Habitat Characteristics of Montezuma Quail Foraging Areas in West Texas

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Abstract

Little information is known about the foraging habitat of Montezuma quail (Cyrtonyx montezumae) in Texas, USA. We compared habitat characteristics of foraging and nonforaging areas to identify trends in habitat attributes across sites with varying levels of quail use on Elephant Mountain Wildlife Management Area in Brewster County, Texas, USA, during May–August 2001. We delineated foraging and nonforaging areas using a system of parallel transects (100 m apart) that spanned the length of the grassland and covered the entire area. We walked transects every 3–5 days searching for signs of feeding (i.e., diggings). We documented a higher mean density of Allium spp. plants in foraging (95% CI: 12.1 ± 4.3 plants/m²) than nonforaging areas (95% CI: 0.8 ± 0.6 plants/m²). Foraging areas also exhibited a greater mean slope (95% CI: 22.6 ± 2.9° vs. 8.0 ± 2.1°). However, species richness, diversity, and equitability were similar between the foraging (23, 6.5, and 0.3, respectively) and nonforaging area (29, 7.6, 0.3). We observed a decreasing trend in density of Allium spp. plants, number of stones, and slope from high- to no-use sites. These 3 variables appear to be key habitat features associated with foraging areas of Montezuma quail in west Texas. (WILDLIFE SOCIETY BULLETIN 34(3):856–860; 2006)

Key words

Cyrtosynx montezumae, foraging habitat, Meams quail, Montezuma quail, Texas.

Montezuma quail (Cyrtonyx montezumae) inhabit pine–oak (Pinus–Quercus) communities at high elevations (>1,200 m) throughout much of the desert southwest (Leopold and McCabe 1957, Heffelfinger and Olding 2000). Montezuma quail are unique from other North American quail species in that they obtain most of their food requirements from subterranean bulbs and tubers (e.g., Cyperus spp., Allium spp., and Oxalis spp.; Bishop and Hungerford 1965, Albers and Gehlbach 1990). Miller (1943) noted that plants bearing bulb or tuber root systems often were associated with open spaces under oak trees and canyon bottoms. It is in these open pine–oak woodlands, with low shrubs and perennial bunchgrasses, that Montezuma quail attain their highest densities (Leopold and McCabe 1957). Montezuma quail have become adapted to a foraging strategy of digging for roots on steep slopes, and their morphological traits (large leg muscles, large feet and claws, strong beak) reflect such evolution (Miller 1943).

Few studies have been conducted on Montezuma quail ecology and life history. The research that does exist has focused primarily on a limited portion of its distribution, namely Arizona, USA (Wallmo 1954, Bishop and Hungerford 1965, Brown 1982) and Chihuahua, Mexico (Leopold and McCabe 1957). The species in general remains poorly understood (Albers and Gehlbach 1990), especially in Texas, USA, where Montezuma quail have declined in numbers and distribution over the past century (Oberholser 1974). Aside from the general association of Montezuma quail to pine–oak communities (Brown 1982, Albers and Gehlbach 1990), little is known regarding specific attributes of Montezuma quail habitat. To our knowledge, only 4 studies have quantified habitat

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Study Area

We conducted our research on Elephant Mountain Wildlife Management Area (WMA) which was located approximately 40 km south of Alpine, Texas, USA, in Brewster County. Elephant Mountain WMA encompassed approximately 9,300 ha including the most prominent terrain feature, Elephant Mountain (Hughes 1993). Elephant Mountain has an elevation of 1,900 m and rises approximately 609 m above the surrounding table lands (Hughes 1993). Annual mean precipitation ranged from 38–51 cm with most of the precipitation occurring during July–August. Soils varied in texture and developed from outwash materials from the mountains (Correll and Johnston 1979). Typical range sites included stony hills, clay flats, sands, saline soils, gyspsum flats, deep upland roughs,
stony mountains, and gravelly outwashes (Gould 1975). The summit of Elephant Mountain was an alpine grassland dominated by native grasses and sparse patches of small shrubs including oak (Quercus spp.), mountain laurel (Sophora secundiflora), and fragrant sumac (Rhus trilobata). Elephant Mountain WMA was moderately grazed (1 animal unit/50 ha) using a high-intensity, low-frequency grazing system. Livestock grazing was restricted to the foothills and grazed (1 animal unit/50 ha) using a high-intensity, low-frequency grazing system. Livestock grazing was restricted to the foothills and grazed (1 animal unit/50 ha) using a high-intensity, low-frequency grazing system.

**Methods**

We delineated foraging and nonforaging areas of Montezuma quail on the alpine grassland of Elephant Mountain using a system of parallel transects (100 m apart) that spanned the length of the grassland and covered the entire area. During April–May 2001, we walked transects every 3–5 days visually searching for signs of feeding (i.e., diggings). Length of transects varied given the shape of the grassland on top of Elephant Mountain proper; however, search effort (distance walked/unit time) was approximately equal on all transects. We conducted searches by sequentially walking transects until the entire area had been searched. We obtained Universal Transverse Mercator coordinates for any foraging sites we detected from the transects using a hand-held global positioning system with ±3-m accuracy (GARMIN International Inc., Olathe, Kansas). We defined a foraging site as a site consisting of >3 diggings or a cluster of diggings within a 0.5-m radius of each other. We did not directly quantify visibility among transects that may affect the precision of our delineation of foraging and nonforaging areas. However, our intent was not to obtain a precise demarcation of the areas (an impractical task) but rather to compare general habitat characteristics between areas of relative high and low forage use. In this context what variation in visibility might have existed among transects would not invalidate our crude delineation of relative high- and low-use areas. In addition, vegetation data suggested similar visibility between the foraging and nonforaging areas because percent bare ground (the complement of percent vegetation canopy cover) was similar (see below).

To delineate the foraging area, we created a minimum convex polygon encompassing all foraging sites that were within 100 m of another using ArcView 3.2. (ESRI, Redlands, California) and the Animal Movement Extension (Hooge and Eichenlaub 1997). We defined the area encompassed by the polygon as the foraging area, only 8 (4 sightings) were within the low-use area. Thus, our crude delineation of these areas of relative use appeared valid.

Bulbs comprised 75% of the quail diggings \( (n = 121) \) followed by grass (16%), other (8%), and forbs (1%). We also documented a higher mean density of Allium spp. plants in the foraging area (95% CI: 12.1 ± 4.3 plants/m²) compared to the nonforaging area (95% CI: 0.8 ± 0.6 plants/m²), as well as greater mean slope (95% CI: 22.6 ± 2.9% vs. 8.0 ± 2.1%). However, species richness, diversity, and equitability were similar between the foraging (23, 6.5, and 0.3, respectively) and nonforaging area (29, 7.6, 0.3; Table 1). Mean percent exposure of bare ground also did not differ (95% CI: 78.6 ± 4.7% [foraging]; 73.5 ± 5.2% [nonforaging]).
We observed a decreasing trend in density of *Allium* spp. plants, number of stones, and slope from high- to no-use sites (Fig. 1). Mean density of *Allium* spp. plants was the habitat feature that exhibited the most pronounced decreasing trend across the levels of use (Fig. 1). Percent bare ground was similar between the levels of low use (95% CI: 80.6 ± 9.2%) and high use (95% CI: 77.7 ± 13.0%).

### Discussion

We begin by noting that differences in visibility could have affected the precision of our delineation of areas of relative foraging use. However, percent bare ground (the complement of percent vegetation canopy cover) was similar between the foraging and nonforaging areas, as well as between the low- and high-use areas within the foraging area. We also documented increasing numbers of foraging sites and quail detections with increasing level of foraging-use category. Given this data, our crude delineation of relative foraging-use areas appeared valid.

Species richness, diversity, and equitability were similar between the foraging and nonforaging area in our study. Bristow and Ockenhels (2002) reported that species richness of herbaceous plants generally was greater at used sites than randomly available habitat. They documented that *Montezuma* quail flush-sites contained an average of 5.3 grass and 6.1 forb species compared to random points, which averaged 4.1 and 4.3 species, respectively. Because of the small difference (1–2 species) in species richness between used and random points, it is uncertain whether the finding was biologically significant. However, we note that our study is not directly comparable to Bristow and Ockenhels (2002). Species diversity may be important in selection of use areas but not forage areas. We believe that species richness and diversity did not adequately characterize foraging habitat in our study because of the specialized diet of *Montezuma* quail. Bishop and Hungerford (1965) documented that 50–85% of the annual diet of *Montezuma* quail consisted primarily of bulbs and tubers from a select genera of plants (e.g., *Allium*, *Cyperus*, *Oxalis*). Given this specialized diet, it is intuitive to expect that habitat use by *Montezuma* quail would be influenced more by density of a few key food plants rather than species diversity at the community scale. Our data support this generalization. We documented that the foraging area differed from the nonforaging area in density of *Allium* plants but not in species diversity. *Allium* was the primary food plant for *Montezuma* quail at our study site, and its density was about 10^3 greater in the foraging area.

In addition to density of *Allium* plants, a second habitat feature that differed between the foraging and nonforaging areas was percentage. Albers and Gehlbach (1990) also reported that slope was a major indicator of feeding habitat for *Montezuma* quail in central Texas. This link between slope and quail use had been noted in previous research (Fuertes 1903, Swarth 1909, Stromberg 1990), but no formal explanation had been offered.

Albers and Gehlbach (1990) proposed that *Montezuma* quail used steep slopes because the soil properties present therein afforded higher quantities of food plants. Soil depth and soil moisture differentiated between foraging habitat and unused areas in their study, with greater soil depth and lower soil moisture characterizing feeding sites. Albers and Gehlbach (1990) believed that wood sorrels (*Oxalis drummondii*) were more abundant on deeper soils and digging was easier on drier soils. Thus, increased precipitation runoff on steep slopes resulted in drier soils relative to more level terrain and, consequently, higher quail use.

The rationale of Albers and Gehlbach (1990) is somewhat faulty (or incomplete), however, because increased runoff on steep slopes would also increase soil erosion, thereby decreasing soil depth, a condition associated with unused sites in Albers and Gehlbach (1990). We observed an increasing trend in the amount of exposed stone from no- to high-use sites. Based on our data and field observations, we believe that considering amount of exposed stone can help strengthen Albers and Gehlbach’s (1990) rationale.

During our field sampling, we noticed that relatively deep pockets of fertile soil formed on the uphill side of rock outcrops. These soil pockets appeared to hold moisture for longer periods of time and were less compact than surrounding, thinner soils. We also observed that higher densities of *Allium* plants generally were

### Table 1.

<table>
<thead>
<tr>
<th>Type</th>
<th>Common name</th>
<th>Scientific name</th>
<th>Foraging Count</th>
<th>Density</th>
<th>SE</th>
<th>Nonforaging Count</th>
<th>Density</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forb</td>
<td>Wild onion</td>
<td><em>Allium drummondii</em></td>
<td>364</td>
<td>12.1</td>
<td>2.2</td>
<td>25</td>
<td>0.8</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Lazy daisy</td>
<td><em>Aphanostephus riddelli</em></td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>12</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>False nightshade</td>
<td><em>Chamaesara sp.</em></td>
<td>117</td>
<td>3.9</td>
<td>0.9</td>
<td>251</td>
<td>8.4</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>Curlycup gumweed</td>
<td><em>Grindelia squarrosa</em></td>
<td>83</td>
<td>2.8</td>
<td>1.0</td>
<td>83</td>
<td>2.8</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Peppermint</td>
<td><em>Lepidium virgincum</em></td>
<td>65</td>
<td>2.2</td>
<td>0.7</td>
<td>5</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Aster</td>
<td><em>Machaeranthera sp.</em></td>
<td>26</td>
<td>0.9</td>
<td>0.2</td>
<td>32</td>
<td>1.1</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Plantain</td>
<td><em>Plantago sp.</em></td>
<td>124</td>
<td>4.1</td>
<td>1.1</td>
<td>69</td>
<td>2.3</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Upright prairie coneflower</td>
<td><em>Ratibida columnifera</em></td>
<td>16</td>
<td>0.5</td>
<td>0.2</td>
<td>51</td>
<td>1.7</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Silverleaf nightshade</td>
<td><em>Solanum etesagnifolium</em></td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>15</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Grass</td>
<td>Sideoats grama</td>
<td><em>Bouteloua curtipendula</em></td>
<td>62</td>
<td>2.1</td>
<td>0.5</td>
<td>23</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Black grama</td>
<td><em>Bouteloua aristopa</em></td>
<td>100</td>
<td>3.3</td>
<td>1.0</td>
<td>295</td>
<td>9.8</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Tobosa</td>
<td><em>Pleuraphis mutica</em></td>
<td>22</td>
<td>0.7</td>
<td>0.5</td>
<td>36</td>
<td>1.2</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Bristlegrass</td>
<td><em>Setaria sp.</em></td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
<td>44</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Shrub</td>
<td>Pink mimosa</td>
<td><em>Mimosa boreales</em></td>
<td>17</td>
<td>0.6</td>
<td>0.3</td>
<td>11</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>
associated with these steep slopes where rock outcrops existed. Moreover, many of these soil pockets exhibited sign of Montezuma quail use (i.e., diggings). Therefore, we presume that rock outcrops acted as runoff detainments and allowed time for soil sediment to settle, thereby creating soil conditions conducive for Allium establishment (Fig. 2). This scenario may help explain the slope-quail use association, at least in our study area. However, no study to date has quantified food availability relative to terrain or outcrop presence.

Management Implications

Montezuma quail are habitat and foraging specialists. In our study habitat use by Montezuma quail was associated with habitats that had high densities of Allium plants, moderate slopes (20–30%), and rock outcrops. Habitats that had the same species composition but lacked the physical characteristics to support high Allium densities had fewer signs of use by Montezuma quail. Little information exists regarding management practices that may promote primary food resources for Montezuma quail. However, given the apparent interrelationship among rock outcrops on slopes, soil pockets, and Allium presence, management should minimize practices that could disrupt such relationship (e.g., practices that could dislodge rock outcrops and increase soil erosion).

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**Figure 1.** Estimated values (± 1 SE) for habitat characteristics of no-, low-, and high-use foraging areas (n = 2 100 × 100-m plots/area) of Montezuma quail, Brewster County, Texas, USA, May-Aug 2001. High-use sites were defined as sites with high concentrations of quail diggings (>3 diggings within 5-min walking period) whereas low-use sites contained a lower concentration of diggings. No-use sites contained virtually no diggings.

**Figure 2.** Illustration of Allium plant establishment on soil pockets formed within rock outcrops, Elephant Mountain Wildlife Management Area, Brewster County, Texas, USA, 2001. Rock outcrops are thought to detain precipitation runoff on slopes and 1) allow time for soil sediments to settle, 2) form deep, moist soil pockets, and 3) result in a microclimate conducive for establishment of Allium plants.
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