



## Individual and environmental factors associated with stereotypic behavior and fecal glucocorticoid metabolite levels in zoo housed polar bears

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### ARTICLE INFO

#### Article history:

Accepted 2 January 2013

#### Keywords:

Stereotypic behavior  
Stress  
Fecal glucocorticoid metabolites  
Corticosterone  
Temperament test  
Welfare  
Wellbeing  
Husbandry  
Positive reinforcement training  
Human animal relationship

### ABSTRACT

Polar bears (*Ursus maritimus*) are known to exhibit repetitive pacing behaviors, usually described as stereotypic, in zoo environments. However, little quantitative information exists about the prevalence of pacing in the zoo population. Similarly, large, multi-institutional studies conducted to determine the relationship between stereotypic behavior in zoo polar bears and environmental/husbandry variables using corticoids as a measure of stress are lacking. The study reported here includes data from 55 bears housed in 20 North American zoos. Individual and zoo characteristics were collected and behavior and fecal glucocorticoid metabolites (FGM) were measured over a one-year period. Using an epidemiological approach, individual and facility level multiple linear regression models were constructed to determine the nature, strength and significance of environmental/husbandry variables and temperament (measured using a standardized novel object behavior test) on stereotypic pacing and FGM. We found zoo polar bears performed stereotypic pacing behavior during 14% of the day; the proportion rose to 22% when expressed as a percentage of time engaged in locomotory behavior. However, considerable variation in proportion of stereotypy was observed. Variables associated with reduced pacing at zoos were: enrichment, number of bears in the group, and bears having a view out of their exhibit with a strong suggestion that the existence of a positive reinforcement training program may also be important. Among individuals, bears whose temperament measured high on the “interest” axis (defined in terms of behavior directed toward the novel object) tended to display less stereotypic behavior and those that scored high on the “slow to approach” axis displayed more pacing. We found higher FGM levels were associated with higher proportions of stereotypic pacing, lower levels of the temperament variable “interest” and smaller dry land exhibit area. These results support other studies suggesting polar bears are particularly prone to stereotypic pacing behavior in zoos and that there is a link between stress (measured as FGM) and pacing in zoo polar bears. These findings also suggest that some easily available tools, namely environmental enrichment and possibly positive reinforcement training, can effectively reduce the incidence of these behaviors. Exhibit designers should take note that providing bears with a view out of their exhibit and larger land areas are associated with both behavioral and physiological benefits. Finally, certain temperaments are associated with elevated levels of both stereotypic behavior and corticoids. This

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information may provide a tool for proactively identifying the individuals most likely to develop pacing behaviors and providing appropriately enhanced care before the behavior becomes established.

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## 1. Introduction

As one of the most easily recognized and possibly most prevalent abnormal behaviors observed in zoos, stereotypic behavior has received attention in the zoo animal behavior literature over a period of several decades (e.g. Morris, 1964; Hediger, 1968; Meyer-Holzappel, 1968; Boorer, 1972; Dittrich, 1976; Carlstead, 1991; Marriner and Drickamer, 1994; Carlstead, 1998; Vickery and Mason, 2003; Swaisgood and Shepherdson, 2005). This concern is appropriate given the conclusion of Mason and Latham (2004) that in 68% of situations (not just zoos), that cause or increase stereotypic behavior, welfare is also significantly decreased.

Although research to date has largely failed to reveal a simple relationship between welfare and the performance of stereotypic behavior (Mason and Rushen, 2006), recent findings increasingly implicate motivational frustration and/or brain dysfunction in the causation of the behavior (Mason et al., 2007). Further, since stereotypic behavior may sometimes fulfill a coping function (Mason et al., 2007), its absence in individuals within a population of animals in which stereotypic behavior is prevalent does not necessarily mean that those individuals are in a state of better wellbeing than the others. For these reasons the existence of stereotypic behavior in zoo animals is of great concern. Indeed, Mason et al. (2007) suggest a “Zero tolerance” policy for abnormal repetitive behaviors in zoos.

As a group, bears are often thought to be the most prone to stereotypic behavior in captivity and within this group, polar bears are documented to be the most predisposed (e.g. Richardson, 1987; Ames, 1993). Indeed, a 1997 survey of 16 North American zoos carried out by the AZA Ursid TAG revealed that 43% of polar bears were considered to exhibit at least moderate amounts of stereotypic behavior by their keepers (Carlstead, personal communication). There is some evidence to suggest a link between the wild biology of a species and its tendency to perform stereotypic behavior. Clubb and Mason (2003, 2007) found a positive relationship between wild home range size and propensity to perform stereotypic behavior in captivity, an exciting discovery as it sheds light on the motivational underpinnings of the behavior. Not surprisingly, polar bears with their very large arctic home ranges are at the extreme end of this continuum.

A number of small sample case studies have documented stereotypic behavior in polar bears, attempted to assess its significance with respect to welfare, and to test techniques for reducing or eliminating it (e.g. Van Keulen-Kromhout, 1976; Wechsler, 1991; Forthman et al., 1992; Ames, 1993; Hennessy, 1996; Lewis, 2000; Ross, 2006; Canino and Powell, 2010). Although these studies produced some useful information and testable hypotheses, none

were conducted on a large enough scale or with a sufficient sample size for the full range of potential variables to be investigated or for the results to be reliably generalized to the captive population as a whole.

The approach described in this study is both innovative and evolutionary in that it is a multi-institutional study measuring both behavior and physiology and it utilizes a statistical approach to data analysis that is derived from the field of epidemiology. Epidemiological studies are non-experimental studies involving large numbers of variables with the goal of explaining the “risk factors” associated with negative outcomes (in this case pacing and corticoid levels). The application of these techniques to animal behavior studies is relatively new (Millman et al., 2009). A number of influential studies have demonstrated the power of multi-institutional behavioral research in revealing general principles affecting zoo animal behavior and well-being (e.g. Mellen, 1994; Carlstead et al., 1999a). In addition, a number of studies (e.g. Carlstead et al., 1992; Dathe et al., 1992; Carlstead and Brown, 1993; McLeod et al., 1996; Jurke et al., 1997; Wielebnowski et al., 2002; Wielebnowski and Brown, 2003; Shepherdson et al., 2004) demonstrate the value of combining physiological measurements with behavioral assessments as an effective way of furthering our understanding of behavioral motivation and causation. In particular, non-invasive measurement of corticoid metabolites in feces and urine is increasingly being used to assess individual differences in physiological response to captive environments. It is well-known that aversive stimulation or challenging situations can induce adrenocorticotrophic hormone (ACTH) release which, in turn, increases the synthesis and secretion of cortisol by the adrenal gland, also known as the hypothalamic-pituitary-adrenal axis (HPA) (Selye, 1956; Jones, 1979). While acute activation of the HPA can also result from positive stimulation and increased arousal, long term increases in HPA activation resulting in chronically elevated cortisol levels have been clearly linked with reduced wellbeing (Wielebnowski and Watters, 2007). That glucocorticoid metabolite levels can be monitored non-invasively in fecal samples has been validated in a number of exotic species, including timber wolves (*Canis lupus*) (McLeod et al., 1996), cheetah (*Acinonyx jubatus*) (Jurke et al., 1997), and bighorn sheep (*Ovis Canadensis*) (Miller et al., 1991). Corticoid levels measured repeatedly over extended periods can thus be used as an index of stress in captive animals. For example, Carlstead et al. (1993) were able to show a reduction in both pacing and corticoid levels upon provision of concealment to leopard cats (*Felis bengalensis*). Similarly, Jurke et al. (1997) classified seven female cheetah into three categories of corticoid excretion, low, intermediate and high, and found that females in the high category were rated most “nervous” and had had compromised patterns of ovarian cycling.

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