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Do enclosure characteristics affect anti-predator behaviour in the European bison (*Bison bonasus*)?

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Nyckelord
Keyword:

Auditory, behaviour, enclosure, European bison, olfactory, predator, visual

Contents

1 Abstract

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2 Introduction

Over the last decades, several wild populations of various species have declined. This is mainly a result of excessive hunting pressure (Brokordt et al., 2006) and habitat degradation (Griffen and Drake 2008). Reintroduction of animals is a way to save species from extinction and it may become an important tool for the management of wild populations and even species in the future (Griffin et al., 2000). Many of the reintroduction attempts, however, have not been successful in establishing viable populations (Snyder et al., 1996; Griffin et al., 2000), particularly when captive-bred animals have been used (Curio 1996; Mathews et al., 2005). Reintroductions from wild source populations have been more successful (Fischer and Lindenmayer 2000; McDougall et al., 2006; Seddon et al., 2007). Because of this, there are concerns that the individual animals' ability to survive in the wild is reduced in captivity (Seddon et al., 2007). It has been found that the success of captive breeding and release programs depends to a large extent upon the animals' behavioural skills (Sutherland 1998) and many deaths of reintroduced animals have been found to be due to behavioural deficiencies (McPhee 2003). After several generations, captive animals often differ from their wild conspecifics, especially in respect to foraging, social behaviour (Snyder et al., 1996; Kelley et al., 2006) and anti-predator behaviour (Curio 1996; Snyder et al., 1996; Griffin et al., 2000; Griffin et al., 2001; Kelley et al., 2006). Many of these differences have been shown to have deleterious effects on fitness in the wild (Frankham 2008). McPhee (2003) presented a simulated predator to oldfield mice, *Peromyscus polionotus subgriseus*, in order to assess effect of captivity on behaviour. The results showed that the individuals were less likely to take cover after seeing a predator the more generations the populations had been in captivity and that the variation in anti-predator behaviours increased with number of generations in captivity. Behaviours such as anti-predator response loose much of their adaptive significance in captivity and, therefore, both genetic and phenotypic variability for such traits are likely to increase (Price 1999). Such differences in behaviour between wild and captive-bred animals can arise through both intentional and unintentional processes (Kelley et al., 2006).

The attempts to release captive-bred wild dogs, (*Lycaon pictus*), have often failed due to the dogs' lack of survival skills, particularly anti-predator behaviour and hunting skills, in the wild. It appears, however, that captive-bred wild dogs can still be used for release, but only if they are first bonded with wild-born ones (Gusset et al., 2006). Examples of reintroductions that have established self-sustaining populations when captive animals were used include European bison (*Bison bonasus*) (Pucek et al., 2004), American bison (*Bison bison*), Alpine ibex (*Capra ibex*), Bald Eagle (*Haliaeetus leucocephalus*) (Wolf et al., 1996), Addax (*Addax nasomaculatus*) and Scimitar oryx (*Oryx dammah*) (Woodfine et al., 2005). A large part of the successful reintroductions involve large species, such as the European bison, that were reintroduced into areas without predators (Snyder et al., 1996).

Animals that have been isolated from predators, throughout their lifetime or over evolutionary time, may no longer express appropriate anti-predator behaviour (Griffin et al., 2000). The ability of an animal to recognize and respond to a predator may be lost over time in a predator-free environment, because anti-predator behaviours are often costly, but it is not always so (Blumstein et al., 2002). For many species, predator recognition is to some extent experience-independent, but some species have to learn to recognize their predator (experience-dependent) to respond with proper anti-predator behaviour (Blumstein et al., 2002; Blumstein 2006). The presence of a predator may be detected directly by sight, smell or sound, but in social species individual animals may also rely on the warning from conspecifics (Blumstein et al., 2002). In many species, the role of vision is very important in detecting a predator and herbivorous prey species have a close to omni-directional field of vision. Some species, like rodents, also use their acute sense of smell to locate predators and many mammalian species are extra sensitive to predator-derived odours (Taraborelli et al., 2008).

The European bison (*Bison bonasus*), also known as the Wisent, have a well developed sense of smell, which it can use to detect predators (Nilsson 1847; Heck et al., 1920). Its sense of vision and hearing are less developed (Heck et al., 1920). This species is the largest mammal living in Europe today. The males have a shoulder-height of to up to 2 meters and a body weight of up to 1000 kilograms (WAZA 2008). The European bison is classified as Vulnerable (VU) in the IUCN Red List of Threatened Species (IUCN 2009). By the end of the 19^{th} century, only two populations of the European bison were left in the wild in two geographically distant regions. One lived in the Białowieża Forest in Poland and one in the West-Caucasus Mountains in Russia (Perzanowski and Kozak 1999; Akimov et al., 2001; Pucek et al., 2004 Mysterud et al., 2007). They belonged to two separate subspecies, the lowland wisent in Poland (*B.b. bonasus*) and the Caucasian wisent in Russia (*B.b. caucasicus*) (Pucek et al., 2004). During the turmoil following the First World War, the Białowieża Forest population became extinct in 1919, and in 1927 the Caucasian population was also exterminated (Perzanowski and Kozak 1999; Akimov et al., 2001; Pucek et al., 2004 Mysterud et al., 2007). At this time, there were 54 bison that had survived in a few zoological gardens. The whole present-day population is derived from a founder population of 12 hybrid animals (*B.b. bonasus* × *B.b. caucasicus*) and a pure lowland line (*B.b. bonasus*) of only 7 founders, among them a cow residing at Skansen, Stockholm. After World War I, the captive populations started to increase and in 1943 there were 160 animals. During the following years the population decreased again, mainly caused by the World War II. After the war, the population started to increase again and in 1952 the first animals were reintroduced into the wild in the Białowieża Forest in Poland (Pucek et al., 2004). Today there are about 4000 European bison and approximately one third of them live in the Białowieża Forest in Poland and in the Bieloweskaja Forest in Belarus. In spite of this, captive breeding is still considered very important for the continued conservation of the European bison. It serves to maintain as much as possible of the remaining genetic variation and reintroduction from these wild populations into the wild should be continued (Pucek et al., 2004). The European bison is included in the EEP (European Endangered species Programme), run by the European Association of Zoos and Aquaria (EAZA). In this programme each selected species has a coordinator that collects the information of all animals of the species kept in EAZA zoos, keeps a studbook and produces a plan for the species' future management. This plan includes recommendations on which animals that should breed based on a genetic and demographic analysis of the studbook data (EAZA 2009).

The European bison are rather timorous animals that flee when they feel threatened, rather than standing up against the threat (Nilsson 1847). They have evolved together with several predators, such as the wolf, *Canis lupus,* and the brown bear, *Ursus arctos*, and even though adult bison may be able to defend themselves against an attack from these predators, calves and subadults may be subject to predation (Pucek et al., 2004). The bison cannot run for a long time and a pack of wolves can exhaust an animal and eventually kill it (Nilsson 1847; Heck et al., 1920). Within the Białowieża Primeval Forest, wolves were hunted in order to protect the reintroduced European bison against predators until 1989, when this was ended for research purposes (Jedrzejewska et al., 1994). Today there are wolves living in the Białowieża Primeval Forest that may sporadically prey on European bison (Mysterud et al., 2007) but most of the other free-living populations have no natural predators (Pucek et al., 2004). However, for a future expansion into less protected areas, the European bison as a species must still possess appropriate anti-predator behaviours. With the severe bottlenecks that it went through in the early 20th century and the rather unstructured captive breeding (Pucek et al., 2004), it can be feared that such behaviours might have been lost or changed.

The aim of this study was to investigate if captive-bred European bison would respond differently to various stimuli depending on the enclosure characteristics they were kept in and if they would respond differently depending on type of stimuli. The first hypothesis was that the animals would respond differently to the same stimulus due to their enclosure characteristics. The second hypothesis was that they would respond differently to different types of stimuli. The third hypothesis was that the European bison would change their behaviour after having been exposed to a stimulus compared to a pre-test baseline.

3 Material and methods

3.1 Observation sites

The study took place at seven different animal parks in Sweden: Avesta European bison Park, Borås Zoo, Eriksberg Wildlife Sanctuary, Kolmården Wildlife Park, Lycksele Zoo, Skånes Djurpark and Skansen.

The number of animals observed in each park varied from 3 to 24 individuals. Some of the parks were open to visitors in the evenings when the tests were carried out and therefore visitors were sometimes present during the stimuli presentations. The different enclosures were either naturalistic or barren and had different sizes (Table 1). The European bison is a forest living species, but only Eriksberg Wildlife Sanctuary and Lycksele Zoo offered a forest-like habitat. Therefore, in this study, an enclosure was considered to be naturalistic if the animals had the possibility to graze whereas in a barren enclosure they had not.

Table 1. Number of observed animals, visitors absent or present and enclosure characteristics in the participating parks.

Park	No. of individuals	Visitors	Area (sq m)	Naturalistic/ Barren
Avesta	4	Absent	2 500	Barren
Borås	9	Absent	3 450	Barren
Eriksberg	24	Present	9 000 000	Naturalistic
Kolmården	3	Absent	1 400	Naturalistic
Lycksele	3	Absent	24 160	Naturalistic
Skansen	3	Present	2 668	Barren
Skåne	6	Present	7 100	Naturalistic

3.2 Test procedure

3.2.1 Olfactory

This test was performed in five of the parks (Borås Zoo, Kolmården Wildlife Park, Lycksele Zoo, Skansen, and Skånes Djurpark). Faeces from moose, wolf and bear were presented to the animals by throwing about a handful of it into the enclosure. The stimuli were presented once each day between six and seven in the evening. The animals' reactions were recorded with a video camera, starting just before the presentation. The time recorded varied between 20-50 minutes depending on how long the animals showed interest. The duration of interest in the faeces was later analysed and compared between the different enclosure characteristics. The animals in each park were only tested once in order to avoid habituation and pseudo-replicates.

3.2.2 Auditory and Visual

The auditory stimuli test was performed in all seven parks and the visual stimulus test was performed in all parks except Eriksberg Wildlife Sanctuary. Sound from moose, wolf and bear, and a silhouette of a wolf (150 cm length ×65 cm high) (Figure 1) was presented to the animals.

Figure 1. Silhouette of a wolf.

The sound was played from a portable CD-player that was placed as close to the animals as possible and hidden so they could not see it. Each sound playback lasted for about 40 seconds. The moose sound was calling during breeding season, the wolf sound was howling and the bear sound was growling. For the silhouette presentation, a rope was strung between two trees or fence poles. The distance between the two trees or fence poles was 10-15 meters. The silhouette was suspended in ropes attached to two pullies, which run on the strung rope, and released in the high end (Figure 2) so the silhouette passed by with its side visual to the animals for about 4 seconds. It was left in the lower end until the animals lost interest in the silhouette.

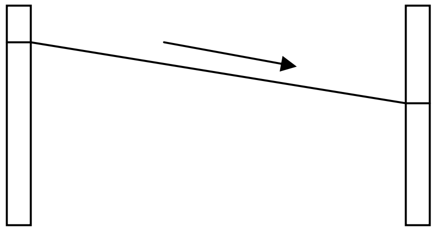

Figure 2. Schematic drawing of how the silhouette was presented.

The auditory and visual stimuli were presented to the animals, one stimulus each day, starting between six and seven in the evening. Each stimulus was presented twice with a three minutes interval. The behaviour was recorded with a video camera, starting about one minute before the presentation. The time recorded varied between 10-40 min depending on how long the animals were showing interest in the stimulus. The animals' reaction to the stimuli was ranked according to a four-level scale (Table 2). The percent of individuals in each response category was calculated for each enclosure characteristic. The animals' reaction to the stimulus and how long time they were interest in the stimuli were later analysed and compared between the different enclosure characteristics. The animals in each park were only tested once in order to avoid habituation and pseudo-replicates.

Table 2. Rank of reaction.

Level	Reaction
0	No reaction
1	Stop/ turn towards the stimuli/ listen/ stand
2	Move towards the stimuli
3	Move away from the stimuli

3.2.3 Behavioural study

The selected behaviours (Table 3) were extracted using focal sampling, operating the Observer version 3.0 (Noldus Information Technology, The Netherlands) on a PSION Workabout handheld computer. Pre-test baseline observations were carried out for four hours during three evenings before the different stimuli presentations in the Olfactory, Auditory and Visual tests (see above). Post-test baseline observations were also done during four hours following the exposures. One female and one male in each park were observed and the observations from all seven parks were combined. The four hours were divided into three parts: 0-15 minutes, 15-60 minutes and 60-240 minutes in order to see if there was any difference between females and males. The change in behaviour over time was then compared between the different types of stimuli and pre-test baseline.

Table 3. Definition of observed behaviours

Behaviour	Definition
Movement	The animal moves all four legs
Stand	The animal stands with at least one leg still on the ground
Eat	The animal grazes or eats from the ground or from trees or bushes or from a feeding station
Rest	The animal lies on the ground or stand and ruminates or lies on the ground and ruminate
Unavailable	The animal is out of sight

3.3 Data Analysis

Since the data from all three tests were found not to be normally distributed, a non-parametric Mann-Whitney U-test was used for the independent data and Wilcoxon signed rank test was used for the paired.

Mann-Whitney U-tests were computed using the MINITAB statistical package version 15 (Minitab inc.) with a significance level of $p \leq 0.05$ or 0.01. Wilcoxon signed rank tests were computed using SPSS for Windows version 10.0 (SPSS inc.) also with a significance level of $p \leq 0.05$ or 0.01.

4 Results

4.1 Olfactory

There was no significant difference between the olfactory stimuli from the different animals (Figure 3a) so the data for these stimuli were combined (Figure 3b). No difference between naturalistic and barren enclosures was found for the time the animals were interested in the olfactory stimuli.

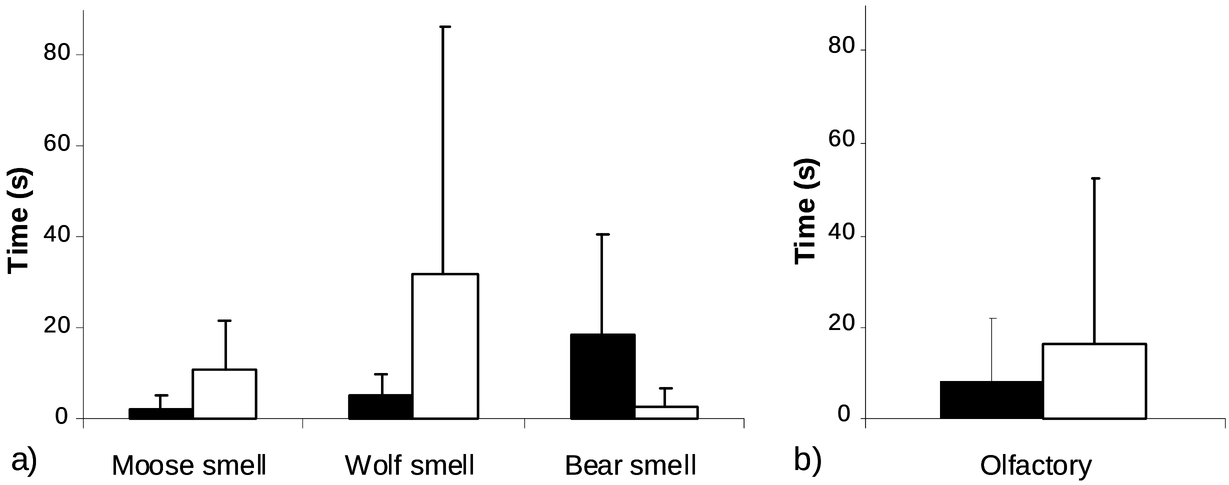

Figure 3. Mean duration of interest (s) (+ S.D.) in a) faeces from moose, wolf and bear, and b) all olfactory stimuli combined in naturalistic (black bar) and barren (white bar) enclosures.

No significant difference between the duration of interest in the three olfactory stimuli was found when data from all five parks were combined (Figure 4).

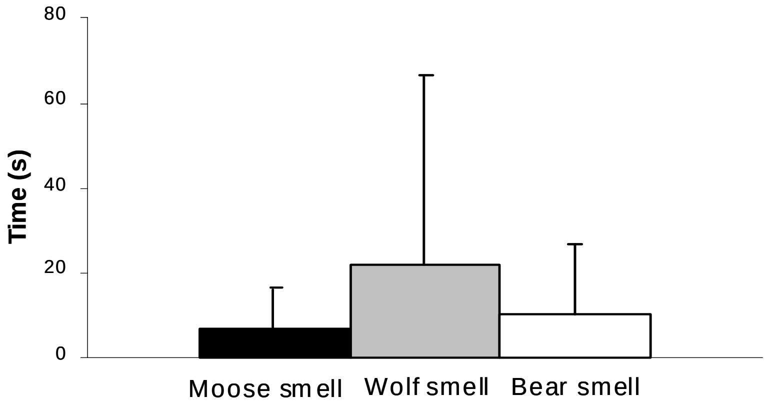

Figure 4. Mean time (s) (+ S.D.) smelled at the different faeces with all five parks combined.

4.2 Auditory and Visual

No difference was found for the duration of interest in the auditory stimuli from the different animals (Figure 5a) so the data for these stimuli were combined (Figure 5b). Difference in response between naturalistic and barren enclosures was found for the auditory stimuli. The animals in barren enclosures were interested for a longer period of time in these stimuli than animals in naturalistic enclosures (U=512.5, $p<0.01$).

The animals in naturalistic enclosures were interested in the visual stimulus, i.e. the wolf silhouette, for a longer duration than they were in the auditory stimuli (Z=-1.960, $p=0.05$).

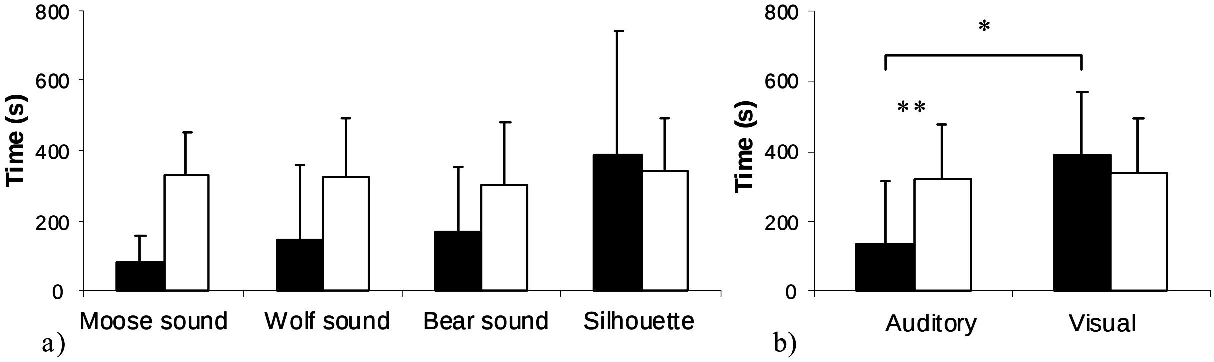

*Figure 5. Mean duration of interest (s) (+ S.D.) in a) the presentation of moose, wolf and bear sounds and in the wolf silhouette, and b) all three auditory stimuli combined and the visual stimulus in naturalistic (black bar) and barren (white bar) enclosures, ** $p \leq 0.01$; *$p \leq 0.05$.*

There were differences between naturalistic and barren enclosures in the animals' reaction to the different auditory and the visual stimuli (Figure 6). The animals that were kept in naturalistic enclosures showed a different reaction to both the auditory stimuli (U= 737.0, $p<0.01$) and the visual stimulus (U= 8.0, $p<0.01$) than the animals kept in barren enclosures.

The animals kept in a naturalistic enclosure showed a different reaction to the visual stimulus than to the auditory stimuli (Z=-2,414, $p<0.05$).

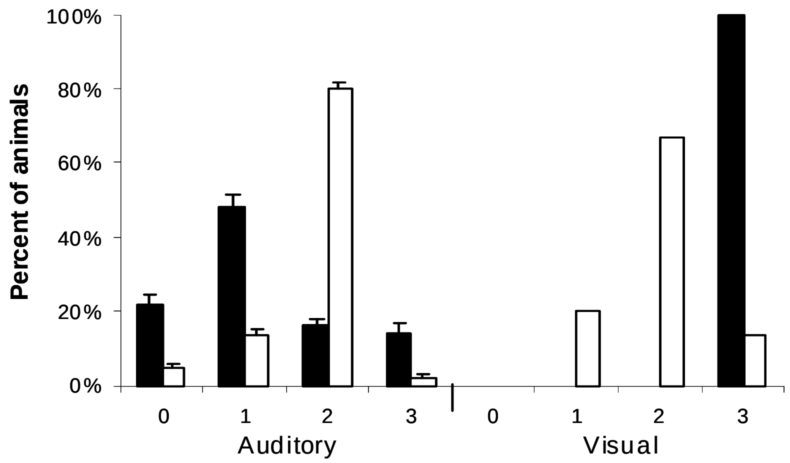

Figure 6. Percent of animals (+S.D.) in each response category for auditory and visual stimuli in naturalistic (black bar) and barren (white bar) enclosures.

There was no significant difference in the time the animals were interested in the different stimuli when all the different parks were combined (Figure 7), but the animals showed a tendency to be interested for a longer period of time in the visual stimulus than in auditory stimulus from bear (Z= -1.857, p=0.063) .

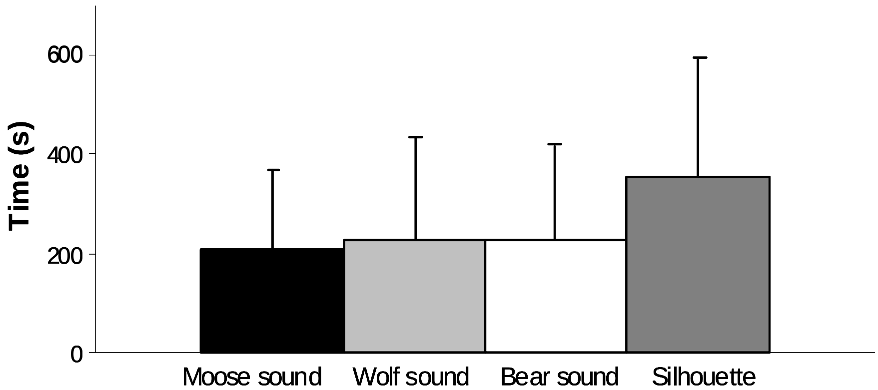

Figure 7. Mean time (s) of interest (+ S.D.) in the different sound and visual stimuli with all seven parks combined.

4.3 Behavioural study

No differences in the behaviour were found between females and males during the 0-15 minutes or the 15-60 minutes following the presentations of stimuli (Figure 8a and b). The only difference found was during the 60-240 minutes following the presentations (Figure 8c) where females ate for a longer period of time than males (U= 534.0, p<0.01) and males rested for a longer period of time than females (U= 498.0, p<0.01). Since it was almost no difference found between females and males, these two groups were combined in the behavioural analysis.

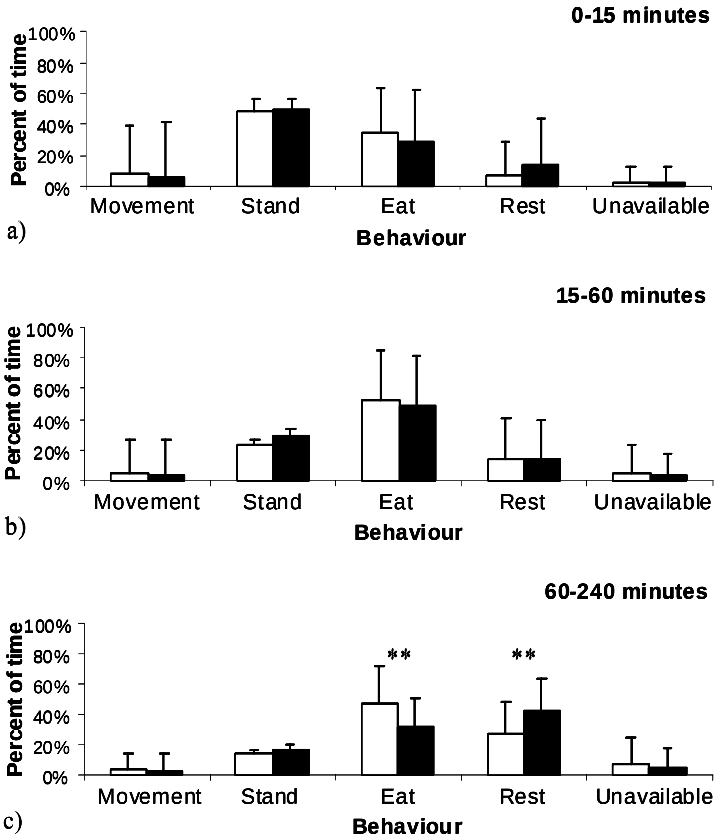

*Figure 8. Percent of time the females (white bar) and males (black bar) performed different behaviours during a) 0-15 minutes, b) 15-60 minutes and c) 60-240 minutes following stimuli presentations, ** $p \leq 0.01$.*

There was some difference in the animals' behaviour after they had been presented the different stimuli compared to the pre-test baseline (Figure 9). The animals moved (Figure 9a) for a significantly longer period of time after both olfactory (Z= -1.994, $p<0.05$) and visual (Z= -1.956, $p=0.05$) stimuli presentations during the 0-120 minutes following the presentation compared to pre-test baseline. They also moved for a longer period of time during the 0-15 minutes following the visual stimulus presentation compared to the pre-test baseline (Z= -1.957, $p=0.05$).

During the 0-90 minutes following stimuli presentation, the animals stood still (Figure 9b) for a significantly longer period of time after olfactory stimuli compared to the pre-test baseline (Z= -2,121, $p<0.05$). The animals also stood still for a significantly longer period of time during the 0-180 minutes following the auditory stimuli presentations compared to the pre-test baseline (Z= -2,375, $p<0.05$). They also stood still for a significantly longer period of time during the 0-30 minutes following the visual stimulus presentation compared to the pre-test baseline (Z= -2,730, $p<0.05$).

The animals ate (Figure 9c) for a significantly longer period of time during the 0-150 minutes following the olfactory stimuli presentation compared to the pre-test baseline (Z= -2.197, $p<0.05$). During the 0-120 minutes following the auditory stimuli presentation the animals ate for a significantly longer period of time than during pre-test baseline (Z= -2,070, $p<0.05$).

During the 0-180 minutes following stimuli presentation the animals rested (Figure 9d) for a significantly shorter time after both olfactory (Z= -2,400, $p<0.05$) and auditory (Z= -2,349, $p<0.05$) stimuli compared to the pre-test baseline. The animals rested for a significantly shorter period of time during the 15-90 minutes following visual stimulus presentation than during pre-test baseline (Z= -2,045, p<0.05).

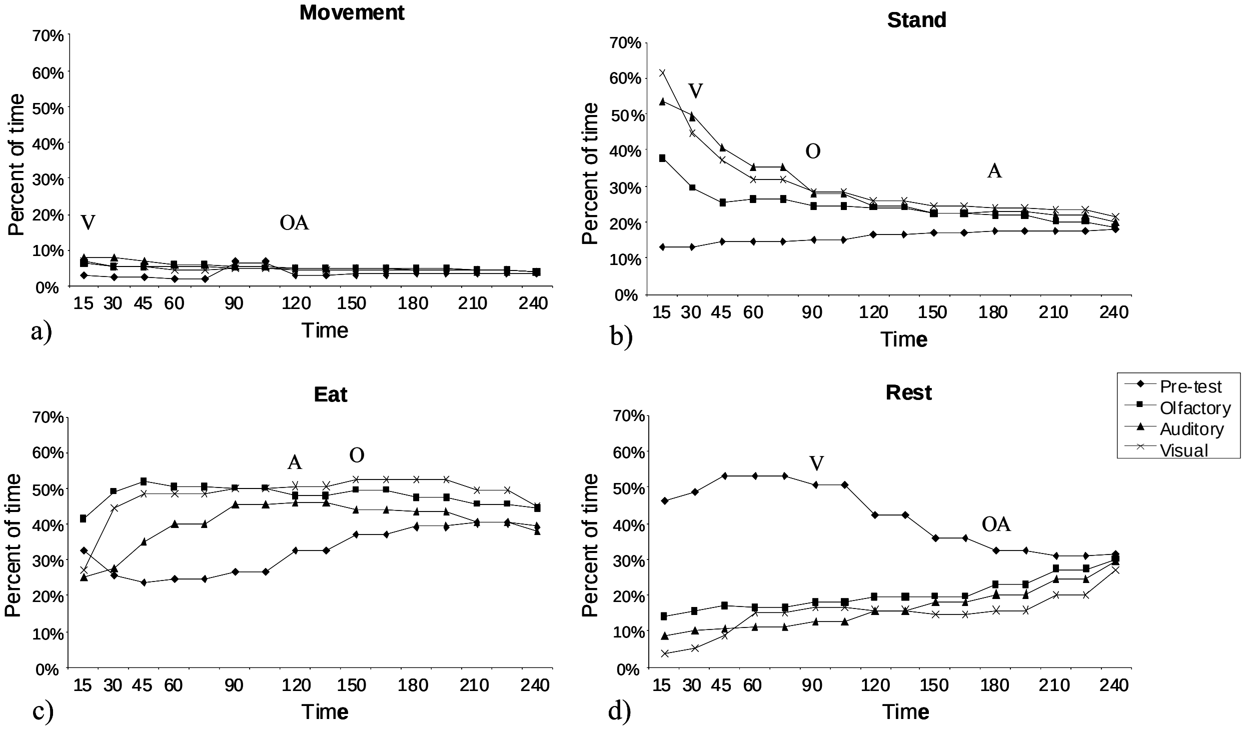

Figure 9. Percent of time the animals a) moved, b) stood still, c) ate, and d) rested after the different types of stimuli presentation, O – p<0.05 for olfactory stimulus, A – p<0.05 for auditory stimulus, V – p<0.05 for visual stimulus compared to pre-test baseline.

5 Discussion

In this study, all parks in Sweden that keep European bison were included. Since there were only seven such parks and few animals in each of them, the number of data samples was small which may have affected the results. Other studies have had similar difficulties to obtain statistically significant results due to small sample size (Boissy 1995). Studies have also shown that, under the same conditions, there is individual variability in many aspects of behaviour (Boissy 1995).

There were no significant differences found in the olfactory tests. This could be due to just chance that the animals passed through the area where the faeces was placed. It could also be because some of the parks kept moose, wolves or bears close to the European bison enclosure. Hence these European bison might have been desensitized to smell and sounds from these animals. In these parks, I tried to present the stimuli from the opposite direction relative to these enclosures. Some species, like some species of rodents, use their sense of smell in order to locate predators. In one study, it was found that prairie voles, *Microtus ochrogaster*, avoided the sites with faeces from predators (Taraborelli et al., 2008). Some species are able to distinguish between the odours of different predators (Taraborelli et al., 2008). No such selectivity could be seen in the European bison in this study; they did not avoid the site of any of the predator faeces and no difference could be seen between their interest in the faeces from the two predators and the moose. This could be because they did not recognize the faeces as smell from a potential predator. Many species need to learn to recognize their predators in order to respond with proper anti-predator behaviour (Blumstein et al., 2002; Blumstein 2006).

The results from the Auditory and Visual tests showed that the European bison kept in barren enclosures had a stronger response to the auditory stimuli than those that were kept in more naturalistic enclosures; they either reacted stronger or showed a longer-lasting interest. The European bison in naturalistic enclosures, on the other hand, had a stronger response towards the visual stimulus than the animals in barren enclosures. The former had a stronger reaction to and showed a longer-lasting interest in the visual stimulus than to the auditory stimuli. Studies on red junglefowl have shown that the captive environment can alter the anti-predator behaviour of animals (Håkansson and Jensen 2008). Håkansson et al., (2007) showed that animals conserved a more natural behaviour when they were bred in a semi-natural enclosures compared to the more traditional captive enclosures. Since no wild European bison were observed in this study, it is difficult to conclude whether animals in naturalistic or barren enclosures conserved a more natural behaviour.

One explanation for the stronger reaction to the visual stimulus than to auditory stimuli might be that the CD-player could not play high enough sound pressure level, so animals that were far away might have only heard it vaguely. This could lead them to believe that the predator was far away and thus not necessary to respond to. The reason for the stronger response towards the visual stimulus in the naturalistic enclosures than in the barren enclosures might be that the European bison kept in the barren enclosures were desensitized since they had been exposed to the presence and activities of people, vehicles and other disturbances close to them. The stronger reaction to the visual stimulus might also be due to the sudden movement of it and not to the fact that it looked like a silhouette of a wolf. In order to resolve this, a silhouette of a non-predator, e.g. a herbivore or a non-biological shape should also have been presented. Unfortunately this was not possible to include in this study because of time constraints. The European bison did not show a stronger reaction to the stimuli from the two predators than from the herbivore control in any of the tests, so their interest in the different stimuli might just have been of curiosity, not an increased vigilance to avoid predation. As said before, they might need to learn to recognize the stimuli such as the sounds from a predator to respond with proper anti-predator behaviour (Blumstein et al., 2002; Blumstein 2006).

Another factor that might have affected the outcome of the tests is the fact that the animals were not tested separately. Hence they might have responded like a group, not as individuals. European bison have been found to run as soon as they feel threatened and if one animal run the others will follow (Nilsson 1847). Other studies have shown that group size also might have an impact on the anti-predator behaviour. When in company of conspecifics, herbivores have been observed to closer inspect a predator, remain in the presence of a predator for a longer period of time before fleeing, and to start feeding more quickly after exposure to a predator (Grand and Dill 1999). At the Eriksberg Wildlife Sanctuary, the tested group was large, up to twelve animals, and the reaction of this group might have had a large impact on the compiled result. The auditory stimuli in this park were presented from the car because if a person on foot got too close, the whole group would run away and then had to be tracked down and found again. These animals were used to having cars around them and might therefore have failed to react to the presented stimuli. The visual stimulus could not be presented in this park due to the large size of the enclosure and the difficulties to anticipate where the animals might be moving. Other parks, like Skansen and Skånes Djurpark, had visitors present during the stimuli presentations which might have affected the response of the European bison. They might have been distracted by the sounds or movement of the visitors.

The behavioural study showed that the European bison used in this study changed their behaviour after presentation of stimuli compared to during pre-test baseline. They moved, stood still and ate for longer periods of time and rested for shorter periods of time after presentation of all three types of stimuli than the pre-test baseline. The increase in movement and stand still could be because the animals got more vigilant after they had been exposed to the different stimuli. One study on elk, *Cervus elaphus*, demonstrated that males were less vigilant than females in the presence of wolves (Winnie and Creel 2007). The European bison used in this study did not show any gender differences in their behaviour following the stimuli presentations.

The results gave some support to the hypotheses in this study. The European bison kept in enclosure with different characteristics did respond differently to the same stimulus which supports the first hypothesis. These results are consistent with the results from other studies. Håkansson and Jensen (2005) found in their study on red junglefowl, *Gallus gallus*, behavioural differences between different captive populations. If these differences were due to adaptation to the different types of enclosures or genetic changes was not clear. Since all European bison are closely related, it is difficult to say if the differences found in this study are en effect of the enclosures the animals were kept in or just due to individual differences. The European bison responded stronger to the visual stimulus than to the auditory stimuli which give some support to the second hypothesis, but no difference between stimuli from different animals was found. The European bison changed their behaviour after the stimuli presentations compared to the pre-test baseline, which supports the third hypothesis.

In conclusion, the results from this study show that enclosure characteristics might have an effect on the anti-predator behaviour in the European bison. However, the differences could also be due to individual differences. Considering the limited number of animals and parks observed in this study and many factors that might have had an affect on the results, makes it difficult to decide whether some of these animals are more or less suitable to be released into the wild. These results should be supplemented with more studies on the behaviours of the European bison in which more animals are included in order to make any proper conclusion of how this species should be kept in the future.

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