INVESTIGATIONS INTO THE ECOLOGY AND MANAGEMENT OF OCELLATED TURKEYS IN CAMPECHE, MEXICO

by

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This was a memorable project and I am grateful to have shared the experience with many great friends…thank you all.

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ABSTRACT

The ocellated turkey (*Meleagris ocellata*) is a neotropical galliform native to the Yucatán Peninsula of Mexico and northern portions of Belize and Guatemala. Little information exists on the ecology or management of the species and previous research has been anecdotal, based on limited visual observations, or is centered on turkeys in protected areas that are semi-habituated to humans. Ocellated turkey populations are currently threatened by unauthorized subsistence hunting and habitat alteration throughout much of their range and sound ecological data are necessary to guide conservation and management decisions.

To address this need, I studied ocellated turkeys in Campeche, Mexico during 2010–2013 with field seasons typically spanning January–June. Broad objectives of my study included, 1) the development and assessment of field techniques used to research ocellated turkeys, 2) a study of food habits of ocellated turkeys in an agricultural environment, 3) an evaluation of the trap and transfer method to reestablish or augment areas with translocated ocellated turkeys, and 4) an assessment of ocellated turkey life history traits including survival, cause-specific mortality, movement patterns, and home range estimates.

I accomplished these objectives by capturing and monitoring turkeys at two study areas: the community owned Las Flores and Carlos Cano Cruz Management Units for Conservation and Sustainable Use of Wildlife (UMA) as well as the privately owned La Montaña UMA. The Las Flores and Carlos Cano Cruz UMAs were a forest-agriculture matrix marked by production agricultural development and the La Montaña UMA was intact forest with few clearings, no agricultural production, and greater topographic relief than Las Flores. La Montaña was located approximately 65.85 km to the south-southwest of Las Flores.

I relied on walk-in traps and a cannon net to capture ocellated turkeys. After capture, I recorded sex and age class and equipped turkeys with either a 95-g Very High Frequency (VHF) or 80-g Global Positioning System (GPS) backpack style transmitter. Radio tracking was challenged by thick vegetation, turkey mobility, and poor access to remote areas. At La Montaña I used walk-in traps with a capture rate of 158.36 trap-days/turkey and a capture mortality rate of 18.18%. Field tests indicated that VHF signal range was 3.89 ± 0.62 (95% CI) km and 1.77 ± 0.23 km in jungle-agriculture matrix and jungle habitats, respectively. When using a GPS transmitter I documented a 90.7% fix-rate from an ocellated turkey hen inhabiting the jungle-agriculture matrix. My combined VHF and GPS transmitter recovery rate was 63.0%. Aerial telemetry was helpful when VHF transmitters were used.

To assess food habits I collected the upper digestive tracts (n=64) of ocellated turkeys at Las Flores and Carlos Cano Cruz during February–May, 2013. I quantified food items consumed by ocellated turkeys using dry weight and frequency of occurrence and found that seeds contributed most to diets with grain sorghum (*Sorghum spp*.), corn (*Zea spp.*), and soybeans (*Glycine spp.*) the most consumed plant species during the study period. Results showed that ocellated turkeys fed heavily on anthropogenic food sources and these habitats should be considered when developing conservation plans.

During my assessment of the trap and transfer methods for ocellated turkey conservation I monitored turkeys (n=18) that were transferred between Las Flores and La Montaña and found that the survival rate of translocated birds was 0.186 (SE = 0.168) and that mortalities occurred near the release site (769.10 m; SE=325.04 m). I also concluded that mortalities were due to small carnivores and subsistence hunters. To increase the likelihood of successful trap and transfers efforts, wildlife managers should release birds in habitats that share characteristics with the capture location, minimize time transporting turkeys, and monitor the fate of released birds.

I used wild-caught ocellated turkeys (n=24) for survival analysis and found an annual survival rate of 0.505 (SE=0.119). Cause-specific mortality results were inconclusive because of a low radio recover rate and challenges identifying a cause of death; however, I did identify small felids and sport- and subsistence hunters as mortality factors. I was able to collect an adequate number of samples to calculate a home range estimates for 5 ocellated turkeys and found that average 95% fixed kernel and 100% minimum convex polygon home range estimates were 9.69 km^2 (SE=2.76) and 8.34 km^2 (SE=1.83), respectively. Displacement movements occurred in February–April and the average one-way displacement distance was 19.81 km (SE=4.89) and the maximum movement I documented from an ocellated turkey was 36.50 km.

Despite being limited by sample sizes, these results are the most comprehensive assessment of ocellated turkey ecology and management and can be used to guide conservation activities. Additional study is critical in order to better understand the species. Researchers should focus on determining population recruitment metrics, the current occupied range of the species, developing a reliable monitoring method, and identifying strategies to manage subsistence hunting pressure and habitat alteration while simultaneously considering the needs of local people.

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CHAPTER I

INTRODUCTION

The ocellated turkey (*Meleagris ocellata*) is a brilliantly colored Neotropical galliform inhabiting the Yucatán Peninsula of Mexico and northern portions of Guatemala and Belize. Ocellated turkeys are the only species to share the genus *Meleagris* with the wild turkey (*Meleagris gallopavo)* of North America. The species was described by Cuvier in 1820 (Integrated Taxonomic Information System 2014); however, the cultural significance of the species dates back to the time of the Mayan civilization (Freidel et al. 1993, Sullivan 2002). Early explorers noted the bird as a food source and collectors attempted to stock European and American collections and menageries during the late 19th and early 20th centuries (Gaumer 1881, Cordier 1943). It was not until a descriptive investigation by Steadman et al. (1979) that progress was made toward explaining and understanding the ecology of ocellated turkeys in their native habitats. Few studies have been published since the seminal work by Steadman and colleagues. This paucity of investigation may be a result of challenging field-study conditions, difficulties in capturing and monitoring birds, seasonal movements of birds, limited funding opportunities, and socio-political uncertainties within the 3 countries in which ocellated turkeys are native.

The National Wild Turkey Federation (NWTF) was first to recognize the need for a study targeting the ocellated turkey, likely because of a recognition of information gaps in our collective understanding of the species. This awareness was timely as land-use changes and anthropogenic pressures on wildlife and habitat within the Yucatán

Peninsula continue to intensify (Turner et al. 2001, Porter-Bolland et al. 2007, Schmook et al. 2011). Conservation and management efforts are needed to combat the current pressures on ocellated turkeys and to reserve the downward trends in populations (Kampichler et al. 2010). Currently the ocellated turkey is recognized as a CITES Appendix III species (UNEP-WCMC 2012). Populations are pressured by habitat alteration and subsistence hunting by local communities (Escamilla et al. 2000, Kampichler et al. 2010, Santos-Fita et al. 2012). Management of the species is limited and uncoordinated, despite the documentation of populations responding positively to localized conservation efforts (Calmé et al. 2010). I believe the information included in this dissertation is timely and can reverse the trend of passive—or entirely absent—management programs. Management can provide economic benefits from ocellated turkeys to local communities in terms of a harvestable sustainable surplus or through the development of regulated eco-tourism or sport hunting industries (see Baur et al. 2012).

This dissertation contains 8 chapters. Chapter II is a species summary that draws upon the limited amount of published research on ocellated turkeys. The literature review is more extensive than what is found in most dissertations, because of the unfamiliarity of the species and to provide a context for results and conclusions presented in subsequent chapters. I authored Chapter II using the format required by The Cornell Lab of Ornithology for publication in the *Neotropical Birds* database. This ocellated turkey species account was published in 2012 (McRoberts et al. 2012) and is included herein with the permission of *Neotropical Birds* Editor, T. Schulenberg.

Chapters III–VII were generated from 4 6-month field seasons at 2 study areas in Campeche, Mexico (Figure 1.1). These chapters are written in the style required by *The*

Journal of Wildlife Management (Block et al. 2011). Each chapter is intended for publication in journals presenting information on avian ecology and wildlife management, and as such, a degree of overlap exists in describing the species and study areas. Chapter III explores field methods to research ocellated turkeys in their native environments and builds upon my experiences conducting field research in Campeche, Mexico. This chapter has tentatively been accepted for consideration in the 11th *National Wild Turkey Symposium*. Chapter IV reports the pre- and breeding season diets of male ocellated turkeys in an agriculture-forest matrix habitat. Chapter V explores the efficacy of the trap and transport management technique to reestablish or augment ocellated turkey populations on the Yucatán Peninsula. Chapter VI presents survival rate and cause-specific mortality results and Chapter VII describes ocellated turkeys home range size and displacement distance. Chapter VIII closes with considerations for future ocellated turkey management and conservation. The following chapters represent partial fulfillment of the requirements of the degree of Doctor of Philosophy in Wildlife Science for the Graduate School at Texas Tech University and I accept responsibility for any errors or misinterpretations included within this document.

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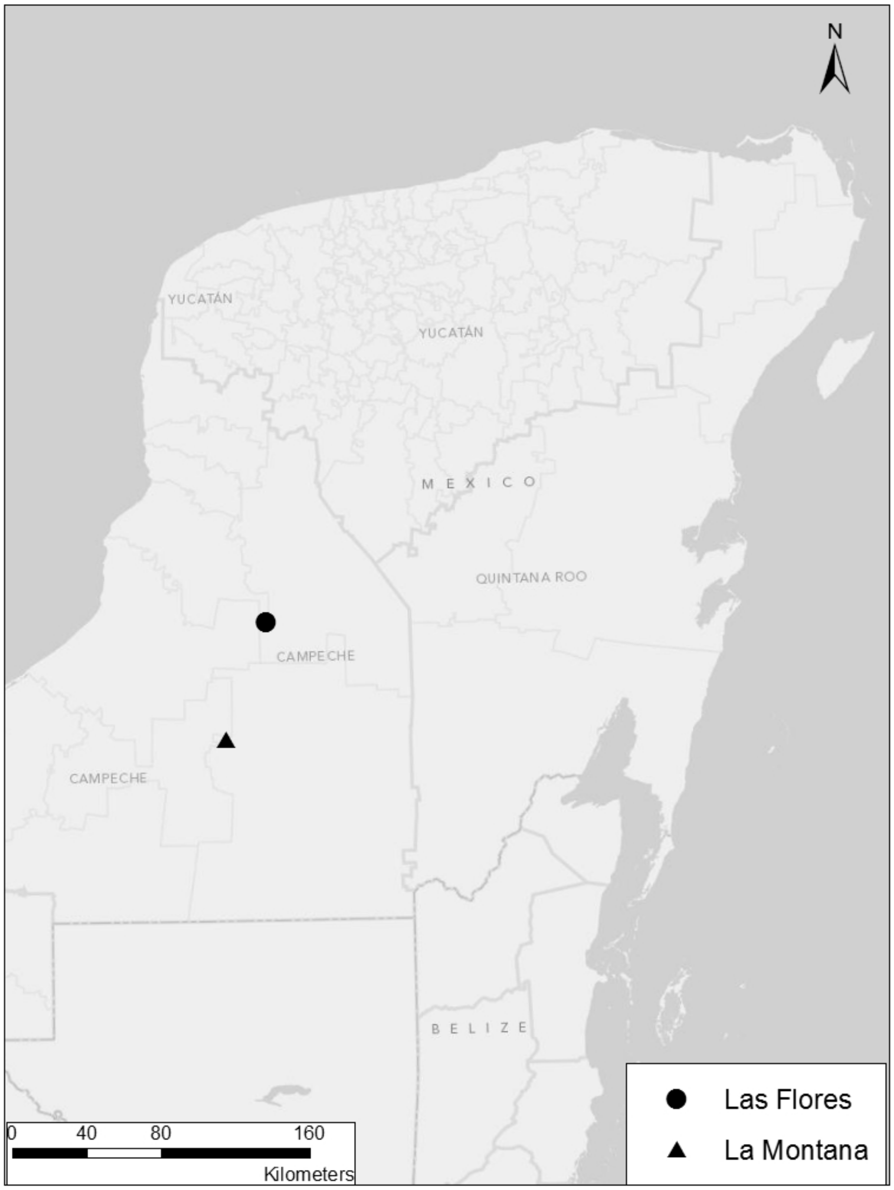

Figure 1.1. Research locations for ocellated turkey project in Campeche, Mexico, 2010–2013.

CHAPTER II

THE ECOLOGY AND NATURAL HISOTORY OF THE OCELLATED TURKEY

Species Overview

The Ocellated Turkey (*Meleagris ocellata*) is the sister species to North America's Wild Turkey (*Meleagris gallopavo*). It is a Neotropical species of high tri-national concern (Mexico–United States–Canada) to Partners in Flight (Berlanga et al. 2010), a CITES appendix III species (UNEP-WCMC 2012), and classified as near-threatened by the IUCN (BirdLife International 2011). Populations are found in the Mexican Yucatán Peninsula as well as in the Petén region of Guatemala and northern Belize. The species utilizes tropical deciduous forests, savanna, open marshland and agricultural-forest matrix environments. Ocellated Turkeys are known locally as *pavo*, *pavo ocelado*, *pavo del monte*, *pavo real*, and by the Mayan name *ucutz il chican*. Its common and scientific names are derived from the eye-spots on the tail feathers, designated as *ocellata*, from the Latin root oculus for "eye." Appearance is unmistakable with brilliantly colored plumage of green, blue, gold, black and bronze. The head is featherless, and the exposed skin is powder-blue and dotted with orange and red nodules. Reproduction takes place during spring months with males performing elaborate display rituals to attract females. Active conservation efforts have recently been conducted within the species' range in Mexico, Guatemala, and Belize. Current conservation risks include subsistence hunting pressure, often a by-product of habitat alteration and anthropogenic encroachment. Quantifiable research will be necessary to bolster conservation efforts and hone population estimates.

Identification

Summary

A large, colorful gamebird with iridescent plumage of blue, green, and bronze and a featherless powder-blue head speckled with red and orange fleshy nodules. Males possess a unique cap-like crown that enlarges during breeding season. The tarsus is deep red; the males also have long, slender spurs that may be in excess of 5 cm with a sharp tip, a feature lacking in females. Beards are absent in both sexes. Wing feathers barred black-and-white with the wing coverts a rich bronze color. Tail feathers a finely barred gray-brown-black ending with a distinctive eye-spot pattern of blue encircled by black with a gold tip. Differentiation between sexes less obvious than Wild Turkey in field conditions due to similar plumage and absence of beards. The remaining body structure is similar to that of Wild Turkey, although approximately half the size.

Similar Species

The Ocellated Turkey is closely similar to the Wild Turkey. The distributions of these two species are allopatric, but domestic Wild Turkeys are found within the range of Ocellated Turkey. Among other differences between the two species, the plumage of Ocellated Turkey is generally brighter and more blue green than the plumage of Wild Turkey; Ocellated Turkey has a blue (not red) dewlap, and lacks the beard of Wild Turkey; and rectrices of Ocellated Turkey have large, subterminal blue spots ("ocelli"), a feature not shared with Wild Turkey.

Vocalizations

The most distinct vocalization is the song of the male marking the reproductive season, often called "singing" as opposed to "gobbling" of the Wild Turkey. The distinctive song is preempted by 3-7 deep drumming sounds followed by a unique trill conducted with the head and neck in a vertical position. Leopold (1959) phonetically describes the vocalization as, "*ting-ting-ting—co-on-cot-zitl-glung*," illustrating the difficulty of describing the call in words. This vocalization is only made by males and takes place from the ground and roost trees during the breeding season. When singing, males extend head and neck straight up into the air. The singing is heard most frequently in the early morning (Gonzalez et al. 1996). Steadman et al. (1979) estimated that the singing vocalization could be heard from a distance of 500 m.

Steadman et al. (1979) identified five additional vocalizations made by Ocellated Turkeys:

Put: A short, low, nasal call, the put given by males and females used as an alarm call or to locate other turkeys. *Puts* were given at frequencies ranging from 6-30 per minute. Steadman et al. (1979) also noted that birds occasionally emitted this call once while on the roost.

Whistle: A high call of approximately 0.5 seconds given by females and yearling males. Vocalization observed frequently in forest habitats and presumably used as a locator call.

Beep: Resembling the call of the American Woodcock (*Philohela minor*); function unknown.

Hee-haw: A nasal call of two notes.

Canada goose call: A highly pitched yell that may decrease in pitch at the end of the vocalization and is similar to the call of the Canada Goose (*Branta canadensis*).

Taylor et al. (2009) reports that Ocellated Turkeys are not as vocal as Wild Turkeys and suggests that this may be a predator avoidance strategy. The majority of calling takes place from the ground. Males will also frequently sing from the roost during the reproductive season.

Nonvocal Sounds

Males rattle pinions against the ground during reproductive displays. Audible wing-flapping accompanies flight in a manner similar to many gallinaceous birds.

Detailed Description (appearance)

Feathers are of iridescent green, bronze, blue, and black. Breast feathers possess a narrow band of gold. Tail feathers have distinguishing eye-spot, leading to the species designation of *ocellata*, from the Latin root oculus for “eye.” Primary flight feathers have black and white barring; secondaries contain more white coloration; wing coverts of bronze. Distinction between the sexes is not as clear as Wild Turkey (*Meleagris gallopavo*) although female plumage is less brilliantly colored. A distinctly keeled chest is present in adult males. Most notable difference between adults and juveniles is the bronze barring of wing coverts which is narrower in juveniles than that found in adults. Some residual feathers may remain on the head of juvenile turkeys.

Bare Parts

Head and upper neck featherless of powder-blue color dotted with orange-red nodules. Nodules become a deeper red nearer to the body and are more prominent in males. A snood is present as well as a conical crown on the head of males that becomes erect during the spring reproductive season. A ring of red-colored skin surrounds the eye. The beak is of black color near the head then becoming whitish-pink; approximately 4 cm in adults. Tarsus and toes also bare and of reddish color. Spurs, a feature only present in males, are onyx, slender and sharp and may exceed 5 cm.

Measurements

The weight of an adult male is approximately 4–5 kg (Leopold 1948, Lint 1977) and an adult female is slightly smaller at 3–4 kg (Lint 1977, Gonzalez et al. 1996). Lint (1977) reports adult males are 100 cm in length and adult females are 81 cm in length. Gonzalez et al. (1996) reports an average tarsus length of 12.3 cm for females (n=8) and 15.4 cm for one male and Ridgway and Friedman (1946) report an average tarsus length of 11.3 cm for females (n=6) and 13.6 cm for males (n=8). Additionally, Ridgway and Friedman (1946) report an average tail length of 32.8 cm for males (n=8) and 26.3 cm for females (n=6) and an average wing length of 38.9 cm for males (n=8) and 34.0 for females (n=6).

Molts

The molt in juvenile birds is nearly complete at four to six months of age (Steadman et al. 1979).

Geographic Variation

No documented geographic variation.

Systematics

The species was first described as *Meleagris ocellata* by Cuvier in 1820. Chapman (1896) presented the monotypic genus *Agriocharis* and the species was recognized as *Agriocharis ocellata* until a review of the osteology, paleontology and natural history by Steadman (1980) returned the species to the genus *Meleagris*. The Ocellated Turkey has been recognized by the American Ornithologists' Union as *Meleagris ocellata* since 1998.

Distribution

The Americas

Resident populations are found in the Mexican peninsular states of Campeche, Yucatán, and Quintana Roo and are reported in Tabasco and Chiapas. Ocellated Turkeys are also found in the Petén region of Guatemala and northern Belize. The species is highly localized within its range and fine-scale distribution data are unknown. Breeding range coincides with occupied range.

Stephens (1841) reports encountering Wild Turkeys in Honduras, but as noted by Leopold (1948), native people of the region, and presumably early explorers, may indiscriminately refer to Great Curassows (*Crax rubra*) as "turkeys."

Outside the Americas

This species is not found outside of North America (Mexico) and Central America (Guatemala and Belize).

Habitat

Ocellated Turkeys are found in lowland dry-tropics characteristic of Chicle-zapote (*Achras* spp.) and Ramon (*Brosimum* spp.) forests, forest gaps and edge, open savannas, marshlands, and scrub-regrowth habitats. They also utilize agricultural areas, with levels of crop production ranging from *milpas* (local small-scale subsistence agriculture plots) to industrial production. Agricultural areas are frequently surrounded by jungle environments creating a habitat mosaic that supports large populations by providing forest cover and clearings, a functional habitat for Ocellated Turkeys (Gonzalez et al. 1996). Leopold (1948) noted the utilization of agriculture by Ocellated Turkeys and the longevity of this association dating back to the time of the Mayan people, a civilization that cleared jungle to produce crops (Pohl 1996). Steadman et al. (1979) reports Ocellated Turkeys roosting on horizontal branches of trees 5–11 m above ground; trees possessing such characteristics are necessary habitat requirements. Open areas or clearings are used by males during breeding season for displaying. Ocellated Turkeys are often most visible in the protected Mayan ruin areas such as Tikal and Calakmul where local birds have been habituated to the presence of humans and are often quite tame.

Historical changes

Ocellated Turkeys have been extirpated from portions of their historic range due to unregulated subsistence hunting, logging, and dry season burning.

Fossil history

Fossil records indicate that Ocellated Turkey was a food source of indigenous Mayan people of the Neotropics (Hamblin and Rea 1985). Additional fossil records indicate that birds were once present on Isla Cozumel, Mexico. However, this could have been the result of Ocellated Turkeys serving as a source of food and resulting trade among Mayan people (Hamblin and Rea 1985). There are no reports of domestication.

Life History

Food

General food types, food capture, and consumption are similar to Wild Turkey. Major food items appear to vary seasonally. Documented food items include the leaves of *Ambrosia artimisiifolia*, *Zebrina* spp., *Vitis* spp. *Paspalum* spp., the grass seed heads of *Paspalum conjugatum*, nuts of Arecoid palms, fruits of *Brosimum alicastrum*

(Sugihara and Heston 1981), fruits of *Solanum hirtum* (Leopold 1948), and the roots of yucca (Gaumer 1883). Invertebrates also make up a portion of the diet (Lint 1977, Sugihara and Heston 1981) and are particularly important during poult development (Lint 1977). Feeding observations from six turkeys in Tikal National Park, Guatemala in April showed that 50.7% of pecks were targeted at seeds of grasses, 30.5% at leaves, 8.1% at fruits, 7.0% at flowers, 2.4% at insects, and 1.3% at grit (Steadman et al. 1979). Grit and gravel are needed to assist with the breaking down of food matter for digestion.

Surface water can be limited in portions of occupied range and dew and fruit appear to contribute greatly to water requirements. Unconfirmed reports exist of extended movements driven by the search for water during dry months.

<u>Behavior</u>

The Ocellated Turkey is a gregarious species. Basic locomotion differs little from Wild Turkey. The species is well-capable of flight and will commonly take to wing having detected a disturbance source or predator. Flight alternates between rapid wing-beats and gliding.

The degree of wariness is variable and depends on conditioning. Steadman et al. (1979) reports birds in national parks becoming very tame, while Leopold (1948) reports their wilder counterparts will take wing when a source of disturbance is several hundred meters distant. When agitated, Ocellated Turkeys often partially fan their tail feathers and dorsally tilt the fan at a 30-45 degree angle while leaving the vicinity of the source of disturbance (J. McRoberts, personal observation).

Observations of foraging behavior indicate that Ocellated Turkeys alternate among food types during a feeding session, spending 30 seconds to one minute on an individual food type (Sugihara and Heston 1981). It has been suggested that alternating food types may dilute toxins that may be present in food sources (Sugihara and Heston 1981); however, this hypothesis has not been confirmed. Average feeding rates, measured by pecks per minute, for adult males of the same flock were found to be higher in January (11.2 pecks per minute; Sugihara and Heston 1981) than in April (4.3 pecks per minute; Steadman et al. 1979). Such a feeding pattern presumably indicates that males spend less time foraging during reproductive periods. Females are reported as feeding at a rate of 10.8 pecks per minute in April (Steadman et al. 1979). An adult male turkey was observed actively foraging in an area with ground litter and was reported to scratch for food in a 1–2–1 pattern (i.e., scratch once with one foot, scratch twice with the other foot, scratch once more with the initial foot) and then search for food present (Steadman et al. 1979).

As nighttime approaches Ocellated Turkeys will select a horizontal limb to use as a roosting location. Birds appear to fly onto the roost soon after sunset and, unless disturbed, will remain on the limb until slightly before sunrise.

Preening and dust bathing are common and anting has been documented (Sugihara and Heston 1981) for self-maintenance. To regulate body temperature Ocellated Turkeys partially lift their wings to enable circulative cooling (J. McRoberts, personal observation). Temperature is also regulated by turkeys remaining stationary, or loafing, in shaded areas during the heat of the day and conducting foraging activities during early morning or late afternoon hours.

Territoriality

Documented existence or degree of territoriality is unknown. Males will actively compete for breeding opportunities and some level of territoriality is plausible. Males fight during the breeding periods (J. McRoberts, personal observation). The average home range size for females (n=9) in Tikal National Park, Guatemala was reported as 27.6 ha (Gonzalez et al. 1998).

Sexual Behavior

The reproductive behavior of Ocellated Turkey is distinct and includes vocal and visual signals. At the onset of a reproductive event, the male crouches on the ground in a partial strut with his head in a downward position (J. McRoberts, personal observation), a behavior apparently unique to the Ocellated Turkey and done in the presence of a female. The reproductive display continues with the male shaking his tail fan side-to-side several times before fanning the tail fan, dropping both wings, laying his head onto the back and pushing his chest forward, forming a distinct keel; the strutting position of an Ocellated Turkey. Strutting males follow and attempt to intercept females and rapidly shake alternating wings while the opposite wing remained rigid (Steadman et al. 1979, Eaton 1992) with wing feather pinions rattled over the ground (Lint 1977). Throughout this display males continue to sing and the head of the male remains its characteristic blue color, as opposed to the color change seen in the head of Wild Turkeys during strutting. The fleshy nodules on the head intensify in color, the crown atop the head becomes erect, and the snood more noticeable. Competition rituals for breeding among males of the same group were reported as two males walking parallel to each other with breasts lowered and then rapid vertical flight to 2 m, followed by more parallel walking until one of the birds retreats (Steadman et al. 1979).

Social and interspecific behavior

Flock size and composition is highly variable, ranging from pairs to flocks numbering several hundred individuals (J. McRoberts, personal observation). During the winter months mixed-sex and -age flocks occur with no segregation among the population (Leopold 1948). Winter flocks break apart in mid-March (Steadman et al. 1979). At the onset of the reproductive period, males may become solitary or remain in small groups with a dominant, breeding male. Flock size will continue to decrease as females leave singly to initiate nesting.

Predation

Turkeys are susceptible on the ground, roost, and nest to a large number of potential predators. Documented predators include ocelot (*Felis pardalis*), jaguarundi (*F. yagouaroundi*) (McRoberts, unpublished data), and snake (Gonzalez et al. 1996), although a number of other potential predators exist, such as gray fox (*Urocyon cinereoargenteusi*), margay (*F. wiedii*), raccoon (*Procyon lotor*), coati (*Nasua nasua*), tayra (*Eira barbara*), and perhaps even large cats such as puma (*F. concolor*) and jaguar (*Panthera onca*) (Gonzalez 1992). Shufeldt (1913) reported the killing and consumption of an Ocellated Turkey by a large hawk (species not reported); however, this turkey was recently captured and could have been susceptible due to capture-related stress or restricted in some manner. Gonzalez et al. (1998) also reported that 5 of 9 nesting females followed through two nesting seasons lost nests to predators.

Reproduction

Singing by males begins in February (Gonzalez et al. 1996), March (Steadman et al. 1979) or April (Leopold 1948), ending in May (Leopold 1948) or June (Lint 1977). The variation of singing initiation could be geographic, as purported by published literature and reports by locals within the Ocellated Turkey's range. Copulation is reported to take place in March (Taylor et al. 2009) and April (Steadman et al. 1979) and begins with the male stepping on the back of the female with his tail at a 45 degree angle to the ground. The female elevates her tail while the male lowers his tail resulting in the meeting of the cloacae and insemination. Copulations take place most frequently in the early morning (Steadman et al. 1979). A dominant male has the capability to mate with many females and will prevent subdominant males from breeding.

Females appear to initiate nests in March–June (Gaumer 1881, Leopold 1948, Steadman et al. 1979), with the timing of nesting likely related to tropical seasonality. Nests are built on the ground and debris is adjusted to make a slight depression. Typical nesting habitat includes tall grass or brush, although nests are occasionally found at the base of trees or among the limbs of a fallen tree (Gaumer 1881, Gonzalez et al. 1998). Reports of nests being built in trees (Cabot 1842) are likely inaccurate and a result of misidentification or associating a roosting turkey with the nest of another species. Females have been documented to re-nest if the initial nest was lost (Gonzalez et al. 1998).

Clutch size ranges from 8 to 15 eggs (Leopold 1948). Gonzalez et al. (1998) located 5 nests and reported an average clutch size of 8.8 ± 2.5 eggs (SE; n=5). The incubation period is reported as 28 days (Lint 1977, Steadman et al. 1979). Hatching takes place from May to July (Steadman et al. 1979). Eggs are buff-colored with fine speckles of brown and on average weigh 47.19 g and measure 60.76 x 44.2 mm (Lint 1977).

Chicks are precocial, departing the nest after hatching and following the hen on foot. Poults are able to fly to roost after two weeks and the hen will brood the chickens under her wing during the night (Lint 1977). Reports indicate that chicks are sensitive to wet weather, becoming chilled, with the condition eventually leading to death (Lint 1977).

Populations and Demography

Males reach sexual maturity at 2-3 years (Lint 1977, Baur et al. 2012) and females are able to reproduce at one year of age (Baur et al. 2012). The expected lifespan of Ocellated Turkeys is unknown. Gonzalez et al. (1996) reported female survival rates during the April–August nesting and brood-rearing periods as 0.75 and 0.60 in 1993 (n=4) and 1994 (n=5), respectively. Gonzalez et al. (1996) tracked nine female turkeys through two breeding season and found that 8 females attempted to nest and 5 attempts were successful in hatching poults; average number of poults hatched per nest was 6.2. Gonzalez et al. (1996) found that poult survival from hatching to September was 0.13.

Conservation

Conservation status

The Ocellated Turkey is listed as a CITES Appendix III species (UNEP-WCMC 2012), near-threatened by the IUCN (BirdLife International 2011), and is a species of high concern to Partners in Flight (Berlanga et al. 2010). Based on determinations of habitat loss, Berlanga et al. (2010) estimated that 50% or more of the population has been lost in Mexico during the last century, and it is likely that similar rates of loss have occurred throughout the species' range. It has an estimated world breeding population of 20,000-49,999 mature individuals (BirdLife International 2011). In Mexico, this species is listed as Threatened (SEMARNAT 2002). Innovative research and monitoring efforts are needed to more fully understand the conservation status of the species. Populations of Ocellated Turkeys have decreased through time and realistic management strategies are needed to alleviate unregulated subsistence pressure within their range.

Several recent research efforts have extended our knowledge of Ocellated Turkey conservation. A capture and relocation project was sponsored by the Mexican government (Secretaría de Medio Ambiente y Recursos Naturales [SEMARNAT]) to re-establish extirpated populations in portions of their historic range. A breeding behavior and parasite-load study has taken place in Belize and a study of the potential to develop a community-based sport hunting industry was recently completed in Guatemala (see Baur et al. 2012).

The current conservation status of this species should be interpreted recognizing the paucity of research on population levels, especially in habitat strata inaccessible to humans. Additionally, published research is often based on observational data from birds inhabiting protected areas that are habituated to humans and may not be representative of wild counterparts.

<u>Effects of human activity on populations</u>

Subsistence hunters are likely a major source of predation to *M. ocellata* (Escamilla et al. 2000, Gonzalez et al. 1996, Baur et al. 2012). Gonzalez et al. (1996) conducted a survey of 48 subsistence hunters within 200 km of Tikal National Park, Guatemala and found that 88% of respondents hunted Ocellated Turkeys and 67% had hunted Ocellated Turkeys within the past year. Hunting generally took place in the months of March, April, and May when the male turkeys could be easily located from their singing. Twenty-five percent of respondents killed fewer than 5 turkeys per year, 25% killed 5–10 turkeys per year, 12% killed 11–20 turkeys per year, 19% killed >20 turkeys per year, and 19% did not know or remember the number of turkeys killed per year. Baur (1999) reports that subsistence hunting pressure is inversely related to employment opportunities for residents living within the Ocellated Turkey's range. Baur et al. (2012) demonstrated that regulated sport hunting managed correctly has the potential to be an effective conservation tool and can boost the economic livelihood of local communities. The increased value per turkey offered by regulated sport hunting is substantially greater than the value for food offered by a single turkey and has motivated localized protection from unauthorized subsistence hunters (Baur et al. 2012).

Anthropogenic habitat alteration impacts Ocellated Turkeys in many ways. Unsustainable logging and wood harvesting, followed by slash and burn agriculture, has the potential to directly eliminate habitat and logging roads or skid trails may increase access to Ocellated Turkey habitat and will likely result in increased subsistence hunting pressure. Small scale conversion of native habitat into agricultural lands may provide an accessible food source and boost populations. However, this will only occur if adequate protection from unauthorized over-hunting is provided, a rarity throughout much of the Ocellated Turkey's range.

Priorities for Future Research

Priorities for future research are many. Most important is the development of methods to assess population levels of Ocellated Turkeys within all habitat types that are able to detect all age and sex classes. If a reasonably accurate population size estimate is desired, monitoring techniques will need to be improved. Population survey methods will also assist with accurately determining the occupied range of the species. Investigation of population dynamics and reproductive ecology will be useful in identifying conservation strategies and goals and the quantification of subsistence hunting pressure and habitat alteration may identify management needs. Further research investigating the applicability of ecotourism, sport hunting, or other methods for placing value on the Ocellated Turkey beyond that of subsistence hunting could boost conservation successes.

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CHAPTER III

FIELD METHODS FOR RESEARCHING OCELLATED TURKEYS

Abstract

The ocellated turkey (*Meleagris ocellata*) inhabits the Yucatán Peninsula of Mexico and northern portions of Belize and Guatemala. Little information exists on the ecology and management of the species and field research methods have not been assessed. I conducted a study of ocellated turkeys in Campeche, Mexico during 2010–2013 and used my experiences, in conjunction with a review of ocellated turkey literature, to summarize field research methods. Turkey capture was complicated by the tropical environment and capture success was greatest in agricultural areas where use of a cannon net was possible. Cannon net capture was most effective at specifically known turkey flock locations; baiting contributed less to capture than expected, likely because periods of food shortage did not exist. All explosives used for capture were tightly regulated and authorized military permits were required for use. In jungle environments I used walk-in traps with a capture rate of 158.36 trap-days/turkey and a capture mortality rate of 18.18%. To monitor turkeys I used backpack style 95-g Very High Frequency (VHF) and 80-g Global Positioning System (GPS) transmitters. Field tests indicated that VHF signal range was 3.89 ± 0.62 (95% CI) km and 1.77 ± 0.23 km in agricultural/jungle matrix and jungle habitats, respectively. When using a GPS transmitter I documented a 90.7% fix-rate from an ocellated turkey hen inhabiting the agricultural/jungle matrix habitat. My combined VHF and GPS transmitter recovery rate was 63.0%. I found that radio tracking was difficult due to thick vegetation, turkey mobility, and poor access to

remote areas. Aerial telemetry was helpful when VHF transmitters were used. I believe ideal methods would include capture with a compressed air netting system and GPS tracking technologies that transmit data remotely. I do not recommend walk-in traps because of the low capture rate and high proportion of capture mortality. I hope my findings will assist in designing and conducting future ocellated turkey studies.

Introduction

The ocellated turkey (*Meleagris ocellata*) is a gallinaceous species inhabiting a variety of habitats on the Yucatán Peninsula of Mexico and northern portions of Guatemala and Belize. Despite being an important cultural totem and food source for the ancient Mayan civilization (Hamblin and Rea 1985, Sullivan 2002), being first described to the scientific community in 1820 (Integrated Taxonomic Information System 2014), and still serving as an important food source for local subsistence hunters (Gonzales et al. 1996, Escamilla et al. 2000, Baur et al. 2012, Santos-Fita et al. 2012), relatively little is known about the ecology of the species. This paucity of knowledge is in large part due to challenges imposed by the local climate and environment inhabited by ocellated turkeys (Cordier 1943, Leopold 1948), as well as behavior characteristics of the species that challenge applied research (Gaumer 1881, Lint 1977). Early naturalists attempted to capture birds for museum study collections and aviaries, but were unable to develop a successful and reliable capture method (Cordier 1943). Furthermore, when ocellated turkeys were captured, keeping birds alive for transport or housing, even briefly, was reported as a substantial challenge (Cordier 1943). As a result of the difficulties in capturing and housing ocellated turkeys, monitoring and descriptions of the species has frequently been limited to visual observations or harvested specimens (Gaumer 1881, Shufeldt 1913, Leopold 1948, Steadman et al. 1979, Sugihara and Heston 1981).

Environments inhabited by the ocellated turkey include open savannahs, lowland marshes, agricultural zones, deciduous tropical forest, and moist-tropical jungle environments (Leopold 1948, Leopold 1959, Gonzales et al. 1998) and the diversity in habitat types shape capture methods, monitoring possibilities, and likelihood of direct visual observations. Much of the occupied range of the species also falls within areas in which access is restricted to abandoned logging roads and paths, while many other areas are completely devoid of roads (McRoberts el al. 2012). Additionally, the common lowland, flood-prone areas, in conjunction with the June–September rainy season, prohibits access to many areas. The amalgam of these challenges shapes the likelihood of successful field research efforts.

My objective was to assess and summarize field methods used to research ocellated turkeys by utilizing my experience researching ocellated turkeys as well as the limited amount of published literature on the species. I hope the assimilation of field research methods will facilitate future research on wild populations of ocellated turkeys and assist with study design. The species has been extirpated in portions of its historic range (Kampichler et al. 2010) and active management efforts, grounded in sound research, will benefit ocellated turkey populations, stakeholders who depend upon ocellated turkeys in the eco-tourism or sport-hunting industries, and a low-income demographic group that utilizes ocellated turkeys as a food source (Gonzalez et al. 1998, McRoberts et al. 2012).

Study Area

I conducted ocellated turkey research at 2 sites in the Mexican State of Campeche. The first was the privately owned La Montaña Wildlife Management Area (18°40′57″ N, 90°6′19″ W), a semi-deciduous upland forest habitat characterized as a sub-humid, warm tropical climate (Porter-Bolland et al. 2006) with an undulating hills and topographic relief ranging from 283 m to 582 m. The second study area was the Las Flores Wildlife Management Area (19°13′56″ N, 89°51′58″ W) which was owned in the community-based *ejido* structure. Historically, Las Flores shared similar habitat characteristics with the La Montaña site; however, approximately 2 decades ago a Mennonite community began clearing forested areas for agricultural purposes (Porter-Bolland et al. 2007), primarily planting grain sorghum (*Sorghum spp.)*, corn (*Zea spp.)*, and soybeans (*Glycine spp.)*. Presently, the landscape is a matrix habitat with cleared crop-fields surrounded by forest and interspersed with secondary vegetation growth with topographical relief ranging from 482 m to 539 m. Surface water was seasonally limited at both sites and the few waterholes, known locally as *aguadas*, were important to local wildlife populations during dry periods.

Las Flores was located approximately 65.85 km to the north-northeast of La Montaña, and although land-use characteristics were different, general climatic patterns were similar at both sites. Regional temperatures ranged from an annual average high of 30.3 °C to an average annual low of 24.6 °C in May and January, respectively (Comisión Nacional del Agua 2014). A predictable rainy season existed from June–September (Comisión Nacional del Agua 2014) and annual rainfall for the state of Campeche in 2013 was 1697 mm with monthly participation ranging from 259 mm to 7 mm in August and March, respectively (Comisión Nacional del Agua 2014). Lowland habitats are frequently flooded during the rainy season.

Methods

I assessed and summarized ocellated turkey field research methods collected from 2 sources: 1) a 4-year study of ocellated turkey ecology and management I conducted in Campeche, Mexico from 2010–2013, and 2) the limited amount of information from past research, observations, and historic collecting expeditions. To assess field methods from published literature I conducted a key-word search using: *Meleagris ocellata*, ocellated turkey, and pavo ocelado, the Spanish name for ocellated turkey. I separated field methods from both data sources into capture and monitoring categories.

Capture

Capture methods depended on study site. At La Montaña I implemented a series of walk-in traps (n=12) to capture turkeys. My traps were approximately 2 m long by 1.5 m wide by 2 m tall. I covered the trap with flexible cloth netting typically used by local fishermen and interspersed vegetation found at the trap site to camouflage the netted trap walls. In the center of the front panel of the trap a funneled entry tunnel approximately 50 cm long and made of chicken-wire led into the interior of the trap; the diameter at the entrance was approximately 60 cm and the exit into the trap was approximately 40 cm and bare ground served as the base of the funnel. I checked traps twice daily and calculated trap-days/turkey. This method of capture was restricted to the La Montaña study site and was utilized because of the lack of forest openings that would allow the use of a larger netting system. I also calculated in-trap capture mortality rates for walk-in traps and experimented with various types of bait to attract ocellated turkeys.

To capture ocellated turkeys in the Las Flores agricultural site I was able to partner with local wildlife managers working on an ocellated turkey translocation project sponsored by Mexico's federal wildlife administration agency, the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). Through this partnership, a cannon net was used to capture turkeys, and although I am able to provide observations on the method, I was not directly responsible for capture due to permitting limitations. The net used a 3-cannon deployment system and dimensions of the net were 20 m by 20 m. Nets were placed on edge of forest and agricultural landscapes and cannons were camouflaged with surrounding vegetation.

<u>Monitoring</u>

I equipped ocellated turkeys with 95-g Very High Frequency (VHF) backpack-style radio transmitters (Advanced Telemetry Systems, Isanti, MN) and 80-g micro-Global Positioning System (GPS) backpack-style transmitters that stored locations onboard the unit (Sirtrack, Havelock North, New Zealand). Both units had an 8-hour mortality switch and I calculated the combined VHF and GPS radio recovery rate.

To determine the distance VHF radio-telemetry signals could be detected I created random coordinates within the boundaries of study areas and placed a 95-g backpack-style radio-transmitter approximately 60 cm above ground-level to represent the height of a transmitter on an ocellated turkey. I then departed the radio placement location at a randomly generated compass bearing and recorded the maximum distance I could detect the radio signal. This procedure was conducted at both study areas to contrast the difference in habitat and topography on radio monitoring efforts.

To increase the distance I could detect ocellated turkeys when monitoring VHF frequencies in forested habitats I constructed a series of listening platforms at the La Montaña study site. These platforms were approximately 3–4 m above ground. I also conducted an aerial survey flown at approximately 1600–1800 m in a Cessna 172 (Cessna Aircraft Co., Wichita, KS) to locate lost birds at the Las Flores study site.

I deployed 2 micro-GPS transmitters as a pilot study to investigate their usefulness to monitor ocellated turkeys (Guthrie et al. 2011). I programmed transmitters to collect locations twice daily at 0500 and 1700 to obtain GPS locations while turkeys were on the roost and during the afternoon feeding period. I then estimated the GPS fix-rate success in ocellated turkey habitat.

Results

The amount of published literature on ocellated turkeys is limited and I am confident the literature review on field methods included all manuscripts published in English. However, despite locating numerous manuscripts published in Spanish, I am unsure if the search was a complete census of data sources published in Spanish.

Capture

The review of literature documented 4 attempts to capture ocellated turkeys (Table 3.1). Twenty-eight ocellated turkeys were captured using: Q-nets and a drop net (n=9; method not differentiated), chemical immobilization with alpha-chloralose (n=7), leg snare (n=3), bamboo pole with noose (n=3 [on roost], n=1 [on nest]), drop net (n=2), walk-in trap (n=1), hand lasso (n=1), and hand net (n=1). The handling and housing of wild and captive ocellated turkeys was described by Cordier (1943) and Lint (1977), respectively. Both authors concurred that ocellated turkeys are a particular nervous species and highly susceptible to stress induced mortality when restrained, handled, or transported and care should be given to minimize exposure to stressors.

I captured 11 turkeys using walk-in traps at La Montaña study site with a capture effort of 158.36 trap-days/turkey. I documented an in-trap capture mortality rate of 18.18% (n=2) with 1 turkey dying after becoming entangled in the netting and 1 turkey dying of lacerations to the head. In 2010 I experimented with corn, black beans (*Phaseolus* spp.), and a local flower and fruit (*Solanum* spp.); however, corn was the only bait with which I was able to attract and capture turkeys at La Montaña. I captured most turkeys during the morning feeding period (63.63%, n=7).

Although I was not directly involved in the implementation of cannon net captures, I observed capture events netting in excess of 40 ocellated turkeys in a single deployment of the net. The cannon netting technique was successful during the morning and evening feeding periods during November–February when turkeys concentrated in large mixed-sex, mixed-age flocks. During the 3-year SEMARNAT study, 300 ocellated turkeys were captured using a cannon net (J. Sansores, Union Regional de UMAS de Campeche, unpublished data).

<u>Monitoring</u>

I estimated a maximum detection distance using 95-g VHF transmitters of 1.77 ± 0.23 km (95% CI) and 3.89 ± 0.62 km (95% CI) at the La Montaña and Las Flores sites, respectively. The difference between the 2 study areas is likely a result of differences in habitat and topography. The habitat at La Montaña was a jungle environment with variable topographic relief and both factors likely reduced the detectability of a VHF signal. In contrast, the habitat at Las Flores was an agriculture/jungle matrix with little topographic relief and more openings with less vegetation to obstruct a radio signal.

I was frequently challenged by monitoring birds because of their seasonal movements in conjunction with a lack of access to portions of the study areas. Constructing elevated listening platforms extended the range of detecting ocellated turkeys, although I did not quantify the increase in distance. I conducted an aerial survey in an area of roadless forest greater than 2,250 km^2 that was adjacent to the Las Flores study area. This method allowed us to determine the mortality status and location of 10 of 14 turkeys that would have been functionally undetectable from ground monitoring methods. The usefulness of aerial surveys to locate missing birds was also noted by previous investigators working at the La Montaña study area (T. Hughes, National Wild Turkey Federation, personal communication).

I radioed 54 ocellated turkeys (52=VHF transmitters, 2=GPS transmitters) and I was able to recover 63.0% (VHF=33, GPS=1) of transmitters. My recovery rate was likely a product of turkeys moving out of areas I was able to monitor and in latter parts of the study, failing transmitter batteries. I recovered 1 of the 2 micro-GPS units deployed on ocellated turkey hens to test the efficacy of GPS monitoring. The recovered unit collected 388 of 428 location attempts for a 90.7% fix rate.

I documented 2 additional occasions when investigators equipped ocellated turkeys with radio transmitters. Gonzalez et al. (1998) radio-marked birds (n=9) in Guatemala with a 103–130 g backpack-style VHF transmitter and Aguilar Garcia and

Calmé (2003) radio-marked birds (n=3) in Mexico with a necklace-style transmitter (weight unknown).

Discussion

Capture

Functionally, 2 types of ocellated turkeys exist that investigators may incorporate into research programs and capture methods differ greatly between groups. The first is the wild bird unaccustomed to human presence and exhibiting a high degree of wariness characteristic of ocellated turkeys (Leopold 1948); this was the focus of my research efforts in Campeche. The second is the highly visible group inhabiting protected areas such as the Calakmul and Tikal Mayan Ruin parks in Mexico and Guatemala, respectively, and numerous private nature preserves within the range of the species. Turkeys inhabiting these areas have become habituated to human presence and a greater variety of capture possibilities exist because of the approachability and lack of wariness, a result of protection and no subsistence hunting pressure (McRoberts et al. 2012). The focus of my discussion emphasizes the capture, monitoring, and research of wild ocellated turkeys, although some useful information can be gained from studying birds habituated to human presence.

Despite minor successes with walk-in traps, I only recommend using this capture method as a last resort. Capture mortality of 18.18% is, in my opinion, too high. I attempted to mitigate capture-related mortality by checking traps after the morning feeding period and again at dusk. Minimizing time in the trap likely reduced stress on turkeys and associated mortality. I suggest ensuring that the netting used for trap walls is tight to ensure that birds cannot be entangled when inside the trap, a cause of mortality I documented during fieldwork in Campeche. I also recommend making the entrance tunnel out of a sturdy, heave gauge wire covered with the same netting material as trap walls. I believe the turkey that died from a head laceration was injured on a trap entrance that was made of chicken-wire mesh, and in an attempt to free itself, entangled its head in the chicken-wire.

I observed that trap location influences likelihood of capture. I constructed 11 walk-in traps along abandoned logging roads, paths, or within small forest clearings. By chance, at the La Montaña site a 1 km by 0.5 km patch of forest was encompassed by a 2 m tall high-fence. I constructed walk-in traps along the fence and observed it serving as a drift-fence into the trap; 36.36% (n=4) of turkeys were captured at 2 trap locations along the drift fence. Researchers should consider constructing drift fences if walk-in traps are used, a practiced used to capture numerous avian species (Schemnitz 2005).

Walk-in traps are not species specific and on 2 occasions I captured great curassow (*Crax rubra*). Although both birds were released unharmed, unintended captures should be considered by the investigator, especially if local regulations prohibit disturbance to non-target species. I was also frequently hindered by groups of coatimundi (*Nasua narica*) and collared peccary (*Tayassu tajacu*) consuming bait used for capturing turkeys soon after I baited traps; researchers should expect to re-bait trap sites twice daily. I also observed traps destroyed by collared peccaries and investigators should plan on damage to traps from non-target wildlife species and budget accordingly.

Capture of ocellated turkeys with a cannon net has been the most successful capture method to date; however, this method can only be used in limited circumstances.

The most limiting factor would be the necessary permits and administrative permissions to use an explosively-propelled net in Mexico. In all likelihood, I would not have been able to obtain such permission had I attempted to on my own; only by joining in with the SEMARNAT study was I able to radio-tag ocellated turkeys captured with a cannon net. Another limitation is the necessary space to deploy the net. The forested habitat at the La Montaña study site, and throughout much of the ocellated turkey range, would greatly limit the usefulness of the cannon net; however, in open agriculture habitat like Las Flores the capture method is ideal. Furthermore, when selecting a specific capture site at Las Flores, it was most helpful to pattern flocks and intercept them between roost sites and feeding or loafing areas, not simply rely on bait because of the surplus waste-grain in the crop fields. Turkeys were often captured in areas that had not been baited.

Prior studies reported capturing ocellated turkeys with a drop-net (Gonzales et al. 1998, Aguilar Garcia and Calmé 2003, Hanlon 2013; Table 3.1) and success appears marginal. I have observed wild ocellated turkeys approach a drop net, suspiciously attuned to the overhead trap structure, and ultimately refuse to pass beneath the net. Past use of this method was likely possible because of the capture sites and level of habituation to anthropogenic disturbance by turkeys. Gonzales et al. (1998) captured birds near the Mayan ruins of Tikal and Aguilar Garcia and Calmé (2003) captured birds within the Calakmul Biosphere Reserve, and although specific capture locations within Tikal and Calakmul are unknown, varying levels of habituation have been eluded to at both study areas (Gonzalez et al. 1996, Aguilar Garcia and Calmé 2003). Additionally, I have observed ocellated turkeys taking food from the hands of tourists in the Calakmul Mayan Ruins parking area, challenging vehicles on roads within the reserve, and male ocellated turkeys displaying aggressive behavior toward humans during the breeding season (J. McRoberts, personal observation). The ability to capture an ocellated turkey with a lasso (Aguilar Garcia and Calmé 2003) and hand net (Hanlon 2013) is also likely restricted to turkeys habituated to human presence and repeating the technique wild ocellated turkeys would be nearly impossible.

Hanlon (2013) reported using corn mixed with alpha-chloralose to chemically immobilize ocellated turkeys for capture. It appears this method has merit and has been successfully used for decades to sedate wild turkeys (Bergman et al. 2007). If this method is utilized, care must be given to actively monitoring baits containing alpha-chloralose to facilitate capture and to minimize non-target consumption. Predatory species are numerous within the range of the ocellated turkey and would pose a mortality risk to immobilized wildlife.

Cordier (1943) used a noose attached to a bamboo pole to capture wild ocellated turkeys on the roost (n=2) and nest (n=1), but also reported that the success rate for this capture technique low with many failed attempts. A leg snare was used to capture ocellated turkeys (n=3) by Cordier (1943; turkey recovered dead in snare), Aguilar Garcia and Calmé (2003), and Hanlon (2013). This capture method could be applicable if turkeys were in predictable locations (e.g., feeding paths, display grounds, corridors between natural obstructions), but Aguilar Garcia and Calmé (2003) reported that this capture technique could induce more trauma on ocellated turkeys than other methods.

I was only successful at capturing turkeys in walk-in traps baited with corn. Corn was also the preferred attractant when drawing birds to bait sites for cannon net capture. However, I observed turkeys would frequently pass baited areas with no interest in feeding and believe this was due to the abundance of natural food items throughout the year. Wild turkey are often captured during times of food scarcity (i.e., winter months), and I did not observe periods when food was not abundant during my research in Campeche.

Regardless of capture method, I recommend minimizing handling time of ocellated turkeys. Previous researchers have noted that the species is particularly delicate (Lint 1977) and susceptible to stress-related mortality (Cordier 1943). When I captured ocellated turkeys in walk-in traps I typically radioed and release birds captured in the morning (n=7) while birds captured in the evening (n=2) were placed in cardboard turkey boxes overnight and released early the following morning. I did not observe capture-related mortality from keeping birds in a box overnight to decrease the likelihood of a post-release predation although my sample size was small.

Monitoring

Monitoring ocellated turkeys in their native range is challenged by the physical environment, climate, inaccessible habitat, and the seasonal movements of the birds. I radioed 54 ocellated turkeys and equipped 52 of those with radios transmitting VHF signals. From my experiences in Campeche, I do not recommend using VHF radios and believe the use of modern GPS technology can minimize several of the problems associated with monitoring ocellated turkeys with VHF methods. However, if GPS radio units are not available, several actions are possible to extend VHF signal detection distances.

An initial step is to locate or construct elevated listening locations to increase the distance a VHF signal can be detected. I accomplished this by constructing platforms throughout my monitoring area and Gonzalez et al. (1996) monitored for ocellated turkeys from the elevated platforms offered from the Mayan ruins at Tikal. The greatest elevation may be obtained through aerial surveys, a method I used in 2011 to locate ocellated turkeys that had traveled beyond the area I could logistically monitor, with 3 turkeys traveling >20 km into inaccessible jungle habitats. If VHF radios are used to monitor turkeys, investigators should expect the need for aerial surveys to locate missing birds. I found it surprisingly difficult to locate an airplane in the region that had struts to which I could attach monitoring antennas and I recommend that future researchers make aerial monitoring arrangements early. In addition to elevated platforms and aerial surveys, I used night-time telemetry to locate turkeys while on the roost, thus increasing the distance I could detect signals.

Investigators should select study areas where movement between listening points is possible to enable radio signal triangulation. Roads or trails are needed so researchers can effectively move between monitoring stations to create location estimates. However, it is also important to realize that roads and trails facilitate subsistence hunting pressure (Baur et al. 2012) and a balance between both factors should be considered. In addition to signal triangulation, I experimented with homing toward radio-marked birds for direct visual observations. I was never able to approach near enough for observation without first being detected by the turkey; visibility in much of the forested habitat is limited to several meters and a quiet, undetected approach is a great challenge.

Given the movement patterns of ocellated turkeys and habitats occupied by the species, a more practical approach to monitoring would use satellite-based monitoring units. I recovered 1 of the 2 micro-GPS units deployed on ocellated turkey hens to test the efficacy of GPS monitoring and the recovered unit collected 388 of 428 location attempts for a 90.7% fix rate. Guthrie et al. (2011) reported a fix rate of 94.5% for 6 male Rio Grande wild turkeys (*M. g. intermedia*) in south Texas and a 96% fix rate for 2 female Rio Grande wild turkeys in the Texas Panhandle. It is likely that the ocellated turkey fix rate estimate was lower because the hen spent much of her time under a closed canopy forest. My pooled VHF and GPS transmitter recovery rate was 63.0% and costs associated with an inability to recover store-onboard locations could be offset with fewer units transmitting locations remotely.

Regardless of monitoring units, investigators should consider radio unit weight and style. Gonzalez et al. (1998) used backpack-style units (n=9) and I used the same attachment style (n=54). Aguilar Garcia and Calmé (2003) equipped ocellated turkeys (n=3) with necklace style transmitters. I did not have any turkeys lose the backpack-style units; Aguilar Garcia and Calmé (2003) reported that 1 of the turkeys they radioed lost its radio unit. Additionally, I elected not to radio 8 juvenile turkeys (6=female, 2=male) with my 95-g VHF transmitters captured in January. Average weight of the non-radioed birds was 2.58 kg and I felt the weight of the transmitter and the radio-marking process would cause undue stress on the young birds.

Management Implications

Ocellated turkey field research is in a developmental stage and should be continued by implementing and adapting recommendations and findings included in this manuscript. I recommend experimenting with new capture methods such as compressed air netting systems or tension-propelled systems such as a “whoosh net,” although such a net would need to be modified to capture a bird the size of an ocellated turkey. If direct involvement with federal and state wildlife organizations is possible using a cannon net is an effective method to capture turkeys; however, adequate permitting and local collaboration is essential.

A reliable, cost effective monitoring method is needed for local wildlife managers to integrate into conservation practices. The advantages offered by GPS technologies alleviate the monitoring challenges of access and turkey movement patterns that are present when using VHF transmitters. Further experimentation with passive monitoring methods is also warranted. Call surveys during the reproductive season, when male ocellated turkeys make their equivalent of a gobble, have been attempted in the past (Steadman et al. 1979), but the efficacy in monitoring for ocellated turkey presence or populations trends remains unknown. Additional investigation and refinement of ocellated turkey field methods will help managers identify occupied range, demographic parameters, population status, 3 necessities in ocellated turkey conservation that are currently unknown.

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Table 3.1. Summary of ocellated turkey capture methods.

Capture Method	Number Captured	Location	Year	Purpose	Source
Leg snare[1]	1	Yaxha, Guatemala	1937	Collection	Cordier 1943
Noose[2] (roost)	3	Yaxha, Guatemala	1937	Collection	Cordier 1943
Noose (nest)	1	Juntecholol, Guatemala	1937	Collection	Cordier 1943
Q-net and drop net	9	Tikal N. P., Guatemala	1993–95	Research	Gonzalez et al. 1996
Lasso	1	Calakmul Biosphere Reserve, Mexico	2002	Research	Aguilar Garcia and Calmé 2003
Drop net	1	Calakmul Biosphere Reserve, Mexico	2002	Research	Aguilar Garcia and Calmé 2003
Leg snare	1	Calakmul Biosphere Reserve, Mexico	2002	Research	Aguilar Garcia and Calmé 2003
Walk-in trap	1	Belize	2012	Research	Hanlon 2013
Hand net	1	Belize	2012	Research	Hanlon 2013
Leg snare	1	Belize	2012	Research	Hanlon 2013
Drop net	1	Belize	2012	Research	Hanlon 2013

Table 3.1. Continued.

Capture Method	Number Captured	Location	Year	Purpose	Source
Alpha-chloralose	7	Belize	2012	Research	Hanlon 2013
Walk-in trap[3]	11	Campeche, Mexico	2009–12	Research	McRoberts 2014
Cannon net	300	Campeche, Mexico	2009–12	Research & Management	McRoberts 2014

[1] Turkey died in snare before recovered.

[2] 1 bird died within 24 h of capture, another died from stress in captivity.

[3] 2 birds died from capture-related injuries.

CHAPTER IV

OCELLATED TURKEY DIETS AND FEEDING ECOLOGY IN AN AGRICULTURAL LANDSCAPE OF CAMPECHE, MEXICO

Abstract

The ocellated turkey (*Meleagris ocellata*) is a gallinaceous bird species endemic to the Yucatán Peninsula of Mexico and northern portions of Guatemala and Belize. Most previous research on ocellated turkeys has been anecdotal or descriptive and sound ecological data are necessary to direct conservation and management decisions. To address this need, I collected the upper digestive tracts of primarily adult male ocellated turkeys in an agricultural region of Campeche, Mexico during February–May, 2013. I identified food items consumed by ocellated turkeys and dry weight and occurrence frequency of food item classifications. I also assessed daily temporal trends in feeding. My results indicated that seeds contributed most to diets and that grain sorghum (*Sorghum spp*.), corn (*Zea spp.*), and soybeans (*Glycine spp.*) were the most consumed plant species by ocellated turkeys during the study period. No temporal patterns existed to explain daily feeding in adult male turkeys, likely because the breeding season coincided with the sampling period and males were occupied with breeding behaviors. Results indicated that ocellated turkeys fed heavily on anthropogenic food sources planted in agricultural areas and these habitats should be considered when developing management plans and when identifying lands for applied conservation strategies.

Introduction

Little is known about the ecology of ocellated turkeys (*Meleagris ocellata*) in their native range of Mexico's Yucatán Peninsula and northern portions of Guatemala and Belize. During recent decades ocellated turkey populations have declined due to unregulated subsistence hunting and habitat alteration (Gonzalez et al. 1996, Calmé and Sanvicente 2000, Santos-Fita et al. 2012); to address this decline an understanding of species life history traits is needed to facilitate active management and reverse localized population reductions (McRoberts et al. 2012). A component of ocellated turkey life history that could shape conservation efforts is feeding habits. A limited number of observations on ocellated turkey diets have been reported (Leopold 1948, Steadman et al. 1979, Sugihara and Heston 1981) and a formal study of ocellated turkey diets in a subtropical forested environment was conducted in the *Flores* region of Guatemala (Baur 2008). However, no analysis has documented the food habits of ocellated turkeys in an agricultural landscape. Forested regions within the range of ocellated turkeys are being converted to agricultural lands (Turner et al. 2001) which can become important areas to target for conservation efforts. Furthermore, evidence has shown that with proper management of agricultural lands ocellated turkey populations can flourish (Calmé et al. 2010), and the agriculture-forest matrix may be prime habitat to target for management where the needs of local people and wildlife can be addressed simultaneously.

Food habit studies are not new to turkey management and during the wild turkey (*Meleagris gallopavo*) restoration efforts of the 20th century the understanding and study of turkey diets impacted management strategies among the five sub-species of wild turkeys (Hurst 1992). My objectives in this study were to document and quantify items consumed by ocellated turkeys in an agriculture-forest matrix, to assess the importance of anthropogenic food sources (i.e., agricultural crops), and to examine daily temporal patterns in ocellated turkey feeding during the February–May study period. I undertook this study as part of a larger study to describe various aspects of ocellated turkey ecology and conservation (McRoberts et al. 2014) and hope a greater understanding of ocellated turkey diets, in tandem with other findings, will offer management alternatives throughout the range of the species.

Study Area

I collected ocellated turkey diet samples in the Carlos Cano Cruz and Las Flores Management Units for Conservation and Sustainable Use of Wildlife (UMAs; known from the Spanish language translation) in the state of Campeche on the western side of Mexico's Yucatán Peninsula. Historically, the region was dominated by undisturbed tropical-deciduous forests (Turner et al. 2001). However, substantial land-use changes have occurred at both study sites in recent decades (Turner et al. 2001, Porter-Bolland et al. 2007). During my study, Carlos Cano Cruz and Las Flores were characterized by large crop fields surrounded by forested areas and secondary regrowth. Cultivation of cereal grains, legumes, fruits and vegetables, and a limited amount of cattle and grazing were present at both study areas. Surface water was limited to cattle stock tanks and the few waterholes, known locally as *aguadas*, which were characteristic of the karst geology of the Yucatán Peninsula. The climate was classified as sub-humid, tropic and a predictable wet season existed between June–September during which the majority of the ≈1,600 mm annual precipitation was received (Comisión Nacional del Agua 2014). April and May are the hottest and driest months in Campeche with temperatures of 37 °C (Comisión Nacional del Agua 2014). Topography was generally flat with elevations ranging from 482 m to 539 m within the study areas.

Land ownership at Carlos Cano Cruz and Las Flores was structured in the community-based *Ejido* system (see Valdez et al. 2006) with a combination of private and communal lands. Additionally, during the past 15 years, active management programs for ocellated turkeys have been in place at Carlos Cano Cruz (Calmé et al. 2010) and Las Flores (J. Sansores, Union Regional de UMAS de Campeche, personal communication) and turkey populations have flourished as a result of reduced subsistence hunting pressure and strategic harvest. A limited amount of sport hunting for male ocellated turkeys currently occurs at both sites.

Methods

I obtained the upper digestive tracts (UDTs; oesophagus, crop, and upper-proventriculus) of ocellated turkeys from sport-hunted birds taken in Carlos Cano Cruz and Las Flores during February–May, 2013. All turkeys were harvested legally with appropriate permits and tags issued to hunting organizers operating in Carlos Cano Cruz and Las Flores by Mexico's wildlife authority, the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). Turkeys were harvested during morning or late afternoon and upon harvest I removed the contents of the UDTs as soon as logistically possible. I then preserved contents in 70% ethyl alcohol to prevent postmortem digestion (Swanson and Bartonek 1970) and I limited my analyses to UDT contents to avoid the biases of varied rates of food item digestion, and thus identifiability, once the item reached the gizzard (Swanson and Bartonek 1970). I transported preserved samples to laboratory space at El Colegio de la Frontera Sur (ECOSUR) in the city of Campeche until samples could be further processed.

In the laboratory, I emptied contents of each UDT into a petri-dish and allowed contents to dry for 48–72 hr. I then removed all grit from samples and identified and separated food items to genus or species level for plant materials and to order or class level for animal materials. I weighed each unique food item to the nearest gram and classified items as bulbs, flowers, fruits, leaves, seeds, stems, animal matter, or unclassified. I reported aggregate percentage of dry weight for each classification and frequency of occurrence of food item classifications in UDTs. I used a chi-square test to contrast the food item classifications from my study to those reported by Baur (2008) in his analysis of ocellated turkey diets from a sub-humid tropical forest environment.

Lastly, I used a site-specific solar calculator (NOAA 2014) to determine the number of minutes turkeys were harvested before or after sunrise and sunset; with these data I calculated Pearson's correlation coefficients to determine if a temporal relationship existed with daily feeding periods represented by weight of UDT contents.

Results

I collected UDTs from 64 (males=61, females=3) ocellated turkeys between 18 February and 10 May, 2013. The UDTs of 5 turkeys were empty and excluded from aggregate weight and frequency of occurrence calculations, but I included the empty UDTs for temporal feeding pattern analysis. Average dry mass of food contents for individual birds was 39.50 g ± 8.50 g (95% CI) and maximum weight of food contents within a UDT was 104.0 g. I identified 22 plants (Table 4.1) consumed by ocellated turkeys and grain sorghum (*Sorghum spp*.), corn (*Zea spp*.), and soybeans (*Glycine spp.*) contributed most to aggregate dry weight with 52.48%, 29.93%, and 9.86% of weight, respectively (Table 4.1). I documented that dry weight of food contents was 79.15% seeds, 7.88% flowers, 5.80% leaves, 4.13% fruits, and the sum of bulbs, stems, animal matter, and unclassified plant items consisted of 3.03% (Table 4.2). I documented 9 species of invertebrates in the UDTs of ocellated turkeys. However, the 9 invertebrates represented only 20.53% of animal matter dry mass, with the remaining 79.47% unidentified. The ability to identify animal matter was hindered by breakdown and nondescript body parts of invertebrates in UDTs.

I found the most frequently occurring food items in UDTs were seeds, leaves, and flowers observed in 81.82%, 54.55%, and 50.00% of samples, respectively (Table 4.2). I documented animal matter in 30.30% of UDTs, and fruits and stems in 21.21% and 19.70% of UDTs, respectively (Table 4.2). I found no difference in diet classification percentages between my results from an agricultural environment and those collected by

Baur (2008) in a sub-humid tropical forest environment ($\chi^2 = 12.59$, $P = 0.999$; Figure 4.1).

I collected time-at-harvest data for 51 ocellated turkeys; 38 harvested in the morning and 13 harvested in the afternoon. I found that a slightly positive relationship existed between time after sunrise and dry weight of UDT contents ($r = 0.301$, $P = 0.066$) and no relationship existed between time before sunset and UDT contents dry weight ($r = 0.274$, $P = 0.362$).

Discussion

The analysis of ocellated turkey diets conducted by Baur (2008) in the Maya Biosphere Reserve of northern Guatemala, an environment dominated by subtropical-moist forests, used the UDTs of 181 ocellated turkeys obtained from subsistence hunters. Contents were dried, classified, and weighed and Baur (2008) reported dry-mass diet composition for ocellated turkeys as: 51.4% seeds, 22.2% grit, 12.1% animal matter, 7.0% pulp, 6.5% leaf, and 0.8% flower/stem. With grit and snail contents removed, percent-classifications were comparable to my results and adjusted to: 77.4% seeds, 10.5% pulp, 9.8% leaf, 1.2% flower/stem, and 1.1% animal matter (Figure 4.1). I observed no difference in ocellated turkey diet composition between agricultural and forested habitats, indicating that adult ocellated turkeys are primarily granivores regardless of habitat. However, despite similarities between my study and the diet composition described by Baur (2008), it should be noted that plant species diet composition is likely very different between studies. With the exception of identifying the fruits of ramon tree (*Brosimum alicastrum*) and *Psuedolmedia* spp., specific food types consumed were not documented, thus limiting comparability of food species between studies.

Several additional studies reported food items consumed by ocellated turkeys, although no quantifications of diet were included. Gaumer (1881) reported ocellated turkeys feeding on the fruits the zapote tree (*Manilkara zapota*) and Leopold (1959) reported ocellated turkeys feeding on the corollas of squash blossoms (species not identified), the fruits of nightshades (*Solanum hirtum*) and the berries of the cohune palm (*Orbignya cohune*). In Guatemala's Tikal National Park, Steadman et al. (1979) reported that breeding season diets included the fruit of *Brosimum* spp., *Ficus* spp., and *Chamaedores* spp., the leaves of *Adiantum* spp., and a caterpillar and dipteran. At the same site during winter, Sugihara and Heston (1981) reported ocellated turkeys consuming the leaves of common ragweed (*Ambrosia artimisiifolia*), *Zebrina* spp., *Vitis* spp., and *Paspalum* spp.; seed heads of *Paspalum conjugaum*; nuts of Arecoid palms; the fruit and seeds of the ramon tree; and insects including leaf-cutter ants (*Atta cephalotes*), moths, and beetles. Items identified in previous studies that I detected include the genera *Brosimum*, *Solanum*, and *Ficus.* Possible differences explaining the incongruence in food items could be seasonal climatic patterns that impact vegetation availability, land-use differences, or biological range of food items. The range of the ocellated turkey has been identified as a biodiversity hotspot (Turner et al. 2001) and the species is a generalists in feeding habits (Lint 1977, Sugihara and Heston 1981); the combination of these two factors suggest dietary variation among populations and habitats.

Animal matter appeared in 30.30% of UDTs, but was only 1.12% of dry mass. Furthermore, some animal matter (i.e., invertebrates) was so small that the food item was likely incidentally consumed by ocellated turkeys while feeding on other items, thus inflating their frequency of occurrence in UDTs. Sugihara and Heston (1981) described ocellated turkey diets during 14–25 January in Guatemala and concluded that insects were a minor component of the diet, and Baur (2008) found that animal matter contributed 1.1% to dry mass of ocellated turkey diets. All results indicate that invertebrates make up a small portion of ocellated turkey diets. However, it is important to consider that samples from my study and Baur (2008) were obtained from sport hunting and subsistence hunting, respectively. As such, adult birds were targeted and young birds appeared less often in analyses. If future researchers include poult diets in analyses the importance of animal material will likely change. Lint (1977) reported that captive ocellated turkey poults at the San Diego Zoo required insects for the first four weeks of their lives and that each poult will consume 6–7 insects 3–4 times per day. At week-5 Lint (1977) reported that poults changed from their insect-based diet to alternative food sources (in this case, commercial trout chow, boiled egg yolks, and tender green forage); by week-6 poults began eating fresh ears of corn and switched to a herbivorous diet.

The seasonality of my sampling period could also explain the low quantity of animal matter in ocellated turkey diets. I sampled during the hottest and driest months in Campeche when invertebrate life was reduced. Ocellated turkeys hatch between May–July (Steadman et al. 1979). At Las Flores and Carlos Cano Cruz nests most frequently hatched in early June (A. Sanchez, Carlos Cano Cruz, personal communication), which coincides with the onset of the rainy season and an emergence of insect life for turkey poults. Had I sampled during that time period, and extended the study to include turkey poults, I would likely have seen more animal matter in diets of ocellated turkeys. Another factor that may have influenced my results was the elapsed time between harvest and preservation of the UDTs. I attempted to preserve samples as quickly as possible, but slight delays in UDT preservation could have negatively biased the frequency and abundance of invertebrates from the analysis since soft-bodied organisms can quickly be difficult to identify after the digestive process has begun (Dillery 1965, Mills et al. 2008).

Steadman et al. (1979) reported that feeding took place between 0600–1000 and 1400–1800 during their early-April observation period. I observed a similar pattern at Las Flores and Carlos Cano Cruz except I typically did not observe afternoon feedings until after 1600. I did not observe a strong temporal correlation in feeding by adult male ocellated turkeys during the February–May sampling period. This observation is likely explained by a preoccupation with courtship displays and breeding opportunities by male turkeys. Sugihara and Heston (1981) and Steadman et al. (1979) reported pecks-per-minute of male ocellated turkeys during feeding in Tikal National Park, Guatemala and documented more pecks in January (11.2 pecks-per-minute; Sugihara and Heston 1981) than in April (4.3 pecks-per-minute; Steadman et al. 1979). This behavior also suggests that males are more attuned to breeding, rather than feeding, during spring. A similar behavioral pattern exists in wild turkeys; males reduce feeding and used energy stored in the fatty breast-sponge during the breeding season (Williams 1981). Male ocellated turkeys also possess a breast sponge at the onset of the breeding season (Gonzalez et al. 1996) and are physiologically prepared to reduce feeding during the breeding season.

Past studies have reported food habits of ocellated turkeys in forested environments, yet this study is the most comprehensive analysis of ocellated turkey diets in an agricultural habitat and agricultural lands offer applicable management opportunities. Ocellated turkeys have often been assumed to be a forest obligate; however, no empirical evidence supports that assumption. Small-scale swidden agricultural practices have been implemented on the Yucatán Peninsula for thousands of years and the ancient Mayan civilization cultivated a variety of crops and utilized a well-developed canal system to irrigate croplands or drain wetlands (Pohl et al. 1996, Fedick and Ford 1990). Therefore, ocellated turkeys have had millennia to adapt to habitats containing agricultural fields. Additionally, although it is food availability that likely attracted ocellated turkeys to agricultural areas, the openness and visibility associated with agricultural fields may also be desirable because of the ability to detect predators while feeding. Several documented predators of ocellated turkeys, including pumas (*Puma concolor*; Aranda and Sánchez-Cordero 1996), ocelots (*Leopardus pardalis*; McRoberts 2014) and jaguarundis (*Puma yagouroundi*; McRoberts 2014), are ambush predators and the open agricultural lands provide a safe place for ocellated turkeys to feed. Conversely, a problem frequently associated with agricultural lands is subsistence hunting and simply having agricultural food sources on the landscape is not sufficient to sustain ocellated turkey populations. Management plans should be in place to mitigate subsistence hunting pressures (Calmé et al. 2010, Baur et al. 2012) which can result in ocellated turkey population growth.

Management Implications

Findings suggest that agriculture can be used to assist with ocellated turkey conservation and management activities. With 92.27% of food items from anthropogenic sources, crops could be planted to attract birds to specific areas for capture or monitoring, or could be used as a predictable and reliable food source during ocellated turkey reintroductions. Ocellated turkeys take advantage of foods in agricultural lands and such environments would offer accessible lands for conservation programs and monitoring.

Additional analyses are needed to compare diets among seasons and between sexes, a common practice in food habit studies (see Wallace et al. 2012). Permitting and logistical limitations prevented me from including females and younger age classes to my analyses and I was only able to assess the pre-breeding and breeding periods with results biased heavily toward adult male turkeys. Furthermore, some food items may have been seasonally unavailable and I would expect a greater diversity of food items if sampling of UDTs had been conducted throughout the year. Incorporating an extended sampling period and including all age classes and sexes would result in a more complete understanding of ocellated turkey food habits.

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Table 4.1. Plant material identified in the upper digestive tracts of ocellated turkeys in Campeche, Mexico, February–May, 2013.

Food Item	Parts Consumed[1]	Percent Dry Weight
Argemone Mexicana (Mexican poppy)	L	0.04%
Bidens pilosa (Beggar-ticks)	F, S	0.16%
Boerhavia erecta (Erect spiderling)	F, S	0.20%
Brosimum alicastrum (Ramon)	S	trace
Bursera spp.	S	trace
Chamaesyce spp.	F, Fr, L, St	0.13%
Commelina spp.	L	0.10%
Cordia spp.	Fr, L, St	1.36%
Digitaria ciliaris (Southern crabgrass)	F, L, S, St	0.53%
Ficus spp.	Fr	0.59%
Gibasis geniculata (Bridal veil)	L	0.10%
Glycine max (Soybean)	F, Fr, L, S	9.86%
Ipomoea spp.	F, L	0.83%
Leucaena spp.	L	0.02%
Lophiaris spp.	B	0.86%
Passiflora foetida (Wild maracuja)	F, Fr	1.23%
Physalis spp.	Fr	0.86%
Serjania spp.	F	0.01%

Table 4.1. Continued.

Food Item	Parts Consumed[1]	Percent Dry Weight
Solanum erianthum (Nightshade)	F, Fr	0.13%
Sorghum bicolor (Grain sorghum)	L, S, St	52.48%
Tridax procumbens (Tridax daisy)	F, L,	0.58%
Zea mays (Maize)	L, S	29.93%

[1]B=bulb, F=flower, Fr=fruit, L=leaf, S=seed, St=stem

Table 4.2. Summary of food item classification percent dry weight and percent occurrence in the upper digestive tracts of ocellated turkeys in Campeche, Mexico, February–May, 2013.

Food Class	Percent Dry Weight	Percent Occurrence
Bulbs	0.77%	1.52%
Flowers	7.88%	50.00%
Fruits	4.13%	21.21%
Leaves	5.80%	54.55%
Seeds	79.15%	81.82%
Stems	0.95%	19.70%
Animal Matter	1.12%	30.30%
Unclassified	0.19%	6.06%

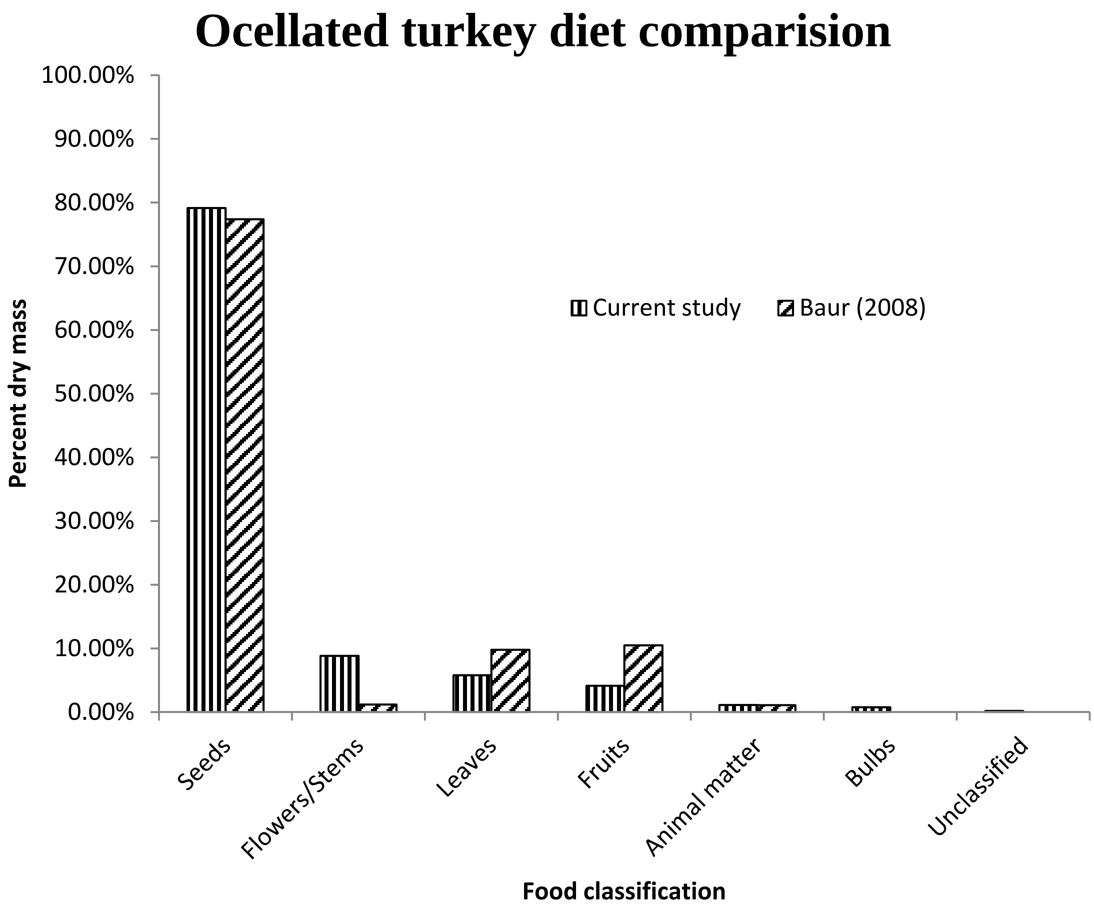

Figure 4.1. Dry mass comparison of the diets of ocellated turkeys (*Meleagris ocellata*) inhabiting agricultural (*n*=64; current study) and forested (*n*=181; Baur 2008) habitats.

CHAPTER V

LESSONS FROM AN OCELLATED TURKEY TRAP AND TRANSFER EVENT IN CAMPECHE, MEXICO

Abstract

Ocellated turkeys (*Meleagris ocellata*) are a large gallinaceous species endemic to the Yucatán Peninsula of Mexico and northern regions of Guatemala and Belize. The occupied range of the species has been reduced from historic levels due to habitat alteration and unregulated subsistence hunting, and active management programs are needed to reverse declining population trends. The trapping and transfer of wild turkeys (*Meleagris gallopavo*) reestablished the species throughout its range and is recognized as one of the great successes in wildlife management. I have investigated the applicability of trap and transfer methods for ocellated turkey conservation by trapping and radio-marking 18 turkeys that were transferred to another site within Campeche, Mexico. I monitored the fate of released ocellated turkeys and found that the survival rate of translocated birds was 0.186 (SE = 0.168) during the 162-day monitoring period, that mortalities occurred near the release site (769.1 m; SE=325.04 m), and that mortalities were due to small carnivores and subsistence hunters. To increase the likelihood of successful trap and transfers efforts, wildlife managers should release birds in habitats that share similar characteristics of the capture location, minimize time spent handling and transporting ocellated turkeys, and monitor the fate of released birds so translocation method can be continually refined to increase management opportunities and successes.

Introduction

The trapping and transfer of wild turkeys (*Meleagris gallopavo*) has reestablished the species through much of its historic range (Lewis 1987), extended the present occupied range beyond historical boundaries (Wunz 1992), and is recognized as a major success in wildlife management (Lewis 1987). Despite the success of trap and transfer of wild turkeys, the method was not applied to ocellated turkeys (*Meleagris ocellata*) until 2009 in Campeche, Mexico (J. Sansores, Union Regional de UMAs de Campeche, unpublished data). The ocellated turkey is a neotropical galliform inhabiting portions of the Yucatán Peninsula of Mexico and northern portions of Belize and Guatemala. Ocellated turkeys are a recognized as a species of high tri-national concern by Partners in Flight (Berlanga et al. 2010) and are an appendix III species under the Convention on International Trade in Endangered Species (UNEP-WCMC 2012).

Despite an ecological and socio-economic need for increased conservation of ocellated turkeys, active management is minimal and uncoordinated. Local subsistence hunters utilize the species as a food source (Escamilla et al. 2000, Santos-Fita et al. 2012), while potentially greater gains exist with the development of an eco-tourism or managed sport hunting industry (Baur et al. 2012, McRoberts et al. 2012). Kampichler et al. (2010) reported localized declines in ocellated turkey populations in areas where management is absent and Calmé et al. (2010) reported increases in populations where management and protection have allowed the species to prosper. The current status of the species and its socio-economic benefits to the region warrant a greater increase in applied management strategies for ocellated turkeys.

I report the first instance of using the trap and transfer method to reestablish or supplement existing populations of ocellated turkeys. My objectives are to assess the efficacy of trap and transfer methods used to increase ocellated turkey populations and to offer suggestions to improve and refine the management technique. To accomplish these objectives I monitored the fate of ocellated turkeys that were trapped and transferred between sites in Campeche, Mexico. I believe that with proper implementation, including consideration of ocellated turkey life history traits, the trap and transfer management technique can be used to reestablish extirpated populations of ocellated turkeys.

Study Area

Research took place in the Mexican state of Campeche located in the south-west portion of the Yucatán Peninsula. Campeche is characterized by a tropical, sub-humid climate with semi-deciduous forests and limited agricultural production. A rainy season exists from June–September (Comisión Nacional del Agua 2014) and average temperatures range from 30.3 °C to 24.6 °C in May and January, respectively (Comisión Nacional del Agua 2014).

Ocellated turkeys were captured at the Las Flores Management Unit for Conservation and Sustainable Use of Wildlife (UMA, from the Spanish translation; see García-Marmolejo et al. 2006, Valdez et al. 2006.). Las Flores was a forest-agriculture matrix with grain sorghum (*Sorghum spp.)*, corn (*Zea spp.)*, and soybeans (*Glycine spp.*) the dominant crops. Ocellated turkeys were released at the La Montaña UMA located approximately 65.85 km to the south-southwest of Las Flores. La Montaña was intact forest with few clearings, no agricultural production, and greater topographic relief than Las Flores. Porter-Bolland et al. (2007) provide a regional summary of historic and recent land use practices of study regions.

Methods

Ocellated turkeys were captured in January 2010 as part of an investigation by Mexico's federal wildlife agency, the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). Project collaborators used a cannon net to capture birds at Las Flores and capture methods were described in length by McRoberts et al. (2014). Turkeys were placed in a National Wild Turkey Federation transport box and driven approximately 4.5 hours to the La Montaña UMA where I equipped birds with a 95-g Very High Frequency (VHF) backpack-style radio transmitter unit with an 8-hour mortality sensor (Advanced Telemetry Systems, Isanti, MN). I only radioed birds judged to be capable of supporting the weight of the radio unit. I monitored the survival status of turkeys from the time of release onward at a frequency of 2-3 times daily using a 3-element Yagi antenna.

When a mortality signal was detected I lead a group of 3–4 local collaborators to locate the radio, record the Universal Transverse Mercator (UTM) coordinates, and we then attempted to document the cause of death. The local collaborators that assisted with searches had spent their lives in the forested regions of Campeche and possessed extensive knowledge of the fauna and flora of the region; I relied on their judgments to assign cause-specific mortality factors. Guides assessed mortality using turkey carcass condition, feathers at mortality site, predator scat and tracks, condition of radio and harness material, and vegetation type where the mortality occurred. I used UTM coordinates to calculate distance between release site and mortality location and reported average distance between these locations.

I estimated survival of ocellated turkeys released at La Montaña using the staggered entry Kaplan-Meier method (Kaplan and Meier 1958, Pollock et al. 1989) with SAS (SAS Institute, Inc., Cary, NC). I selected this survival analysis because the staggered entry Kaplan-Meier allows right-censoring of ocellated turkeys when their fate was unknown and multiple entry of dates for study subjects. Survival analysis was initiated upon release and extended until all turkeys died, it became unfeasible to monitor further, or the status of birds could not be determined. I did not include turkeys in the analysis that died within the first week of release because mortality could have been influenced by capture, handling, or stress associated with the radio unit (Miller et al. 1998).

Results

I transferred 26 ocellated turkeys from Las Flores to La Montaña during 3 trap and transfer events; 13 turkeys on 08 January, 10 turkeys on 12 January, and 3 turkeys on 16 January. Age and sex classes of released birds consisted of 2 adult males, 7 adult females, 3 juvenile males, and 14 juvenile females; I classified juveniles as turkeys between 6 mo and 1 yr of age at the time of release. I assessed condition of birds after transfer and judged that 18 turkeys were suitable to radio-mark; the 8 turkeys not radioed were juvenile birds (6=female, 2=male).

With the assistance of local guides I identified cause-specific mortality sources of 13 ocellated turkeys as: ocelot (*Leopardus pardalis*) or jaguarundi (*Puma yagouroundi*; n=6), gray fox (*Urocyon cinereoargenteus*; n=3), subsistence hunter (n=2), and unknown predator (n=2). Due to similarities in mortality signs and evidence we were unable to differentiate between ocelots and jaguarundi when assigning cause of death. I located all mortality sites the same day the mortality signal was detected to increase the likelihood of identifying a mortality source. I was able to calculate the distance between release site and mortality site for 11 ocellated turkeys, but was unable to determine exact mortality locations for both turkeys killed by unauthorized subsistence hunters. Average distance from release site to mortality site was 769.10 m (SE=325.04 m).

I censored a juvenile female that died the day following release and a juvenile male with a failed radio transmitter from our survival analysis. With the remaining 16 individuals, I found that the Kaplan-Meier survival estimate for released ocellated turkeys was 0.186 (SE = 0.168; Figure 5.1) during a 162-day study period. Two turkeys were right-censored from the survival analysis at days 79 and 92 (Figure 5.1) after they moved into areas where I could not logistically monitor. The monitoring period concluded with one juvenile male still detectable at La Montaña.

Discussion

No other study has documented or analyzed an ocellated turkey translocation event, thus limiting comparisons between my results and past research. Gonzalez et al. (1996) captured ocellated turkeys at Tikal National Park, Guatemala in 1993 and 1994; from 4 ocellated turkeys in 1993 and 5 in 1994, Gonzalez et al. (1996) estimated female breeding period (April–August) survival of 0.75 and 0.60, respectively. McRoberts (2014) reported average annual survival of ocellated turkeys in Campeche, Mexico as 0.505 (SE=0.119; n=24). I believe the estimated survival rate for trap and transferred ocellated turkeys is lower than survival reported by Gonzalez et al. (1996) and McRoberts (2014) for a several reasons. The greatest difference among studies was that ocellated turkeys included in Gonzalez et al. (1996) and McRoberts (2014) were not transferred to a new location, instead all turkeys were radio-marked and released where captured. Despite censoring birds that died within a week of release, the capturing and transporting process could have stressed turkeys and ocellated turkeys have been reported to be particularly susceptible to disturbances and handling (Cordier 1943, Lint 1977). Although such stress may not have been the ultimate cause of mortality (i.e., birds did not die within a week of release), the handling could have been contributed to mortality as a proximate cause and impacted survival.

Another explanation for the lower survival rate of translocated ocellated turkeys was the substantial habitat differences between Las Flores and La Montaña. Ocellated turkeys originating in LF, with the large tracts of open agriculture fields and a consistent food source, appeared to have difficulty adapting to the forested habitat of La Montaña.

McRoberts (2014) documented that the aggregate dry mass contents of the upper digestive tracts of ocellated turkeys (n=64) at Las Flores contained 92.27% agricultural crops. Although ocellated turkeys have been classified as generalists in their feeding habits (Lint 1977, Sugihara and Heston 1981), the sudden change in food-item availability could have temporarily reduced body condition and made birds more susceptible to predation.

An unexpected factor that could have also contributed to the low survival rate of translocated ocellated turkeys was the post-release sociality among birds. At LF, turkeys were gregarious and had a strong flocking tendency. However, I did not observe a similar behavior among birds released at La Montaña. During radio telemetry monitoring I only detected one grouping of turkeys and direct visual observations of released turkeys (n=33) were all of solitary birds. Calmé et al. (2010) reported that ocellated turkeys were typically gregarious to protect individuals against predators, even though a flock-unit was more easily detected by a predator. Without the advantages offered by flocking to detect predators, the released birds were subject to increased predatory pressures and lower survival.

A final consideration that could explain differences in survival is that some turkeys monitored by Gonzalez et al. (1996) at Tikal were in an area of "high human use" (p. 195). The presence of humans may have resulted in a lower predator density; such areas within national parks see high levels of foot-traffic as people visit the Mayan ruins and turkeys become habituated to humans. As a result, survival of the human-habituated birds in the national park may not mirror their wild counterparts.

This is the first report that identifies ocelots or jaguarundis and gray foxes as predators of ocellated turkeys, although Gonzalez et al. (1996) named both as potential predators. Documented predators of ocellated turkeys are limited to puma (*Puma concolor*; Aranda and Sánchez-Cordero 1996) and a poisonous snake (species not identified; Gonzalez et al. 1996). To determine cause-specific mortality we relied heavily upon local guides that were knowledgeable about the behavior and sign of local wildlife. Without the assistance of these cooperators we would have been severally limited in our assessment of mortality factors. However, on two occasions, we were unable to determine what species of predator killed a released turkey. In both cases only wings and a transmitter remained with no additional evidence.

I found that the average distance between release and mortality locations was 769.10 m (SE=325.04 m). Hopkins et al. (1982) reported that dispersal distance of eastern wild turkey (*M. g. silvestris*) reintroduced to east Texas average 4.6 km, and Marable et al. (2012) suggested that wild turkeys in new habitats (i. e., translocated birds) may increase their movements, leading to a greater likelihood of predation mortality. It appears that the birds I radio-tracked were either killed prior to dispersing or that ocellated turkeys are less prone for movements following release. Given the low survival rate of translocated turkeys, it seems that the former explanation is more likely and provides further justification for transferring ocellated turkeys between similar habitat types in hopes of reducing predation rates.

Management Implications

Despite a survival rate of 0.186 (SE = 0.168), I still believe the management tool has potential in reestablishing ocellated turkeys where populations have been extirpated or for supplemental stockings in areas of low density if management and protection plans exist. To improve turkey survival rates following trap and transfer I recommend translocations to take place between similar habitats. If a management objective is to establish an ocellated turkey population in a forested habitat, then the turkeys used for the translocation should also originate from that habitat type. If this is not possible, supplemental feeding programs during an acclimation period may increase survival, although this has not been tested. I would also recommend that managers take steps to minimize handling and transport time between the capture and release sites. Ocellated turkeys are not as hardy as wild turkeys and care must be taken to eliminate disturbances and stressors. A final recommendation would be to release turkeys in small groups, as opposed to individually, in hopes that turkeys would flock and predation rates could be reduced.

Additional investigation into cause-specific mortality sources, ideally differentiated among seasons and age-classes and between sexes, will help explain ocellated turkey population dynamics and assist with population projections and management goals. Evidence of a mortality source disappears quickly in the sub-humid tropical environment and investigators should be prepared to monitor ocellated turkey survival frequently and respond rapidly when a mortality signal is detected.

I acknowledge that recommendations are based on a small sample size from a one-time event. However, I hope that these findings will serve as a baseline for future ocellated turkey management efforts. Investigators should expand upon these results and not be overly restricted to conclusions generated from my limited sample.

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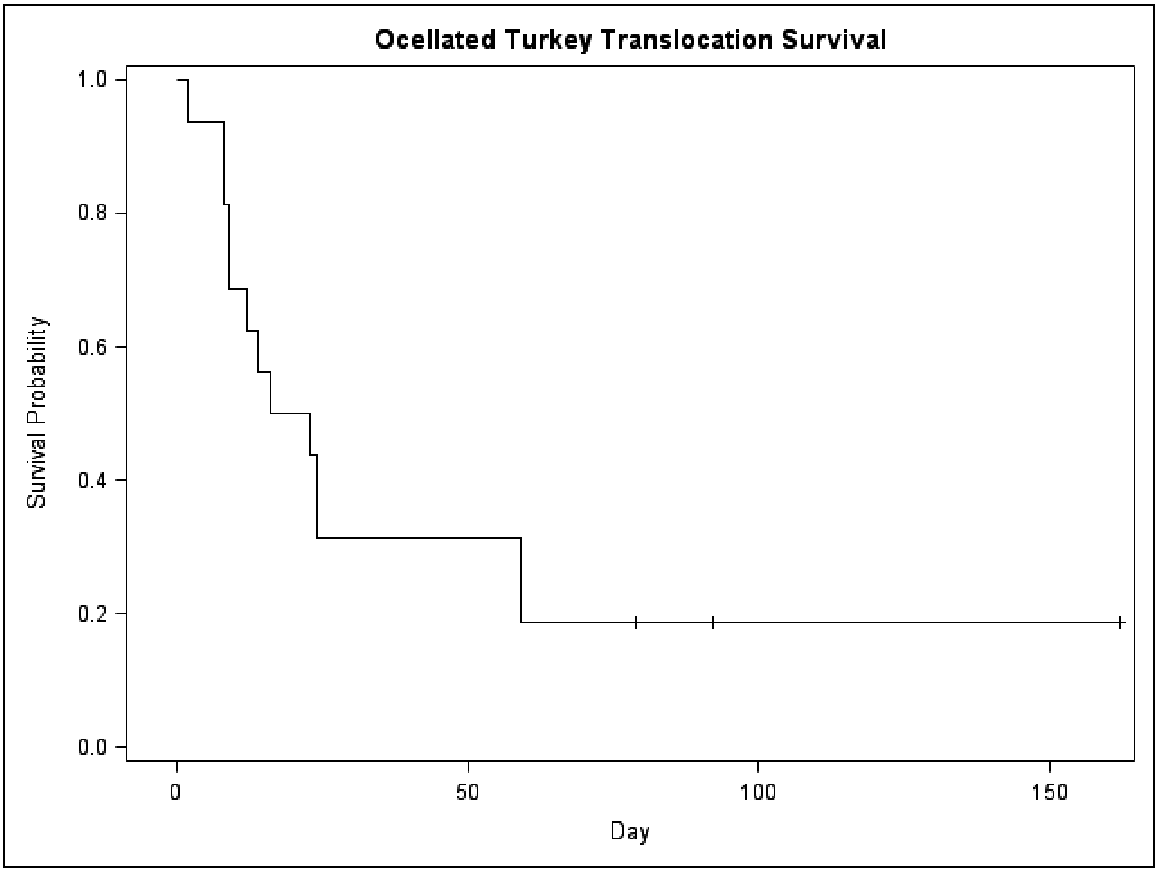

Figure 5.1. Survival rate of translocated ocellated turkeys (n=16) in Campeche, Mexico, 8 January–18 June, 2010. Tick marks represent censored individuals at days 79 and 92.

CHAPTER VI

ANNUAL SURVIVAL, CAUSE-SPECIFIC MORTALITY, AND AGE-SEX STRUCTURE OF OCELLATED TURKEYS IN CAMPECHE, MEXICO

Abstract

Ocellated turkeys are a large galliform native to the Yucatán Peninsula of Mexico and the northern regions of Belize and Guatemala. Little research has been conducted on the species and the majority of past studies have been based on visual behavioral observations and anecdotal reports. Habitat alteration and subsistence hunting have resulted in localized population declines and quantifiable research is now needed to guide management decisions. To address this need, I studied ocellated turkeys in Campeche Mexico from 2010–2013 with the objectives of estimating an annual survival rate, identifying cause-specific mortality factors, and estimating age- and sex-structures. I captured and radio-marked 24 ocellated turkeys used for survival analysis and found an annual survival rate of 0.505 (SE=0.119). Cause-specific mortality results were often inconclusive because of a low radio recover rate and challenges identifying a cause of death. However, I did identify small felids and sport- and subsistence-hunters as mortality factors. I analyzed 179 ocellated turkey capture records from a 2009–2011 research project sponsored by the Mexican government and found age- and sex-ratios of 2.89 juveniles per 1 adult and 0.443 males per 1 female. This is the first occasion demographic parameters have been reported for wild ocellated turkeys and I believe

results can shape management strategies to reverse localized declines in ocellated turkey populations.

Introduction

An understanding of wildlife demographic parameters can assist with population projections and help identify management objectives. The study of wild turkey (*Meleagris gallopavo*) survival has accompanied the reestablishment of the species and survival estimates were summarized by Vangilder (1992). Despite the management benefits from the extensive study of survival rates among age class, season, and sexes of wild turkey, little effort has been directed toward the demographics of ocellated turkeys (*Meleagris ocellata*). The ocellated turkey is the sole congener to the wild turkey and is native to Mexico's Yucatán Peninsula and northern Guatemala and Belize. Ocellated turkey populations have declined in recent decades due to unregulated subsistence hunting and habitat degradation (Calmé and Sanvicente 2000, Kampichler et al. 2010, Ingram et al. 2014). Novel management strategies, which consider the needs of the often economically depressed local people and the ecology of the species, are needed to reverse negative population trends. Evidence exist that the species will respond to active management efforts and Calmé et al. (2010) reported that ocellated turkey populations showed positive growth in both forested and forest-agriculture habitats when proper management plans were in place. A greater understanding of the ecological characteristics and limitations of ocellated turkeys will allow managers to further refine and improve management strategies.

Previous studies of ocellated turkey demographics are extremely limited, likely a result of difficulties in capturing and monitoring. My objective was to fill this demographic void by estimating annual survival of wild ocellated turkeys, describing cause-specific mortality factors, and estimating age- and sex-structure. I hope these data can be incorporated into population models used to more effectively manage ocellated turkeys throughout their range.

Study Area

My study took place at 2 locations on the southwest portion of the Yucatán Peninsula in the state of Campeche, Mexico. Campeche is a tropical, sub-humid climate with semi-deciduous forests interspersed with small amounts of cleared lands used for agriculture production. A wet season exists from June–September and the hottest and driest months are April and May (Comisión Nacional del Agua 2014).

Research occurred at the Las Flores and La Montaña Management Units for Conservation and Sustainable Use of Wildlife (UMA, from the Spanish translation). Las Flores was a forest-agriculture matrix with grain sorghum (*Sorghum spp.)*, corn (*Zea spp.)*, and soybeans (*Glycine spp.*) as dominant crops. La Montaña was forested with some secondary growth and few clearings, no agricultural production, and greater topographic relief than Las Flores. The study areas were separated by 65.85 km with La Montaña located to the south-southwest of Las Flores. Porter-Bolland et al. (2007) provide a detailed summary of land use practices in the study regions.

Methods

Ocellated turkeys were captured using walk-in traps at La Montaña and a cannon net in Las Flores during 2009–2012; capture methods are described in depth by McRoberts (2014). Due to local regulations, the actual cannon net capture at Las Flores was coordinated by Mexico's federal wildlife agency, the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). I aged captured birds as adults or juveniles (McRoberts et al. 2012), and considered juveniles birds between 6 mo and 1 yr of age at the time of capture. I then equipped turkeys with a 95-g Very High Frequency (VHF) backpack-style radio transmitter (Advanced Telemetry Systems, Isanti, MN) or an 80-g micro-Global Positioning System (GPS) backpack-style transmitter (Sirtrack, Havelock North, New Zealand). Both radio models had an 8-hour movement-triggered mortality switch. I released turkeys at the capture location and monitored the survival status of turkeys using a 3-element Yagi antenna. During the January–June field season I typically monitored the survival status of turkeys daily, but survival monitoring was greatly reduced during July–December. I also conducted a single aerial telemetry flight with a Cessna 172 (Cessna Aircraft Co., Wichita, KS) to monitor the survival status of birds in May 2011.

When a suspected mortality event was detected, I followed the signal to the radio location, and with the assistance of local collaborators knowledgeable of the local environment, attempted to identify the cause of mortality. We assessed turkey carcass condition, feathers at the mortality site, predator scat and tracks, condition of radio and harness material, and vegetation type where the mortality appeared to have taken place. I relied heavily upon the judgments of the locals when predicting the reason for mortalities.

I used the nest survival model in program MARK (version 7.2) to estimate annual survival using months as the time-occasion. Any turkeys that died within 7 days following capture were excluded from analyses (Miller et al. 1998). I right-censored individuals from my survival analysis at the conclusion of my monitoring period or when fates were unknown (Pollock et al. 1989). I used the last known date a turkey was alive as the censor-date when I was no longer logistically able to monitor an individual.

I analyzed capture data from a 2009–2011 ocellated turkey research project sponsored by SEMARNAT in the Las Flores region and reported proportions of sex and age classes of ocellated turkeys; these demographics were used to ecologically interpret my survival estimate.

Results

During the 2010–2013 I was able to capture and monitor 24 ocellated turkeys that were included in my estimation of annual survival; 12 adult males, 7 adult females, 3 juvenile males, and 2 juvenile females. I radio-marked 23 turkey with VHF units and 1 turkey with a GPS unit and I combined data from both radio-types for analyses. Seventeen turkeys were captured at Las Flores and 7 were captured at La Montaña. Two additional turkeys captured at Las Flores and 1 turkey captured at La Montaña that died within a week of radio-marking were excluded from my analysis because their deaths were likely a result of capture and handling. I estimated that annual ocellated turkey survival was 0.505 (SE=0.119; Figure 6.1). Capture records from SEMARNAT were provided for 179 ocellated turkeys and from those data I found age- and sex-ratios of 2.89 juveniles per 1 adult and 0.443 males per 1 female.

I located the mortality sites of 12 of the 24 radio-marked ocellated turkeys; the remaining turkeys were censored from the study because of unknown fates and radios were not recovered. I concluded that probable causes of mortality were small felids (n=2), subsistence hunters (n=2), sport hunter (n=1), and unknown predator (n=2). I was not able to determine a cause of death for 5 turkeys because of a lack of evidence at the site of radio recovery.

Discussion

An estimate of ocellated turkey survival was offered by Gonzalez et al. (1996) using radio-marked birds at Tikal National Park in Guatemala. Survival was monitored from April–August in 1993 and 1994 with yearly samples of 4 and 5 ocellated turkeys, respectively. Gonzalez et al. (1996) reported survival rates of 0.75 in 1993 and 0.60 in 1994, with both rates greater than the 0.505 survival I observed. Several explanations exist for the greater survival rates observed by Gonzalez at al. (1996) including that some turkeys in their study were captured and monitored in areas of "high human use" (Gonzalez et al 1996; pg. 195). These turkeys had been habituated to humans and survival estimates may not mirror that of wild ocellated turkeys. Additionally, since hunting was prohibited in the national park, anthropogenic mortality pressures were greatly reduced, if not altogether absent. Lastly, the monitoring period for the Gonzalez et al. (1996) study was 5 months, and the shorter duration resulted in less time for mortalities to occur. I reported annual survival and the longer duration could only result in a survival estimate less than or equal to a 5 month period within the same survival analysis.

The only other ocellated turkey survival estimate was provided by McRoberts (2014) who monitored the survival of translocated ocellated turkeys (n=16) and found a survival rate of 0.186 (SE = 0.168). This estimate is likely lower than the 0.505 survival rate I documented from birds captured and released at La Montaña and Las Flores for 2 reasons. First, turkeys in the current study were not transferred between different habitat types; instead they were released at the locations of their capture. Second, the stressors associated with transporting birds between capture and release sites were absent in the current study. Ocellated turkeys have been reported as a species particularly susceptible to mortality resulting from capture and handling (Cordier 1943, Lint 1977), and the trap and transfer process could have negatively impacted the survival rate of the translocated turkeys.

Despite an abundance of survival estimates for wild turkeys, I cannot justify a comparison between the species because of apparent differences in predatory species, anthropogenic pressures, and climatic patterns that shape the life history of ocellated turkeys. Furthermore, I also chose not to analyze survival rates with covariates such as study area, sex, age, season, or study-year because of the small sample size of my study. These are all common delineations made in survival analyses (Vangilder 1992) and future investigations should compare survival rates among these covariates to better understand the factors limiting populations.

Analysis of SEMARNAT capture data indicated that the Las Flores ocellated turkey population was skewed towards females and that greater than 75% of turkeys were hatched the previous year (i.e., were classified as juveniles). I had no data reporting demographic ratios at La Montaña, but the level of recruitment suggested by the sex and age ratios at Las Flores helps explain how populations could sustain an annual survival rate of 0.505. Additional research is needed to quantify ocellated turkey reproductive ecology parameters such as nest success and poult survival rates.

Results from my assessment of cause-specific mortality factors were inconclusive and this was, at least in part, a product of long-distance turkey movements into inaccessible habitats and my subsequent inability to determine the fates of turkeys (McRoberts 2014). I was unable to recover half of the radio-birds used to assess cause-specific mortality and this greatly reduced my ability to draw inferences from my sample. Furthermore, when radios were recovered at suspected mortality sites, evidence was often lacking and identifying a cause of mortality was not possible. The small felids that appeared to have killed 2 ocellated turkeys were either ocelot (*Leopardus pardalis*) or jaguarundi (*Puma yagouroundi*) and we were unable to differentiate between the mortality evidence from these 2 species. McRoberts (2014) reported that ocelots or jaguarundis were the most common predators of translocated ocellated turkeys at the La Montaña study site. Additional documented mortality sources of ocellated turkeys include puma (*Puma concolor*; Aranda and Sánchez-Cordero 1996) and poisonous snake (species not identified; Gonzalez et al. 1996), and an assessment of potential predators of ocellated turkeys was included in Gonzalez et al. (1996) and McRoberts et al. (2012).

Anthropogenic sources resulted in 3 ocellated turkey moralities. Sport hunting took place at Las Flores and La Montaña during my study and a sport-hunter harvested one radio-marked adult male ocellated turkey at Las Flores. The radio from this turkey was returned to me by the hunting guide and I was shown the harvest location. Unauthorized subsistence hunters were responsible for the death of 1 turkey at each study site. I classified these turkeys as subsistence hunters because of the locations of recovered radio transmitters. Gonzalez et al. (1996) reported that 88% of subsistence hunters in the Tikal National Park area had hunted the ocellated turkey and Santos-Fita et al. (2012) reported that ocellated turkeys were one of the top harvested species and extremely important for rural communities of the Yucatán Peninsula. The amalgam of these results shows that subsistence hunting must be addressed if managers hope to increase ocellated turkey populations.

Management Implications

My annual survival estimate is the first for wild ocellated turkeys and it can be used as a baseline for future survival studies or conservation modeling efforts. My results included 2 habitat types, and both age- and sex-classes. Future studies should strive for sample sizes allowing assessment of survival among the different age- and sex-classes.

Additional research is needed to better quantify cause-specific mortality factors. The sub-tropical environment of Campeche requires that investigators frequently monitor survival status and when a mortality signal is detected, locate the site quickly. Scavenger insects often made assessment of turkey carcass difficult and certain habitat types, such as tall, thick grasslands at Las Flores, made locating any evidence of predators difficult. The reliance on locals to assist with identification of mortality causes was essential to my study

Wildlife managers must address the impact of subsistence hunting on ocellated turkey populations and solutions should consider the needs of the rural, economical challenged communities when creating ocellated turkey conservation strategies. Educational efforts showing the benefits of sex and seasonal harvest restrictions would be a pragmatic starting point.

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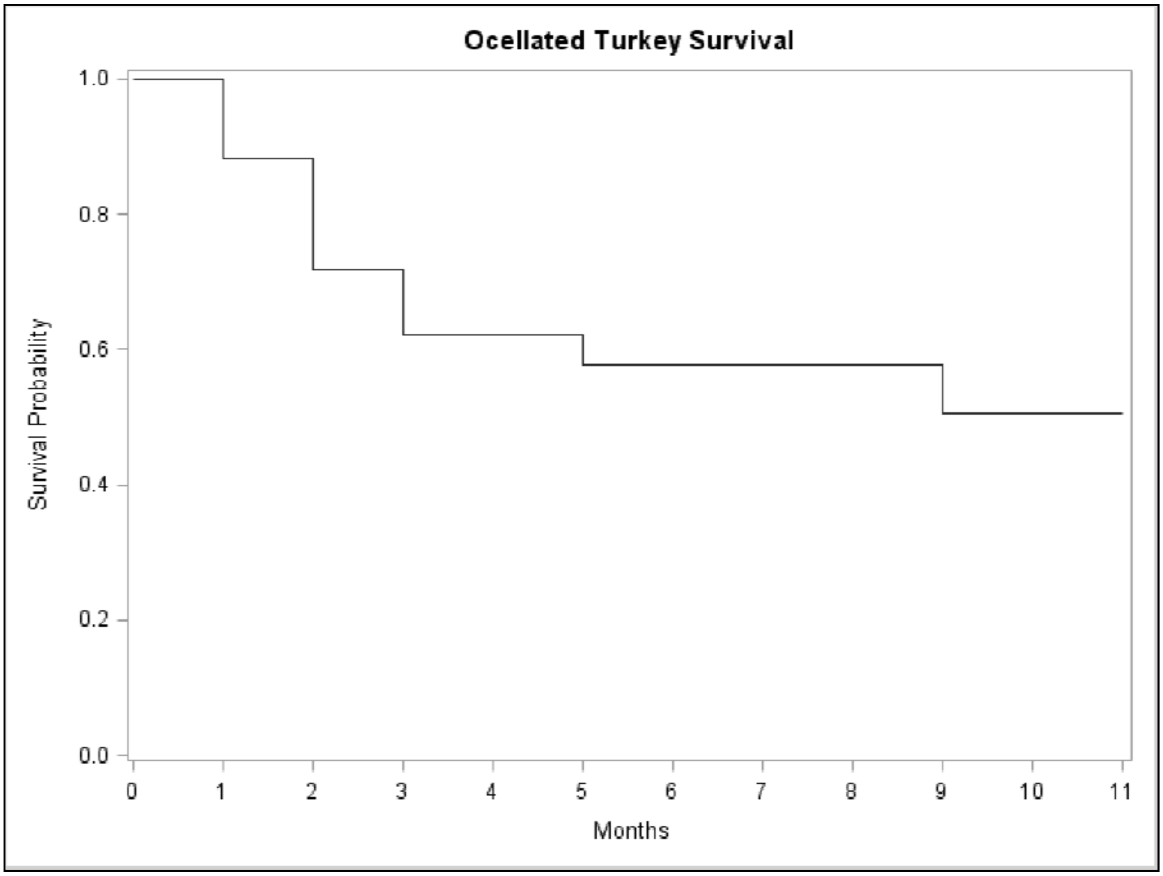

Figure 6.1. Estimated annual survival of ocellated turkeys (n=24) in Campeche, Mexico, 2010-2013.

CHAPTER VII

REPRODUCTIVE SEASON HOME RANGES AND DISPLACEMENT DISTANCES OF OCELLATED TURKEYS IN CAMPECHE, MEXICO

Abstract

The ocellated turkey is a neotropical galliform inhabiting Mexico's Yucatán peninsula and northern portions of Guatemala and Belize. Habitat alteration and subsistence hunting pressures have resulted in localized ocellated turkey population reductions and a greater understanding of life history traits is needed to reverse population declines. I radio-marked and monitored ocellated turkeys (n=31) at two locations within the Mexican state of Campeche during 2010–2013 and calculated average 95% fixed kernel and 100% minimum convex polygon (MCP) home ranges. I also reported displacement distance between wintering grounds and areas inhabited by turkeys during the reproductive season. I was able to collect an adequate number of samples to calculate a home range estimate for 5 ocellated turkeys and found that fixed kernel and MCP average home range sizes were 9.69 km^2 (SE=2.76) and 8.34 km^2 (SE=1.83), respectively. Displacement movements occurred in February–April and the average one-way displacement distance was 19.81 km (SE=4.89). Despite being limited by small sample sizes, these results are the most comprehensive assessment of wild ocellated turkey home range size and displacement distance and can be used to guide conservation and management activities.

Introduction

Estimates of home range have been a common objective in wildlife studies (White and Garrott 1990), and many investigators have reported wild turkey (*Meleagris gallopavo*) home ranges to better understand differences among subspecies, life history stages, seasons, and harvest strategies (e.g., Badyaev et al. 1996, York and Schemnitz 2003, Miller and Conner 2005, Hall et al. 2006, Rauch et al. 2012). Despite an abundance of wild turkey research that has been used to direct management efforts, similar ecological information describing the second member of the *Meleagris* genus, the ocellated turkey (*Meleagris ocellata*), is nearly absent from scientific literature. Ocellated turkeys are native to Mexico's Yucatán Peninsula and northern portions of Guatemala and Belize. The species is utilized by subsistence hunters as a food source (Escamilla et al. 2000, Santos-Fita et al. 2012) and localized population reductions or extirpations have occurred throughout the historic range of ocellated turkeys (Calmé and Sanvicente 2000, Kampichler et al. 2010). Additionally, the conversion of forests into agricultural lands has occurred in Campeche (Porter-Bolland et al. 2007) and these land-use changes have not only altered ocellated turkey habitats, but have also provided increased access to remote areas for subsistence hunters (McRoberts et al. 2012).

Past research on ocellated turkey home range and displacement distance is limited to a single study of turkeys in Tikal National Park, Guatemala (Gonzalez et al. 1998). Birds at this site were partially habituated to humans and I believe the need exists to quantify home range and movement patterns of wild ocellated turkeys because these findings would be more transferable to other wild birds throughout the range of the species. Therefore, my study objectives were to estimate ocellated turkey home range size and displacement distance during the breeding season in Campeche, Mexico. I believe these data can be used to better understand the species, reverse downward population trends, and assist with developing future conservation strategies.

Study Area

Campeche is located on the southwest portion of the Yucatán Peninsula. The climate was sub-humid, tropic and a rainy season existed between June–September with annual rainfall reaching 1,600 mm (Comisión Nacional del Agua 2014). April and May were the hottest and driest months in Campeche with temperatures approaching 37.0 °C (Comisión Nacional del Agua 2014). Topography at study areas ranged from flat agricultural lands to undulating karst hills.

I conducted research at two Management Units for Conservation and Sustainable Use of Wildlife (UMA, from the Spanish translation; García-Marmolego et al. 2006, Weber et al. 2006). The La Montaña UMA was characterized as a semi-deciduous upland forest environment with few forest openings and secondary growth from past logging activities. The Las Flores UMA was a forest-agricultural matrix; dominant crops included grain sorghum (*Sorghum* spp.), corn (*Zea* spp.), and soybeans (*Glycine* spp.) The bulk of my research took place within the Las Flores UMA, but I also conducted some field work in the surrounding areas, including the Carlos Cano Cruz UMA. Regional land-use practices were similar and reference to Las Flores in this manuscript represents the region, not the political boundaries of the Las Flores UMA.

La Montaña was located approximately 65.85 km to the south-southwest of Las Flores.

Methods

I conducted field work during 2010–2013 and broadly define January–July as the ocellated turkey reproductive season because the timeframe included pre-breeding period, the onset of singing (i.e., gobbling; singing is a term derived from a Spanish word to describe the male's reproductive call) and strutting by male turkeys, copulations, nesting, and hatching (Leopold 1948, Lint 1977, Steadman et al. 1979, Gonzalez et al. 1998). During this time, I captured turkeys using walk-in traps at La Montaña and a cannon net at Las Flores (McRoberts 2014). Local permitting constraints required me to rely on personnel associated with Mexico's federal wildlife agency, the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), to conduct the cannon net capture. After turkeys were captured, I recorded age and sex and equipped turkeys with a 95-g Very High Frequency (VHF) backpack-style radio transmitter (Advanced Telemetry Systems, Isanti, MN) or a 80-g micro-Global Positioning System (GPS) backpack-style transmitter (Sirtrack, Havelock North, New Zealand). Both radio models had an 8-hour movement-triggered mortality switch. I programmed the GPS transmitter to collect locations twice daily, once at 0500 and again at 1700. This schedule would presumably enable a location to be taken when a turkey was on the roost (excluding nesting females), thus resulting in less signal interference from the forest canopy, as well as during the afternoon feeding period (Steadman et al. 1979). I selected against a more frequent GPS fix-schedule to extend the battery life of the units. I used signal triangulation to estimate locations for ocellated turkeys equipped with VHF transmitters and collected 3 compass bearings within a 30 minute span. I used program LOAS (version 4.0) to plot monitoring locations and bearings, and to estimate turkey locations. I monitored turkeys marked with VHF units as frequently as possible, but because my time was split between 2 study areas, my minimum-target was to collect ≥2 locations per week. I conducted an aerial telemetry survey flown at approximately 1600–1800 m in a Cessna 172 (Cessna Aircraft Co., Wichita, KS) to locate ocellated turkeys that had dispersed from the Las Flores study area. Monitoring of turkeys marked with GPS units consisted of weekly survival assessments.

I plotted ocellated turkey locations in ArcGIS (version 10.1; Environmental Systems Research Institute, Inc., Redlands, CA) and used Geospatial Modeling Environment (GME) to create 95% fixed kernel estimates of ocellated turkey home ranges using the plug-in bandwidth and 30 m grid-cells. I also used GME to calculate 100% minimum convex polygons (MCPs) as an alternative home range estimator. My objective was to calculate home range estimates using ≥30 locations for individual turkeys (Seaman et al. 1999, Kernohan et al. 2001), and I generated 2 estimates of home range (i.e., fixed kernel and MCP) to enable comparisons to future ocellated turkey studies (Harris et al. 1990). To calculate the minimum displacement distances from turkeys marked with VHF units I used ArcGIS to measure the linear distance between the last known position from ground-based telemetry and the location obtained during the aerial telemetry flight. When estimating displacement distance from turkeys marked with GPS units I calculated the minimum distance between the last known point that would be obtainable in the VHF monitoring area and the core use area after the displacement movement; this structure enabled pooling of VHF and GPS displacement monitoring results.

Results

I radio-marked 7 turkeys at La Montaña with VHF units and, in cooperation with the SEMARNAT, radioed 24 turkeys (VHF=22, GPS=2) at Las Flores. My monitoring efforts were challenged by the movements of ocellated turkeys in combination with a lack of access to remote areas at La Montaña and Las Flores. Access to monitoring areas was rarely impacted by landowner cooperation, but instead by a lack of trails or roads to reach forested areas used by radio-marked ocellated turkeys. I was able to collect ≥30 locations to calculate home range estimates for 4 ocellated turkeys (La Montaña=3, Las Flores=1), and also calculated the home range of a turkey at La Montaña using 26 locations (Table 7.1). Average home range size from my 95% fixed kernel and 100% MCP estimates were 9.69 km^2 (SE=2.76) and 8.34 km^2 (SE=1.83), respectively (Table 7.1).

I recovered 1 of the GPS units from a turkey captured at Las Flores and data offered unexpected insight into ocellated turkey home range ecology. Two distinct clusters of locations, separated by 17.82 km, existed during the 03 March–28 September, 2012 monitoring period, and the radio-marked adult female traveled between the clusters in ≤48 hrs (Figure 7.1). I believe it was biological relevant to separate the two clusters and calculate separate home ranges; the 95% fixed kernel and 100% MCP estimates were

9.70 km^2 and 15.82 km^2 for the north cluster and 5.17 km^2 and 10.15 km^2 for the south cluster, respectively. I only included the southern home range in the average home range calculation because the seasonality of locations corresponded more closely to the ocellated turkey reproductive season. Had I not separated the locations into two clusters, the 95% fixed kernel and 100% MCP home range estimates including all locations were 197.09 km^2 and 127.94 km^2, respectively.

I calculated displacement distance of 7 radio-marked ocellated turkeys (VHF=6, GPS=1) at Las Flores. Displacement events occurred between 04 February and 06 April, 2011 and on 17 April 2012. All turkeys followed a similar pattern of emigrating southward from the agricultural wintering grounds at Las Flores into undeveloped forested areas. I was unable to access this area from the ground and on 23 May 2011 conducted an aerial telemetry flight. From this flight I located 6 turkeys equipped with VHF radios that had dispersed and later documented another displacement movement with the recovered GPS transmitter. The average one-way displacement distance was 19.81 km (SE=4.89) and the maximum movement that I documented was 36.50 km by an adult female ocellated turkey. Furthermore, I found that 5 of the 7 ocellated turkeys that dispersed from the Las Flores agricultural area returned to that region by January the following year, with a minimum round-trip distance averaging 26.76 km (SE=7.55).

Discussion

Prior to my study, the only record of ocellated turkey home ranges was reported by Gonzalez et al. (1998) from the study of 9 female ocellated turkeys in Tikal National

Park, Guatemala. Gonzalez reported that average ocellated turkey MCP home range size was 0.28 km^2 with a maximum home range size of 12.5 km^2. Unfortunately, no report of the number of locations used to create MCPs or variance of estimates was provided which limits the interpretation of her results. Additionally, some birds included in the Gonzalez et al. (1998) study were in areas of high human activity and became habituated to people; this turkey population may not be representative of ocellated turkeys in unprotected settings, such as the birds included in my study. The average home range size reported by Gonzalez et al. (1998) may also have been less than the average home range size I observed because of temporal differences in monitoring. Although the exact telemetry monitoring period during which Gonzalez et al. (1998) estimated turkey locations was unclear, it appears that the female nesting period was a large portion of their study. Incubation requirements likely kept female turkeys in close proximity to nests and therefore reduced home range sizes. My study also included nesting females, but home range estimates would be less restricted by nesting locations because of my longer study duration.

Hall et al. (2006) provided a summary of wild turkey home ranges and results ranged from 1–48.75 km^2, depending on subspecies, sex, age, and time period. This wide extent of home range sizes illustrates an underlying challenge of comparing ocellated turkeys with wild turkeys: finding a meaningful comparison is a subjective decision of the researcher and marked differences among subspecies and study designs can bias comparative conclusions. A better approach to understand the species would be to initiate additional studies of ocellated turkeys. Such studies should target wild birds instead of turkeys in national parks or nature preserves that are habituated to people and may not be representative of their wild counterparts.

Other researchers note the need for ≥ 30 locations when calculating fixed kernel estimates (e.g., Seaman et al. 1999; Kernohan et al. 2001); however, one of my home range estimates was generated from 26 locations. I believe using this sample is justified because of the scarcity of additional results that quantifiably describe the ecology of ocellated turkeys. My results were limited by access to remote tracts of forest devoid of trails or roads and relying on VHF telemetry in this environment prevented me from approaching the necessary location sample size for all birds marked with VHF units at Las Flores. The single home range I was able to calculate from a turkey at Las Flores was marked with a GPS radio unit.

Gonzalez et al. (1998) also conducted the only study of ocellated turkey movements and reported that the average displacement distance between capture location and the location of attempted nesting for 9 ocellated turkeys was 2.4 km (range: 0.2–8 km). We observed greater average displacement distance of 19.81 km^2 during the ocellated turkey reproductive season at Las Flores. Factors that drive ocellated turkey displacements remain unclear, but future investigators should consider pre-breeding season turkey density, water availability, and nesting habitat requires. Unfortunately, I did not have data to explore these possibilities.

My ocellated turkey displacement results were generated from a small sample size, but it appears a seasonal migratory pattern may exist among ocellated turkey populations in the Las Flores region and exploration of this behavior deserves further investigation. Four of the 6 ocellated turkeys radio-marked with a VHF transmitter that emigrated from Las Flores in the spring reappeared in the following field season with an average minimum round-trip movement of 24.58 km. Additionally, the single GPS transmitter showed that an adult female moved 27.29 km from the capture site into inaccessible forested habitat, presumable to nest, and then returned to the approximate capture location where I recovered the GPS unit 0.34 km from the capture site.

Sample size limitations prevented me from analyzing displacement movements by sex or age, despite reports that differences exist between these classes (Schmutz and Braun 1989, Miller et al. 1995). A goal of future investigators should be to assess ocellated turkey patterns by sex and age.

Management Implications

Inferences from my study of ocellated turkey home range and displacement distance are limited by small sample size. However, these results can serve as a baseline for future analyses and for establishing conservation strategies. My sample size was most restricted by challenges with VHF monitoring and an alternative GPS-based monitoring system should be a priority in future studies. If GPS technologies are unavailable, researchers should budget for aerial telemetry monitoring.

In addition to larger sample sizes, a future need for effective ocellated turkey management is to quantify annual home range size. My results were limited to the reproductive period and do not represent the total yearly area used by ocellated turkeys because I was unable to monitor post-reproductive months. Additionally, when describing home ranges I recommend that future researches include relevant study details including duration of the monitoring period, number of locations used to calculate home range estimates, and sex and age class of radio-marked birds. I was challenged when attempting to compare my results to previous research because such details were omitted.

Displacement or migratory patterns deserve more examination. No mention of seasonal migrations exists in ocellated turkey literature and a greater understanding of this behavior will help define habitat types or areas that should be targeted for conservation. The movement patterns I observed in ocellated turkeys also show the scale of habitat conservation that must be considered when creating management plans.

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Table 7.1. Summary of ocellated turkey home range sizes (km^2) in Campeche, Mexico, 2010–2012.

Turkey ID	Sex & Age	Locations	Monitoring Period	95% Fixed Kernel	100% Minimum Convex Polygon
283	adult female	70	2/27–7/20, 2010	2.73	2.81
1943	juvenile female	26	3/19–7/20, 2010	12.79	5.24
574	adult female	57	3/27–7/18, 2010	9.47	10.91
244	juvenile male	59	3/20–7/18, 2010	18.30	12.46
411(south)[1]	adult female	208	4/18–8/15, 2012	5.17	10.15
Average	-	-	-	9.69 (SE=2.76)	8.31 (SE=1.83)

[1]Turkey 411 was radio-marked with a Global Positioning System transmitter and two clusters of points (north and south) were evident; the southern cluster is reported here because it was more representative of our reproductive season time period.

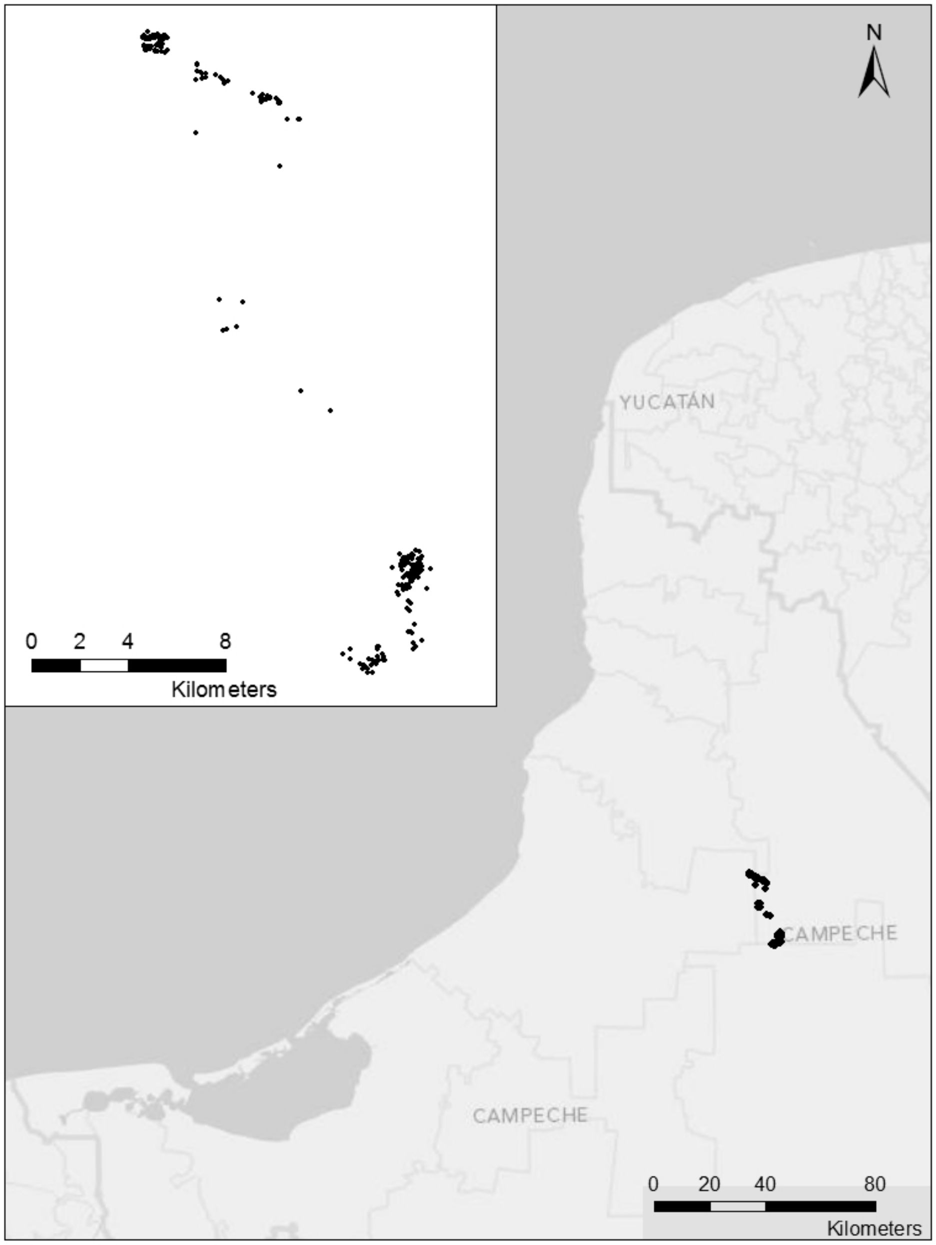

Figure 7.1. Radio locations of ocellated turkey female radio-marked with a Global Positioning System transmitter in Campeche, Mexico, 2012.

CHAPTER VIII

CONCLUSION

The need for this study was first identified by the National Wild Turkey Federation (NWTF), presumably because the NWTF recognized a gap in our collective understanding of the ocellated turkey (*Meleagris ocellata*). The timing of this realization was fortunate because land-use changes and anthropogenic pressures on the wildlife and ecosystems of the Yucatán Peninsula are intensifying (Turner et al. 2001, Porter-Bolland et al. 2007, Schmook et al. 2011). Additionally, the Mexican State of Campeche, where my study occurred, is one of most economically depressed areas of Mexico (US State Department 2010) and rural people often rely on wildlife as a dependable food source (Escamilla et al. 2000, Santos-Fita et al. 2012). These conditions create the need for prompt conservation actions to rectify the downward trends in ocellated turkey populations (Kampichler et al. 2010). I hope that findings from my 4-year study can contribute to the wise use of a renewable natural resource: the ocellated turkey.

Ocellated turkeys are an excellent candidate for applied conservation efforts throughout their native range. Evidence has shown that the species responds well when protected from unauthorized subsistence hunting pressure and management can still permit the sustainable use of turkeys (Calmé et al. 2010, Baur et al. 2012). Additionally, my results and observations indicate that agricultural production and ocellated turkey management are not mutually exclusive activities and rural stakeholders can maintain an agrarian livelihood while conserving ocellated turkeys, provided a wildlife management and protection plan is in place. Developing landscape-specific management plans that can be easily implemented, at a low cost, and that show the tangible benefits of conservation should be a priority for regional wildlife managers.

An initial step towards developing and applying wildlife management plans in Campeche would be to increase wildlife educational opportunities. These efforts could be classified as professional training for wildlife biologists or educational outreach opportunities designed for the rural people of Campeche who are often in close contact with wildlife and natural areas. Wide-range application of these educational efforts could be conducted by Campeche's talented wildlife biologists, educators, and researchers if a funding mechanism was in place. Directing the funds acquired from permitting costs associated with the extraction of regional natural resources (wildlife, timber, oil and gas, minerals, etc.) would be a logical funding source.

There is also merit in requiring the application of more rigorous wildlife management plans in order to be recognized as a Management Unit for Conservation and Sustainable Use of Wildlife (UMA). García-Marmolego et al. (2006) and Weber et al. (2006) assessed the efficacy of the UMA system within the ocellated turkey range and concluded that changes and alterations are needed to adapt to the environmental and social conditions of southeast Mexico.

Results from this study have improved our understanding of ocellated turkeys. However, simply learning more about ocellated turkey life history and ecology will not automatically result in conservation victories; findings must be applied through "on the ground" conservation efforts to increase ocellated turkey populations and improve the lives of local people.

In closing, this study was a collaborative effort among many stakeholders and is currently the most in depth investigation of the ocellated turkey. However, it is not my intention to discredit the work of prior naturalists and scientist who published their findings on ocellated turkeys. Every piece of available literature has contributed to the understanding of ocellated turkeys and I am grateful to those who have shared their knowledge of this captivating species. Leopold (1948), Steadman et al. (1979) and Gonzalez et al. (1996) established a firm foundation for our shared understanding of the ocellated turkey and their work was invaluable as I conducted this study. I am hopeful that my findings will be of equal assistance to future researchers studying the ocellated turkey.

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APPENDIX A

SOUND INTENSITY OF THE REPRODUCTIVE CALLS OF MALE OCELLATED TURKEYS AND IMPLICATIONS FOR RESEARCH

Currently, no coordinated strategy exists to monitor ocellated turkey (*Meleagris ocellata*) population trends or to determine occupied range. This is a result of inadequate funding to develop range-wide survey methods in conjunction with habitats that are logistically difficult to access and monitor. Audibility surveys targeting the male ocellated turkey's spring reproductive call (analogous to the gobble of the wild turkey [*Meleagris gallopavo*]) may provide a range-wide and cost-effective survey method to meet coarse-scale population monitoring objectives. To explore this possibility, I measured the sound intensity (dB) of 99 reproductive calls made by male ocellated turkeys during 16–27 April, 2013 in Campeche, Mexico (Table A.1). Calls measured at varying distances were standardized using the inverse-square law (Davis and Masten 2004) and sound intensity was predicted (Figure A.1). Future steps will implemente a design similar to Butler et al. (2010) to develop an easily implemented and coordinated ocellated turkey survey approach.

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Table A.1. Measurements of the sound intensity of reproductive calls from male ocellated turkeys in Campeche, Mexico, 2013.

Date	Age	Bird ID	dB	Measurement Distance (m)
16-Apr-2013	Adult	1	61.7	8.6
16-Apr-2013	Adult	2	54.9	12.3
16-Apr-2013	Adult	2	52.4	12.3
16-Apr-2013	Adult	2	53.0	12.3
16-Apr-2013	Adult	3	55.6	15.7
16-Apr-2013	Adult	3	47.9	18.0
16-Apr-2013	Adult	3	51.1	12.7
17-Apr-2013	Adult	4	56.6	15.5
17-Apr-2013	Adult	4	58.8	15.5
17-Apr-2013	Adult	4	58.4	15.5
17-Apr-2013	Adult	4	55.8	15.5
17-Apr-2013	Adult	4	57.4	15.5
17-Apr-2013	Adult	4	58.5	15.5
17-Apr-2013	Adult	4	56.5	15.5
17-Apr-2013	Adult	4	54.4	15.5
17-Apr-2013	Adult	4	57.1	15.5
17-Apr-2013	Adult	4	56.2	15.5
17-Apr-2013	Adult	4	59.7	15.5

Table A.1. Continued.

Date	Age	Bird ID	dB	Distance (m)
17-Apr-2013	Adult	4	52.6	15.5
17-Apr-2013	Adult	4	55.2	15.5
18-Apr-2013	Juvenile	5	51.6	8.8
18-Apr-2013	Juvenile	5	60.0	9.1
18-Apr-2013	Juvenile	5	60.1	10.1
18-Apr-2013	Juvenile	5	60.3	10.1
18-Apr-2013	Juvenile	5	58.1	10.1
18-Apr-2013	Juvenile	5	52.2	9.8
18-Apr-2013	Juvenile	5	58.7	9.1
18-Apr-2013	Juvenile	5	65.1	4.2
18-Apr-2013	Juvenile	5	63.3	4.9
18-Apr-2013	Adult	6	62.6	8.2
18-Apr-2013	Adult	6	59.4	6.2
18-Apr-2013	Adult	6	55.4	8.2
18-Apr-2013	Adult	6	63.2	8.2
18-Apr-2013	Adult	6	60.0	8.2
18-Apr-2013	Adult	6	56.4	8.2
18-Apr-2013	Adult	6	55.4	6.2
18-Apr-2013	Adult	6	63.9	5.2

Table A.1. Continued.

Date	Age	Bird ID	dB	Distance (m)
18-Apr-2013	Adult	6	65.1	5.2
18-Apr-2013	Adult	6	66.6	5.2
18-Apr-2013	Adult	6	66.8	4.2
18-Apr-2013	Adult	6	66.0	6.4
18-Apr-2013	Adult	6	68.5	6.4
18-Apr-2013	Adult	6	67.9	6.4
18-Apr-2013	Adult	6	69.7	6.4
18-Apr-2013	Adult	6	67.7	6.4
18-Apr-2013	Adult	6	70.2	6.4
18-Apr-2013	Adult	6	67.8	6.4
18-Apr-2013	Adult	6	70.6	6.4
18-Apr-2013	Adult	6	68.8	6.4
18-Apr-2013	Adult	6	61.6	6.4
18-Apr-2013	Adult	6	68.0	6.4
18-Apr-2013	Adult	6	69.6	6.4
18-Apr-2013	Adult	6	67.5	6.4
18-Apr-2013	Adult	6	67.0	6.4
18-Apr-2013	Adult	6	63.1	5.4
18-Apr-2013	Adult	6	64.7	5.4

Table A.1. Continued.

Date	Age	Bird ID	dB	Distance (m)
18-Apr-2013	Adult	6	65.1	2.5
18-Apr-2013	Adult	6	68.8	2.5
18-Apr-2013	Adult	6	75.0	2.2
18-Apr-2013	Adult	6	72.9	2.2
27-Apr-2013	Adult	7	54.6	10.3
27-Apr-2013	Adult	7	62.7	4.6
27-Apr-2013	Adult	7	68.8	4.6
27-Apr-2013	Adult	7	65.1	4.6
27-Apr-2013	Adult	7	72.3	5.0
27-Apr-2013	Adult	7	67.4	4.5
27-Apr-2013	Adult	7	69.4	4.0
27-Apr-2013	Adult	7	70.0	4.1
27-Apr-2013	Adult	7	70.5	4.0
27-Apr-2013	Adult	7	72.2	5.1
27-Apr-2013	Adult	7	62.6	4.1
27-Apr-2013	Adult	7	65.5	6.3
27-Apr-2013	Adult	7	54.5	6.3
27-Apr-2013	Adult	7	64.2	6.3
27-Apr-2013	Adult	7	62.7	6.3

Table A.1. Continued.

Date	Age	Bird ID	dB	Distance (m)
27-Apr-2013	Adult	7	67.8	3.3
27-Apr-2013	Adult	7	67.0	3.3
27-Apr-2013	Adult	7	67.7	3.3
27-Apr-2013	Adult	7	65.9	3.3
27-Apr-2013	Adult	7	70.1	3.3
27-Apr-2013	Adult	7	67.7	3.3
27-Apr-2013	Adult	7	70.2	3.3
27-Apr-2013	Adult	7	69.6	3.3
27-Apr-2013	Adult	7	71.0	3.3
27-Apr-2013	Adult	7	71.2	3.3
27-Apr-2013	Adult	7	68.1	3.3
27-Apr-2013	Adult	7	68.1	3.3
27-Apr-2013	Adult	7	68.8	3.3
27-Apr-2013	Adult	7	70.5	3.3
27-Apr-2013	Adult	7	65.8	3.3
27-Apr-2013	Adult	7	71.2	3.3
27-Apr-2013	Adult	7	70.6	3.3
27-Apr-2013	Adult	7	68.5	3.3
27-Apr-2013	Adult	7	69.9	3.3

Table A.1. Continued.

Date	Age	Bird ID	dB	Distance (m)
27-Apr-2013	Adult	7	68.9	3.3
27-Apr-2013	Adult	7	67.6	3.3
27-Apr-2013	Adult	7	68.8	3.3
27-Apr-2013	Adult	7	68.7	3.3

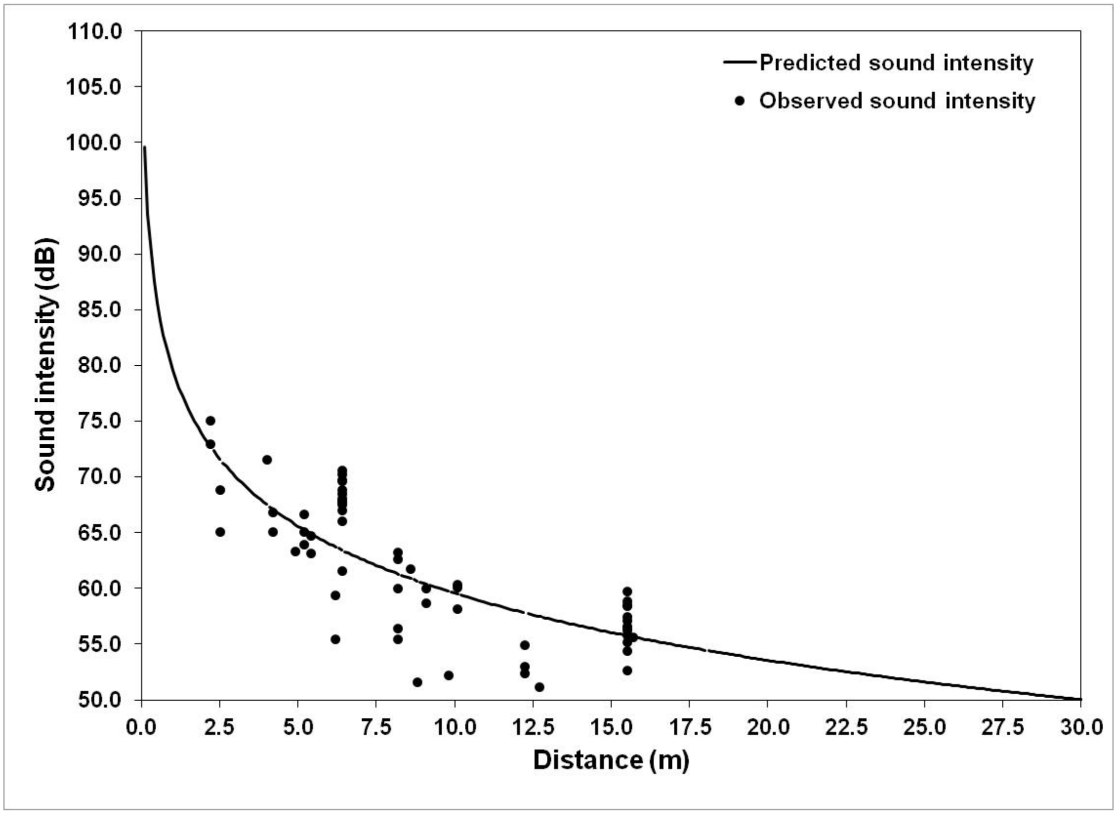

Figure A.1. Predicted and observed sound intensity of the reproductive calls of male ocellated turkeys in Campeche, Mexico, 2013.