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Biology of Tropical Birds

Ocellated Turkey diets and feeding ecology in an agricultural-forest matrix habitat in Campeche, Mexico

Dieta y ecología alimentaria del Pavo Ocelado en un hábitat de matriz agrícola-forestal en Campeche, México

Guillermo E. Castillo-Vela[1], *Jon T. McRoberts*[2] *and Griselda Escalona-Segura*[1]

ABSTRACT. Assessment of diet and feeding habits can provide a greater understand of habitat requirements and conservation needs for target species. One such species that would benefit from an evaluation of feeding ecology is the Ocellated Turkey (*Meleagris ocellata*), a gallinaceous endemic of the Yucatán Peninsula of Mexico and northern Guatemala and Belize. Little is known about the natural history and ecological requirements of this near threatened species, and sound ecological data are necessary to direct conservation and management decisions, especially in altered environments. To address this need, we collected upper digestive tracts of primarily adult male Ocellated Turkeys in agricultural regions of Campeche, Mexico during February–May 2013. We identified food items consumed by Ocellated Turkeys and reported relative importance of food items. We also assessed daily patterns of feeding activity. Seeds contributed most to diets and grain sorghum (*Sorghum bicolor*), maize (*Zea mays*), and soybeans (*Glycine max*) were the most consumed plant species. We also documented 19 native plants consumed by Ocellated Turkeys. No temporal patterns were observed in daily feeding activity by 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.

RESUMEN. La evaluación de la dieta y los hábitos de alimentación, puede proporcionar un entendimiento mayor de los requerimientos de hábitat para especies clave. Una de estas especies que podría beneficiarse de una evaluación de su ecología alimentaria es el Pavo Ocelado (*Meleagris ocellata*), una gallinácea endémica de la península de Yucatán en México y el norte de Guatemala y Belice. Poco se sabe sobre la historia natural y los requerimientos ecológicos de esta especie casi amenazada, y son necesarios datos ecológicos sólidos para dirigir las decisiones de conservación y manejo, especialmente en ambientes alterados. Para abordar esta necesidad, colectamos tractos digestivos superiores, primariamente de adultos machos de Pavos Ocelados, en regiones agrícolas de Campeche, México, durante Febrero-Marzo 2013. Identificamos ítems alimenticios consumidos por los Pavos Ocelados y reportamos la importancia relativa de los ítems alimenticios. También evaluamos los patrones diarios de la actividad de alimentación. Las semillas fueron las que más contribuyeron a las dietas, y los granos de sorgo (*Sorghum bicolor*), maíz (*Zea mays*), y soya (*Glycine max*) fueron las especies de plantas más consumidas. También documentamos 19 plantas nativas consumidas por Pavos Ocelados. No se observaron patrones temporales en la actividad de alimentación diaria por los pavos adultos machos, posiblemente porque la época reproductiva coincidió con el periodo de muestreo y los machos estuvieron ocupados con comportamientos reproductivos. Los resultados indicaron que los Pavos Ocelados se alimentaron en gran medida de fuentes de alimento antropogénicas plantadas en áreas agrícolas y estos hábitats deberían ser considerados cuando se desarrollen planes de manejo y cuando se identifiquen tierras para estrategias de conservación aplicadas.

Key Words: *Campeche; food habits; Ocellated Turkey*

INTRODUCTION

Food habit studies are important in understanding life history needs to direct conservation efforts. An understanding of Wild Turkey (*Meleagris gallopavo*) food habits and dietary needs impacted management strategies during management and restoration of the species in the 20th century (Hurst 1992), and the same would hold true for Ocellated Turkeys (*Meleagris ocellata*). Little is known about the ecology of Ocellated Turkeys in their native range, which includes 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 to reverse localized population reductions (McRoberts et al. 2012).

Feeding habits is a component of Ocellated Turkey life history that could shape conservation efforts. Several observations on Ocellated Turkey diets have been reported (Leopold 1948, Steadman et al. 1979, Sugihara and Heston 1981), including from a subtropical forested environment in Guatemala (Baur 2008), and a study from Mexico (Rivas Romero 2000). However, no substantial analysis has documented the food habits of Ocellated Turkeys in an agricultural landscape, which is a seasonally useful habitat for the species. Forested regions within the range of

[1]Departamento de Conservación de la Biodiversidad, El Colegio de la Frontera Sur, Lerma, Campeche, [2]W. A. Franke College of Forestry and Conservation, University of Montana

Ocellated Turkeys are being converted to agricultural lands (Turner et al. 2001) which may be 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).

Our 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 February–May. We believe our findings can help wildlife managers develop informed conservation strategies for Ocellated Turkeys.

MATERIALS AND METHODS

Study area

We collected Ocellated Turkey diet samples in Carlos Cano Cruz (9600 ha; 19° 22′ 15″ N, 89° 53′ 15″ W) and Las Flores (6174 ha; 19° 13′ 56″ N, 89° 51′ 58″ W) management units for conservation and sustainable use of wildlife (UMAs; from the Spanish language acronym) in the state of Campeche on the western side of Mexico's Yucatán Peninsula (Fig. 1).

Historically, the region was dominated by 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). 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 number of cattle grazing occurred at both study areas. Surface water was limited to cattle stock tanks and a few waterholes, known locally as *aguadas*, which were characteristic of the karst geology of the Yucatán Peninsula. Climate is classified as sub-humid, tropical and a predictable wet season occurs between June–September during which the majority of the ≈1,600 mm annual precipitation is 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).

During our study, active management programs for Ocellated Turkeys were 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 because of reduced subsistence hunting pressure and strategic harvest. A limited amount of sport hunting for male Ocellated Turkeys occurs at both sites.

Sample collection and preparation

We obtained the upper digestive tracts (UDTs; esophagus, 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 outfitters 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, we removed the contents of the UDTs within 90 minutes. We then preserved contents in 70% ethyl alcohol to prevent postmortem digestion (Swanson and Bartonek 1970) and limited our analyses to UDT contents to reduce biases of varied rates of food item digestion, and thus identifiability once items reached the gizzard (Swanson and Bartonek 1970). We transported preserved samples to El Colegio de la Frontera Sur (ECOSUR) in Lerma, Campeche until samples could be further processed.

In the laboratory, we emptied contents of each UDT into a petri dish and allowed contents to dry for 48–72 hr. We then removed all grit from samples and separated food items. We used an electronic Z4 Zoom stereomicroscope (10X to 45X; LW Scientific, Lawrenceville, Georgia, USA) and dichotomous keys to identify plant materials to genus or species level and animal materials to order or class level. We compared samples with images from the National Herbarium of the National Autonomous University of Mexico and the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad to confirm species identification. We classified food items as bulbs, flowers, fruits, leaves, seeds, stems, animal matter, or unknown and weighed the aggregate of these classifications found within a UDT to the nearest gram. We reported aggregate percentage of dry mass for each classification and frequency of occurrence of food item classifications in UDTs. We used a chi-square to test whether the percentage of dry matter of each food item classification differed from those reported from a sub-humid tropical forest (Baur 2008).

Lastly, we 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 we calculated Pearson's correlation coefficients to test for a temporal relationship between daily feeding periods and mass of UDT contents.

RESULTS

We collected UDTs from 71 (68 male and 3 female) Ocellated Turkeys during 18 February–10 May 2013. The UDTs of five turkeys were empty and excluded from aggregate mass and frequency of occurrence calculations, but we included the empty UDTs for temporal feeding pattern analysis. We found no difference between male and female diet composition and acknowledge our low female sample limits inference. Average dry mass of food contents for individual birds was 39.5 g ± 3.9 g (SE) and maximum mass of food contents within a UDT was 104.0 g. We identified 22 plants (Table 1) consumed by Ocellated Turkeys and found that grain sorghum (*Sorghum bicolor*), maize (*Zea mays*), and soybeans (*Glycine max*) contributed most to aggregate dry mass making up 52.4%, 29.9%, and 9.8%, respectively (Table 1). We documented that dry mass of food contents was 79.1% seeds, 7.8% flowers, 5.8% leaves, 4.1% fruits, and the sum of bulbs, stems, animal matter, and unknown plant items was 3.0% (Table 2). We identified nine species of invertebrates in the UDTs of Ocellated Turkeys. However, the nine invertebrate species represented only 20.5% of animal matter dry mass, aggregated across samples, with the remaining 79.4% unidentified. The ability to identify animal matter was hindered by breakdown and nondescript body parts of invertebrates in UDTs.

We found the most frequently occurring food items in UDTs were seeds, flowers/stems, and leaves, which were observed in 81.8%, 57.6%, and 54.6% of samples, respectively (Table 2). We documented animal matter in 30.3% of UDTs and fruits in 21.2% of UDTs, respectively (Table 2). We found no difference in diet classification percentages between our results from an agricultural environment and those collected by Baur (2008) in a sub-humid tropical forest environment ($\chi^2 = 12.5$, $P = 0.99$; Fig. 2).

Fig. 1. Carlos Cano Cruz and Las Flores management units for conservation and sustainable use of wildlife, Campeche, Mexico.

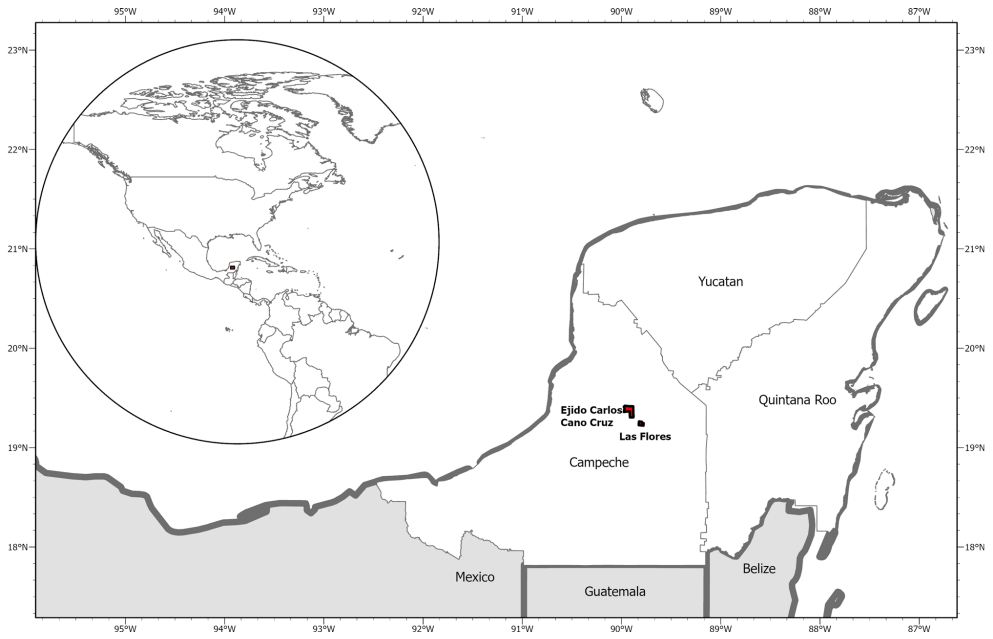


Table 1. Plant material identified in the upper digestive tracts of Ocellated Turkeys (*Meleagris ocellata*) in Campeche, Mexico, February–May 2013 (n = 66).

Food item	Parts consumed[†]	Percentage dry mass (%)
Argemone mexicana (Mexican poppy)	L	0.04
Bidens pilosa (beggar-ticks)	F, S	0.1
Boerhavia erecta (erect spiderling)	F, S	0.2
Brosimum alicastrum (ramon)	S	trace
Bursera spp.	S	trace
Chamaesyce spp.	F, Fr, L, St	0.1
Commelina spp.	L	0.1
Cordia spp.	Fr, L, St	1.3
Digitaria ciliaris (southern crabgrass)	F, L, S, St	0.5
Ficus spp.	Fr	0.5
Gibasis geniculata (bridal veil)	L	0.1
Glycine max (soybean)	F, Fr, L, S	9.8
Ipomoea spp.	F, L	0.8
Leucaena spp.	L	0.0
Lophiaris spp.	B	0.8
Passiflora foetida (wild maracuja)	F, Fr	1.2
Physalis spp.	Fr	0.8
Serjania spp.	F	0.01
Solanum erianthum (nightshade)	F, Fr	0.1
Sorghum bicolor (grain sorghum)	L, S, St	52.4
Tridax procumbens (tridax daisy)	F, L	0.5
Zea mays (maize)	L, S	29.9

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

Thirty-eight UDTs were collected from Ocellated Turkeys harvested in the morning, 13 UDTs were harvested in the afternoon, and harvest time was not known for 20 UDTs. We found a slightly positive relationship between time after sunrise and dry mass of UDT contents (r = 0.30, P = 0.06) and no relationship between time before sunset and UDT contents dry mass (r = 0.27, P = 0.36).

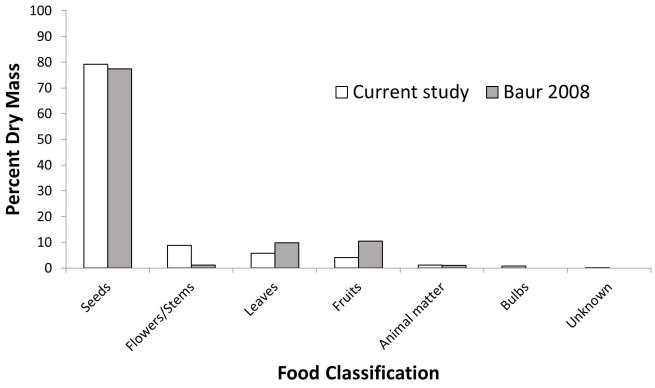
Table 2. Summary of food item classification percent dry mass and percent occurrence in the upper digestive tracts of Ocellated Turkeys (*Meleagris ocellata*) in Campeche, Mexico, February–May 2013 (n = 66).

Food class	Percentage dry mass (%)	Percentage occurrence (%)
Bulbs	0.8	1.5
Flowers/stems	8.8	57.6
Fruits	4.1	21.2
Leaves	5.8	54.5
Seeds	79.2	81.8
Animal matter	1.1	30.3
Unknown	0.2	6.0

DISCUSSION

Ocellated Turkey UDTs (n = 181) from the Maya Biosphere Reserve of northern Guatemala, an environment dominated by subtropical-moist forests, were obtained from subsistence hunters and analyzed (Baur 2008). Dry-mass diet composition for this population was 51.4% seeds, 22.2% grit, 12.1% animal matter, 7.0% pulp, 6.5% leaf, and 0.8% flower/stem (Baur 2008). With grit and snail shell contents removed, percentage-classifications were comparable to our results and adjusted to: 77.4% seeds, 10.5% pulp, 9.8% leaf, 1.2% flower/stem, and 1.1% animal matter (Fig. 2). We 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 our study and the diet composition from a subtropical-moist forest (Baur 2008), it should be noted that plant species diet composition is likely very different between studies. With the exception of

Fig. 2. Dry mass comparison of the diets of Ocellated Turkeys (*Meleagris ocellata*) inhabiting agricultural (n = 66; current study) and forested environments (n = 181; Baur 2008).



identifying fruits of ramon tree (*Brosimum alicastrum*) and *Psuedolmedia* spp., specific food types consumed were not documented by Baur (2008), 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. Ocellated Turkeys have been reported feeding on fruits of zapote trees (*Manilkara zapota*), fruits of nightshades (*Solanum hirtum*), berries of the cohune palm (*Attalea cohune*), and corollas of squash blossoms (Gaumer 1881, Leopold 1959). In Guatemala's Tikal National Park, observations during breeding seasons and winter indicated that Ocellated Turkeys fed on fruits of *Brosimum* spp., *Ficus* spp., and *Chamaedores* spp., leaves of common ragweed (*Ambrosia artemisiifolia*), *Adiantum* spp., *Zebrina* spp., *Vitis* spp., and *Paspalum* spp.; seed heads of *Paspalum conjugatum*; nuts of arecoid palms; and insects including leaf-cutter ants (*Atta cephalotes*), caterpillars, Diptera, moths, and beetles (Steadman et al. 1979, Sugihara and Heston 1981). Items identified in previous studies that we detected include the genera *Brosimum*, *Solanum*, and *Ficus*. Possible differences explaining the incongruence in food items could be seasonal climatic patterns that influence vegetation availability, land-use differences, or geographic range of food items.

Animal matter appeared in 30.3% of UDTs but was only 1.1% of dry mass. Furthermore, some animal matter (i.e., invertebrates) was so small the food item was likely incidentally consumed by Ocellated Turkeys while feeding on other items, thus inflating their frequency of occurrence in UDTs. Other studies also indicate vertebrates make up a small portion of Ocellated Turkey diets (Sugihara and Heston 1981, Rivas Romero 2000, Baur 2008). However, it is important to consider that samples from our 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 our analyses. If future researchers include poult diets in analyses, the importance of animal material will likely change. Captive Ocellated Turkey poults at the San Diego Zoo fed on insects for the first four weeks, eating 6–7 insects 3–4 times per day; at week 5 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 an herbivorous diet (Lint 1977).

Seasonality of our sampling period could also explain the low quantity of animal matter in Ocellated Turkey diets. We sampled during the hottest and driest months in Campeche when invertebrate life is reduced (Pozo et al. 2008, Essens et al. 2014). 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 we sampled during that time period and extended the study to include turkey poults, we would likely have seen more animal matter in diets. Another factor that may have influenced our results was the elapsed time between harvest and preservation of UDTs. We 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 because 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. We observed a similar pattern at Las Flores and Carlos Cano Cruz except we typically did not observe afternoon feedings until after 1600, which could be a product of sampling from a hunted population. We 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. Steadman et al. (1979) and Sugihara and Heston (1981) 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 because males reduce feeding and use 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 research on Ocellated Turkey food habits has been limited to forested environments, which overlooks the growing presence of agricultural lands within the species' range. Small-scale slash-and-burn agricultural practices have been used on the Yucatán Peninsula for thousands of years and the ancient Mayan civilization cultivated a variety of crops (Fedick and Ford 1990, Pohl et al. 1996). 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. 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 may lead to Ocellated Turkey population growth.

Additional analyses are needed to compare diets among seasons and between sexes, a common practice in food habit studies (Wallace et al. 2012). Permitting and logistical limitations prevented us from including females and younger age classes in our analyses and we were 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 we 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 and help determine if agricultural areas were most suitable for Ocellated Turkeys outside of the nesting season and during the dry season when alternative food resources could be limited.

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Data Availability:

Data/code sharing is not applicable to this article because no data/code were analyzed in this study.

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