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Influence of exotic horses on the use of water by communities of native wildlife in a semi-arid environment

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ABSTRACT

Introduced species can impact native communities by altering competition dynamics. Large exotic species, such as the horse (*Equus caballus*), may have a competitive advantage over smaller native species and could exclude them from access to limited resources. Our objective was to determine the influence of the exotic horse on the use of water by native species in a semi-arid environment where availability of water is limited. From July 2010 to August 2011, we used remote cameras to monitor water sources in the Great Basin Desert where horses had drinking access and where horses were excluded (with fencing) to compare 1) composition of native communities and 2) water usage by native species. We captured 96,601 images representing 40 species of birds (29,396 images) and 13 species of mammals (67,205 images). Of the 67,205 images of mammals, 79% contained horses. Horses were associated with decreased richness and diversity of native species at water sources. Furthermore, native species had fewer visits and spent less time at water sources frequented by horses. Our results indicated that horses displaced other species at water sources providing evidence of a negative influence on how communities of native wildlife access a limited resource in an arid environment.

1. Introduction

Competition for limited resources influences the organization and structuring of biotic communities (Schoener, 1974; Carothers and Jaksić, 1984). Where species co-occur and compete for resources there are often mechanisms that enable coexistence and community stability. Because species differ in their competitive abilities, some species outcompete others for access to resources (Côté, 2005). To ensure coexistence in multi-species environments, subordinate competitors often partition resources with dominant competitors (MacArthur, 1958; Barot and Gignoux, 2004). However, mechanisms that stabilize community structure (e.g., resource partitioning) typically evolve over long periods of time.

Consequently, communities with species that have co-evolved over relatively long periods of time likely have better developed strategies for coexistence than newly formed communities. For example, within the community of native herbivores in semi-arid Africa, there is evidence that the large-bodied elephant (*Loxodonta africana*) influences community structure at waterholes (Valeix et al., 2007). Smaller herbivores that compete with elephants tend to avoid peak times of elephant visitation to waterholes. These smaller herbivores have co-existed with elephants over millions of years and have likely evolved strategies for temporal resource partitioning to minimize competition. In native communities, dominance hierarchies are typically well established, helping to stabilize community organization (Schuette et al., 2013). In communities where relatively new competitors have been introduced (i.e., exotic species), dominance hierarchies and competition dynamics may be altered, negatively influencing resource partitioning and the structure of native communities.

The introduction of exotic species is a global phenomenon that has had far-reaching implications for the stability of native communities (Wolfe and Klironomos, 2005; Lach, 2008; Kenis et al., 2009). Many exotic species have a competitive advantage over

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native species due to a variety of factors related to life history and physiology (e.g., growth rate, reproduction rate, lack of natural predators and/or competitors; Humphrey and Schupp, 2004; Côté, 2005; Preston et al., 2012). In addition, physical attributes such as body size further enable some exotic species to outcompete native species (Gherardi and Cioni, 2004; Reed et al., 2012). Exotic species that are large-bodied and behaviorally dominant can disrupt native communities due to competitive advantages over native species.

The horse (*Equus caballus*) is a large, exotic ungulate that has been introduced around the world since its domestication (Clutton-Brock, 1981; Mills and McDonnell, 2005). Horses have been shown to negatively influence soil, vegetation, small vertebrates and invertebrates in a variety of systems (Beever and Brussard, 2000; Zalba and Cozzani, 2004; Beever and Herrick, 2006; Parvage et al., 2011; Davies et al., 2014). Exotic horses (and burros [*Equus asinus*]) have also displaced native ungulates from preferred habitats and at water sources (Ostermann-Kelm et al., 2008; Attum et al., 2009; Girard et al., 2013; Gooch, 2014). Species inhabiting arid or semi-arid environments rely on the availability of water (Rautenstrauch and Krausman, 1989; Cain III et al., 2006; Cain III et al., 2012; Bock, 2015) and there may be implications for species that compete with horses for access to water. Horses are gregarious, behaviorally dominant, and water-limited (an individual horse can drink up to 33 L of water/day; Berger, 1985; Groenendyk et al., 1988; Stevens, 1988) and these characteristics may compound competition for native species at water sources. Moreover, horse populations have increased dramatically in arid regions of western North America over the past several decades and are currently exceeding management objectives in many areas (Palmer et al., 2013; Davies et al., 2014). Little is known, however, concerning the degree to which horses compete with communities of native species for water in environments where water is scarce or how increased populations of horses may influence native communities.

Our objective was to determine the influence of horses on the use of water by communities of native wildlife in the semi-arid Great Basin Desert. We monitored water sources where horses had drinking access (horse included; hereafter HI) and water sources where horses were excluded with fencing (hereafter HE) to determine if there were differences in 1) composition of native communities or 2) use of water sources by native species. We expected native species to alter use of water (indirect evidence of competition) to minimize overlap with horses. We predicted that communities of wildlife would 1) be less species-rich and less diverse and 2) spend less time at HI water sources compared to HE water sources.

2. Materials and methods

2.1. Study area

We conducted this study on 631 km^2 of land managed by the United States Department of Defense, United States Army Dugway Proving Ground located in the Great Basin Desert of western Utah, USA. Valley terrain was typical of Lake Bonneville lakebed characterized by dune systems and alkaline flats which were dominated by black greasewood (*Sarcobatus vermiculatus*). Along mountain foothills, big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* spp.), juniper (*Juniperus osteosperma*), and cheatgrass (*Bromus tectorum*) were common plants. Annual weather consisted of mean air temperatures of 12.3 °C (range: −20.0–40.6 °C) and mean precipitation of 146 mm (MesoWest, Bureau of Land Management & Boise Interagency Fire Center). Unlike typical neighboring land managed by the United States Department of the Interior, Bureau of Land Management, this study area had not been grazed by domestic livestock for more than 60 years allowing us to assess the influence of exotic horses on wildlife communities at water sources without this potential confounding influence. Recent estimates of the horse population in and around our study area suggested herd size was 464 horses (Bureau of Land Management, 2012).

2.2. Sampling design & data collection

We monitored 12 HI water sources and 13 HE water sources during June 2010 through August 2011. Water sources included water developments targeted for wildlife (13), overflow ditches and ponds from water treatment facilities (2), and natural springs (10). The majority of water sources were small (mean surface area = 2.6 m^2) with the exception of the two overflow water sources (mean surface area = 1620 m^2). To exclude horses at water sources, but not native species, HE water sources were enclosed with a two-tier, barbless cable fence in the late 1990s (AGEISS Environmental, 1998). Different strategies have been used so that perimeter fencing surrounding water sources does not exclude native ungulates such as mule deer (*Odocoileus hemionus*) or pronghorn (*Antilocapra americana*) (Larsen et al., 2011). In our study area, perimeter fencing was ≥5 m from the water source, with the top cable 92 cm from the ground, the bottom cable 44 cm from the ground, and a 48 cm space in between both cables, allowing native ungulates ample space to crawl underneath or jump over the fencing. Both native ungulates regularly occurred at HE water sources.

To sample species visitation to water sources, we used Reconyx PC900 covert infrared cameras (Reconyx, Inc., Holmen, Wisconsin) at all water sources. We mounted each camera to a metal post and positioned it 40 cm above ground level and approximately 3 m from the water source. Cameras were preset to detect motion and heat and were set to record an image at a minimum interval of 30 s. We checked cameras for proper function, battery status, and replaced memory cards every two weeks. We used Exifer v.2.1.5 (www.friedemann-schmidt.com/software/exifer) software to extract metadata (date and time stamps) from each image file. With date and time information for each image, we then sorted photos into species visits. We defined separate “visits”as consecutive images of a species separated by at least 30 min (Hall et al., 2013).

Water sources (and fences) were in place prior to our study (AGEISS Environmental, 1998), thus we did not have experimental control over location of water sources. This lack of experimental control created the potential for location and surrounding habitat features to influence species use of water sources and confound our results (Burger and Gochfeld, 1992; Larsen et al., 2007, 2012). To address this limitation, we collected a suite of habitat variables associated with each water source. We measured vegetation and topographic characteristics up to 100 m around each water source. We estimated cover and density of shrubs with a Random T-Square sampling approach (Krebs, 1999). To measure vegetation height, we used a Robel pole (Robel et al., 1970) and recorded vegetation measurements at 10, 20, 50, 75, and 100 m intervals radiating away from the water source in all four cardinal directions. We also used ocular estimation to classify the area surrounding each water source with the two dominant types of vegetation present at each site. To further describe each water source, we used ArcGIS (ArcMap, version 10.2, Environmental Systems Research Institute, Redlands, California) to calculate slope, aspect, and ruggedness (Sappington et al., 2007) around water sources using a 10 m resolution digital elevation model.