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OPPORTUNISTIC FORAGING BEHAVIOR BY COYOTES (*CANIS LATRANS*) OF A NOVEL FOOD SOURCE OBSERVED WITH REMOTE CAMERAS

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Abstract—The opportunistic foraging behavior and wide dietary niche breadth of coyotes (*Canis latrans*) allows them to inhabit a variety of environments. Behavioral observations of wild animals are often logistically difficult, making remotely triggered cameras a valuable tool to document behavior. I placed cameras across a

desert woodland ecosystem in western Colorado, USA, 2015–2016, to document mammalian species distributions. Through these cameras I observed coyotes foraging on a previously undocumented food item, pinyon pine (*Pinus edulis*) nuts; a nutritious seed with a hard exterior. This feeding behavior was verified by observations of coyote scat composed of these seeds. Coyotes fed on pine nuts with greater frequency, longer durations, and in larger groups during 2015 compared with 2016, which coincided with a pine nut masting event. These observations support the hypothesis that coyotes consume prey in relation to availability and increase our understanding of the foraging ecology of an opportunistic canid.

Resumen—Un comportamiento oportunista en la búsqueda de alimento y una dieta diversa permiten a los coyotes (*Canis latrans*) subsistir en diversos hábitats. La observación del comportamiento de animales silvestres es, a menudo, logísticamente difícil. Por esta razón, las cámaras trampa activadas por movimiento son una herramienta valiosa para observar animales y documentar su comportamiento. Se colocaron cámaras trampa a lo largo de un ecosistema forestal desértico en el oeste de Colorado, USA, durante 2015–2016 para documentar la distribución de las especies de mamíferos presentes. Mediante las cámaras, se observaron coyotes consumiendo alimentos que no habían sido documentados previamente, las nueces del piñón (*Pinus edulis*); una semilla nutritiva con una cáscara dura. Este comportamiento se confirmó al encontrar excretas con restos de esta semilla. En 2015, los coyotes se alimentaron de nueces de piñón con mayor frecuencia, con más duración y en grupos más grandes que durante 2016, coincidiendo con un evento de alta producción de semillas. Estas observaciones apoyan la hipótesis de coyotes consumiendo alimentos en relación a su disponibilidad y aumentan nuestro entendimiento sobre la ecología de forrajeo en un cánido oportunista.

Coyotes (*Canis latrans*) are found throughout North America from the boreal forests of Canada to the deserts of Mexico, ranging from rural to urban settings (Bekoff and Gese, 2003). Their broad distribution is largely attributable to their omnivorous diet and behavioral plasticity. Coyotes are generalist predators that tend to consume prey in relation to its availability (MacCracken and Hansen, 1987). They have been documented eating mammals, birds, reptiles, insects, vegetation, and human garbage, although the majority of coyote diets are often composed of relatively few mammals (Gese et al., 1988; Dowd and Gese, 2012). In accordance with the opportunistic behavior of this adaptable animal, I observed coyotes foraging on a food source that might only become available in mass quantity once every decade.

Across approximately 6,000,000 ha of the arid southwestern United States, pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) are primary overstory species, and big sagebrush (*Artemisia tridentate.*), Utah serviceberry (*Amelanchier utahensis*), bitterbrush (*Purshia tridentate*), and rabbitbrush (*Ericameria nauseosa*) dominate the understory (Lendrum et al., 2014). This ecotype can be highly productive for mule deer (*Odocoileus hemionus*) and a variety of lagomorph species (Order Lagomorpha), which are the primary prey species for coyotes of the region (Bartel and Knowlton, 2004) and, therefore, can support high densities of coyotes. Mule deer, however, are often migratory in these systems (Lendrum et al., 2014) and lagomorphs exhibit cyclical patterns in their abundance (MacCracken and Hansen, 1987), which can result in periodic prey limitations. Nevertheless, coyotes are able to persist and even flourish in such environments. It is speculated that the mechanism allowing compensation for seasonal fluctuations in food availability is the coyote's ability to switch between food sources (Gese et al., 1988; Dowd and Gese, 2012).

Many carnivore species are often cryptic or wary by nature, which makes it logistically challenging, if not impossible, to record behavioral observations in their natural habitat. The use of remotely triggered camera traps to monitor wildlife has increased in popularity over the past decade (Burton et al., 2015) and can be useful for documenting species distribution, population trends, and animal behavior (O'Connell et al., 2011). I placed 80 motion-activated, digital cameras distributed across 300 km^2 of critical mule deer winter range in the Piceance Basin of northwestern Colorado, USA, from 2015 to 2016, to document mammalian species distributions relative to anthropogenic disturbance in the form of energy extraction.

While cataloging the photographs, I noticed a greater occurrence of coyotes at a particular camera during the months of September and October 2015. In those 2 months, I obtained 370 photographs of coyotes which I grouped into 12 separate independent events that occurred >1 h apart. Upon closer inspection it appeared the coyotes were foraging on pinyon pine nuts (Fig. 1), which are a large and nutritious seed with a hard exterior (Botkin and Shires, 1948). While coyotes are known to forage on soft mast fruits (Roehm and Moran, 2013), their consumption of nonfleshy seeds is scarcely documented (Dowd and Gese, 2012). The first observation was of a single coyote foraging and then in a later event five coyotes were captured in a single picture frame foraging together (Fig. 1). As confirmation, I searched the area for coyote scat while servicing other cameras and detected scats that consisted almost entirely of pinyon pine nuts (Fig. 1). Photo documentation of multiple foraging events by coyotes and coyote scats containing pinyon

Fig. 1—Five coyotes forage on pinyon pine nuts recorded with a remotely triggered camera (top) in 2015, which was later verified by coyote scat composed of primarily pinyon pine nuts (bottom) in the Piceance Basin, northwest Colorado, USA, 2015.

pine nuts, documented over 10 km away from the camera site, suggests this is not an isolated behavior, although it is unclear how common this foraging strategy is for coyotes in this area.

Pinyon pine trees exhibit regional synchrony in cone production and have masting events every 5–7 years (Tueller and Clark, 1975), and there was a particularly large abundance of pinyon pine cones in 2015 (pers. observ.). If coyotes do in fact consume prey in relation to its availability (MacCracken and Hansen, 1987), this might explain the observed behavior. In an attempt to determine the frequency of use for this food source, I also examined the photographs from September and October of 2016 as a comparison. The same camera site recorded over 120 fewer total photographs of coyotes (247), yet almost twice as many independent events (21) as in 2015.

However, a 2-sample t test revealed that the mean time a coyote, or group of coyotes, was observed per event was approximately 2.5 times shorter in 2016 compared with 2015 (18.3 and 48.5 s, respectively; $t = 1.96$, $P < 0.05$) and ranged from 2 to 147 s in 2015 vs. 1–96 s in 2016. Furthermore, only 19% of the independent events in 2016 included coyotes foraging on pine nuts compared with 50% of the events in 2015. The majority of photographs in 2016 were of coyotes rapidly traveling across the field of view. Coyote group size also varied greatly between years. In 2015, two or more coyotes were photographed together in 50% of the events and groups of four and five coyotes were observed in two of the events. In 2016, groups of two coyotes were only photographed twice and there were never groups larger than two individuals.

Coyote group size may change seasonally, with larger groups in winter, which coincides with an increase in the consumption of large prey (Gese et al., 1988), neither of which apply to this instance, although I cannot rule out the possibility of this being a family group in 2015. The fact that coyotes, a highly mobile habitat generalist, may increase group size in relation to the availability of a low-risk food source as opposed to large prey highlights the nutritional importance of pine nuts as a food source. Furthermore, coyotes have been documented raiding middens made by American red squirrels (*Tamiasciurus hudsonicus*) to obtain pine nuts from white bark pine trees (*Pinus albicaulis*; Dowd and Gese, 2012); however, unlike white bark pine, I have not observed readily available middens composed of pinyon pine nuts in the Piceance Basin. To consume seeds individually from the ground rather than from a midden increases handling time, also highlighting the value of this food source. Additionally, lagomorphs were not limited in the system in 2015 when this observation was recorded (pers. observ.), and lagomorph remains also were consistently found in coyote scat, suggesting use of pinyon pine nuts was not due to food limitation. Regardless of the mechanism underlying the behavior, this novel observation increases understanding of the foraging ecology of an opportunistic canid.

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