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Pedro M. Chavarria
Texas A&M University

Alison R. Kocek
Liberty Wildlife Rehabilitation

Nova J. Silvy
Texas A&M University

Roel R. Lopez
Texas A&M University

USE OF PORTABLE INFRARED CAMERAS TO FACILITATE DETECTION AND CAPTURE SUCCESS OF MONTEZUMA QUAIL

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

Alison R. Kocek
Liberty Wildlife Rehabilitation, Scottsdale, AZ 85267, 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

Survey and trapping methods for Montezuma quail (*Cyrtonyx montezumae*) require means not traditionally used for other quail species (e.g., northern bobwhite, *Colinus virginianus*). Trapping Montezuma quail is most effective using pointing dogs at night when coveys can be located and captured by net during roosting. However, reduced visibility at night, cryptic coloration of plumage, and behavioral adaptive stillness reduce detection rates and increase accidental flushing of birds while searching for roost locations. Forward-looking infrared (FLIR) cameras have been used to aid in detection of cryptic wildlife, including avifauna roosting sites. We conducted 25 survey and night-trapping sessions for Montezuma quail in southeast Arizona using a combination of trained pointing dogs and a portable FLIR camera. Detection of coveys on a roost was less successful when ambient climate conditions were freezing (below –3.88 °C), when residual heat signatures from surrounding soils and rocks were greater than 18.33 °C, or when density of grass cover exceeded 40% and the distance to covey was $>$ 2.5 m. The small thermal signatures of quail were often obstructed by vegetative cover or confused with residual thermal signatures reflected by inanimate objects (e.g., rocks, bare ground). Successful detection of coveys combining the use of dogs and FLIR before trapping was 6.06%. Trapping success and detection of coveys with FLIR was improved when used with radiotelemetry and coveys which included radio-marked individuals. Proper tuning of FLIR camera sensitivity to a limited thermal bandwidth, or isotherm range, may effectively narrow covey locations approximated by a pointing dog. The FLIR camera was of limited benefit when actively trapping coveys with dogs and a team of 2–3 people, but may be beneficial for non-invasive monitoring and estimating covey size of marked birds on roosts in landscapes with reduced vegetative cover.

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Key words: Appleton-Whittell Research Ranch, Arizona, Coronado National Forest, *Cyrtonyx montezumae,* FLIR, forward-looking infrared, Mearn's quail, Montezuma quail, roost, survey, trapping

INTRODUCTION

Knowledge gaps in the natural history of wild Montezuma quail populations exist due to difficulties in locating and capturing these birds using traditional methods for similar species in North America (e.g., northern bobwhite) (Leopold and McCabe 1957, Stromberg 1990, Harveson et al. 2007). Cryptic coloration and behavioral adaptive stillness permit limited study opportunities due to lack of detection without use of trained pointing dogs. Pointing dogs provide the most practical means of conducting daytime flush counts for population estimates (Brown 1975, 1976; Hernández et al. 2009) and for locating coveys at night for trapping on roosts. Night-trapping of Montezuma quail, however, is complicated by reduced visibility and accuracy in covey locations by pointing dogs. This decreases covey detection rates and increases accidental flushing of birds while trappers search for exact roost locations.

Use of night-vision and thermal-infrared cameras has facilitated detection of wildlife at night, especially large ungulates and carnivores (Boonstra et al. 1994, Garner et al. 1995, Focardi et al. 2001). These technologies have increasingly been applied in avifauna surveys, particularly for more cryptic and elusive species (Boonstra et al. 1995, Mills et al. 2011), and to aid in detection of avifauna at roosting sites (Locke et al. 2006, Tillman 2009). Use of FLIR cameras has potential to aid in narrowing the probable location of a covey, once an estimated location has been detected, by a pointing dog or triangulated via telemetry of radio-marked birds. Our objectives were to evaluate the efficacy of FLIR cameras in improving detection and capture success of wild Montezuma quail in southeast Arizona when used in combination with dogs.

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

We also evaluated its potential for monitoring covey size of marked birds on a roost.

STUDY AREAS

Surveys of Montezuma quail were conducted throughout Arizona Game and Fish Department's (AZGFD) Management Unit 35 in southeastern Arizona within areas administrated by the Coronado National Forest in Santa Cruz County. Most research was concentrated near Stevens Canyon and Smith Canyon in Patagonia, Apache Tank, and Williamson Tank in the San Rafael Valley, Apache Spring, Hog Canyon, and Gardner Canyon near Sonoita, and Appleton-Whittell Research Ranch (AWRR) near Elgin. Trapping and long-term monitoring of radio-marked individuals occurred primarily in Stevens Canyon, Hog Canyon, and AWRR.

AZGFD's Comprehensive Wildlife Conservation Strategy (AZGFD 2006) notes the major vegetation types occupied by Montezuma quail in southeastern Arizona consist of: Plains and Great Basin Grasslands, Subalpine Grasslands, Madrean Evergreen Woodland, and rarely Montane Conifer Forest. Hog Canyon (~31° 40′ N, 110° 42′ W) is dominated by Madrean Evergreen Woodland and Montane Meadow for vegetation and Caralampi gravelly sandy loam (22.2%) soils (NRCS 2012). Steven's Canyon (~31° 35′ N, 110° 45′ W) is also dominated (52.8%) by Caralampi gravelly sandy loam soils (NRCS 2012) and has similar vegetative characteristics to Hog Canyon but with a reduced overstory canopy layer; Madrean Evergreen Woodland is sparser and intermixed with Desert Scrub midstory species (i.e., *Acacia* sp.; mesquite, *Prosopis* sp.). AWRR (~31° 35′ N, 110° 30′ W) consists mainly of Plains and Great Basin Grasslands dominated by Big Sacaton (*Sporobolus wrightii*) bottomlands along Turkey Creek and Madrean Evergreen Woodlands sparsely dispersed among the sloping hills (Stromberg 1990). Dominant soils (52.5%) at AWRR consist of White House gravelly loam (NRCS 2012). Climate data from the nearest long-term weather station (#1231, Canelo 1 NW; Canelo, AZ) indicated mean temperatures of 22.6 °C in June, the hottest month, and mean temperature of 6.3 °C in January, the coldest month, from 1981 to 2010 for this region (WRCC 2012).

METHODS

Initial surveys for Montezuma quail were conducted with trained dogs along survey routes, including some previously established by AZGFD. Covey locations, identified from flush points, were georeferenced using Universal Transverse Mercator (UTM) coordinates in NAD83 datum. Potential roosting sites near flush locations were resurveyed at night during trapping and monitoring events. A Forward-looking Infrared (FLIR) ThermaCAM*t* B-20 handheld camera (FLIR Systems, North Billerica, MA, USA) was used. It is a 1.7-kg long-wave (7.5-13-μm) camera with a 24° lens that allows for a 24 $\times$ 18° field of view at a minimum focus distance of 0.3 m. Image resolution is 320 $\times$ 240 pixels and can be displayed in real-time on a 10-cm liquid crystal screen. The thermal sensitivity of the camera is 0.06 °C at 30 °C and can be adjusted by the user to show either broad-range or fine-range isotherm bandwidths in color or gray scale. The B-20 FLIR also contains focus and zoom functions that permit monitoring potential targets from distances of $>$ 20 m. Image events captured with the camera in the field can momentarily be 'frozen' on-screen, allowing the user to save an image in its current display setting to the camera's memory card. Image copies of the same event, but which display a broader or finer range of temperatures, or isotherm bandwidths, can consequently be saved if the current image event is still 'frozen' on-screen.

Montezuma quail were captured with hoop nets with the combined of use pointing dogs and FLIR camera. Traditional methods of trapping quail require trained dogs to hold point when quail are located, allowing a short interval of time for 1 or 2 researchers to approach, identify the location of, and capture a bird with a hoop-net (Brown 1975). The FLIR camera was used to narrow the potential location of quail by tracking heat signatures in close proximity to where the dog was 'pointing'. FLIR was used to scan the surrounding landscape where the dog roamed for 5–10 min before the dog went on-point, when the dog's behavior indicated it was nearing a potential roost site. We scanned an area with FLIR for shorter durations the closer a dog was thought to be to a roost, the longer the dog was on-point, and the fewer crew members were present. A 2-person field crew typically had 3–5 min to scan an area with FLIR for the roost site once a dog went on-point while closing-in from a distance of 10 m or more, but only 0.5–1.5 min once the 2-person crew was within 2–5 m. One crew member in a 3-person trap crew was dedicated to restraining the dog, allowing another member to scan potential roost sites for 0.5 to 3.0 min. Detection of birds on a possible roost was attempted from distances of 2, 5, and 10 m. FLIR pictures were taken from these distances, at a 45 ° angle to the ground target with the height, dependent on camera operator, between 1.5 and 2.0 m above ground. We recorded potential identifications and positive identifications of target animals with FLIR and evaluated density of vegetation from event images captured within the FLIR field of view. These were categorized at percent cover intervals of 0–20, 21–40, 41–60, 61–80, and 81–100. We also recorded the number of quail on a roost and temperature at the roost location when targets were positively identified at a scanned location.

Most survey, trapping, and monitoring sessions were conducted after sunset, from 1900 to 0300 hrs, when quail were expected to be on roost and when the darkness and cooler temperatures in the surrounding environment allowed for clearer contrast of thermal signatures. Trapping was discontinued from 0300 hrs until sunrise to: (1) allow dispersed coveys to reassemble overnight, thus reducing potential mortality from trapping effort, and (2) allow sufficient time to process trapped birds to release before dawn the morning following trapping. We hypothesized, when overnight snowfall was present, that the thermal signature of quail was easier to detect when

Table 1. Combinations of the number of personnel, use of dog (D), and telemetry (T) in conjunction with FLIR for trapping Montezuma quail with the outcome of sessions for each combination.

Combination used with FLIR	Number of times tested	Dog points	Possible detection instances with FLIR	Number of birds possibly detected	Number actually detected	Number of coveys flushed	Total number of birds flushed	Average (± SD) covey size	Number of birds captured
1D	1	1	0	0	0	1	6	6.0	0
1D, T	3	3	1	4	0	4	20	5.0 ± 1.4	7
1T	3	–	3	7	6	4	15	3.0 ± 1.6	7
2D	5	12	2	2	0	5	36	7.2 ± 2.7	8
2D, T	4	6	1	2	0	7	22	3.1 ± 2.3	6
2T	1	–	1	2	0	2	4	2.0 ± 0	4
3D	4	11	1	2	2	7	20	2.9 ± 0.9	6
3D, T	4	11	2	3	1	9	33	4.1 ± 3.4	8

contrasted to the colder surroundings; trapping and monitoring sessions in those conditions were conducted between 1900 and 1 hr past sunrise.

RESULTS

We conducted 25 survey and trapping sessions (Table 1) for Montezuma quail, accounting for 128 person-hrs and 75 dog-hrs, between January 2008 and July 2009. Trapping sessions with dogs averaged (± SD) 2.61 ± 1.14 hrs per session, and telemetry-only sessions averaged 2.63 ± 0.65 hrs per session. Average time scanning for targets using FLIR was 0.782 hrs per session, about 30% of the session. We counted 156 birds flushed from roosts during dog-, telemetry-, and FLIR-assisted trapping sessions but estimate the actual number to be $>$160 birds. Average covey size flushed or potentially detected with FLIR (Table 1) varied depending on the season in which trapping was conducted. We observed larger coveys (6–10 individuals) when trapping only with dogs in late fall–early winter, and smaller coveys (3–7 individuals) or pairs of birds in early spring and late summer, respectively. Nine of the total birds flushed (5.7%) were detected with FLIR. Infrared heat signatures of quail possibly and actually detected with FLIR ranged from 11.11 to 29.44 °C. Detection of coveys on a roost was less successful when ambient climate conditions were freezing (below –3.88 °C) or when residual heat signatures from surrounding soils and rocks were greater than 18.33 °C. We detected quail with FLIR from a distance of 5 and 10 m only once in a recently burned landscape. All other possible and actual detections of quail were observed 2.0–2.5 m from a roost. We occasionally flushed multiple coveys roosting within 5 m of one another but these were not detectable with FLIR when scanning within 2.5 m.

Vegetation densities ranged from 41 to 80% at most roost sites where coveys were possibly detected with FLIR. However, actual detection rate was 0% for all combinations (Table 1) when understory-grass density was $>$ 40% because obstructed line-of-sight prevented detection with FLIR. Instances of positive identifications made prior to netting of unmarked quail when using dogs were low ($n = 2$). The density of understory vegetation in both instances was $<$ 40%: the successful session at Hog Canyon had 20–40% density of understory-grass and succulent species while the understory-grass density at AWRR, in a burned landscape, was 0–20%. Actively trapping with dogs was most effective when the field crew had 1 person dedicated to trapping birds with the net, another to restrain the dog, and a third person to scan potential roost sites with FLIR (Table 2). Use of telemetry further facilitated detection and capture success (Tables 1, 2). Positive detection was 66% when FLIR was used in combination only with telemetry ($n = 4$) in areas with an understory-grass density of 0–40%.

DISCUSSION

A variety of factors including ambient climate conditions, density of grass cover, and distance to covey affected our ability to make positive detections of coveys with FLIR (Table 2). The small thermal signature of quail was often obstructed by dense vegetative grass cover, masked by snow on the ground, or confused with residual thermal signatures reflected by nearby inanimate objects (e.g., rocks, trees, bare ground). An appropriate crew size to assist in trapping made use of FLIR more feasible when trapping with dogs (Table 3). The camera was considered portable, but the weight and bulk of our particular model, ThermaCAM*t* B-20, interfered with concurrent use of the camera and net limited our reaction time to net birds on a roost. The dog on-point would also often break point to retrieve birds once an attempt was made to capture them. Preventing dog-related trap injuries and quail mortality required assistance of additional crew members for restraining the dog and operating the camera.

Additional crew members translated into more time invested in scanning an area with FLIR, thereby increasing chances of making possible and actual detections. Detection of coveys on roost required adjusting FLIR to display isotherm bandwidths that provided sufficient contrast between target animals and nearby inanimate objects. Optimal tuning of FLIR to specific isotherm bandwidths produced more accurate estimates of covey size. However, learning how to tune the FLIR camera to display optimal isotherms required a moderate learning curve and experience in a variety of field conditions. Switching isotherm display settings on

Table 2. Advantages and disadvantages of FLIR in different combinations of crew size, use of dog (D), and telemetry (T).

Combination with FLIR	Advantage	Disadvantage
1D, 2D, 3D	1. Dogs are essential for initially trapping birds and can locate unmarked birds or coveys once flushed from roosts.	1. Dog may accidentally flush birds from roost.
	2. Useful for scanning landscapes with $< 20\%$ vegetative cover before actively trapping with dog.	2. Vegetative cover $> 40\%$ density, especially understory grass, may obstruct line-of-sight.
	3. May be used to estimate covey size before trapping.	3. Accurate estimation of covey size with FLIR reduced with higher densities of vegetative cover.
	4. When crew size = 2, one person can restrain dog and scan with FLIR for 0.5–1.5 min and while other person handles net.	4. When crew size < 2, the bulky ThermaCAM*t* B-20 model prevents simultaneous handling of large hoop net and restraining dog when birds are captured.
	5. When crew size = 3, one person can scan with FLIR for 0.5–3.0 min duration while others handle dog and net.	5. Time allowed to scan a roost is reduced more when crew size is smaller because dogs cannot be restrained simultaneously while trapping and scanning with FLIR.
	6. Isotherm settings in camera can be adjusted to separate infrared signatures of quail from residual thermal signatures of surrounding inanimate objects.	6. Residual thermal signatures of surrounding inanimate objects may mask infrared signature of quail when camera is not set to an optimal isotherm setting; optimal setting varies with ambient conditions.
		7. Freezing conditions seem to negatively impact camera imaging and snowfall masks heat signature of quail.
1DT, 2DT, 3DT,	1. Same as above, but using telemetry allows trapping crew to better approximate location of a radio-marked bird and its covey, and scan with FLIR for a longer duration before having to use the dog.	1. Same as above, but operation of telemetry equipment reduces ability to simultaneously operate other equipment when actively trapping, including scanning with FLIR, capturing birds with net, and restraining dog.
	2. Telemetry may be used to monitor covey size before trapping.	
1T, 2T	1. The location of a radio-marked bird and its covey can be approximated with telemetry and then scanned with FLIR for a longer duration than when using dogs.	1. Same as for 1D, 2D, and 3D, except for absence of using dog.
	2. Absence of dog to assist in trapping reduces chance of accidentally flushing birds from roost.	2. Absence of dog to assist in trapping extremely limits chances of capturing unmarked birds once they flushed from roost.

the ThermaCAM*t* B-20 in the field was not always instantaneous—leading to short intervals of lag time in the software that proved to be most inconvenient when actively trapping with dogs.

Detection of quail with the FLIR camera was especially problematic 2–3 hrs after sunset when the surrounding environment still reflected heat absorbed from daytime solar radiation. Trapping later in the night when cooler temperatures are present reduced the amount of residual thermal signatures reflected in the environment. However, trapping too late at night may increase risks to Montezuma quail survival when displaced from their covey at a roost. Montezuma quail survival may depend on thermal insulation, safety, or awareness provided by the covey and there are limited data in the literature that examines to what extent this species regroups once they are displaced from a roost at night.

The total number of detected targets on roost was not certain when positive identifications were made, but the FLIR was useful, when set to an optimal isotherm, for narrowing the possible roost location within the field of view. False-positives detected with FLIR outnumbered positive identifications and attempts to trap at locations misinterpreted with FLIR as targets on a roost at times lead to accidental flushes. However, roosts could generally be found within 0.25–3.5 m of where a dog went on-point and coveys could be approached within 2.5 m with FLIR before they were accidentally flushed.

The FLIR camera in our study was most beneficial for increasing chances of detecting and trapping a covey when assisted by triangulation via telemetry. There was less risk to accidentally flushing birds from a roost than when assisted with a dog when telemetry was used to locate radio-marked birds and, consequently, the unmarked birds in their covey. It was then possible for a single researcher to conduct trapping and monitoring with the aid of telemetry and FLIR once at least 1 bird in the covey was radiomarked. The FLIR was particularly useful with telemetry for non-intrusive monitoring of covey size on a roost when the surrounding vegetation did not considerably insulate or mask a target's small heat signature or obstruct its line-of-sight. We were able to non-obtrusively monitor a breeding pair of Montezuma quail roosting in a burned landscape and observe movements of radio-marked individuals released on roosts the same night. We also considered using FLIR to monitor mated pair behavior and hatch success during the nesting season. Use of FLIR technology that is lightweight and mountable as head-gear would improve

Table 3. Suggested use of FLIR for trapping and monitoring Montezuma quail.

Before trapping	1. Scan the landscape and note the range of residual thermal infrared signatures from inanimate objects, especially soil and rocks; this will vary with ambient conditions (i.e., temperature). 2. Adjust FLIR to isotherm settings that do not closely resemble the infrared signature of a live animal; use the dog or another captive bird (e.g., pigeon) for reference.
Trapping and monitoring	1. Avoid using FLIR when actively trapping with dogs and crew size is $<$ 2 people. 2. Use a crew of 3 people and a dog to initially locate coveys throughout the landscape. Have 1 person operate the FLIR, 1 person handle and restrain the dog, and 1 person to handle net. If crew size is 2, the dog handler also operates the FLIR. 3. The FLIR operator scans the surrounding landscape when the dog's behavior indicates it is close to a roost location; pictures of a location should be taken from 10, 5, and 2.5 m as soon as the dog goes on-point. 4. Quickly adjust the FLIR to an isotherm setting that best distinguishes the infrared signature of the dog and the surrounding rocks, then scan the ground where the dog is on-point for possible detections of quail. 5. The FLIR operator evaluates images in-field to narrow probable location of a covey and dog handler restrains the dog with a leash. If crew size is 2, FLIR operator reduces maximum scan time to 1.5 min and restrains dog. If the person with the net cannot visually detect the covey, an attempt is made to drop the net on the probable roost location suggested by FLIR operator. When capture attempt is successful, the FLIR operator leaves the camera and assists in handling and capture of quail. 6. Radiomark at least 1 bird from each covey. Release marked birds and trap remaining unmarked members of each covey in consequent attempts using radiotelemetry and FLIR but without use of dogs.

its integration in future studies for trapping and monitoring Montezuma quail.

MANAGEMENT IMPLICATIONS

Management of Montezuma quail has historically relied on use of dogs to conduct daytime flush counts to assess covey sizes, habitat use, and estimate population abundance. However, use of radiotelemetry in conjunction with flush counts, produces more accurate estimates. Trapping wild Montezuma quail remains a challenging endeavor that can be overcome using a combination of field methods described in our study. Tools such as night vision or FLIR complement use of dogs when used in trapping. Trapping efficiency is improved as is detection of quail, and more individuals can be radiomarked and monitored in the wild. Improved implementation of radiotelemetry reduces or eliminates the need to conduct daytime flush counts for evaluating covey sizes, habitat use, and estimating population abundance. There is increased potential for non-intrusive monitoring of Montezuma quail at night using FLIR. Knowledge of covey dynamics, covey size, nesting and roosting behavior at night remain poorly documented for this species. Further application of less expensive and more portable FLIR-like technologies, when used with radiotelemetry, can help to resolve these knowledge gaps and contribute to the conservation of this species.

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