



Influence of habitat structure and food on patch choice of captive coyotes



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ARTICLE INFO

Article history:

Accepted 1 May 2014

Available online 9 May 2014

Keywords:

Boldness

Canid

Canis latrans

Carnivore

Personality

Urban

ABSTRACT

Increasing urban development can have significant effects on wildlife species, including carnivores. Some carnivore species have been able to adapt to and even thrive in urban environments, including coyotes (*Canis latrans*). The presence of carnivores in urban areas can sometimes lead to conflicts with humans and their pets. Although coyotes may frequently use urban areas, they also inhabit natural areas surrounding urban development. Understanding the various factors affecting patch choice of urban coyotes may assist wildlife officials in managing human-coyote conflicts. Both sex and behavioral profile can influence patch choice; bold individuals are more likely to be exploratory than shy animals, which can result in increased conflicts in urban environments. Using a captive population of coyotes, we tested whether coyotes preferred urban (anthropogenic) habitat structure, natural structure, or a mixture of structures and whether sex, behavioral profile, biological season, or food manipulation affected coyote patch choice. Coyotes generally preferred the control, homogeneous structure representing their natal habitat (mean percentage of time $23.3\% \pm 19.3$ SD; $P=0.037$). The next most preferred habitat for coyotes, especially females ($23.7 \pm 16.6\%$ for 25% urban pen; $P=0.020$) and bold coyotes ($27.8 \pm 23.2\%$ for 75% urban pen; $P=0.005$), was a mixture of anthropogenic and natural structures rather than uniform structure (all natural or all anthropogenic), and this preference was more strongly expressed during the non-breeding season ($25.6 \pm 23.2\%$ for 75% urban pen; $P=0.017$). Food had no effect on patch choice ($P=0.983$); coyotes appeared to be primarily motivated by the structure of the habitat rather than by the amount of food within each habitat. Our results suggested that urban areas containing large amounts of both natural and anthropogenic structures are more likely to be used by coyotes and, thus, could have the potential for human-coyote conflicts.

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1. Introduction

Patch choice theory states an animal will choose the most profitable patch, or the patch containing the highest density of prey (Goss-Custard, 1977; Krebs et al., 1977;

Stephens and Krebs, 1986). However, some studies contradict this theory, reporting that animals are willing to expend more energy even when food is freely available (Forkman, 1991; Inglis and Ferguson, 1986; MacLean et al., 2005). Inglis and Ferguson (1986) suggested animals are willing to spend more time and energy foraging in order to gather information about their environment, including knowledge of alternative food sources. This concept might apply to animals that are more certain of their survival

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(Forkman, 1991) or have certain behavioral profiles, such as boldness (Kurvers et al., 2012).

Studies have shown individuals within many animal species can have varying personalities, or behavioral profiles (i.e., more bold or more shy; Gosling, 2001; Sih et al., 2004). Bold individuals are more likely to be exploratory, and shy individuals may exhibit a greater degree of vigilance in unfamiliar situations (Wilson et al., 1993). Differences in behavioral profiles can affect animal movements, including the ability to find novel food sources (Fraser et al., 2001), and can influence patch choice. Patch choice decisions may vary between urban and natural systems because animals living in urban environments frequently display different behaviors than animals living in rural areas (Sol et al., 2013). Certain behavioral profiles, e.g., boldness, might be important in successful colonization of urban areas (Lowry et al., 2011).

Global landscapes are becoming increasingly urbanized, and the world's human population is now dominated by more individuals living in cities than in rural areas (Seto et al., 2012; United Nations Population Fund, 2007). Urban development significantly affects the natural environment and, therefore, many wildlife species (McDonald et al., 2008; McKinney, 2002). Several species are able to persist in urban environments, including those species previously associated only with rural or undeveloped landscapes (Ditchkoff et al., 2006), by modifying their behaviors (Tigas et al., 2002), habitat use (Prange et al., 2004), and foraging strategies (Fleischer et al., 2003). Certain carnivore species have also demonstrated an ability to adapt to and thrive in urban environments (Baruch-Mordo et al., 2008; Beier, 1995; Gehrt et al., 2009; Riley et al., 1998). Patch choice in carnivores can be influenced by both landscape structure and the availability of food resources in fragmented landscapes (Mortelliti and Boitani, 2008), although cost-benefit thresholds may be reached beyond which carnivores cannot use highly-urban, human-dominated patches (Baruch-Mordo et al., 2013).

Coyotes (*Canis latrans*) are highly adaptable, opportunistic carnivores and habitat generalists (Bekoff and Gese, 2003; Morey et al., 2007) and are increasingly colonizing urban areas (Gehrt et al., 2009; Grinder and Krausman, 2001). Coyotes living in close proximity to humans and their pets may cause conflicts, which have become an important consideration for urban wildlife managers (Gehrt et al., 2009; Lukasik and Alexander, 2011; Poessel et al., 2013). Although urban coyote diets are typically dominated by native small mammals, such as rodents and lagomorphs (Fedriani et al., 2001; Lukasik and Alexander, 2012; Morey et al., 2007), coyotes will sometimes take advantage of anthropogenic food sources associated with humans, placing them in increasing contact with humans and their pets (Gehrt and Riley, 2010). The availability and abundance of food may be an essential determinant of coyote habitat use (Knowlton et al., 1999; Morey et al., 2007; Turner et al., 2011). However, food may not always influence coyote spatial patterns. Alternative factors, including habitat features or denning sites, might be more important than food in determining space use in coyotes (Young et al., 2008).

Previous studies of space use in urban areas have shown coyotes select natural habitats within their home ranges and minimize exposure to human development (Atwood et al., 2004; Gehrt et al., 2009; Gese et al., 2012; Grinder and Krausman, 2001; Quinn, 1997; Riley et al., 2003). Hence, although coyotes may use urban areas, they generally utilize natural areas integrated into or surrounding urban development. Understanding the factors influencing a coyote's decision regarding patch choice could prove beneficial in managing human-coyote conflicts in urban areas and predicting coyote behavior related to space use.

Our objective was to determine which factors, including sex, behavioral profile, and biological season, affected coyote patch choice along a gradient from natural to urban habitat structure, and how manipulation of the quantity of food might guide coyote decision-making. We defined habitat as the resources necessary for an animal to survive; however, we only manipulated food and the structure within the habitat. We used captive coyotes, maintained for research purposes, to experimentally test these factors. We hypothesized that bold coyotes would use urban patches more than shy coyotes, and that food availability would affect coyote patch choice more than habitat type.

2. Materials and methods

2.1. Study site

We conducted the study at the USDA/National Wildlife Research Center (NWRC) Predator Research Station in Millville, UT, USA, which houses a large population of coyotes maintained individually and in pairs. For this study, we used an interaction pen system consisting of one center pen and six pens (each pen 0.1 ha measuring approximately 40 m across at the widest point) surrounding and attached to the center pen by fenced alleys with gates at each end of the alleys (Fig. 1); the topography was flat. Each of the six outer pens contained a den box (0.5 m high × 0.5 m diameter) with corn cob bedding (Green Products Company, Conrad, IA, USA), an automatic water source, and a 0.7 m high wooden shade table, which were standard items placed in all coyote pens at the facility. The center pen consisted of native grasses, i.e., native habitat, but no additional structures or plants; this habitat was similar to the environment in which coyotes at the facility were raised. Five of the six outer pens were designed to simulate a gradient of habitat structure from planted shrubs and trees (defined as "natural") to anthropogenic structures (defined as "urban"); the coyotes at the facility were unfamiliar with these types of habitat structures. The sixth outer pen remained similar to the center pen and acted as the experimental control pen (hereafter "control"). One pen was designated as all natural (hereafter "0% urban") and included structurally native vegetation (i.e., shrubs and trees) planted before study commencement. Another pen was designated as all urban (hereafter "100% urban") and included anthropogenic structures made from plywood and wood pallets, trash cans, a culvert, and solar lights placed on top of certain wooden structures. The remaining three pens included a mixture of natural vegetation and urban structures, with one pen containing 25% urban and

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