniach na różnicach między preferowanymi roślinami na podstawie obserwacji zwierząt zajmujących duży areał o różnorodnym składzie gatunkowym flory. Stado przebywa na terenie byłego poligonu w pobliżu Berlina “Döberitzer Heide” i nie jest w żaden sposób dokarmiane zimą. Zwierzęta były obserwowane w okresie całego roku i notowano, które gatunki roślin są przez nie preferowane. Można stwierdzić, że istnieją różnice w tych preferencjach między porami roku. Podczas lata dieta żubra jest bardzo różnorodna i bazuje na ziołach, liściach i turzycach. Kora z drzew i gałęzie stają się podstawową częścią diety zimowej. Badania ukierunkowane są na rozwój wiedzy służącej właściwej opiece nad żubrami i wyborze właściwych siedlisk spełniających wymagania całoroczne, gdyż, jak wynika z badań, żubry wymagają urozmaiconego środowiska.
