

The seasonal variations in the activity of brown bears (*Ursus arctos*) in the wild, is also observed in the aberrant behavior of two females in captivity?

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Four species of bear are known that in their habitat natural manifest variable behaviors depending on the season. The objective of the present study was to assess if aberrant behaviors -as indicators of animal welfare- have annual variations for three seasonal periods –spring, summer and autumn-. Data were collected from two female brown bears (*Ursus arctos*) housed in the same facility at the Barcelona Zoo. Using a multi-focal continuous and a scan sampling methods, a total of 63 hours of behavior was observed and recorded per individual. Old female's aberrant behavior displays frequencies about 17%, whereas young female had a value about 5%. The results indicate that some aspects of the aberrant behavior varied according to the three seasonal periods. The old female's aberrant episodes duration and young female's aberrant behaviors intensity and occurrence varied according to the three seasonal periods. In last cases, the aberrant behavior was higher in spring followed by summer and autumn coinciding with seasonal changes of wild bears with two activity peaks: one on spring in relation to mate-seeking behaviors and another on autumn in relation to foraging food behavior.

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Four species of bear are known that, in their natural habitat, manifest variable behaviors depending on the season (Roth, 1983; Roth & Huber, 1986; Stelmock & Dean, 1986), with the most notable differences demonstrated in food habits (Mace & Jonkel, 1986) and reproduction (Fundación Oso Pardo & Márquez, 1998; Stirling, 1993; Brown, 2009). Little research has addressed the impact or influence of seasons on the brown bear (*Ursus arctos*) in captivity, but the seasons having an influence on aberrant behavior is indicated (Ames, 1993; Carlstead & Seidensticker, 1991; Kolter & Zander, 1995). These abnormal behaviors are characterized because they are not observed in the typical behavior patterns of wild or free animals (Criswell & Galbreath, 2005; Meyer-Holzappel, 1968).

Difficulty lies in defining stereotypes before unknowing the details about their causation. Stereotypes are defined as aberrant behavior observed in conditions of captivity characterized by morphologically identical movements repeated regularly and without any apparent motive (Mason, 1991; Mason & Rushen, 2006).

One of the important criticisms of this theory is that the stereotypes do have a real function if they represent symptoms of an illness or unbalanced mentally state (Hosey et al., 2009). Symptoms are overt characteristics of the normal homeostatic reactions of an organism trying to restore a disturbed equilibrium. In this sense, stereotypes are devised for adapting in an inadequate environment (Ödberg, 1978; Rees, 2011). The problem knows whether any external stimuli play a role in the abnormal behavior or if it is caused by internal neurological factors. Some authors have suggested that an appetitive behavior elicited in captivity gets repeated because it is no longer guided, whereas in nature it is continuously directed by various external stimuli; stereotypes have also been suggested to be rewarding themselves, such as reducing anxiety. In order to diminish the stereotypes there are the enrichment program techniques in order to motivating the lives of bears in zoos (Law & Reid, 2010).

Several studies have evaluated aberrant behavior in the Ursidae family because these animals are more susceptible to exhibiting this kind of behavior (Carlstead, 1998; van Keulen-Kromhout, 1976). Some studies in *U. maritimus* (Ames, 1993; Kolter & Zander, 1995; Fernández, 2010) and *U. americanus* (Carlstead & Seidensticker, 1991) indicate seasonality in

these species aberrant behaviors. A large volume of research has focused on *U. maritimus*, and the most studied stereotypies are related to *pacing* (Wechsler, 1991, 1992) and the corresponding pharmacological treatment (Poulsen et al., 1995, 1996, 1997). Studies on *Tremarctos ornatus* (Fischbacher & Schmid, 1999) and *U. americanus* (Carlstead & Seidensticker, 1991) were also focused on *pacing*.

In other species, such as *Helarctos malayanus* (Cheng, 2001) and *U. thibetanus*, two types of stereotypies have been researched: motor and oral (Vickery & Mason, 2004). In a study on *Ailuropoda melanoleuca*, the authors classified 11 different types of stereotypies, mainly motor and oral (Lindburg et al., 2001). And finally, in a study on *Melursus ursinus*, the authors studied the effect of environmental enrichment on stereotypies in order to improve bear welfare (Anderson et al., 2010).

The objective of the present study was to determine if the duration, occurrence, intensity of the aberrant behaviors and frequency of activity in two brown bears' females varied according to the three seasonal periods –spring, summer and autumn-. These variations were observed on feeding and reproduction in the wild conditions and compared it with results of this study was used as animal welfare indicator.

MATERIALS AND METHODS

Animals and Installations

Two female European brown bears (*Ursus arctos arctos*) housed in the same facility at the Barcelona Zoo were used in this study. Both of the animals had come to the Barcelona Zoo from Parque de la Naturaleza de Cantabria (Cantabria, Spain) in November 2003. Young female was born in Cabárceno on March 1, 1994, and reared by her mother, but these details are not known for old female.

During the observation period, the two bears were housed together in a moat-style, semi-naturalized enclosure with a structure originally made from cement (see Figure 1) and a total area of 230 m². A wall divided the enclosure with an opening to connect the two parts.

Each side had an aquatic zone for the animals to drink and bathe. The features in each of the enclosures were trees, bushes, several large stones, large overturned logs for climbing, and several terraces at different levels with a natural substratum of gravel, sand, and bark. The indoor enclosures were cement cages out of sight from the public with a drinking trough and bath (total surface area of approximately 10 m² each) (Soriano et. al., 2006).

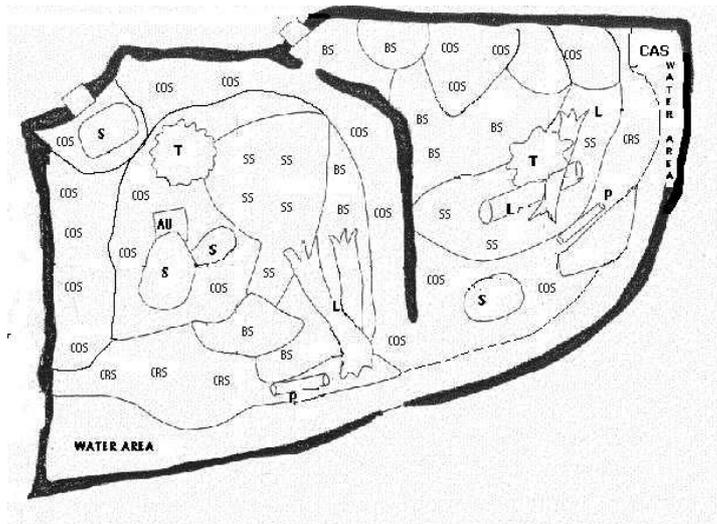


FIGURE 1 A plan of the brown bear enclosure. S=stones, T=tree, L=logs, BS=bark substrate, CAS=water fall, CRS=crushed stone substrate, SS=sand substrate, COS=concrete substrate, P=PVC pipe, AU=honey dispenser.

The study period was March to December 2004. The guidelines for allowing the bears out into their outdoor enclosures depended on the hours of daylight (between 9 am and 4 pm in the spring, to 8 pm in the summer and 7 pm in the autumn). The animals' diet consisted of fruit, vegetables, and meat once a day when they came into their indoor enclosures in the evening. Old female and young female slept in the interior enclosures alone. These animals were took part in two-day enrichment session.

Method

Two types of multi-focal sampling methods were used in this study: 1) the aberrant behavior was recorded using continuous method and 2) the frequency of activity (% scans in activity) was a recorded using instantaneous sample at 2-min intervals (Martin & Bateson, 1991). The

observation sessions were 1 hour in duration. A total of 63 hours of observation were recorded for both females.

The data collected in each session was 1) seasonal periods: spring, summer, or autumn, with a total of 21 h for each seasonal period; 2) frequency of activity –activity defined as dynamic action that makes an animal and involves some energy expenditure unlike inactivity defined as rest with relaxed musculature and involves little energy expenditure and, 3) the aberrant behavior: each bear displayed a different kind of aberrant behavior, and for this reason the data collection was different: A) Old female displayed aberrant episodes that consisted of biting the trunk. The morphology of this kind of aberrant behavior was the animal, in a four-legged position, partly introduced its mouth over the trunk and repeatedly opened and closed its mouth, tightening its jaw against the base of the furniture. Thus, the variables gathered during each session of observation for this female were: start time, end time, average duration of the aberrant episodes (duration), the time between one aberrant episode and the next (intensity) and, the number of abnormal episodes per session (occurrence); B) Young female had a different type of aberrant behavior, consisting of an event of aberrant turn of the head anti-clockwise in the vertical plane. The duration of this aberrant behavior was very short, five seconds, and the variables to record were the time she started, the duration between one turn of the head and the next (intensity), and the number of aberrant events per hour (occurrence).

Data Analysis

All data analyses were performed using SPSS 15.0. Normality was assessed using Lilliefors' test. A rejection criteria of $p=0.05$ was applied to all tests. In order to determine the relation between numerical variables (duration, occurrence and intensity of aberrant behaviors and activity frequency) and the three seasonal periods (spring, summer and autumn) was determined through one-way ANOVA test (parametric test) or Kruskal-Wallis test (non-parametric test).

RESULTS

Table 1 shows the mean and standard deviation for duration, intensity, occurrence and frequency of activity (%) of the 137 aberrant episodes analyzed for old female and 4283 aberrant events for young female.

TABLE 1

Mean and standard deviation for the different variables for brown bear's aberrant behaviors in relation to the three seasonal periods

		Duration (s)	Intensity (s)	Occurrence (n° aberrant episodes/session)	Frequency of activity (%)
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Old female	Spring	1074.1 ± 658.0	179.0 ± 143.7	2.1 ± 1.2	81.6 ± 33.3
	Summer	415.8 ± 356.2	244.5 ± 226.7	2.8 ± 2.2	71.3 ± 28.9
	Autumn	383.1 ± 459.5	268.8 ± 246.6	1.9 ± 2.1	66.4 ± 30.3
Young female	Spring		41.3 ± 84.2	84.6 ± 32.9	97.1 ± 13.4
	Summer		53.3 ± 146.2	63.9 ± 36.4	91.6 ± 18.3
	Autumn		61.5 ± 141.0	53.7 ± 28.4	97.1 ± 6.3

Table 2 shows that for old female only the duration depended on the three seasonal periods meanwhile for the young female the intensity and occurrence depended also on the three seasonal periods.

TABLE 2

Brown bears' values for one-way ANOVA and Kruskal-Wallis test to determine the relation between duration, intensity, occurrence and frequency of activity (%) and the three seasonal periods

	Duration (s)			Intensity (s)			Occurrence (n° aberrant episodes/session)			Frequency of activity (%)		
	F	df	p	F	df	p	F	df	p	H	df	p
Old female	29.34	2,147	0*	1.28	2,87	0.28	1.12	2,57	0.33	5.10	2	0.08
Young female				3.96	2	0*	4.83	2,61	0*	4.27	2	0.12

Figure 2 shows that the highest aberrant behavior duration for old female was in spring followed by summer and autumn.

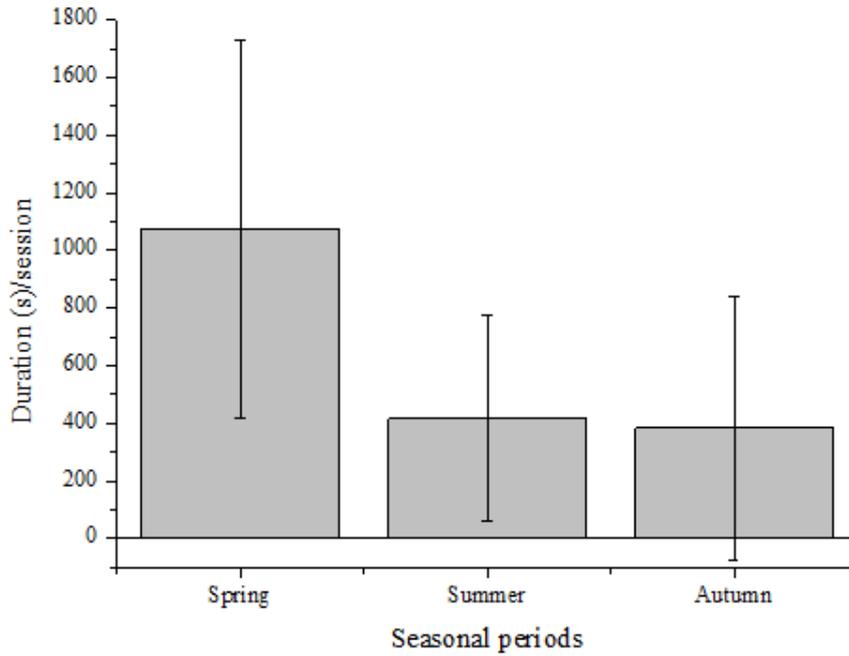


FIGURE 2 The mean (\pm SD) duration of old female's aberrant episodes by the three seasonal periods.

Figure 3 shows that the lowest aberrant behavior intensity (the time elapsed between two aberrant behaviors) for young female was in spring followed by summer and autumn.

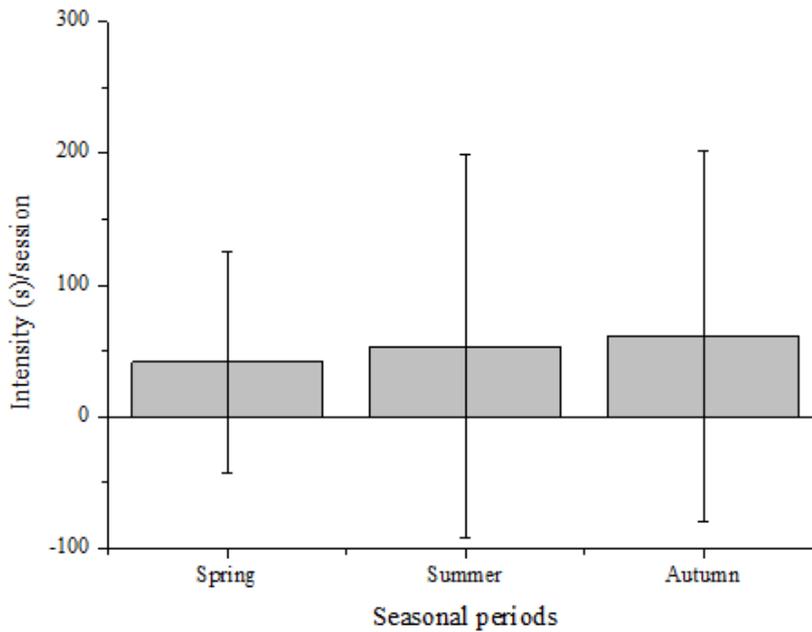


FIGURE 3 The mean (\pm SD) intensity of young female's aberrant episodes by different seasonal periods.

Figure 4 shows that the highest aberrant behavior occurrence (n° of aberrant behaviors/session) for young female was in spring followed by summer and autumn.

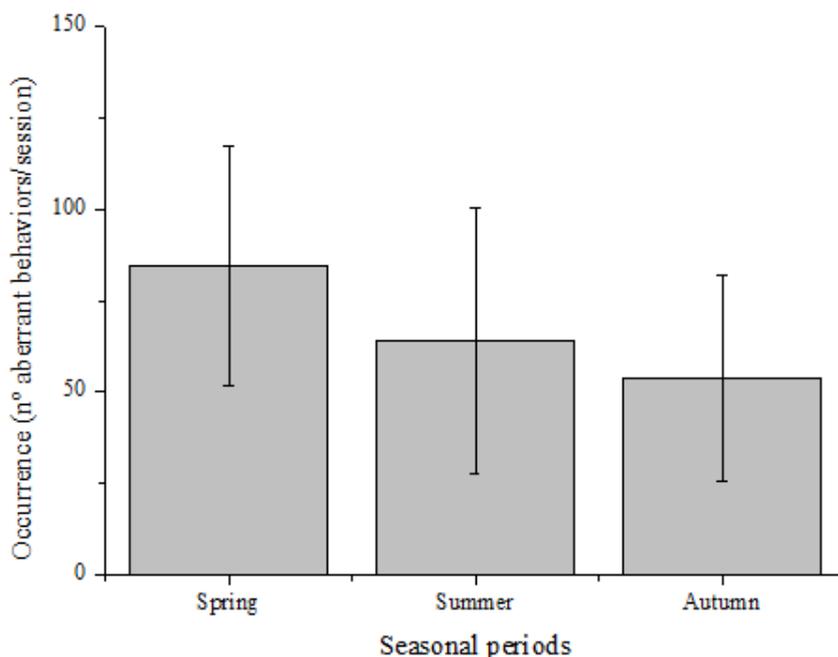


FIGURE 4 The mean (\pm SD) occurrence of young female's aberrant behavior based on the three seasonal periods.

DISCUSSION

The activity of these brown bears was not highly dependent on the seasonal periods, as is the case for wild brown bears (Stirling, 1993; Brown, 2009) unlike of some aspects to the aberrant behavior as duration for the old female and intensity and occurrence for the young female. Both results demonstrate that captive conditions of these two females do not meet their physical and psychological needs. The results of wild-captive comparison (Veasey et al., 1996) and aberrant behaviors (Broom, 1983) can be used as indicators of animal welfare. It is necessary to determine if captive animals with seasonal variations of behavior (i.e. bears, bats, marmots, squirrels, woodchucks, rodents etc.) have a greater degree of welfare through studies such stress-related hormones (Möstl & Palme, 2002; Brown, 2009).

If it is determined that animals with seasonal variations have higher levels of animal welfare when living or reproducing the same environmental conditions that wild counterparts

would be needed more studies in order to determine if the seasonal variations of the behavior of bears are caused by external factors (i.e. temperature, food availability) and/or internal factors (i.e. hormonal factors that are triggered depending on the length of the days) or by combination of both (Ward & Kynaston, 2003; Brown, 2009).

Knowledge of factors that induce hibernation of bears allows imitate, predict and control the seasonal changes in captivity in order to adapt the management on each occasion (i.e. diet composition, length of day, temperature, design of facilities, socialization of animals during zeal period, building dens for hibernation and reproduction) and provide the best conditions for the animals to meet their physical and psychological needs.

You can find seasonal variations animals housed in zoos located in the same latitudes in which they live or they live out as hibernation exhibit for Japanese black bear (*Ursus thibetanus japonicus*) at Ueno Zoological Gardens in Japan (Itoh et al., 2010). In the latter case, provided that the welfare of animals required, would be necessary adapt management and facilities in order to enhance these species-typical behavior.

The results of this study demonstrate that, in general, the frequency of activity of these two females not varied according the three seasonal periods unlike the aberrant behaviors with a longer duration in spring, similar to observations made in the polar bear (*U. maritimus*) by Ames (1993) and Kolter and Zander (1995), and in contrast to the observations made in the American black bear (*U. americanus*) by Carlstead and Seidensticker (1991), who reported an elevated proportion of aberrant behavior during summer. The increased frequency of episodes observed in spring in the brown bear and polar bear could be related to the hormonal changes that take place during the zeal period, which increases the activity of adults (Fundación Oso Pardo & Márquez, 1998; Ward & Kynaston, 2003).

Limitations of this study are: 1) small sample of individuals who cannot generalize to the species level but for zoos is increasingly important to study individual level than the population level (Fa et al., 2011) and, 2) studying the winter period would have been interesting to identify variation in the aberrant behaviors at a time that entails diminished activity in this species in its natural habitat.

Despite the two daily enrichment sessions aimed at improving the wellbeing of these animals, the present work shows that old female's aberrant behavior displays frequencies superior to the 10% (17%) undesirable value espoused by Shepherdson (1989), whereas young female had a desirable value (5%).

Be very useful to describe an animal welfare index related to different aspects of aberrant behavior and therefore unify the methodology to allow rates or levels compare wellbeing of individuals of the same species that can be housed under different conditions (i.e. different zoos parts of the world).

The welfare of the Ursidae depends on many factors, including daily management as: 1) composition of the diet with seasonal variations as wild (Grandia et al., 2001; Larsson & Tove, 1995; Morimura & Ueno, 1999), 2) enrichment programs (Hare, 1995), 3) facility design including conditioned facilities, dens and materials needed to build dens (Soriano et al., 2006; Spendrup & Larsson, 1997; Seidensticker & Doherty, 1996), 4) social conditions related to determine if animals welfare of solitary individuals is worse when coexist with conspecifics outside the breeding season (Kleiman et al., 2010) through welfare and physiological (hormones) indicators, 5) public influence (Montaudouin & Le Pape, 2005), 6) veterinary care (Hosey et al., 2009) and, 7) training programs in order to facilitate veterinary practices (i.e. vaccines, biological sample collection, etc.) and animal body maintenance (i.e. hair or skin brushing, nail filing, etc.) (Ramirez, 1999). All of these factors contribute to the occurrence of aberrant behaviors. Studying all of these aspects would be necessary to discern which conditions are suitable for the maintenance of these animals in the best captivity conditions (Swaisgood & Shepherdson, 2005) and for considering the reintroduction of individuals of this species, as proposed by Vickery and Mason (2003), because we are talking about a species in serious danger of extinction.

Other authors have indicated a crucial relationship between the size and type of the enclosure and the number of stereotypies manifested. Where facilities are larger and more naturalized less stereotypies observed in the housed animals (Spendrup & Larsson, 1997).

In order to guarantee the well-being of the captive animals and reduce aberrant behavior, considering factors that can be crucial in the appearance and fixation of stereotypy behaviors is necessary, including the origin and age of subjects before transfer from one zoo to another. In the present study these factors were not considered, which may impact the appearance and persistence of these behaviors despite the application of an enrichment program.

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