SPATIAL ECOLOGY AND HABITAT UTILIZATION OF MONTEZUMA QUAIL IN THE DAVIS MOUNTAINS OF TEXAS

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Abstract.–Montezuma quail (*Cyrtonyx montezumae*) occur throughout the desert mountain ranges in the Trans-Pecos of Texas as well as Arizona, New Mexico, and Mexico. Limited information on life history and ecology of the species is available due to the cryptic nature of the bird. Home range, movements, and preferred habitats have been speculated upon in previous literature with the use of observational or anecdotal data. We used innovative trapping techniques and technologically advanced radio transmitters to assess these ecological parameters for Montezuma quail. The goal of this study was to monitor Montezuma quail to determine home range size, movements, and habitat preference for the Davis Mountains population. We captured a total of 72 birds over the course of two years (2009 – 2010) (36M, 35F, 1 Undetermined). Thirteen individuals with >25 locations/bird were used to estimate the home range, movement, and habitat selection analyses. Home ranges (95% kernel density estimators) averaged 12.83 ha and varied greatly (0.02 – 43.29 ha). Maximum straight-line distances between known locations within home ranges varied from 0.73 – 14.83 km. Distances of movements were greater than previously reported. Preferred habitats consisted of Canyon Mountain Savannah and Foothill Slope Mountain Savannah across three spatial scales. Although our study was able to address some basic ecological attributes of Montezuma quail, additional research is warranted to better understand their population dynamics.

Keywords: *Cyrtonyx montezumae*, home range, movement

Quails such as northern bobwhite (*Colinus virginianus*), scaled quail (*Callipepla squamata*), and Gambel's quail (*C. gambelii*) have been studied throughout much of their ranges with literature describing movements and home ranges for each (Brennan 2007, Zornes & Bishop 2009). Montezuma quail (*Cyrtonyx montezumae*) however, have received little attention on their spatial ecology with only one radio-telemetry study (Stromberg 1990) providing limited information on home range and movements in Arizona. This lack of research is surprising, as all four species of quail are found in Texas,

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and are highly valued for various ecological, cultural, and economic reasons (Brennan 2007). The population and range of Montezuma quail are declining, and understanding their spatial and habitat needs are the first step towards more successful management.

Other information on Montezuma quail movements and ranges are anecdotal (Leopold & McCabe 1957; Brown 1976; Brown 1978). Brown (1978) speculated the home range of Montezuma quail were <6 ha. Large movements performed by Montezuma quail have been suspected, but were thought to be no more than a few km (Leopold & McCabe 1957). Montezuma quail behavior, foraging strategy, terrain, and remoteness of areas limit the opportunity to capture and monitor radio-marked birds effectively (Hernandez et al. 2006). Home range estimates for Montezuma quail are thought to be generally less than sympatric Gambel's quail or scaled quail. Estimates for home range size of Gambel's quail were similar to those of Montezuma quail (8 – 38 ha) (Zornes & Bishop 2009). Scaled quail are thought to have larger home ranges varying from 10 – 882 ha (Zornes & Bishop 2009).

In the United States, Montezuma quail are found in southeastern Arizona, southern New Mexico, and western Texas within mountainous habitats or rolling foothills (Stromberg 2000). Sightings of Montezuma quail can be rare, and their presence is often identified by signs or vocalizations such as diggings, roost sites, and calls during the breeding season (Hernandez 2006). Most of the literature about Montezuma quail habitat has been based on these sightings or signs, and therefore founded on anecdotal evidence (Leopold & McCabe 1957; Brown 1978; Bristow & Ockenfels 2002; Bristow & Ockenfels 2004). Most studies on Montezuma quail have been subjective because of the challenges researchers were faced with capturing and keeping them alive (Hernandez et al. 2006; Harveson et al. 2007; Hernandez et al. 2009).

Montezuma quail are considered an indicator species for pine oak woodlands throughout the southwest (Harveson et al. 2007). Using flush sites to determine habitats used, vegetation height and dense grass cover were determined to be important habitat components (Bristow & Ockenfels 2004). Cattle grazing practices have been shown to directly affect Montezuma quail (Brown 1982). Dense bunchgrasses have been found to provide nesting structure and such herbaceous cover provides protection from predators (Brown 1989; Stromberg 2000).

Stromberg (1990) performed a telemetry study on Montezuma quail in the Huachuca Mountains of southeastern Arizona in which some habitat use was evaluated. However, number of locations used and number of individuals were low limiting the utility of his findings. Other researchers have faced hardships when monitoring Montezuma quail because of the increased mortalities created by traditional neck-loop transmitters (Garza 2007; Hernandez 2004). The increased mortality may be attributed to the fact that Montezuma quail excavate the tubers and rhizomes in the root system of various plants to comprise much of their diet, and traditional neck-loop transmitters may interfere with this behavior (Stromberg 2000; Hernandez 2004). Thus, we utilized improvised trapping techniques employing pointing dogs and hand nets, and a modified backpack style transmitter to alleviate the detrimental effects of traditional neck-loop transmitters. Using these techniques, we were able to capture larger quantities of birds and monitor them over longer periods of time.

The specific objectives of this study were to 1) determine home range size of Montezuma quail in the Davis Mountains, 2) describe movements for Montezuma quail, and 3) determine habitat use by Montezuma quail. Meeting such objectives is progress towards contributing to baseline ecological information on Montezuma quail in the Davis Mountains of Texas.

Materials & Methods

This study took place on 8,760 ha in the central portion of the Davis Mountains in Jeff Davis County, Texas (Figure 1). The Davis

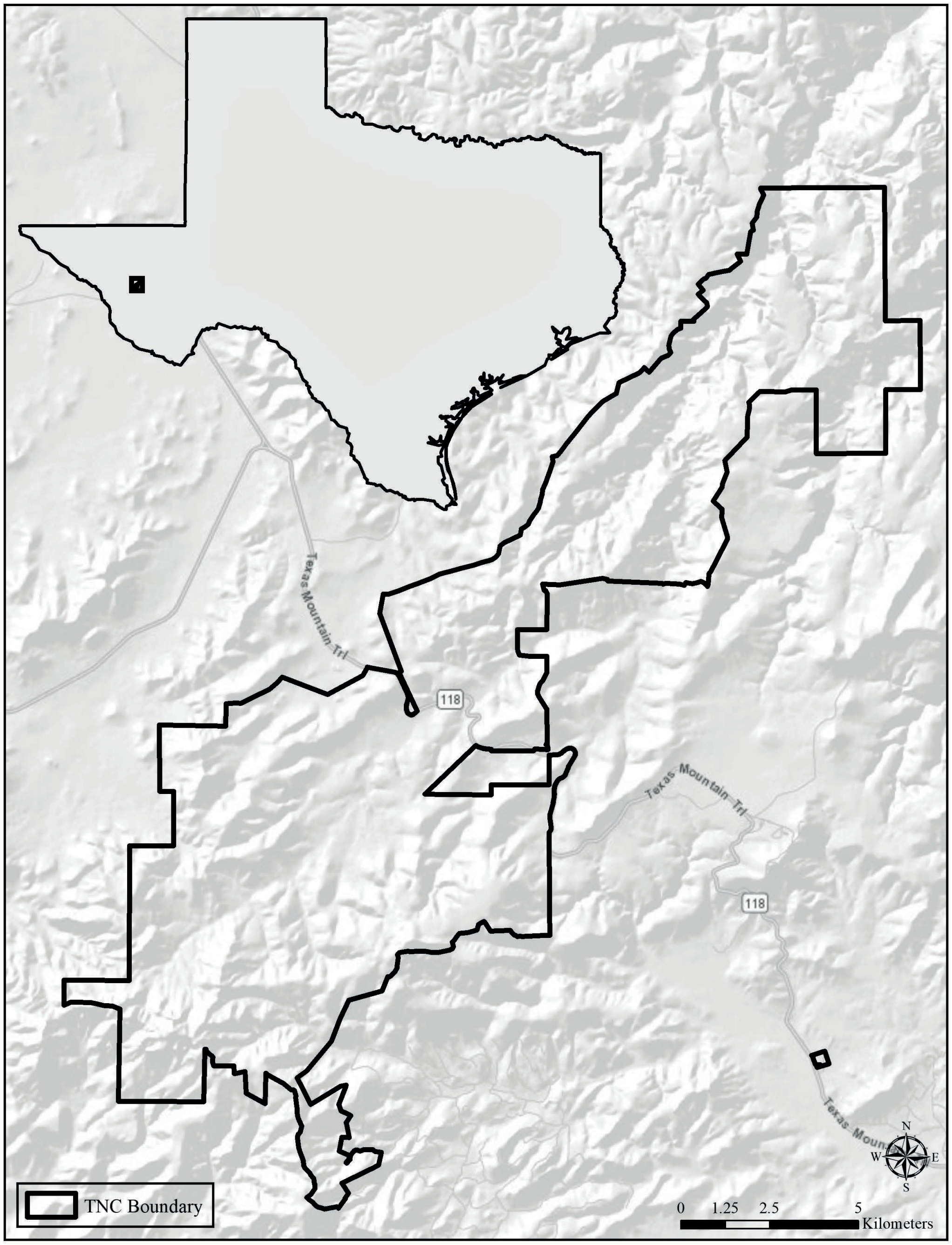

Figure 1. Location of the study area used for monitoring Montezuma quail in the Davis Mountains of Texas, 2009–2010.

Mountains Preserve served as the core study site but the study also included portions of neighboring ranches. The Davis Mountain Preserve is approximately 40 km northwest of Fort Davis. Elevation ranges from 1,600 – 2,200 m with annual precipitation varying from 28.2 – 56.9 cm (Greene 2013). Range conditions varied throughout the study area: deferred grazing, heavily grazed to the point of affecting plant vigor, and ungrazed for several years. Prescribed fire was used throughout the study site primarily for limiting brush encroachment and reducing fuel loads. Pine-oak woodlands and juniper-oak woodlands occur throughout the study site. These mountain savannahs consisted of alligator juniper (*Juniperus deppeana*), emory oak (*Quercus emoryi*), gray oak (*Q. grisea*), Mexican pinyon pine (*Pinus cembroides*), rose-fruited juniper (*J. coahuilensis*), and red berry juniper (*J. pinchotii*) (Powell 1998). Stands of ponderosa pine (*P. ponderosa*) and southwestern white pine (*Pinus strombiformis*) were the dominant vegetation type in the higher elevations (>1800 m). Lower elevations of the study area were highland grasslands with blue grama (*Bouteloua gracilis*) being the dominant grass. Other gramas, bluestems (*Bothriochloa* spp.; *Schizachyrium* spp.), threeawns (*Atrstida* spp.), and needlegrass (*Stipa* spp.) occurred throughout the study area.

Home Ranges and Movements.–We captured Montezuma quail Feb–Mar 2009 and Jan–May 2010 (SRSU IACUC #2008014). We employed two methods of capture, one that occurred in the evening using throw nets and another that occurred after dark using large hoop nets. The first method was a modified version of the capture technique described by Brown (1976) using trained pointing dogs and hand nets. The dogs were deployed in various locations throughout the study area focusing primarily on the Davis Mountain Preserve. The majority of dog searches took place within four hours of sunset. Once the dogs were able to locate a covey during evening searches, a global positioning system (GPS) was used to mark the flush site of birds. The use of throw nets during the day was applied by casting in front of a pointing dog when habitat conditions allowed (e.g., free of brush).

The other (and primary) trapping technique involved trained dogs, large hoop nets, and throw nets at night. In contrast to the previous technique, day-time surveys were conducted using the dogs within two hours of sunset. Once a dog located a covey, the covey was flushed and the location was marked on a GPS. Capture crews revisited covey locations ≥ 30 min after sunset accompanied by a bird dog. A lighted collar and tracking device (Astro 220 GPS, Olathe, Kansas) was used for monitoring the dog at night. Search efforts at night were focused in the general area of the original flush site but expanded using approximately a 200-m radius. Once the dog was on point, headlamps were used to locate the exact location of the roost. A research crew then maneuvered a hoop net or cast a throw net down on top of a covey. Birds were carefully removed from the net, put in a small tote sack, and placed in a carrying device. Captured birds were then taken back to a lighted facility where sex, age, and other standard morphological variables were recorded. Captured birds were then fitted with a backpack style radio transmitter (4 – 6 g) and banded with an individually numbered aluminum leg band. The birds were then held in a small cage overnight and returned to the capture site the following morning for release. All trapping activities were conducted in accordance with state (Texas Parks and Wildlife Department SPR-0592-525) and university laws (Animal Care and Use Committee).

In continuance of this capture method, we utilized a Judas method to locate marked birds within a covey to allow us to potentially capture more birds out of each covey. Once a covey had ≥1 transmitted bird, the covey was located again at night. Using a night-netting technique initially described by Labisky (1959; 1968), researchers homed-in on the radio-marked birds at night. Using hoop or throw nets, a net was placed over as many birds in the covey as possible. Previously captured birds were examined and weighed, while newly captured individuals were aged, sexed, and measured.

Birds were chosen at random to be radiomarked until the covey had ≥3 radio-marked individuals within a covey.

The monitoring period began within a week of each respective capture. Monitoring of radio-marked birds was carried out with the use of a receiver (ATS R4000, Isanti, MN) and a yagi antenna. After birds were located using radiotelemetry, a GPS location and aziumuth were recorded to constitute a "fix". Locations of each individual were recorded 2 – 5 times weekly using ≥3 fixes/location to triangulate an actual location. A GPS unit, compass, and handheld device (Palm T/X or Palm Tungsten E2) unit with Locate III (Tatamagouche, NS, Canada) software was used to ensure the accuracy of each location. Accuracy considered acceptable was set to be <30,000 m^2 area of error ellipse (<100 m). Usable locations were imported into ArcGIS 10.1 (ESRI, Redlands, CA) where shapefiles were created.

We calculated 95% kernel density estimators (KDE) and minimum convex polygons (MCP) home ranges for each Montezuma quail monitored with ≥25 locations. We used Home Range Tools and Hawths Tools in ArcGIS for calculating home ranges and measuring movements, respectively. For each individual with ≥25 locations, a distance matrix between points was created. This matrix depicted the distance moved between successive locations as well as the longest straight-line measurement across an individual home range.

Habitat Utilization.–Soil type shapefiles were obtained from the United States Department of Agriculture Natural Resource Conservation Service (NRCS) soil data mart (soildatamart.nrcs.usda.gov/). Ecological site names within the soil type attribute tables were used to generate habitat types. Selection ratios (S') were calculated as $S' = ([U+0.001]/[A+0.001])$ where U is the observed use and A is the availability of the habitat variable (Manly et al. 2000; Lopez et al. 2004). Habitat selection ratios were analyzed at three spatial scales (Johnson 1980).

First-order selection was evaluated by creating a 100% MCP for all individuals with >25 locations. This MCP was used to clip the habitat shapefile and define available habitat characteristics within the study area. All location characteristics were then compared to the characteristics of the study area (i.e., point to study area). Second-order selection was evaluated by creating 100% MCPs for each individual. The habitat shapefile was clipped down to each respective MCP, and the individual habitat MCPs were compared back directly to the available study area MCP (i.e., range to study area). Third-order habitat selection was evaluated by comparing individual's location habitat characteristics with the habitat characteristics contained within its respective MCP (i.e., point to range).

Results

Seventy-two Montezuma quail were captured from January 2009 – September 2010. Of the birds captured, 68 were radio-marked and a total of 966 locations were collected. Thirteen of the 68 radio-marked quail had sufficient relocations (>25) for analysis, totaling 638 locations. Two birds (M21 and F23) were monitored in both years of data collection. All other birds were monitored during only one field season (Table 1).

Home Ranges and Movements.–Home ranges varied greatly in size (Figure 2). Using 95% KDEs, the smallest home range was 0.02 ha and the largest was 43.29 ha (Table 2). Mean home range size was 12.83 ha (*SD* = 15.29 ha). When using MCPs, the smallest and largest home ranges were 12.35 ha and 1,516.21 ha, respectively. The mean MCP home range was 437.84 ha (*SD* = 503.94 ha). Large movements occurred such as a movement of 11.3 km from 29 June – 20 July by birds M62 and F65. Maximum straight-line distances across home ranges varied from 0.73 – 14.83 km.

Short-range altitudinal migrations due to weather have been noted at higher elevations in Arizona and New Mexico but were thought to never exceed a few km (Leopold & McCabe 1957; Zornes & Bishop 2009). No such migrations were observed in this study. We did

Table 1. Monitoring periods for 13 (8M, 5F) radio-marked Montezuma quail used in home range and habitat utilization analysis in the Davis Mountains of Texas from 2009-2010.

Sex	Band Number	No. of Locations	Capture Date (Monitor Begin)	Last Location Date (Monitor End)	Monitor Days
Males	13	29	02/19/09	03/02/10	376
	21	45	03/13/09	07/31/10	505
	22	30	03/13/09	07/07/09	116
	50	36	02/06/10	07/12/10	156
	52	27	02/09/10	05/18/10	98
	54	28	02/11/10	07/30/10	169
	62	50	03/06/10	07/29/10	145
	63	49	03/06/10	07/30/10	146
Females	23	82	03/13/09	07/31/10	505
	47	30	01/14/10	04/21/10	97
	48	41	01/14/10	05/28/10	134
	61	37	03/06/10	07/27/10	143
	65	27	05/19/10	07/29/10	71

Table 2. Home range size and maximum distance across home ranges for radio-marked Montezuma quail in the Davis Mountains of Texas from 2009-2010.

Sex	Band Number	No. of Locations	95% KDE[a] (ha)	MCP[b] (ha)	Distance[c] (km)
Males	13	29	0.26	72.65	1.65
	21	45	0.15	27.00	0.95
	22	30	0.02	12.35	0.73
	50	36	1.43	49.03	1.11
	52	27	0.02	23.54	0.89
	54	28	0.07	33.62	1.00
	62	50	24.88	744.45	7.07
	63	49	1.55	129.26	2.01
Females	23	82	28.06	1,516.21	12.50
	47	30	28.15	1,139.00	6.40
	48	41	43.29	736.63	14.82
	61	37	11.95	392.16	6.79
	65	27	26.90	815.96	14.83
Mean			12.83	437.84	5.44
SD			15.29	503.94	5.47

[a]Kernel Density Estimator.
[b]Minimum Convex Polygon.
[c]Greatest distance across home range.

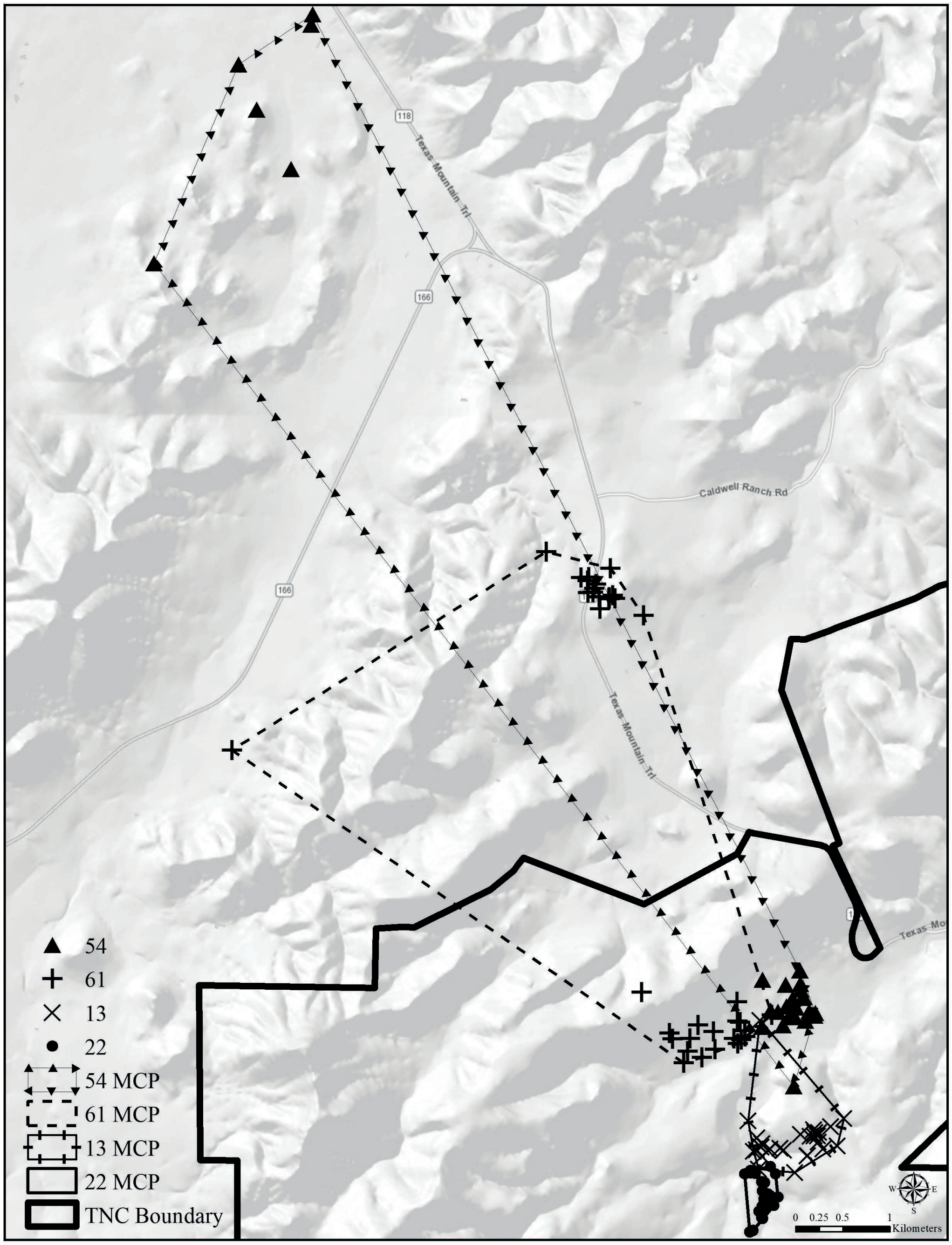

Figure 2. Movements and Minimum Convex Polygons of four Montezuma quail in the Davis Mountains of Texas, 2009–2010.

observe quail throughout varying elevations regardless of the time of year. Montezuma quail were observed at the highest elevations along mountain rims as well as along drainages in the summer and winter months. The highest elevation in the Davis Mountains occurs atop Mount Livermore (elevation = 2,554 m) where hikers often have Montezuma quail sightings throughout the year (Pipes pers. comm.).

Habitat Utilization.–For first-order analysis, Montezuma quail preferred canyon mountain savannah, foothill slope mountain savannah, and igneous divide mountain savannah (Table 3). Montezuma quail appeared to use igneous hill and mountain mixed prairie in proportion to availability while avoiding other habitat types.

For second-order analysis, Montezuma quail preferred canyon mountain savannah and foothill slope mountain savannah (Table 4). Igneous hill and mountain mixed prairie and mountain loam mountain savannah were both preferred by three radio-marked and breeding season (March – July). Montezuma quail appeared to avoid draw desert grassland, gravelly mixed prairie, igneous divide mountain savannah, loamy mixed prairie, and shallow mixed prairie.

For third-order analysis, Montezuma quail preferred canyon mountain savannah and 4 preferred foothill slope mountain savannah

Table 3. First-order habitat selection using the S-statistic (see methods) for radio-marked Montezuma quail in the Davis Mountains of Texas from 2009 – 2010. *Indicates a selection ratio >1.00, therefore a selected habitat type.

Habitat Type	Selection Ratio
Igneous Hill and Mountain (Mountain Savannah)	0.10
Canyon (Mountain Savannah)	13.79*
Draw (Desert Grassland)	0.70
Draw (Mixed Prairie)	0.30
Foothill Slope (Mountain Savannah)	3.48*
Gravelly (Mixed Prairie)	0.34
Igneous Divide (Mountain Savannah)	1.67*
Igneous Hill & Mountain (Mixed Prairie)	1.13*
Loamy (Mixed Prairie)	0.13
Mountain Loam (Mountain Savannah)	0.12
Shallow (Mixed Prairie)	0.07
Water	0.93

Table 4. Second-order habitat selection using the S-statistic for radio-marked Montezuma quail in the Davis Mountains of Texas, 2009 – 2010.

	Bird Band Number												
Habitat Type	13	21	22	23	47	48	50	52	54	61	62	63	65
Igneous Hill & Mountain (Mountain Savannah)											0.03		0.22
Canyon (Mountain Savannah)	1.52*	2.07*	2.24*	3.01*	0.09	0.45	2.01*	2.81*	0.43	0.12	4.61*	1.75*	3.49*
Draw (Desert Grassland)	0.04					0.01	0.04	0.03	0.05	0.03	0.10		0.17
Draw (Mixed Prairie)									0.01	7.70*		0.94	
Foothill Slope (Mountain Savannah)	0.04				1.01*	1.22*	6.10*	0.10	7.94*	0.06	3.60*	1.27*	6.45*
Gravelly (Mixed Prairie)							0.30		0.02			0.79	
Igneous Divide (Mountain Savannah)				0.10				0.23					0.56
Igneous Hill & Mountain (Mixed Prairie)	0.93	0.71	0.46	0.57		0.32	0.69	0.24	0.00	1.04*	2.37*	0.67	2.07*
Loamy (Mixed Prairie)							0.01		0.00	0.00	0.41		0.51
Mountain Loam (Mountain Savannah)							0.02			0.02	1.71*	1.51*	1.95*
Shallow (Mixed Prairie)											0.03		0.03

*Indicates a selection ratio >1.00, therefore a selected habitat type.

Table 5. Third-order habitat selection using the S-statistic for radio-marked Montezuma quail in the Davis Mountains of Texas, 2009 – 2010.

	Bird Band Number												
Habitat Type	13	21	22	23	47	48	50	52	54	61	62	63	65
Igneous Hill & Mountain (Mountain Savannah)											0.00		0.00
Canyon (Mountain Savannah)	1.61*	1.75*	2.19*	2.78*	3.09	1.52*	0.02	2.42*	0.43	0.03	32.5*	8.45*	27.4*
Draw (Desert Grassland)	0.04					0.56	0.04	0.03	0.05	0.03	0.43		0.64
Draw (Mixed Prairie)									0.99			3.41*	
Foothill Slope (Mountain Savannah)	1.33				0.98	0.99	5.79*	0.56	28.5*	7.05*	0.34	0.92	0.32
Gravelly (Mixed Prairie)							0.86		0.02	1.63*		0.99	
Igneous Divide (Mountain Savannah)				0.10				0.23					0.56
Igneous Hill & Mountain (Mixed Prairie)	0.86	0.79	0.48	0.62		8.09*	0.65	0.35	0.14	1.01*	0.93	0.28	1.53*
Loamy (Mixed Prairie)							0.55		0.33	0.00	0.23		0.48
Mountain Loam (Mountain Savannah)							0.52			0.58	0.01	0.01	0.01
Shallow (Mixed Prairie)											0.03		0.03

*Indicates a selection ratio >1.00, therefore a selected habitat type.

(Table 5). Igneous hill and mountain mixed prairie were preferred by three individuals with no more than one individual preferring any other habitat type when analyzed on a point to range scale.

Discussion

Our data reflected home range sizes similar to previous reports, there was incredible variation between individuals and sexes. Stromberg (1990) was the first to describe home range and movements of Montezuma quail. However, his sample size (15 radio-marked birds) and the number of relocations (<25) were very limited which provided the basis of the home range estimates. Leopold and McCabe (1957) suggested 4–10 ha for general range, but these estimates were based on observations of non-marked coveys. Brown (1978) observed that coveys normally have home ranges <6 ha. Before pairing season, the coveys we monitored generally did not make large movements and covered similar home ranges to the 6 ha suggested by Brown (1978). Montezuma quail had the ability to cover long distances even though they rarely fly. Stromberg (1990) reported that Montezuma quail have multiple small use areas within their range. Our study concurred with Stromberg's (1990) findings, only movements between small use areas were considerably greater distances.

Contradictory to the findings of Stromberg (1990), quail moved distances >61 m in a day. In our study, larger movements (>1 km/day) were recorded in summer months (May–July). These longer movements were made following covey break-up and prior to, or during, the pairing season. The longest movement was observed for a pair in which both M62 and F65 were radio-marked. From 29 June–20 July the pair moved 11.3 km and eventually nested at their new site. Reasons for the large movement are unknown. Much of the habitats the pair traversed across was considered optimal and supported other Montezuma quail. A similar instance occurred with M63 after he lost his mate (F66) on June 3. M63 was captured again with a new mate (F68) on June 10 and then proceeded to move 4.86 km (June 17 –25), again moving through optimal habitat containing other Montezuma quail.

Another example of abnormal movements was with a male Montezuma quail (M50). Bird M50 was located with an unmarked female throughout the pairing season. The movements began to become concentrated as if preparing for a nesting attempt. Following the smaller movements, an erratic movement caused his disappearance from May 5 – June 4. M50 lost his pair bonded female and began to move more freely. Once he was located again, he was captured without a mate. The distance between the last location before being lost and the recapture was 3.15 km. After the apparent disappearance of the mate, he began moving great distances (>1 km) between locations. In doing so we considered him to be a satellite male looking for a mate.

Leopold & McCabe (1957) suggested Montezuma quail showed feeding site fidelity. Although our study did not analyze site fidelity, it should be mentioned that radio-marked coveys were observed in the same general area over short durations (e.g., 1 – 4 weeks) suggesting Montezuma quail do display site fidelity in Texas as well.

In our study, Montezuma quail occupied much of the study area throughout the year and, therefore, habitat requirements were assumed to have been met. Across the three spatial scales, trends of habitat selection emerged. Canyon mountain savannah and foothill slope mountain savannah were the most positively selected habitats in this study. Such habitat types are often associated with drainage areas or creeks. These lowlands are known to keep fertile soils and higher moisture content. These habitats also appeared to provide an adequate vertical structure with a higher diversity of forbs, grasses, trees, and shrubs. During the pairing and nesting season, movements were made into the igneous hill and mountain mixed prairie habitat type. Two nests were documented in the mixed prairie habitat consisting of less canopy cover by trees and a higher abundance of bunchgrasses. Bristow & Ockenfels (2004) found similar results of selection for dense grass cover during the pairing season.

Previous studies have described habitats used by Montezuma quail (Walmo 1954; Leopold & McCabe 1957; Brown 1978; Brown 1989; Stromberg 1990; Bristow & Ockenfels 2004). The use of diggings, flush sites, and roosts have allowed researchers to determine areas known to be used and compared such areas to random locations for evaluating the habitat use areas (Stromberg 1990; Garza 2007). In Arizona, Montezuma quail used areas where there was a higher diversity of grasses, forbs, and tree species (Bristow & Ockenfels 2000; 2002; 2004). Height of grass has also been distinguished to be an important component in areas used (Bristow & Ockenfels 2000; 2002; 2004). Canopy cover has been determined to be at optimal levels from 20–50% (Brown 1982, Bristow & Ockenfels 2000). Diet composition throughout the winter months has been identified and consisted primarily of bulbs and tubers of sedges (*Cyperus* spp.) and woodsorrels (*Oxalis* spp.) (Bishop & Hungerford 1965; Brown 1978). Insects and acorns were identified as staple food items in the summer months (Bishop & Hungerford 1965; Albers & Gehlbach 1990).

Montezuma quail have been a challenge to capture and monitor in the past limiting what is known about movements amongst a population. Using trained dogs during the day and at night proved to be successful in capturing birds. Modern backpack style transmitters allow for prolonged monitoring when compared to using neck-loop transmitters previously (Hernandez 2004). These transmitters also allowed for a higher survival rate (12.8%) than the Hernandez (2004) study (0%) that utilized neck-loop transmitters (Greene 2013). Although our sample size was 13, knowing Montezuma quail have the ability to make long movements and have large home ranges influence management strategies and an overall understanding of the species.

Previous studies have provided information on desired habitat components and grazing strategies to benefit Montezuma quail (Leopold & McCabe 1957; Brown 1982; Bristow & Ockenfels 2004). The ability to monitor individuals with radio telemetry allowed for determining what habitat types were selected for throughout various times of the day. Land managers can focus efforts on improving habitat conditions on preferred habitat types to make management practices, such as closely monitored prescribed grazing and prescribed burning, more effective and cost-efficient. Identifying preferred areas could provide insight into key areas of interest for locating Montezuma quail for hunting purposes or ecotourism.

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