IMPACT OF INCLEMENT WEATHER ON OVERWINTER MORTALITY OF MONTEZUMA QUAIL IN SOUTHEAST ARIZONA

Pedro M. Chavarria[1]
Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843, USA

Angel Montoya
U.S. Fish and Wildlife Service, Silver City, NM 88061, USA

Nova J. Silvy
Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843, USA

Roel R. Lopez
Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843, USA

ABSTRACT

Inclement weather such as droughts or hard freezes are known to negatively impact quail species and population viability models exist which have evaluated northern bobwhite (*Colinus virginianus*) response to summer and winter catastrophes. Previous research suggests inclement weather may be an important factor that contributes to mortality of Montezuma quail (*Cyrtonyx montezumae*), but few data have been collected to evaluate actual rates of overwinter mortality. We evaluated the overwinter mortality of Montezuma quail in southeast Arizona following an episode of severe winter weather consisting of 27.54 cm of precipitation, which occurred from January to March 2010. Overwinter mortality for radio-marked birds ($n = 23$) was 95.6%. Total abundance using flush counts at a control site estimated an 88% reduction in the population following the episode of above-average precipitation. Post-hunting season flush counts across multiple study sites throughout the Coronado National Forest also support this trend. The 3-year (2007–2009) average ($\pm$ SD) (41.67 $\pm$ 4.73) of birds flushed was $\sim$ 80% higher than number of birds ($n = 8$) flushed in the 2010 post-hunting season.

Citation: Chavarria, P. M., A. Montoya, N. J. Silvy, and R. R. Lopez. 2012. Impact of inclement weather on overwinter mortality of Montezuma quail in southeast Arizona. Proceedings of the National Quail Symposium 7:346–351.

Key words: Appleton-Whittell Research Ranch, Coronado National Forest, covey size, *Cyrtonyx montezumae,* dog surveys, flush counts, freezing, Mearn's quail, Montezuma quail, National Audubon Society, overwinter mortality, precipitation, radiotelemetry

INTRODUCTION

Precipitation is a key variable for predicting population fluctuations of quail in North America. Numerous studies have shown the strong influence of summer rainfall on productivity of northern bobwhite (Guthery et al. 2002), Gambel's quail (*Callipepla gambelii*) (Swank and Gallizioli 1954), scaled quail (*C. squamata*) (Lusk et al. 2007), and Montezuma quail (Smith 1917, Bishop 1964, Bishop and Hungerford 1965, Brown 1979), but fewer studies focus on the impact of winter precipitation on these species. Winter climate is known to contribute to over-winter mortality of northern bobwhite and has been evaluated through models of population dynamics (Guthery et al. 2000). Less is known about Montezuma quail, but some evidence suggests severe winter weather can have detrimental impacts on their abundance. Leopold and McCabe (1957: 22) noted that "one cause of sudden decline in Montezuma Quail is periodic winter mortality resulting from abnormally deep snow." Similar observations have been made by Ligon (1927) in New Mexico and O'Connor (1936) in Texas.

Population declines following inclement weather, especially during periods of heavy and persistent snowfall have been reported to be as high as 86.7% (Yeager 1966), but the direct cause of these declines is unknown. Observations reported by ranchers (Yeager 1966) suggest that mortality was directly related to exposure to severe winter storms, but no studies have validated these impacts through monitoring of marked populations. Recent studies using radiotelemetry on Montezuma quail (Stromberg 1990) have overcome past challenges (Hernández et al. 2009) in studying this species, paving the way to better understanding their population dynamics and causes of mortality. This is particularly beneficial for understanding population reductions observed during a severe storm from a winter-storm event from January to March 2010.

We evaluated abundance of Montezuma quail throughout southeast Arizona in the pre- and post-hunt seasons from 2008 to 2010 and compared these estimates to changes in climate observed throughout those periods. Our objective was to evaluate sources or causes of

[1]*E-mail: pmchavarria@tamu.edu*

overwinter mortality, movements, and covey dynamics for a radio-marked population of Montezuma quail during a period of extreme winter weather in 2010.

STUDY AREAS

Surveys of Montezuma quail were conducted along pointing-dog survey routes previously established by the Arizona Game and Fish Department (AZGFD) as well as 3 study sites where marked populations were studied through radiotelemetry. Areas where only pointing-dog survey routes were conducted were dispersed throughout the San Rafael Valley in areas administrated by the Coronado National Forest in Santa Cruz County. Survey routes that included long-term trapping and telemetry were Stevens Canyon, Hog Canyon, and Appleton-Whittell Research Ranch (AWRR) in Elgin.

Hog Canyon (~ 31° 40′ N, 110° 42′ W) is dominated by Madrean Evergreen Woodland and Montane Meadow (AZGFD 2006). Similar vegetation occurs at Steven's Canyon (~ 31° 35′ N, 110° 45′ W) but there is a reduced overstory canopy layer and the oak (*Quercus* spp.) composition is sparse and intermixed with desert scrub species (i.e., *Acacia* sp., and mesquite, *Prosopis* sp.). Plains and Great Basin Grasslands, dominated by sacaton (*Sporobolus wrightii*) bottomlands along Turkey Creek occur at Appleton-Whittell Research Ranch (~ 31° 35′ N, 110° 30′ W). Madrean Evergreen Woodlands dot the landscape on the long-sloping hills at the ranch. Oaks and other overstory species occur in greater densities along the southern and eastern borders of the ranch that neighbor the Coronado National Forest. Hunting and grazing are permitted at both Stevens Canyon and Hog Canyon. Grazing activities are administrated by the Coronado National Forest and seasonal hunting of Montezuma quail is permitted and regulated by AZGFD from mid-November to mid-February. The National Audubon Society owns and manages AWRR and prohibits both grazing and hunting on their property.

METHODS

Climate Data

Weather data were obtained from the National Oceanic and Atmospheric Administration's (NOAA) climatological data reports (NOAA 2010a, b, c) and National Weather Service (NWS) Forecast Office climate reports for Tucson, Arizona from January to March 2010 (NWS 2010a, b, c). The National Climatic Data Center (NCDC 2010) provided online access to records from weather station #1231, Canelo 1 NW in Santa Cruz County (~ 31° 34′ N, 110° 32′ W) at 1,527 m elevation. Average temperatures and departures from normal (°C) as well as total precipitation and departure from normal (cm) were used for analysis. We evaluated temperature and precipitation collected at AWRR when data from weather station #1231, Canelo 1 NW were missing.

Abundance Surveys

Flush-counts were conducted using trained pointing dogs (Brown 1976) along 9 survey routes, some previously established by AZGFD, throughout southeast Arizona from October 2008 to February 2010. Pre-hunt season surveys occurred the last week of October through the first week of November each year. Post-hunt season surveys occurred the last week of February through the first week of March each year. These were conducted during the day from 0500 to1700 hrs, ending no later than 1800 hrs and generally averaged 1.5 hrs per route. The total number of coveys and total quail were recorded and their locations georeferenced using Universal Transverse Mercator (UTM) coordinates in NAD83 datum. Three separate study sites from those surveyed just with dogs—Stevens Canyon, Hog Canyon, and AWRR—were also evaluated from January 2008 to May 2010. These sites were surveyed with dogs to locate possible roost locations for night trapping. Total number of coveys and total quail were also recorded but birds were also trapped and radiomarked. Flush-counts with dogs were conducted periodically, about 2–4 times a month, during the day to record changes in covey size and gender demographics throughout the 3 study sites. Flush-counts were conducted more frequently from November to April. This was reduced from May to October when research activities could potentially impact pair formation, breeding, and nesting.

Capture and Telemetry

Trapping initially required assistance from trained dogs to locate quail at night. Birds were captured with large hoop-nets (Brown 1975) once a roost was located, and evaluated for morphological characteristics (i.e., sex, age, body condition, wing length). Captured birds were fitted with backpack radio transmitters (about 5–8 g, < 5% of body mass; Wildlife Materials, Murphysboro, IL, USA) and aluminum leg bands using methods adapted from Stromberg (1990) and Hernández et al. (2009), and were released before dawn the following morning. Quail were monitored ~ 2–5 times a week through random hours stratified by day (0700–1900 hrs), when quail were most active. Some telemetry sessions were conducted at night (1901–0659 hrs) for trapping or evaluating roost locations. We monitored covey size and covey dynamics by observing movements of radio-marked quail among coveys of those quail originally trapped in the same group. Aspects of habitat use, including roost selection, were also evaluated. Quail movements were analyzed using Quantum GIS 1.7.0 (QGIS 2011).

Survival and Mortality

We used the Kaplan-Meier staggered entry estimator (Pollock et al. 1989) to calculate survival probability rates ($S \pm$ SE) for radio-marked quail at AWRR from January to April 2010. Survival rates and standard errors were calculated using Program ECOLOGICAL METHODOLOGY (Krebs 2002). The condition at last observation was recorded for each individual tracked including sources of

Table 1. Abundance data of Montezuma quail at 4 study areas from pre-hunt (Oct–Nov) and post-hunt (Feb–Mar) surveys for the 2007–2010 seasons in southeast Arizona. Flush-counts report the total number of coveys and quail. Missing data are indicated where surveys were not conducted. AWRR does not permit hunting—the pre- and post-hunt designations are used only as frame of reference for when the surveys were conducted. SR Valley = San Rafael Valley.

	Flush count abundance					
Year	2007–2008		2008–2009		2009–2010	
Season	Pre-hunt Oct-Nov 2007	Post-hunt Feb-Mar	Pre-hunt Oct-Nov 2008	Post-hunt Feb-Mar	Pre-hunt Oct-Nov 2009	Post-hunt Feb-Mar 2010
Stevens Canyon	–	3 coveys: 11–20	2 coveys: 12	0 coveys: 0	–	0 coveys: 0
Hog Canyon	–	4 coveys: 15–30	3 coveys: 15	2 coveys: 8	2 coveys: 11	0 coveys: 0
AWRR	–	–	–	8 coveys: 64	8 coveys: 60	3 coveys: 10
SR Valley	23 coveys: 182	10 coveys: 38	20 coveys: 175	11 coveys: 47	10 coveys: 65	2 coveys: 8

mortality, if known. We noted the most probable or 'suspected' cause of death if cause of death was not directly known.

RESULTS

Pre-hunt flush counts within the traditional pointing-dog survey routes in the San Rafael Valley found similar number of coveys in October–November 2007 when compared to October–November 2008 (Table 1). There was a decline in both number of coveys and total quail in October–November 2009 (Table 1). Post-hunt data had similar trends for February–March 2007 when compared to February–March 2008 (Table 1), but with fewer coveys and slightly more total quail in the later season. The 2009–2010 interval had a decrease in both coveys and total quail in both pre- and post-hunt intervals. The greatest reduction in total coveys and total quail was in the post-hunt period in February–March 2010 with a 87.7% reduction within season. Changes in abundance within season for 2007–2008 (79.1%) and 2008–2009 (73.1%) were considerably lower than in 2009–2010. The 3-year (2007–2009) average ($\pm$ SD) of birds flushed post-hunting (41.67 $\pm$ 4.73) was $\sim$ 80% higher than number of birds ($n = 8$) flushed in the 2010 post-hunting season.

Reductions in number of coveys observed and total quail at Stevens Canyon were similar in post-hunt 2009 and post-hunt 2010, but the amount of quail sign observed in the field (not reported in Table 1) was less than in previous years. No quail sign (i.e., scratching) was observed from surveys at Stevens Canyon in late March 2010. Pre- and post-hunt data for Hog Canyon were comparable to those of the traditional survey routes from the 2008–2009 and 2009–2010 seasons. However, in the 2010 post-hunt season, no quail were flushed and little sign was observed—a 100% reduction in abundance within season. Abundance trends at the AWRR could only be analyzed from 2009, when research was initiated at that site. Surveys in early January 2010 estimated the population to be between 38 and 75 individuals. Estimates obtained from surveys in the post-hunt season indicated a decrease in the population following winter storms in late January. A within-season reduction in abundance of at least 83.3% was observed in 2009–2010. These estimates fail to account for further reductions in abundance observed from March to April 2010.

We had 22 Montezuma quail radiomarked and monitored from January to April 2010. One adult female (#243) remained from the previous season but died from suspected mammal predation on 11 January. Six birds were captured in 1 covey on 13 January and consisted of 1 adult male, 1 adult female, 2 juvenile males, and 2 juvenile females. Male #247 died from suspected raptor predation on 17 January, female #248 died from suspected raptor predation on 24 January, juvenile male #249 died from suspected mammal predation on 22 January, and juvenile female #250 died from suspected mammal predation on 26 January. Juvenile male #702 and juvenile female #701, also trapped in that covey, were found frozen on their roosts on 23 and 24 January, respectively. Female #701 was found frozen on its side and it is unclear if she roosted alone but, at the time of her death, the covey size had been reduced to 3 members. The following day, 2 additional members of the covey died, with 1 (#701) having been frozen in an exposed rocky grass hill within 10 m of oak trees. Most radio-marked birds joined other nearby coveys when numbers in their original coveys were reduced below 4. Those that did not join other coveys, as observed for #701, #248, and #250, died within days. These mortalities coincided within 3 days of the first severe winter storm during 19–23 January. Another quail, juvenile male #706, was found frozen on its roost on 1 February–within 4 days following heavy precipitation. Male #706 was 1 of 4 birds captured in a covey of 6 on 23 January, all of which had full crops at the time. Other members within that covey remained alive post-storm but, by 10 February, at least 3 of the marked birds had died and 1 was missing but assumed depredated.

Radiotelemetry surveys conducted in February noted 2 coveys of 6 and 3 individuals on 2 February during the night but all were observed to be together in a group of 10 during the day. The same 2 coveys monitored on 5 February and 6 February consisted of 5 and 4 individuals. Heavy winter precipitation, followed by extremes of low temperatures persisted in early and late February (Table 2). Reductions in abundance occurred by mid-February, and were confirmed from dead radio-marked birds. Only 1 covey of 6 birds was observed on 15 February and only 1 radio-marked bird remained through 13 March. The Kaplan-Meier estimate for finite survival probability for radio-marked Montezuma quail from January to April 2010 was $S = 0.048 \pm 0.037$.

Table 2. Mean maximum and minimum temperatures, total precipitation, and departures from normal, including coldest recorded dates with data in parentheses measured in °C, and dates of precipitation with data in parenthesis in cm. Data obtained from weather station # 1231, Canelo 1 NW in southeast Arizona from January to March 2010.

	Jan 2010	Feb 2010	Mar 2010
Mean temp (°C)	5.4	5.5	7.8
Departure from normal (°C)	–1.5	–4.1	–3.7
Mean max temp (°C)	13.8	13.0	17.2
Mean min temp (°C)	–3.0	–2.0	–8.2
Coldest days: date (followed by temperature °C in parentheses)	1 (–8.3), 2 (–8.3), 24 (–7.2), 25 (–6.1), 26 (–6.1), 30 (–6.1)	8 (–5.5), 9 (–5.5), 24 (–7.2)	11 (–5.5), 12 (–5.5), 15 (–4.4), 21 (–4.4), 22 (–4.4)
Precipitation days: date (followed by amount in cm in parentheses)	19 (3.51), 20 (1.55), 21 (5.28), 23 (4.27), 28 (4.57)	3 (2.06), 7 (0.33), 10 (2.03), 20 (0.71), 22 (0.84), 28 (1.57)	8 (0.46), 9 (1.52), 10 (0.25), 11 (0.41)
Total precipitation (cm)	19.18	5.72	2.64
Departure from normal (cm)	15.62	2.72	–0.15

DISCUSSION

A series of winter storms occurred during January–February 2010 bringing a combination of sleet, snow, heavy rain, and strong winds throughout southeast Arizona. Mean temperatures were low compared to the previous 2 years with departures from normal of –1.5 °C January, - 4.1 °C in February, and –3.7 °C in March. Total precipitation exceeded previous years with departures from normal of 15.62 cm in January and 2.72 cm in February. Some of the coldest days followed precipitation events, particularly on 24–26 January. The soil was frozen hard at AWRR following the period of heavy rainfall on 22 February. At least 5.08 cm of snow persisted on the ground and standing water and ponds saturated the landscape. Strong winds with gusts to 64 to 97 km/hr were reported in the valleys, and gusts to 129 km/hr in the mountains. The National Weather Service in Tucson reported January 2010 as the 8th wettest January on record and 22 January as the 5th wettest January day on record. The NWS in Tucson reported the continuing storm system made 2010 the 11th wettest February on record and 28 February as the 7th wettest February day on record.

Reductions in abundance of Montezuma quail were observed throughout the pointing-dog survey routes and the 3 study sites examined through radiotelemetry in southeast Arizona in the 2010 post-hunt season. These sharp changes from pre-hunt to post-hunt season and cause of mortalities were evaluated with radiotelemetry at AWRR. Some birds were found frozen on their roosts when the number of individuals within a covey was below 4. Quail that lost members in their covey often joined other nearby coveys. This may have increased chance of survival due to the increased insulation provided from roosting as a group. Weather conditions during January–February 2010, however, may have overcome physiological tolerance of Montezuma quail due to the extreme low temperatures. Many birds were observed to be lethargic and would choose to run rather than flush when approached. This may have increased vulnerability to predation.

Yeager (1966) and Brown (1979) noted the potential negative impacts associated with winter precipitation. Brown (1979) observed a negative correlation coefficient between winter (Oct–Mar) precipitation and the following season's reproductive success ($r = -0.73$, $P \leq 0.02$). Yeager (1966) reported emaciated dead birds following a severe storm that left parts of southeast Arizona covered with 25.4 to 35.56 cm of snow. Yeager (1966:7) reported conditions where "snow cover lasted from 4 to 6 days on south and west slopes" and that "up to 30.48 cm of undrifted snow still covered many of the east and north slopes through 19 February 1966." Snow cover was not as deep or persistent at AWRR in 2010 compared to conditions described by Yeager (1966), but snow cover persisted on the nearby Patagonia, Santa Rita, and Huachuca slopes through April. Freezing rain rather than snow accounted for most of the precipitation at AWRR in 2010.

Abundance of Montezuma quail at AWRR was lower in February 2010 compared to estimates from 2009. We estimated at least 64 Montezuma quail remaining in May 2009, while in May 2010 we estimated the total population at AWRR to be 10 or less with only 2–4 of these individuals being detectable through intensive surveys. Intensive reductions in abundance also occurred at Stevens Canyon and Hog Canyon—sites that were monitored via flush-surveys but not with radiotelemetry. Flush-count surveys and estimates of survival from radio-marked birds at those 2 sites in previous years suggests hunting does not impact the population by severely reducing the abundance to those levels observed in the 2010 post-hunting season. Surveys at Stevens Canyon in previous years suggest that site is vulnerable to localized extirpation because of intensive hunting and grazing. Hog Canyon has more resilience to both of those pressures because of topography. We expected abundance at Hog Canyon to be higher than observed in our surveys in the post-hunt season through May 2010. It is possible the combination of severe weather and hunting pressure was responsible for marked reductions in abundance observed at both Stevens Canyon and Hog Canyon in the 2010 post-hunt season.

Yeager (1966) and Brown (1979) did not evaluate movements of radio-marked Montezuma quail. Neither Yeager (1966) nor Brown (1979) could account for possible migrations of populations from their study areas.

Brown (1979: 525) suggested the possibility of underestimating a population in surveys, noting that "local populations have been observed to apparently leave an area, presumably because food sources are depleted." Yeager (1966) also suggested the possibility that migration might explain why birds could not be found in areas where they were abundant the month before in his study. However, Yeager (1966: 8) concluded there was no solid evidence to support that claim and, because of the relative sedentary nature of this species, there was evidence to support the assumption that snow cover "can and probably does cause relatively high mortality." Our research with integration of radiotelemetry to supplement dog-assisted flush counts, confirms that: (1) Montezuma quail are relatively sedentary and have small home ranges, and (2) severe winter weather, including freezing temperatures and snow cover, causes high mortality in this species.

MANAGEMENT IMPLICATIONS

Timing and amount of precipitation impact reproduction (Brown 1979, Heffelfinger et al. 1999) of quail and emphasis has been placed on observing summer rather than winter precipitation events. Some quail biologists suggest winter and early spring precipitation may be favorable for early production of vegetation that can benefit quail before the breeding season. Our research shows, however, that timing of precipitation, as well as the severity of the storm system that brings it, are important factors when considering possible benefits to Montezuma quail and developing better estimates of overwinter mortality. Inclement weather impacted the survival of Montezuma quail in our study from the series of record-setting storms with below-average departures from normal in both precipitation and monthly mean temperatures. Montezuma quail have evolved adaptations to survive snowfall and winter storms but the combination of conditions brought by the severe weather in 2010 reduced abundance throughout much of southeast Arizona. Evaluation of shifting weather patterns remains crucial for conservation of quail in the midst of potential climate change (Root 1993). The potential impacts from severe storms can be problematic to Montezuma quail if severe drought conditions follow.

ACKNOWLEDGMENTS

Many volunteers assisted with this research, including Audubon interns Richard Chasey and Lindsey Reifl. Generous support was provided by a Sloan Foundation Fellowship, Ariel-Appleton Fellowship, and a National Audubon Society Apacheria Fellowship. I thank my graduate assistant dogs Blanca and Chico, who did not mind searching for birds in freezing conditions in the field.

LITERATURE CITED

Arizona Game and Fish Department (AZGFD). 2006. Comprehensive wildlife conservation strategy: 2005–2015. Phoenix, USA.

Bishop, R. 1964. The Mearns quail (*Cyrtonyx montezumae mearnsi*) in southern Arizona. Thesis. University of Arizona, Tucson, USA.

Bishop, R. A., and C. R. Hungerford. 1965. Seasonal food selection of Arizona Mearns quail. Journal of Wildlife Management 29:814–819.

Brown, D. E. 1979. Factors influencing reproductive success and population densities in Montezuma quail. Journal of Wildlife Management 43: 522–526.

Brown, R. L. 1975. Mearns' quail capture method. Final Report. Federal Aid Project W-78-R-15, Work Plan 1, Job 2. Arizona Game and Fish Department, Phoenix, USA.

Brown, R. L. 1976. Mearns' quail census technique. Federal Aid in Wildlife Restoration Project W-78-R-15, Work Plan 1, Job 1. Arizona Game and Fish Department, Phoenix, USA.

Guthery, F. S., M. J. Peterson, and R. R George. 2000. Viability of northern bobwhite populations. Journal of Wildlife Management 64: 646–662.

Guthery, F. S., J. J. Lusk, D. R. Synatzske, J. Gallagher, S. J. DeMaso, R. R. George, and M. J. Peterson. 2002. Weather and age ratios of northern bobwhites in South Texas. 5: 99–105.

Heffelfinger, J. R., F. S. Guthery, R. J. Olding, C. L. Cochran Jr., and C. M. McMullen. 1999. Influence of precipitation timing and summer temperatures on reproduction of Gambel's quail. Journal of Wildlife Management 63:154–161.

Hernández, F., E. Garza, L. A. Harveson, and C. E. Brewer. 2009. Fate and survival of radio-marked Montezuma quail. Gamebird 2006: Quail VI and Perdix XII: 426–431.

Krebs, C. J. 2002. Ecological methodology. Second edition. Harper and Row, New York, USA.

Leopold, A. S., and R. A. McCabe. 1957. Natural history of the Montezuma quail in Mexico. Condor 59:3–26.

Ligon, J. S. 1927. Wildlife of New Mexico, its conservation and management. New Mexico State Game Commission, Santa Fe, USA.

Lusk, J. J., F. S. Guthery, M. J. Peterson, and S. J. DeMaso. 2007. Evidence for regionally synchronized cycles in Texas quail population dynamics. Journal of Wildlife Management 71: 837–843.

National Climatic Data Center (NCDC). 2010. Climate data online. National Oceanic and Atmospheric Administration, Reno, Nevada, USA. www.ncdc.noaa.gov/cdo-web/

National Oceanic and Atmospheric Administration (NOAA). 2010a. Climatological data, Arizona, January 2010, Volume 114. Number 01 ISSN 0145–038. Rocket Center, West Virginia, USA.

National Oceanic and Atmospheric Administration (NOAA). 2010b. Climatological data, Arizona, February 2010, Volume 114. Number 02 ISSN 0145–038. Rocket Center, West Virginia, USA.

National Oceanic and Atmospheric Administration (NOAA). 2010c. Climatological data, Arizona, March 2010, Volume 114. Number 03 ISSN 0145–038. Rocket Center, West Virginia, USA.

National Weather Service (NWS). 2010a. January 2010 climate report for Tucson. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Tucson, Arizona, USA. www.wrh.noaa.gov/twc/climate/monthly/jan10.php

National Weather Service (NWS). 2010b. February 2010 climate report for Tucson. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Tucson, Arizona, USA. www.wrh.noaa.gov/twc/climate/monthly/feb10.php

National Weather Service (NWS). 2010c March 2010 climate report for Tucson. U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Tucson, Arizona, USA. www.wrh.noaa.gov/twc/climate/monthly/mar10.php

O'Connor, J. 1936. Mystery quail. Field and Stream, March 1936: 24, 25, 72–74.

Pollock, K. H., S. R. Winterstein, C. M. Bunick, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry approach. Journal of Wildlife Management 53: 7–14.

Quantum GIS Development Team (OGIS). 2011. Quantum GIS Geographic Information System, Version 1.7.0. Open Source Geospatial Foundation Project. Vancouver, British Columbia, Canada. qgis.osgeo.org

Root, T. L. 1993. Effects of global climate change on North American birds and their communities. Pages 280–292 *in* Biotic interactions and global change, P. Kareiva, J. Kingsolver, and R. Huey, eds. Sinauer Associates, Sunderland, Massachusetts, USA.

Smith, A. P. 1917. Some birds of the Davis Mountains, Texas. Condor 19: 161–165.

Swank, W. G., and S. Gallizioli. 1954. The influence of hunting and of rainfall upon Gambel's quail populations. Transactions of the North American Wildlife Conference 19: 283–297.

Stromberg, M. R. 1990. Habitat, movements and roost characteristics of Montezuma quail in southeastern Arizona. Condor 45: 57–65.

Yeager, W. M. 1966. Mearn's quail management information. Special Report. Federal Aid Project, W-53-R-16. Arizona Game and Fish Department, Phoenix, USA.