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Short communication

Potential thermoregulatory advantages of shade use by desert bighorn sheep

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Abstract

Ungulates in arid climates use a variety of mechanisms to cope with environmental conditions that can result in heat stress and dehydration. Use of shade during midday is common among desert ungulates of the southwestern United States. Desert bighorn sheep (*Ovis canadensis mexicana*) use both vegetation and caves as sources of thermal cover. We assessed potential thermoregulatory advantages of the use of vegetation and caves by desert bighorn sheep on the Cabeza Prieta National Wildlife Refuge, Arizona. Midday ambient temperatures in caves were an average of 6.9 °C (SE = 0.344) lower than control sites; ambient temperature under tree canopies was an average of 3.3 °C (SE = 0.950) below control sites. Caves provided higher quality shade than tree canopies; midday temperature in caves was an average of 3.4 °C (SE = 1.06) lower than under tree canopies. Potential thermal benefits of both caves and tree canopies increased with increasing daily high temperature. Behavioral adaptations function in combination with physiological and morphological mechanisms and are of critical importance for the maintenance of temperature and water balance. Short-term physiological and ecological performance is influenced by habitat selection and use of microhabitat; abiotic factors (e.g., ambient temperature) can ultimately influence animal fitness and the demography of animal populations.

Keywords: Arizona; Bighorn sheep; *Ovis canadensis*; Shade; Sonoran desert; Thermoregulation

1. Introduction

Ungulates in arid climates are challenged with maintaining body temperature within physiologically acceptable limits and minimizing water loss (Feldhamer et al., 1999). In response to these environmental factors, ungulates adapted to deserts use a variety of physiological, morphological, and behavioral

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mechanisms to cope with environmental conditions that can result in heat stress and dehydration (Cain et al., 2006; Louw and Seely, 1982; Schmidt-Nielsen, 1979).

Behavioral adaptations function in combination with physiological and morphological mechanisms and are of critical importance for the maintenance of temperature and water balance within physiologically acceptable limits (Bartholomew, 1964). Restricting of daily activities to time periods that reduce daily heat loads and water loss, diet selection, use of microhabitats, and body orientation are behaviors commonly used by desert ungulates for maintaining temperature and water balance (Berry et al., 1984; Cain et al., 2006; Sargeant et al., 1994).

During the hottest, driest periods of the year, desert ungulates tend to spend a smaller proportion of daytime hours being active and shift their activity patterns to crepuscular and nocturnal periods (Alderman et al., 1989; Jarman, 1973, 1977; Sargeant et al., 1994; Vrahimis and Kok, 1992; Wilson, 2006). In addition, animals commonly spend their inactive periods using cooler microclimates (Lewis, 1978; Ostrowski et al., 2003; Tull et al., 2001; Wilson, 2006) or forage in shaded areas (Matson et al., 2005; Owen-Smith, 1998).

Use of shaded microhabitat during midday when temperatures are highest is a common behavior among desert ungulates of the arid southwestern United States, including, desert bighorn sheep (*Ovis canadensis mexicana*, *O. c. nelsoni*, *O. c. weemsii*), desert mule deer (*Odocoileus hemionus eremicus*), Sonoran pronghorn (*Antilocapra americana sonoriensis*), and collared peccary (*Pecari tajacu*) (Anthony, 1972; Krausman et al., 1999; Sowls, 1997; Tull et al., 2001; Wilson, 2006). These species seek vegetation with a dense canopy during the heat of midday and are commonly observed using shade created by vegetation. When available, caves are an additional source of thermal cover. Due to the nature of their habitat, desert bighorn sheep often have caves more readily available than other species of desert ungulate (e.g., Sonoran pronghorn, desert mule deer) and they commonly use caves as sources of thermal cover (Hansen, 1980; Simmons, 1969a, b, 1980; J.W. Cain, personal observation). However, other desert ungulates (e.g., white-tailed deer (*Odocoileus virginianus carminis*), collared peccary (*P. tajacu*)) also use caves when available (Krausman, 1979).

Although use of caves by desert bighorn sheep has been reported, potential thermoregulatory benefits of cave use have not been quantified. Our objectives were to assess the potential thermoregulatory advantages of the use of caves as thermal cover by desert bighorn sheep and to quantify the differences in the potential thermal load experienced by desert bighorn using caves for thermal cover relative to unshaded areas, and to compare potential thermal benefits provided by caves and trees in desert bighorn sheep habitat.

2. Materials and methods

2.1. Study area

We conducted this study on Cabeza Prieta National Wildlife Refuge (CPNWR), Arizona, USA. Topography consisted of a series of rugged mountain ranges surrounded by wide alluvial valleys; elevations ranged from 200 to 900 m. The study sites were located in the Sierra Pinta (32.26263°N, 113.54157°W) and Cabeza Prieta Mountains (32.34915°N, 113.82309°W); each mountain range was inhabited by a population of 60–100 desert bighorn sheep (Cain and Krausman, unpublished data). Climate of CPNWR was arid; annual precipitation occurred in a bimodal pattern, with peaks during summer from monsoon thunderstorms and during winter rains. Long-term mean annual precipitation in the area (1969–2005, Tacna, Arizona approximately 64 km north of study area) was 105 mm. During summer, temperatures often exceeded 45 °C; average low temperature was 22.3 °C (Western Regional Climate Data Center, 2005). Winters were mild with a mean daily high temperature of 21.1 °C and mean daily low temperature of 2.6 °C (Western Regional Climate Data Center, 2005). Vegetation was typical of the Lower Colorado River Valley subdivision of Sonoran desertscrub. Valleys are characterized by plains of creosote bush (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), and ocotillo (*Fouquieria splendens*), with ironwood (*Olneya tesota*), blue palo verde (*Parkinsonia florida*), and triangle-leafed bursage (*A. deltoidea*) common along washes. Vegetation in mountains was characterized by ironwood, catclaw acacia (*Acacia greggii*), foothill palo verde (*Parkinsonia microphyllum*), creosote bush, white bursage, ratany (*Krameria* spp.), brittlebush (*Encelia farinosa*), elephant tree (*Bursera microphylla*), and mallow (*Sphaeralcea* spp. and *Hibiscus* spp.). Common grasses and forbs included three-awn (*Aristida* spp.), grama (*Bouteloua* spp.), big galleta grass (*Pleuraphis rigida*), Indian wheat (*Plantago patagonica*), and scorpionweed (*Phacelia ambigua*) (Simmons, 1966; Turner and Brown, 1994).