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The effect of enclosure type on the behavior and heart rate of captive coyotes

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ABSTRACT

The potential for captivity to elicit changes in animal behavior and physiology is well known. Recent research on captive populations has examined the effect of feeding protocols, enclosure types, and enrichment programs on indices of stress and displays of species-typical behaviors. We investigated the impact of enclosure type upon captive coyotes (*Canis latrans*) by examining differences in coyote behavior and heart rate, among 3.3 m^2 kennels (K), 65.5 m^2 small pens (S), and 1000 m^2 large pens (L). Time budgets and repertoire of species-specific behaviors were compared among each enclosure type and to a sample of wild (W) coyotes. Baseline heart rates and heart rate (HR) responses to food delivery and fecal collection (measured as mean heart rate and latency of heart rate to return to baseline) were also compared among treatments. We found that behavioral budgeting, but not repertoire, differed significantly among enclosure types. Relative to small and large pen enclosures, coyotes maintained in kennels exhibited the greatest amount of stereotypic behavior ($P < 0.0001$). Coyotes kept in large pens were most similar to wild coyotes in the percentage of time they spent performing exploratory (K: 2.7%; S: 4.9%; L: 8.5%; W: 12.0%) and stand and scan (K: 8.0%; S: 16.4%; L: 22.0%; W: 22.3%) behaviors. Heart rate analysis showed that baseline heart rates and heart rate responses to food delivery did not differ significantly among enclosure types. Mean heart rate responses to fecal collection were significantly higher for kennel coyotes than for those maintained in large pens ($P = 0.04$). Similarly, latency to return to baseline was significantly higher in kennels than in small and large pens ($P = 0.001$). These results suggest that enclosure type does influence coyote behavior and heart rate responses to some human activities.

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1. Introduction

Concerns about animal welfare, the potential for environmental conditions to influence farm productivity, research observations, and conservation efforts in zoos have prompted numerous studies on the effects of captivity on animal behavior and physiology (Carlstead et al., 1993; Meijer et al., 2006). The impact of the captive environment upon an individual may be influenced by several factors including species, age, reproductive status, and previous experience; however, detrimental changes to behavior and physiology become increasingly prevalent as the housing environment becomes more barren and spatially or socially restrictive (Hubrecht, 2002; Meehan and Mench, 2007). Adverse changes such as displays of self-injurious behaviors, increased restlessness and vigilance, and reduced fecundity have been linked with stress and inadequate housing conditions (Fraser and Broom, 1997; Morgan and Tromborg, 2007). Chronic stress in the captive environment can be caused by repeated exposure to inescapable

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stressors such as an inability to avoid unwanted interactions with caretakers, unpredictable husbandry schedules, and handling for experimental procedures (Carlstead et al., 1993; Meijer et al., 2006). Restrictive enclosures exacerbate the impact of these stressors by prohibiting species appropriate responses, reducing flight distance or both (Morgan and Tromborg, 2007). Thus, enclosure type has been the focus of much research regarding captive animal welfare.

Several attributes of captive animal housing have been investigated using behavioral indices of stress (Brown and Grunberg, 1996; Jarvis et al., 2002). Abnormal behaviors such as stereotypies, excessive grooming, increased vocalizations, increased activity, paw lifting, and increased levels of fearfulness and reactivity to unpredictable events are associated with canids experiencing chronic stress, inadequate sensory stimulation or both (Hetts et al., 1992; Nimon and Broom, 2001; Rooney et al., 2007). Although pacing is probably the most common form of stereotypy observed in captive carnivores (Clubb and Mason, 2007) other stereotypical behaviors such as repetitive circling and gnawing on enclosure walls have also been observed (Beerda et al., 1999).

The prevalence of species-typical behaviors (behaviors apparent in the behavioral repertoire and budget of wild conspecifics) has also been used to evaluate enclosure condition (Kistler et al., 2009). Providing animals with the adequate space and materials needed for displays of species-typical behaviors has been shown to reduce abnormal behaviors and mitigate stress responses in several species (Vestergaard et al., 1997; Grindrod and Cleaver, 2001; Bolhuis et al., 2005). Previous research on gray wolves, red fox, and domestic dogs (Hubrecht et al., 1992; Nimon and Broom, 2001; Frézard and Le Pape, 2003) suggests that enclosure conditions influence the amount of time spent performing species-specific behaviors. It remains unclear, however, if the same holds true for coyotes. Shivik et al. (2009) found that enclosure type had a limited impact on the behavioral budget or repertoire of captive coyotes.

In addition to behavioral indices of stress, physiological indices are often used to investigate the impact of enclosure condition (Rooney et al., 2007). Heart rate, a measure of the sympathetic adrenal medullary (SAM) axis, is considered a sensitive and effective measure of the physiological response to stressful stimuli (Weisenberger et al., 1996; Boissy et al., 2007). Heart rate may also reflect psychogenic responses to other stimuli and events such as agonistic behavior between pen mates, isolation, and feeding when observed heart rates exceed those expected due to physical exertion alone (Kreeger et al., 1990; Palestrini et al., 2005).

Increased responsiveness to novel stimuli, both behaviorally and physiologically, has been linked to barren and spatially restricted enclosure conditions (Veissier et al., 1997). In pigs and mice, restrictive enclosures increase baseline heart rates and promote psychogenic responses to husbandry and experimental practices (Schouten et al., 1991; Marchant et al., 1997). Several studies have examined heart rate response to novel or aversive stimuli in canids and increased heart rates appear to be a common response in dogs, red fox and gray wolves (Kreeger et al., 1989; White et al., 1991; Palestrini et al., 2005). Heart rate increases have also been observed in response to, presumably, less aversive and more routine events such as caretaker approach and feeding in gray wolves (Kreeger et al., 1990). A comparison of heart rate responsiveness to stimuli among enclosure types has not been previously conducted in canids, although several studies have investigated the heart rate responses of dogs housed in animal shelters and research institutions.

The focus of this study was to examine the effect of enclosure type on captive coyotes (*Canis latrans*) by measuring differences in behavior and heart rate. Captive coyote behavioral budgets and repertoire were compared among enclosure types and to a wild reference population with an emphasis on the prevalence of abnormal and species-specific behaviors. Baseline heart rates and heart rate responses to food delivery and an intrusive human activity (fecal collection) were also compared among enclosure types.

2. Materials and methods

2.1. Subjects and experimental design

This study was conducted using 10 (six male and four female) parent-reared coyotes maintained in the colony at the United States Department of Agriculture (USDA), Animal Plant and Health Inspection Services (APHIS), Wildlife Services (WS), National Wildlife Research Center (NWRC) Predator Research Station in Millville, UT, USA. Coyotes were between five and eight years of age when this study was conducted from November 2003 through January 2004. The study was conducted during winter months to minimize forage related behavior differences between captive and wild coyotes; food availability for wild coyotes is most similar to that of captive coyotes during the winter due to increased carcass availability (Gese et al., 1996). Throughout the study each coyote was fed one daily ration of 650 g of commercial mink food diet (Fur Breeders Agricultural Cooperative, Logan, UT, USA) and water was provided *ad libitum*. Coyotes on this study received the same regimen of feeding and care as non-study animals.

In this study we used a three time period, three treatment cross-over study design where subjects were housed within a different treatment enclosure: kennel (K), small pen (S), or large pen (L) each period. Each treatment sequence (KSL, KLS, SKL, SLK, LKS, LSK) was randomly assigned to one male and one female coyote, with the exception of KSL and KLS which were assigned to one male each. The start and end dates for each treatment period was as follows: period one 15 November 2003 to 3 December 2003; period two 4 December 2003 to 19 December 2003; and period three 20 December 2003 to 6 January 2004. No data were collected prior to day 8 of each period to allow time for the coyotes to acclimate to their new enclosures and provide a washout period between treatments (Gilbert-Norton et al., 2009). Enclosure histories varied between subjects; however, all coyotes had prior exposure to both kennels and large pens. No coyote had prior experience in the newly constructed small pens. Directly before study onset, each subject was maintained individu-