Habitat selection of two European bison (*Bison bonasus*) on the Danish island Bornholm

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Abstract: Habitat selection of the European bison has until now mainly been studied in the Carpathian Mountains and in the Polish and Belarusian Bialowieska Forest, where the bison selected deciduous forest-dominated habitats with a preference for complex mosaics of forest and patches of grass in the vegetative season.

In May 2012, the Danish Nature Agency Bornholm introduced seven European bison to an enclosure in Almindingen Forest with the aim of creating a more open and natural forest. We examined habitat selection of two of the bison, a male and a female, which were both radio-collared, and used population extrapolation to investigate the potential of the herd as ecosystem engineers.

We found that the two bison in the vegetative season spent most of their time in coniferous (45%), uncultured cut coniferous (25%) and deciduous habitat (24%). Compared with the habitat availability in the enclosure, the two bison preferred uncultured cut coniferous forest habitat. This preference may gradually lead to a more open and natural Almindingen Forest, as requested by the Danish Nature Agency Bornholm.

Key words: habitat selection, habitat availability, population growth, ecosystem engineer, European bison.

Introduction

Large herbivores influence the environment and change the landscape by their presence (Smit & Putman 2011, Valeix *et al.* 2011, Beest *et al.* 2010). In Norway, moose have modified forest areas by feeding on young stands of Scots pine (Beest *et al.* 2010), and in Zimbabwe, elephants have impacted the woody vegetation leading to a decreased number of trees and exceedingly more open or coppiced areas (Valeix *et al.* 2011). These herbivores have complex, scale-dependent effects on habitat structure (Valeix *et al.* 2009) and are therefore defined as ecosystem engineers (Jones *et al.* 1994).

In May 2012 a small herd (1 male and 6 females) of European bison (subspecies *B. b. bonasus*) was introduced to an enclosure in Almindingen Forest on the Danish island Bornholm with the aim to create a more open and natural forest. The herd will be confined to the enclosure for the first five years, but the long-term goal is to have a free-ranging herd of European bison on the island.

In this study, we examine habitat selection of two of the bison in this enclosure and use population extrapolation to investigate the herd's potential as ecosystem engineers.

Study area

The bison enclosure is located in Almindingen Forest on the island of Bornholm (55.1333°N, 14.9167°E).

Almindingen Forest is of one of the largest and least fragmented forests in Denmark covering about 6000 ha. The herd of European bison is located in an enclosure of approximately 200 ha consisting of various habitats such as coniferous and deciduous forest as well as meadows. Apart from the European bison, the location is inhabited by two other species of ungulates, roe deer (*Capreolus capreolus*) and fallow deer (*Dama dama*). No large predators, such as canines, inhabit the island.

The climate is temperate with clearly marked cold (non-vegetative) and warm (vegetative) seasons. The mean annual temperature is 7.9°C. The coldest month is February (mean temperature –0.3°C), and the warmest is August (mean temperature 16.7°C). The mean annual rainfall is 609 mm, scattered over the year (DMI 2012).

Materials and methods

Habitat selection

The male and the oldest female from the herd in Almindingen were equipped with Vectronic Arerospace's GPS—PLUS collars. The collars provided information on GPS locations in differential mode (latitude, longitude, date and time) at pre-programmed intervals of 20 minutes from July to October 2012 (13 weeks). In total 6980 GPS locations for the male and 6982 for the female were used in this habitat selection analysis.

The GPS locations and a GIS (geographical information system) forest map (Danish Nature Agency, Almindingen, Bornholm, Denmark, 2012), generated using ArcView version 9.1, were converted to UTM zone 32 and then joined in the packages Shapefiles and PBS mapping using R version 2.12.1. The GIS forest map included seven habitats, Coniferous, Deciduous, Meadow, Farmland, Road, Water, and Other being defined as uncultured cut coniferous forest. In R, data on the time for the collection of the GPS locations with related habitats was used to create a dataset with the mean percentage of GPS locations in various habitats per week for the male and the female. This dataset was used in the statistical analysis for habitat selection. Eventually, Preference Ratios (PR) for all seven habitats were calculated.

A nonparametric Kruskal Wallis one-way ANOVA tested if the male and the female resided equally in the various habitats. Subsequently a Kruskalmc

multi-comparison test investigated in which of various habitats the male and the female were mostly present.

A nonparametric Wilcoxon Rank Sum tested if there was a difference between the two bison in the amount of time spent in the four most widespread habitats.

Future population size

The future population size for the European bison herd was estimated using the extrapolation programme *FITOM Bison* version 2. The estimations were carried out 100 times and the mean, upper and lower standard deviation (S.D) were calculated.

All statistical analyses were carried out using R version 2.12.1, and graphs were prepared in Microsoft Excel version 2011.

Results

Habitat selection

The enclosure consisted in 51.3% of Coniferous habitat, 26.2% of Deciduous habitat, 11.4% of Other, 5.3% of Meadow, 3.6% Water, 1.6% Road, and 0.7% of Farmland.

The male and female bison used all seven habitats during the 13 weeks the data collection took place. There was a significant difference in time spent in various habitats (Male: $K = 81.5$, $P < 0.0001$, $df = 6$, Female: $K = 82.0$, $P < 0.0001$, $df = 6$), but no significant difference was found between the male and the female (Deciduous: $W = 85$, $P = 1$, Coniferous: $W = 86$, $P = 0.96$, Meadow: $W = 83$, $P = 0.96$ and Other: $W = 87$, $P = 0.92$).
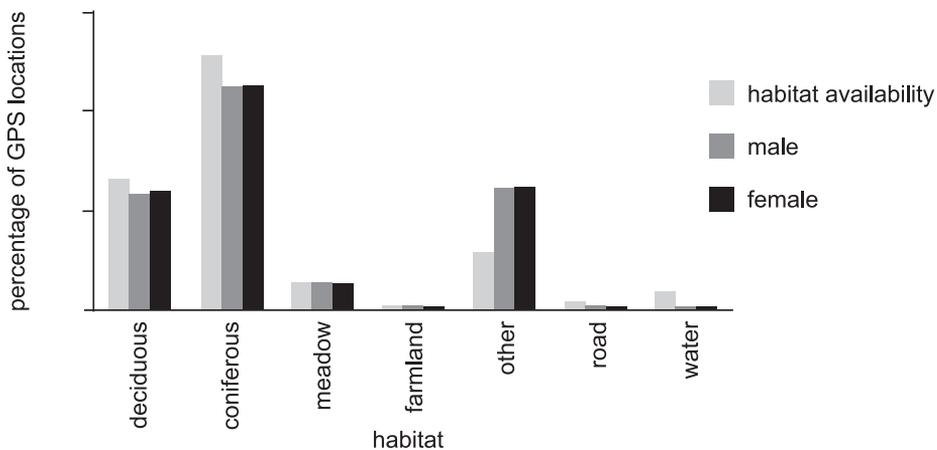
Figure 1. The effect of habitat availability on the habitat selection of the two European bison during July-October 2012. The graph indicates that the two European bison preferred the habitat Other, uncultured cut coniferous forest

Table 1. Results of Kruskal multi-comparison test, testing if there is a significant difference between the percentage of time spent in various habitats for both European bison during July-October 2012. Significant differences ($P = 0.05$) are marked with S and non-significant differences are marked NS

habitat	Coniferous	Deciduous	Farmland	Meadow	Other	Road	Water
Coniferous							
Deciduous	NS						
Farmland	S	S					
Meadow	S	NS	S				
Other	NS	NS	S	NS			
Road	S	S	NS	NS	S		
Water	S	S	NS	S	S	NS	

Both European bison selected the three most represented habitats (Coniferous, Deciduous and Other), indicating an effect of habitat availability in the enclosure (PR: Coniferous = 0.88, Deciduous = 0.90, Meadow = 0.99, Farmland = 0.91, Other = 2.18, Road = 0.36 and Water = 0.003) with a preference for the habitat labeled Other (Fig. 1). Despite the fact that the enclosure contained less percentage of the habitat Other than Deciduous and Coniferous habitat, there was no significant difference between the time spent in the three habitats for either bison (Tabl. 1), thereby supporting the indication found in the calculated PR values.

On average, of the 13 weeks in the vegetative season, the two European bison spent 45.3±6.5% of their time in Coniferous habitat, 23.6±6.9% in Deciduous habitat, 5.2±3.3% in Meadow, 0.6±1.4% in Farmland, 24.7±9.9% in Other, 0.6±0.6% at Road and 0.01±0.06% in Water.

Future population size

The estimations from the programme *FITOM Bison* predicted that the herd in Almindingen would grow from seven individuals to approximately 25 in the first 10 years, with a possibility of a population size between 5 and 50 individuals (Fig. 2).

Discussion

Previous studies (Kuemmerle *et al.* 2011, Kuemmerle *et al.* 2010; Krasińska & Krasiński 2007, Krasińska *et al.* 1987) have found that the European bison spent more time in deciduous than in coniferous habitat during the vegetative season. This is not supported by this study or in the reconstructing study on the historical distribution of the European bison during the last 8000 years (Kuemmerle *et al.* 2012). On Bornholm, the two European bison preferred
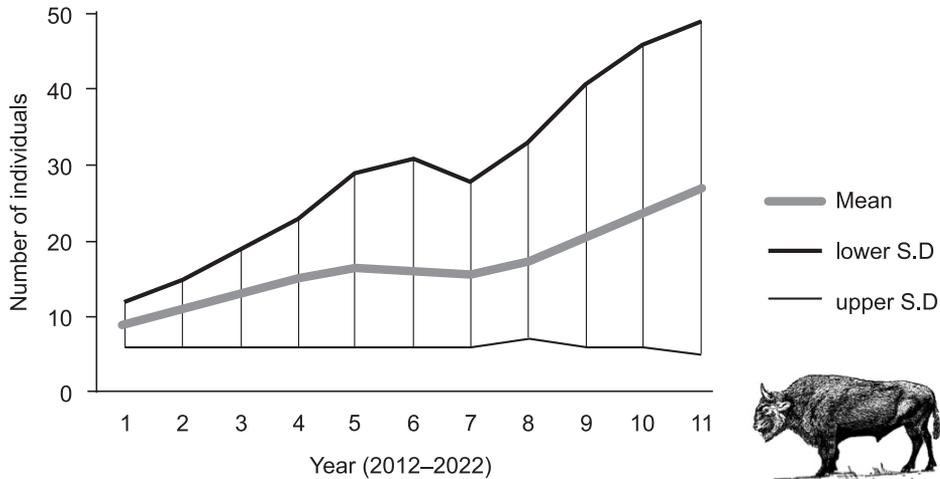
Figure 2. The predicted numbers of individuals in the Danish population of European bison in 10 years after the introduction in 2012

a habitat consisting of uncultured cut coniferous forest, thereby indicating an ability to adapt to an environment greatly impacted by human activity. However, a previous study indicated that the European bison preferred open habitats and that the large amount of time spent in the forest habitats (Coniferous and Deciduous) could reflect threat avoidance and not habitat preference (Kerley *et al.* 2012).

In this study, the two European bison spent a large amount of time in the coniferous habitat, which could be due to the presence of the preferred barked tree *Picea abies* (Pucek *et al.* 2004) that dominated the habitat, despite the fact that the European bison does not often forage on trees in the vegetative season.

Most of the preferred plants of the European bison (*Urtica dioica*, *Rubus idaeus*, *Carex hirta*) found in the enclosure, were mainly found in the deciduous habitat, but the two European bison spent less time in the deciduous habitat compared to the proportion of its availability, indicating that the presence of formerly known preferred plants in a Polish herd of European bison, did not affect habitat selection in the two European bison in Almindingen. Analysis of the European bison's excrements could explain whether the herd in Almindingen preferred other plants than the ones suggested in previous studies (Kowalczyk *et al.* 2011, Krasinska & Krasinski 2007, Pucek *et al.* 2004).

Predator risk is an important factor for influencing ungulate habitat selection (Theuerkauf & Rouys 2008, Dussault *et al.* 2005), but no large predators inhabit the island. Instead human presence and disturbance (Kuemmerle *et al.* 2010, Theuerkauf & Rouys 2008) along with habitat availability could be important factors for the habitat selection of the two European bison in this study.

Inter-competition with other animals can affect habitat selection of herbivores (Andrew 2008). Inside the enclosure a population of roe deer was present, but because of different feeding strategies the roe deer should have no impact on the European bison during the vegetative season. The fallow deer instead has a feeding strategy similar to the European bison (Kamler *et al.* 2003, Hofmann 1989), and though it is present in low numbers on Bornholm, there should be none in the enclosure.

This study was carried out in the vegetative season where the diet of an adult European bison consists of 23–32 kilos of grasses, herbs, shrubs and trees (Kowalczyk *et al.* 2011, Pucek *et al.* 2004). The enclosure in Almindingen Forest is only 200 ha, but in five years the herd will be a free-ranging herd and thereby be able to move around in the whole Almindingen Forest, which is 6000 ha. The herd can only refill the role as ecosystem engineers in Almindingen Forest, if the herd will be allowed to grow larger as found in the predicted future population size.

Conclusion

The European bison were introduced to Bornholm by the Danish Nature Agency Bornholm with the aim of becoming ecosystem engineers and thereby in time help creating a more open and natural Almindingen Forest. Therefore, by crossing and spending time in the most forest dense habitat, Coniferous, a wish for a more open landscape may occur, but only on a small scale and if the population size grows as predicted.

Acknowledgement

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Wykorzystanie środowiska przez dwa osobniki żubra (*Bison bonasus)* bytujące na duńskiej wyspie Bornholm

Streszczenie: Wykorzystanie środowiska przez żubry było do tej pory badane w populacjach bytujących w Karpatach Wschodnich oraz w polskiej i białoruskiej części Puszczy Białowieskiej, gdzie żubry w sezonie wegetacyjnym preferują dominujące środowisko lasów liściastych i otwartych terenów. W maju 2012 roku Duńska Agencja Środowiska Bornholm wprowadziła siedem żubrów do zagrody w Lesie Almindingen w celu uzyskania w przyszłości większego udziału otwartych przestrzeni. Badaniami objęto wykorzystanie środowiska zagrody przez dwa żubry, samca i samicę, zaopatrzone w obroże telemetryczne. Celem była wstępna ocena, czy stado żubrów można nazwać „inżynierami środowiska".

Stwierdzono, że w sezonie wegetacyjnym obydwa żubry większość czasu spędzały w lesie iglastym (45%), nieczyszczonym lesie iglastym (25%) i lesie liściastym (24%). Porównując z dostępnością wymienionych siedlisk można stwierdzić, że żubry preferują nieczyszczony las iglasty. Ta preferencja może prowadzić do większej otwartości siedlisk Lasu Almindingen, zgodnie z życzeniem Duńskiej Agencji Środowiska.