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Abstract

The isotopic composition (δ^{13}C, δ^{15}N) of bone collagen from Ontario Late Woodland archaeological turkeys was compared with that of modern Ontario wild turkeys, and archaeological turkeys from American Southwestern, Mexican and other Woodland sites to determine whether Late Woodland Ontario peoples managed wild turkeys by provisioning them with maize, the only isotopically distinct horticultural plant at that time. Despite the fact that humans from Late Woodland Western Basin and Iroquoian traditions consumed equal amounts of maize, wild turkeys utilized by the two groups exhibit different diets. Western Basin turkeys reflect a C_3-only diet, whereas Iroquoian turkeys were consuming significant quantities of maize (a C_4 plant). Both groups of archaeological turkey consumed less maize than modern wild turkeys with access to waste left in fields by mechanized agriculture, but because ancient crop yields were much lower, we suggest that Iroquoian turkeys must have been provisioned, probably to create a reliable and nearby hunting niche (Linares 1976). Archaeological and isotopic evidence supports ethnohistoric accounts that turkeys were hunted after the fall harvest. Iroquoian archaeological turkey diets, in general, reflect the seasonal consumption of maize that would have been created by cold weather maize provisioning, with the major exception of one turkey from an Attawandaron (Neutral) site that appears to have been fed maize year round. Motivations for provisioning by Middle Ontario Iroquoian people likely included climate change and ritual/ceremonial activity as well as a reliable food supply. Because Iroquoian women controlled the harvest, it is likely that they were instrumental in altering this human/animal interaction, creating a position on the wild/domesticated continuum that is unique in the North American archaeological literature.

Keywords: wild turkeys, Late Woodland, carbon and nitrogen isotopes

Introduction

Isotopic studies of archaeological fauna in southwestern Ontario, Canada, (Figure 2), were originally conducted primarily to reconstruct food webs for use in interpretation human isotopic data (Katzenberg 1989; Katzenberg 2006; Pfeiffer et al. 2014; van der Merwe et al. 2003). Here we use isotopic zooarchaeology; (1) to enable an understanding of human/animal interactions, especially those related to the wild versus domesticated animal continuum, (2) to infer landscape use/change related to those interactions, and (3) to reconstruct ancient subsistence and hunting strategies and their relationship to cultural ideologies. A widely accepted definition of domestication is the selection of genetic/morphological modifications for human benefit (Bökönyi 1969; Branford Oltenacu 2004; Clutton-Brock 1994; Harris 1996; Ingold 1994). Although this definition enables easier morphological separation of wild and domestic species and examination of how selected changes benefit humans, it leaves little room for understanding other human-animal interactions. For example, management of "wild" populations would not be recognized as domestication, but may still have altered natural distributions and behaviors of a species. Although the dominant definition of domestication is rooted primarily in biology, the range and nature of interactions between humans and animals is of considerable anthropological interest, and may also be part of the domestication process. For example, with or without intent to domesticate, different human behaviours associated with taming, protective herding and free-range management may initiate the process of modification, and change animal behaviors, including adaptation to evolving human landscapes and consumption of waste products discarded by humans (Harris 1996; Ingold 1994; Russell 2012). The limiting dichotomy of wild versus domestic, therefore, has justifiably been challenged by many researchers who advocate a more fluid conceptualization or a continuum of this human-animal relationship (Harris 1996;

Ingold 1994; Russell 2012; Zeuner 1963). We provide evidence here for the usefulness of the continuum approach.

The eastern wild turkey (*Meleagris gallopavo silvestris*, or *M.g. silvestris*) is native to the eastern United States and southeastern Canada (Figure 1) (Eaton 1992; Godfrey 1966; Shorger 1966) but was extirpated from Ontario in the 1800s and only re-introduced to the region in the 1980s (Heckleau et al. 1982; McIlwraith 1886; Weaver 1989). It is highly adaptable to diverse and unstable environments (Weaver 1989), with an equally variable diet that is dominated by hard and soft mast (Eaton 1992; Schorger 1966; Weaver 1989). Maize fields are abundant in southwestern Ontario and preferred locations for wintering (Ellis and Lewis 1967; Leopold 1944; Weaver 1989).

Although wild turkeys have been called crop-pests, they rarely cause crop damage. They are only capable of consuming kernels from cobs already on the ground. Cobs on standing stalks are too high for turkeys to reach in both modern and archaeological varieties of maize from this region (Kuhnlein and Turner 1991; Waugh 1916). Turkeys will scratch at cobs on stalks that have been knocked down by wind, water or other animals, or left in the fields after harvest (Greene et al. 2010; Groepper et al. 2013; Ontario Ministry of Natural Resources 2007; Tefft et al. 2005; Wright et al. 1989). Their presence in fields may actually benefit farmers because insects that damage crops are an important summer food for turkeys, particularly young poults (Groepper et al. 2013; MacGowan et al. 2006; 2008; Wright et al. 1989).

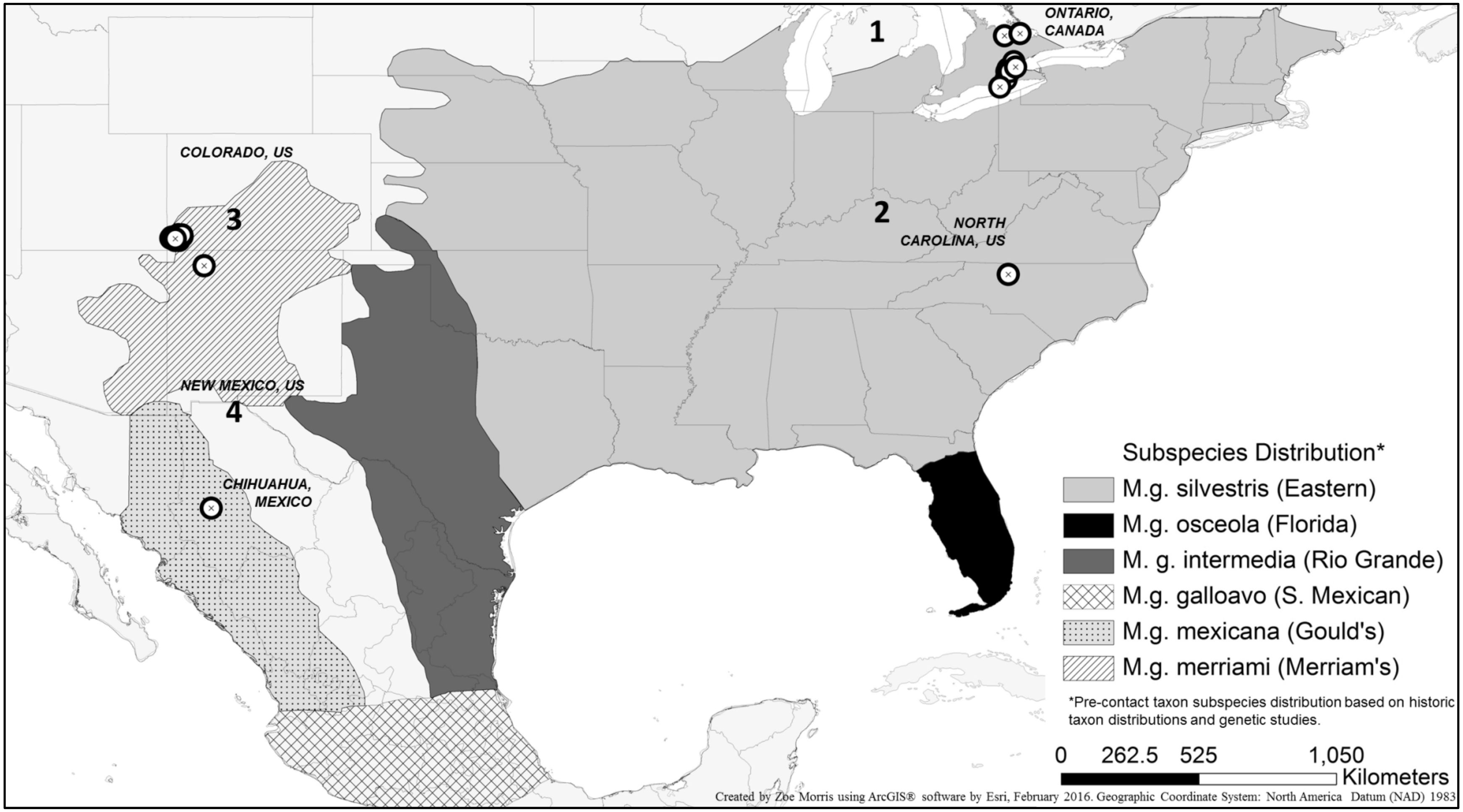

Figure 1: Distribution of wild turkey prior to European contact and site locations discussed in text.

Adapted from Speller et al. (2010: Figure 4) (United States and Central America), Eaton (1992) (Ontario) and Schorger (1966:43, 49) (United States and Canada). Sites with published isotope results discussed in text are marked by circles: (1) Southwestern Ontario (Katzenberg 1989, 2006; Morris 2015), (2) Southeastern United States (Price 2009; Price et al. 2010), (3) Southwestern United States (McCaffery et al. 2014; Rawling and Driver 2010), and (4) north–central Mexico (Webster and Katzenberg 2008).

Wild turkeys exhibit behavioural patterns critical for domestication, including their social nature (flocking behaviour), promiscuous mating system, strong parent-young bonding, high fertility, non-migratory behaviour, low reactivity to humans and environmental change, omnivorous diet and innate adaptability (Breitburg 1993:163, after Hale 1969). The turkey was the only animal domesticated (in the strict sense) in North America prior to European contact (Beachum and Durand 2007; Davis 2001; Dickson 1992; McKusick 1986; Rawlings and Driver 2010). There is evidence of independent turkey domestication events in the American southwest and Mexico (Mock et al. 2002; Speller 2009; Speller et. al. 2010; Thornton et. al. 2012). The reason for turkey domestication is unclear. Ethnohistoric accounts suggest turkeys were domesticated for food (meat, eggs) and feathers (used in ritual) (Breigburg 1993, McKusick 1986; Speller 2009; Thorton et al. 2012). Feasting involving the ritual and practical use of animals has also been suggested as a major motivation for animal domestication (Hayden 2009). The separation of ritual and food uses of turkey may, therefore, be artificial (*e.g.*, Zimmerman-Holt 1996) when trying to understand their domestication.

In this paper, we compare the isotopic compositions of turkeys from a subset of Ontario Late Woodland faunal assemblages with those from modern Ontario wild turkeys and archaeological turkeys from American Southwestern, Mexican and other Woodland sites. This comparison is used to aid interpretation of the faunal record and to determine whether Ontario Late Woodland peoples managed wild turkeys by provisioning them with maize. Because wild turkeys are non–migratory, terrestrial birds that opportunistically forage on available resources (Eaton 1992; Lippold 1974; Schorger 1966), and maize was the only isotopically distinct horticultural plant in Woodland southwestern Ontario, they are an ideal candidate for testing this hypothesis and for use a proxy when reconstructing human subsistence behavior and landscape change. Although there is no evidence of turkey domestication, they might have been managed and/or loosely protected by food baiting, *i.e.*, leaving maize in fields after harvest, a practice used today by hunters/farmers and conservation organizations to aid their survival or re-introduction survival (see for example the New Hampshire Fish and Games and Department of Environmental Conservation 2014, advisory for feeding wild turkey).

Wild turkeys were ubiquitous in Late Woodland faunal assemblages, though their importance in the Western Basin Tradition and (ancestral) Attawandaron (Neutral) sites varies by site and time (Foreman 2011; Prevec and Nobel 1983; Sadler and Savage 2003; Stewart 2000). It is speculated that long-term settlement use and increasing maize dependency over the Late Woodland period (A.D. 900 to 1650) diverted labour previously used for hunting cold weather species (white-tailed deer and wild turkey) resulting in less specialized, more informal faunal procurement (Foreman 2011; Prowse 2008). Although maize became a dietary staple around A.D. 1000 for two neighbouring Great Lakes Woodland groups (Ontario Iroquoian and Western Basin) (Harrison and Katzenberg 2003; Katzenberg et al. 1995; Pfeiffer et al. 2014; Schwarcz et al. 1985; Stothers and Bechtel 1987; van der Merwe et al. 2003; Watts et al. 2011), these groups maintained different subsistence-settlement strategies (Foreman 2011; Murphy and Ferris 1990; Warrick 2000). Sedentism and population growth increased exponentially after A.D. 1000 among the Iroquoian people while Western Basin peoples pursued more varied settlement patterns, often moving in order to exploit seasonal resources.

Isotopic Background

The carbon and nitrogen isotopic compositions of animal tissues reflect those of consumed food. Carbon and nitrogen isotopic compositions are expressed in per mil (‰) units relative to internationally standards (for carbon, VPDB, after the original Pee Dee Belemnite, Coplen 1996, 2011; for nitrogen, AIR, *i.e.*, atmospheric nitrogen, Mariotti 1983) using the standard δ–notation:

$\delta = (R_{sample}/R_{standard}) / R_{standard}$

where $R = {}^{13}C/{}^{12}C$ or ${}^{15}N/{}^{14}N$ (McKinney et al. 1950:730).

Carbon isotope ratios are used to identify the consumption of varying plant types (C_3, C_4 and CAM) based on differences in photosynthetic pathways (DeNiro and Epstein 1978; van der Merwe 1982). The Crassulacean Acid Metabolism (CAM) plant type, which includes cacti and succulents, is not isotopically distinct from C_3 and C_4 plants (van der Merwe 1982), but was not a component of Ontario ecosystems. Globally, the most common plants are C_3. They include most vegetables, fruits, nuts, trees, and temperate grasses, have low $\delta^{13}C$ values (~–34 to –23‰, average –26.5‰) (O'Leary 1988; van der Merwe 1982), and would have dominated Ontario ecosystems before the adoption of maize horticulture (Allegreto 2007; Katzenberg et al. 1995; Schwarcz et al 1985). Along with several other tropical grasses, maize is a C_4 plant that is ^{13}C–rich (~–16 to –9‰, average –12.5‰) relative to C_3 plants (O'Leary 1988; van der Merwe 1982; Tieszen and Fagre 1993). Late Woodland maize has a high mean $\delta^{13}C$ value (–9.1±0.3‰) (Schwarcz et al. 1985). Because C_3 versus C_4 plants have bimodally distributed $\delta^{13}C$ values, isotopic analysis has been useful for tracking the spread of maize into North America (Allegreto 2007; Boyd et al. 2008; Katzenberg et al. 1995; Schoeninger 2009; Schurr and Redmond 1991; van der Merwe 1982; Vogel and van der Merwe 1977), and has been identified archaeologically at southwestern Ontario sites as early as A.D. 200 (Allegreto 2007; Boyd et al. 2008; Cappella 2005; Crawford and Smith 1996; Crawford et al. 1997; 2006; Katzenberg 2006). By A.D. 1200 maize horticulture was practiced extensively across much of the region (Katzenberg 2006; Cappella 2005; Crawford and Smith 1996; Crawford et al. 1997). Isotopic analyses of human remains have provided the most detailed information on the timing of maize introduction and its spread in pre-contact southwestern and central Ontario, and the Western Lake Erie region (Allegretto 2007; Dewar et al. 2010; Katzenberg 1989; 2006; Katzenberg et al. 1995; Schwarcz et al. 1985; van der Merwe et al. 2003; Harrison and Katzenberg 2003; Pfeiffer et al. 2014; Stothers and Bechtel 1987; Watts et al. 2011).

The burning of fossil fuels and deforestation that accelerated since the beginning of the Industrial Revolution has resulted in steadily decreasing δ^{13}C values of atmospheric CO_2 and, therefore, lower δ^{13}C values of modern plants and animals (Friedli et al. 1986; Verburg 2007; Yakir 2011). Thus all δ^{13}C values of modern plants and animals in this study have been corrected by +1.65‰ (Yakir 2011) to enable direct comparison with samples from the Late Woodland or earlier, for which no correction was made.

Nitrogen isotope compositions (δ^{15}N) of animal tissues reflect the source of nitrogen at the base of the food chain and the trophic level of the animal. Typically, δ^{15}N values increase by +3-5‰ with each level in the food chain. Values of δ^{15}N are also used to differentiate terrestrial from marine/aquatic food webs, which have many more trophic levels (Schoeninger et al. 1983; Schoeninger and DeNiro 1984). Plant δ^{15}N values vary with climate (*e.g.*, increase with aridity), soil conditions (*e.g.*, increase with use of organic fertilizers), and means of nitrogen incorporation (*e.g.*, decrease with nitrogen fixation). There has been continuity in soil conditions within the southwestern Ontario region from Late Woodland to modern times (Cormie and Schwarcz 1994) but terrestrial plants in southwestern Ontario nonetheless exhibit a wide range of δ^{15}N values (–9 to +3‰) (Longstaffe, *unpublished data*).

Although modern isotopic research has been conducted for several modern bird species (Kelly 2000 for summary), there are few studies of ancient birds. Contemporary research has focused on metabolic factors (Hobson and Clark 1992a, 1992b), migration (Hobson 1999, 2006; Rubenstein and Hobson 2004), starvation and fasting (Hatch 2012; Hobson et al. 1993; Kempster et al. 2007), diet reconstruction (Mizutani et al. 1992) and seasonality (Stearns 2010). The isotopic composition of any tissue represents diet and drink as well as the time and rate of tissue formation, which is a function of metabolism (Hobson and Clark 1992a; Tieszen et al. 1983). Birds, in general, have higher metabolic rates than land mammals (Hobson and Clark 1992a; Nagy 1987), and those differences are influenced by habitat, dietary niche and body size (Nagy 1987, 2005). Metabolism is not expected to be a major confounding factor in this study, however, as the order to which turkeys belong (Galliformes) has a low metabolic rate compared to other birds (Nagy 2005), and as large terrestrial birds, turkeys have a metabolic rate comparable to equivalent-sized mammals (Lasiewski et al. 1967). Birds also produce uric acid instead of urea, which could also affect tissue-diet isotope fractionation but no such effect has been found for collagen between birds and mammals (Hobson and Clark 1992b).

Materials and Methods

Archaeological samples were selected from a subset of southwestern Ontario faunal collections (Supplementary Table A). Modern wild turkey samples were donated by the Zooarchaeology Laboratory, Western University, as well as by several individuals. Figure 2 shows the locations for the archaeological sites and hunted modern turkeys. Archaeological samples were selected based on their availability within the faunal collection and further vetted for preservation quality using their C/N ratios (see Table 1, Supplementary Tables B). Two techniques were employed to avoid sampling the same individual twice when selecting multiple samples from a single feature: (1) selection of specific elements from the same side (*e.g.*, multiple left ulnas), and (2) selection of bones that varied in size suggesting sex or age differences.

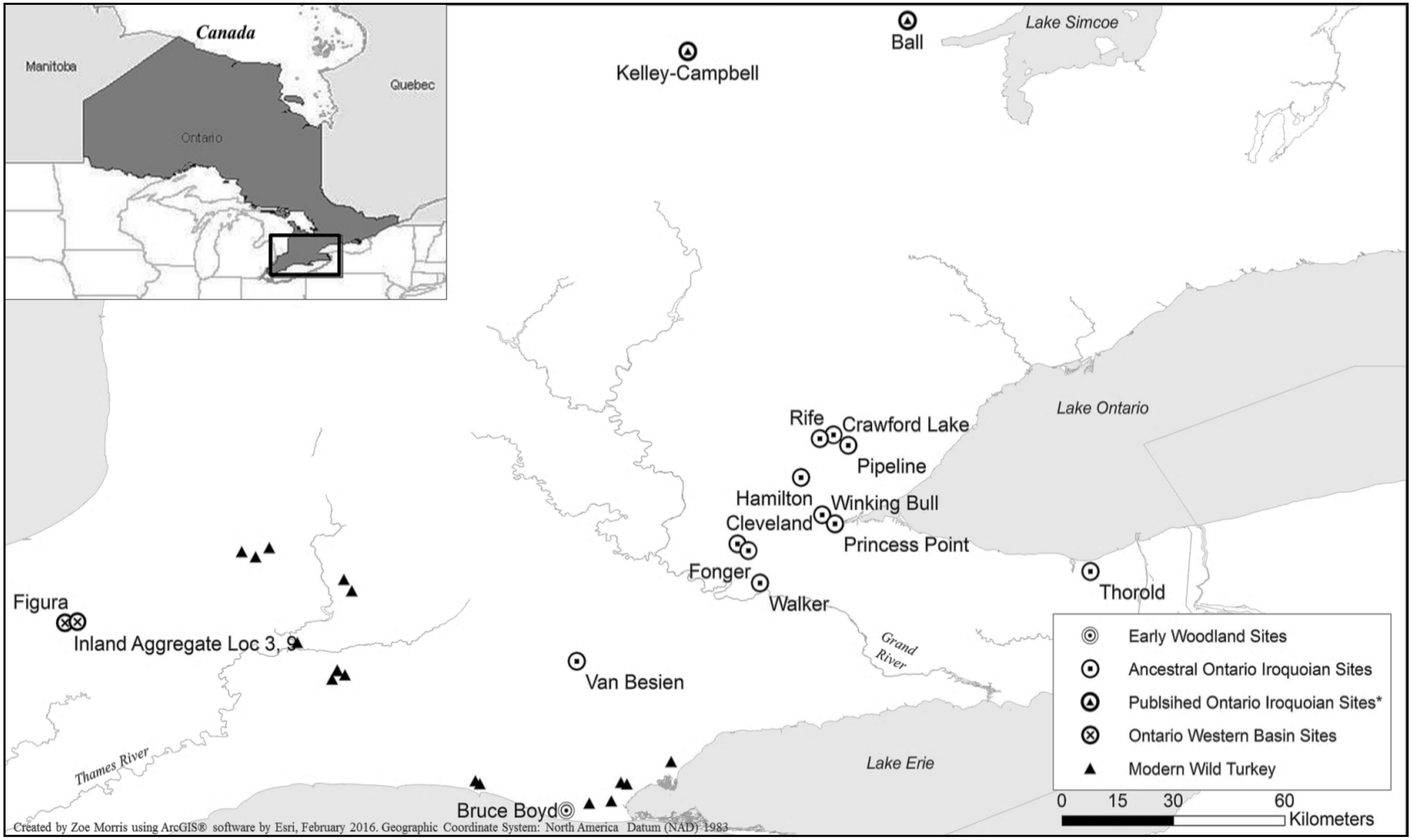

Figure 2: Archaeological sites sampled for this study and modern wild turkey retrieval locations.

*Published wild turkey data from Kelley-Campbell and Ball Katzenberg 1989.

Table 1: Summary of turkeys analyzed for this study.

	Early Woodland	Ontario Iroquoian A.D. 900–1650	Western Basin A.D. 900–1550	Modern Wild Turkey
Number of Sites	1	10	3	6
Adult	2	34	15	18
Juvenile	0	10	0	1
TOTAL	2	44	15	19

Wild turkeys are sexually dimorphic, males being larger than females. All fleshed modern turkeys were visibly adult males, but sex identification of the archaeological remains (Supplementary Table B) was based on presence/absence of the tarsometarsal spur (a male trait) and occasionally, distal coracoid breadth (Gilbert et al. 1996). Spur as well as beard presence and length enabled age determinations for the modern turkeys (Dickson 1992; Schroger 1966). Modern turkeys were all adults (1-5 years) but the archaeological samples included several juveniles (3-5 months, after McKusick's [1986] criteria). Today, wild Ontario turkeys begin nesting as early as late April and into May with an incubation period of approximately thirty days. If early nests are destroyed more eggs may be laid (Weaver 1989). The majority of juvenile turkeys were, therefore, likely killed in the fall/winter, between late September and January (also see Lennox 1977).

Most turkey bones were recovered from middens in permanent villages of varying sizes. Exceptions were: (1) the turkey that was part of a spring-hunted animal grouping placed in a human burial at the Bruce Boyd site (ca. 700–400 B.C.) (Spence et al. 1978), (2) a possible purposeful burial at Crawford Lake (A.D. 1435–1459), (3) a turkey from a winter house at the Walker village (A.D. 1640), and (4) multiple individuals that might indicate consumption or disposal in a single fall/winter event at the Crawford Lake (A.D. 1435 to 1459) and Hamilton (A.D. 1638–1651) sites.

Extraction of collagen from bone samples followed Szpak et al. (2009) and included procedures to remove lipids, humic substances and inorganic material. Excellent preservation of collagen from the archaeological turkey samples was indicated by C/N ratios (3.21±0.16, range 3.03 to 3.44) and collagen yields (14.6±6.5%, range 5.6 to 25.2%) that lie within the ranges typically accepted for isotopically unaltered collagen (DeNiro 1985; Van Klinken 1999).

Carbon and nitrogen isotope analyses of collagen ($\delta^{13}C_{col}$, $\delta^{15}N_{col}$) were obtained using a Costech Elemental Combustion System (ECS 4010) coupled to a Delta V Plus isotope ratio mass spectrometer. Calibration to VPDB and AIR was performed using USGS40 and USGS41 as anchors of the calibration curve, as described by Qi et al. (2003). Duplicate collagen extractions of 10% of samples yielded a mean reproducibility of ± 0.06‰ for $\delta^{13}C_{col}$ and ± 0.11‰ for $\delta^{15}N_{col}$. Duplicate analyses of the same collagen aliquot had a precision of ±0.03‰ for $\delta^{13}C_{col}$ and ±0.05‰ for $\delta^{15}N_{col}$. Standard keratin (MP Biomedicals Inc., Cat. No. 90211, Lot No. 9966H) was measured every five samples. Its $\delta^{13}C$ (–24.08±0.08‰; n=86) and $\delta^{15}N$ (+6.31±0.15‰; (n=80) compared well with accepted values ($\delta^{13}C$ = –24.04‰; $\delta^{15}N$ = +6.36‰).

Results and Discussion

Archaeological Wild Turkey $\delta^{13}C_{col}$ and $\delta^{15}N_{col}$ Values

Table 2 and Figure 3 summarize the isotopic results for all turkeys analyzed in this study (see Supplementary Tables B and C for individual data). A Mann–Whitney U comparison of adult and juvenile Ontario Iroquoian turkeys showed no significant difference in their $\delta^{13}C_{col}$ and $\delta^{15}N_{col}$ values, despite slightly higher $\delta^{13}C_{col}$ values for juvenile turkeys. These data suggest that either there is no difference in the diet of adult and juvenile wild turkeys, or consumption of large quantities of insects, expected for juvenile turkeys, does not significantly alter the carbon isotopic composition of collagen. The discussion examines juvenile wild turkeys separately because of seasonal hunting implications. Statistically, however, juveniles were pooled with adult wild turkeys for comparison with modern turkeys and other archaeological turkey groups. No juvenile Western Basin turkeys were available for comparative analysis.

Modern turkeys (n=19) had significantly higher $\delta^{13}C_{col}$ values than archaeological turkeys (n=61), (Mann–Whitney U, Z=–2.730, p<0.000 and Z=–2.378, p=0.017, respectively). Modern wild turkeys also had significantly lower $\delta^{15}N_{col}$ values (Mann–Whitney U, Z=–2.511, p=0.012).

Mann Whitney-U tests indicated that there were significant differences among the $\delta^{13}C_{col}$ values of archaeological turkeys. Ontario Iroquoian turkeys have significantly higher values than Western Basin turkeys (n=15) whether analyzed as adults only (n=34, Z=-3.905, p=0.000) or grouping the juveniles with the adults (n=44, Z-4.126, p=0.000), but not the two Early Woodland turkeys analyzed from the Bruce Boyd site (700 – 900 B.C.). There was no significant difference in $\delta^{15}N_{col}$ values among the archaeological turkeys. For the archaeological turkeys, the $\delta^{13}C_{col}$ and $\delta^{15}N_{col}$ values correlated significantly (Pearson's R=0.295, p=0.021).

Table 2: Summary of collagen ($\delta^{13}C_{col,}$ $\delta^{15}N_{col}$) results.

	n	**$\delta^{13}C_{col}$ (‰, VPDB) (Range)**	**$\delta^{15}N_{col}$ (‰, AIR) (Range)**
Early Woodland 700 to 900 B.C	2	–20.8±0.2 (–20.9 to –20.7)	+5.4±0.2 (+5.3 to +5.5)
Ontario Iroquoian (Adult) A.D. 900–1650	34	–20.5±2.5 (–23.0 to –10.0)	+6.2±0.8 (4.4 to +8.5)
Ontario Iroquoian (Juvenile) A.D. 900–1650	10	–19.7±2.0 (–22.80 to –17.1)	+6.2±0.8 (+4.9 to +7.3)
Western Basin (Adult) A.D. 900–1550	15	–22.4±1.0 (–23.7 to –20.2)	+6.5±1.0 (+4.7 to 8.5)
Modern Wild Turkey	19	–16 ±1.7 (–19.1 to –12.4)	+5.5±1.0 (+4.4 to +7.6)

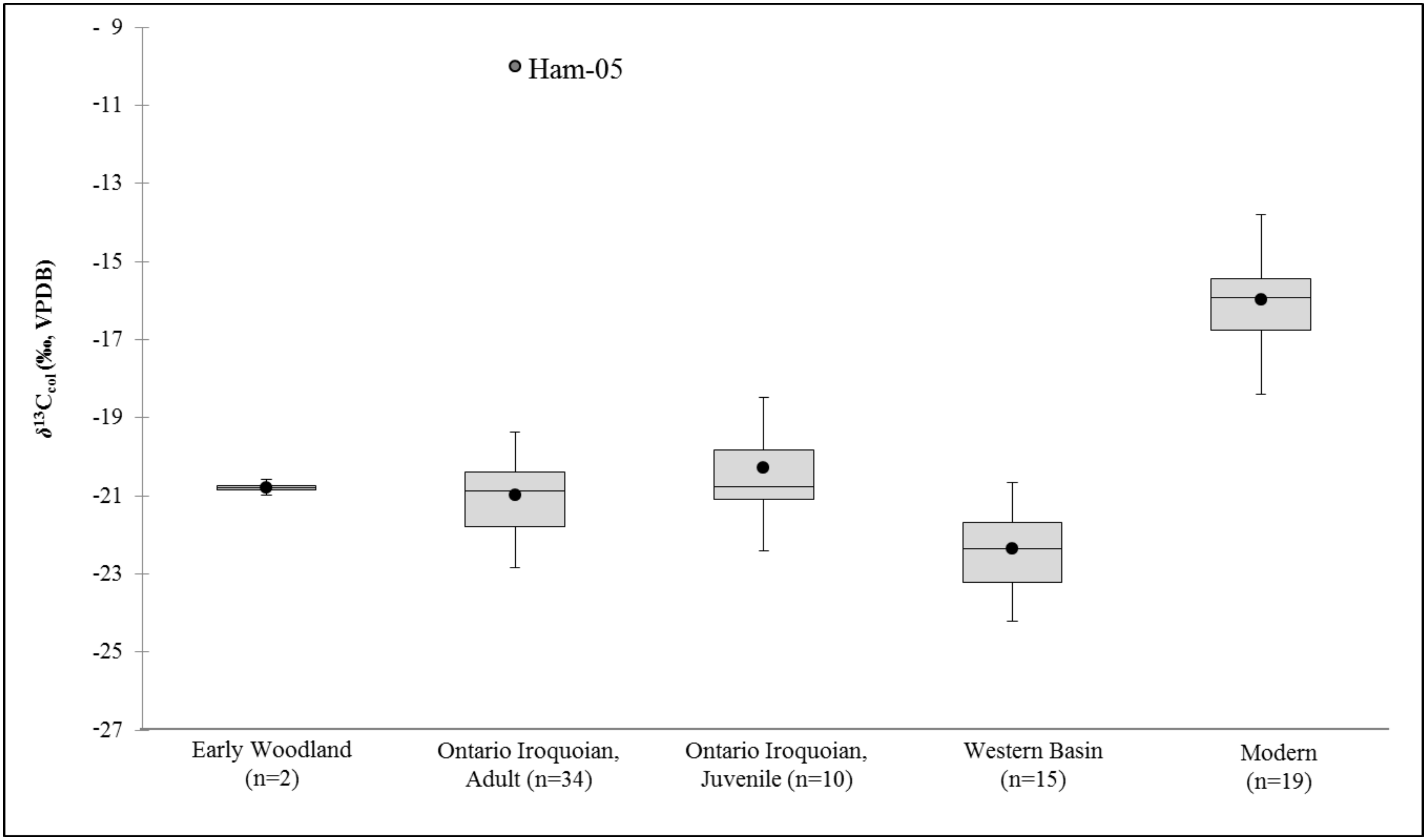

Figure 3: Box-and-whisker plot of $\delta^{13}C_{col}$ values for all samples in this study. Gray boxes are one standard deviation about the mean (black circles). Whiskers represent a quartile. See Supplementary Tables B and C for complete data set.

Adult and Juvenile Archaeological Wild Turkey Isotopic Composition Comparison

Although the diet of Ontario Iroquoian turkeys was primarily composed of C_3 foods, some consumed C_4 foods (Figure 3), which is consistent with evidence for other C_4 resource-consuming species in Late Woodland southwestern Ontario (Katzenberg 1989, 2006; Morris 2015). The isotopic compositions of modern and archaeological turkeys clearly overlap (Figure 4). There was sporadic, or perhaps seasonal, maize consumption by adult and juvenile wild turkeys at many of the Middle Ontario Iroquoian and Attawandaron sites.

Table 3: Summary of $\delta^{13}C_{col}$ data by cultural time period. All sites listed are located on Figure 2.

Time Period	n	$\delta^{13}C_{col}$ (‰, VPDB)	Sites Included
Early Woodland	2	-20.8±0.2	Bruce Boyd
Princess Point/Early Ontario Iroquoian	4	-20.5±1.4	Princess Point, Van Besien
Middle Ontario Iroquoian	22	-20.3±1.4	Crawford, Pipeline, Rife, Winking Bull
(Ancestral) Attawandaron/Neutral	20	-20.3±3.0	Ball*, Cleveland, Fonger, Hamilton, Kelley-Campbell*, Thorold, Walker
Western Basin Younge Phase	15	-22.3±1.0	Figura, Inland West Aggregate Locations 3 and 9

**Katzenberg 1989: Table 3*

A juvenile turkey (Pri–07) at the relatively early Princess Point site (~A.D. 500–1000) shows significant maize consumption ($\delta^{13}C_{col}$ = –18.3‰) as do both juvenile and adult birds at the Middle Ontario Iroquoian sites (A.D. 1200 to 1450) of Crawford Lake, Pipeline, Rife and Winking Bull ($\delta^{13}C_{col}$ > –21.0‰). This trend continues at Attawandaron sites (A.D. 1450 to 1650) such as Hamilton and Walker, as well as Ball and Kelley–Campbell (Katzenberg 1989; 2006) but is not spatially consistent (Table 3). For example, there is no *definitive* maize consumption at the Early Ontario Iroquoian site (~A.D. 900) of Van Besien or at the Attawandaron sites of Cleveland, Thorold, and Fonger. To determine whether maize may have been consumed only seasonally, the juvenile turkeys were examined in more detail along with the ethnohistoric and zooarchaeological literature.

The average age-at-death for poults in this study is between three to five months, based on a late spring hatching (Table 4). Of the ten juvenile turkeys identified, eight have $\delta^{13}C_{col}$ values indicative of C_4 resource consumption. As all the juvenile turkeys were less than one year of age at death, their carbon isotopic composition only reflects a single maize-harvest season. Their presence in faunal assemblages supports the interpretation of a fall turkey hunt (Foreman 2011; Prevec and Noble 1983). While ethnohistoric documents also describe their winter consumption (Denke 1804; Thwaites 1896–1901 vols. 32; 59; 60), these juveniles, from five different Ontario Iroquoian sites, are indicative of hunting during harvest (*i.e.*, September through October).

Table 4: Summary of the juvenile turkey's carbon and nitrogen isotopic composition, age at death [based on McKusick's Age Categories (1986:19-29)] and estimated season of death.

Sample Name	$\delta^{13}C_{col}$ (‰, VPDB)	$\delta^{15N}{}_{col}$ (‰, AIR)	Approximate Age at Death*	Estimated Season of Death*
Clv-033	-20.8	+6.3	3 to 5 months	Early to Mid Fall
Crf-046	-18.5	+6.6	3 to 5 months	Early to Mid Fall
Crf-047	-17.5	+7.3	3 to 5 months	Early to Mid Fall
Ham-08	-17.1	+6.8	3 to 5 months	Early to Mid Fall
Ham-10	-22.8	+4.9	3 to 5 months	Early to Mid Fall
Ham-11	-19.1	+5.6	3 to 5 months	Early to Mid Fall
Pip(2)-070	-20.1	+6.9	2 to 3 months	Late Summer
Pri-007	-18.31	+5.2	n/a	n/a
Rif-062	-20.61	+7.1	3 to 5 months	Early to Mid Fall
Rif-080	-22.31	+6.8	6 to 10 months	Winter to Early Spring

**Based May/June Hatching*

Turkey hunting in the northeast, today and in the past, appears to have been restricted to cooler months (September through March), likely because summer turkeys are low weight and tick-infested (Foreman 2011; Lippold 1974; McIlhenny 1914; Schorger 1966). Because juvenile birds were found at sites dating from Princess Point through Middle Ontario Iroquoian and Attawandaron stages, fall turkey hunting was likely continuous throughout the Late Woodland period. Except in rare cases [*e.g.*, Wal–50 from a winter house at Walker village (Wright 1981)], it has not been possible to provide a season-of-death for the adult remains. The ability to correlate seasonal turkey hunting with higher $\delta^{13}C_{col}$ values (*i.e.*, maize consumption) in juveniles younger than one year old is therefore an exciting find. This observation suggests that a connection was made by these ancient hunters to hunt turkeys that were accessing maize. The hunting of turkeys in fields, a form of garden hunting (Linares 1976), may have been incidental to the primary task of harvesting maize. While it is not possible to conclude all turkeys were hunted in or near maize fields, the juvenile data is highly suggestive that at least some were.

Modern and Archaeological Turkey Dietary Niches

The $\delta^{13}C_{col}$ and $\delta^{15}N_{col}$ values of Ontario Late Woodland Iroquoian turkeys are best understood within the context of modern wild turkeys and other archaeological wild and domestic turkeys (Figure 4). At least three different dietary niches (Figure 4) are identifiable: (1) a C_3-only environment *i.e.*, all $\delta^{13}C_{col}$ values < –21.0‰, 95%), (2) a C_3–environment with occasional or seasonal C_4 (*i.e.*, maize) access and (3) consistent maize provisioning, *i.e.*, $\delta^{13}C_{col}$ values > –12.0‰, suggesting purposeful feeding of captive and/or free–ranging birds). These dietary niches are statistically distinct based on a Kruskal-Wallis H (Chi-Square) test for both $\delta^{13}C_{col}$ (Chi=144.014, df=3, p<0.000) and $\delta^{15}N_{col}$ values (Chi=46.792, df=3, p<0.000). Further, Mann Whitney U tests confirmed that the turkeys from Ontario Iroquoian sites form a unique dietary niche, distinct from the C_3-only diets of turkeys from Donnaha and Western Basin sites (Mann–Whitney U, Z=–4.307, p<0.000) as well as the domesticated turkeys from the southwest United States and Mexico ((Mann–Whitney U, Z=–9.177, p<0.000).

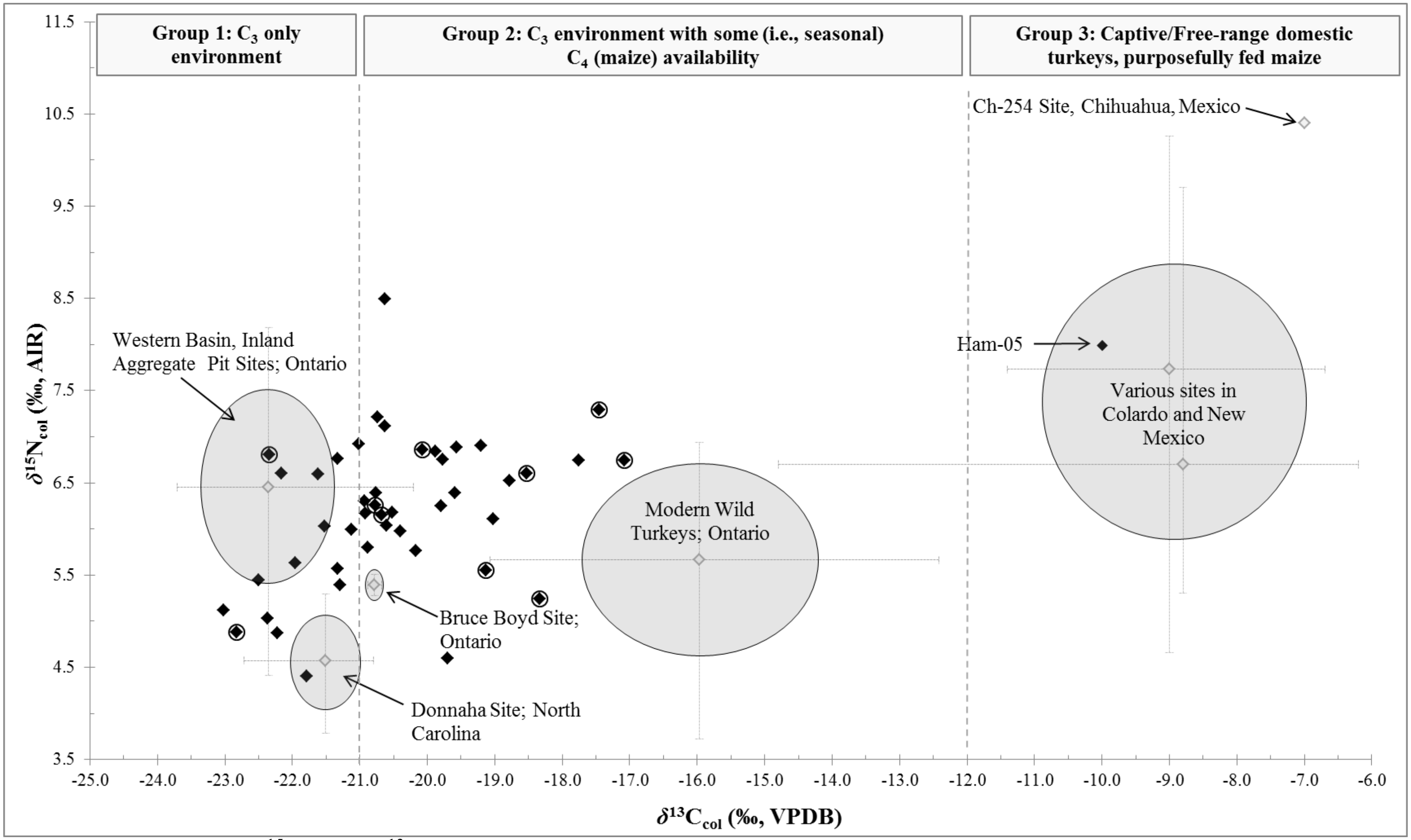

Figure 4: Comparative $\delta^{15}N_{col}$ and $\delta^{13}C_{col}$ values for archaeological turkeys from several regions of North America. Individual turkeys from Ontario Iroquoian sites are represented by black diamonds; circled black diamonds represent juveniles. All other data are shown as grey diamonds (mean), standard deviation (surrounding circle) and range (error bars). Published Data Sources: Western Basin Inland Aggregate Pit sites, Ontario (this study); Donnaha Site, North Carolina (Price 2009; Price et al. 2010); various sites in Colorado (Rawlings and Driver 2010) and New Mexico (McCaffrey 2014); Mexico (Webster and Katzenberg 2008).

An entirely C_3-based diet is evident for turkeys from Donnaha (southeastern United States) and Western Basin (western Ontario) sites. Donnaha, North Carolina, (A.D. 1000 to 1450) was a village that was occupied year-round with a mixed subsistence economy anchored variably to maize throughout its occupation (Lambert 2000; Woodall 1984). The turkeys there, however, do not appear to have had access to maize or any other C_4 foods (Price 2009; Price et al. 2010). Their $\delta^{15}N_{col}$ values are also significantly lower than those of the Ontario turkeys (Mann Whitney U -3.144, p=0.002), possibly indicating different soil conditions or plant access.

The Western Basin Tradition Inland Aggregate Pit sites include a group of consecutively occupied villages dating to the late Younge Phase (A.D. 1050 to 1270). In spite of the presence of charred maize remains and a maize storage pit system (Golder and Associates 2012), and isotopic data indicating maize consumption for humans (–12.5‰, n=1, Spence et al. 2014), dogs (–14.9±1.8‰, n=16, Morris 2015) and raccoons (–20.7±0.5‰, n=12, Morris 2015), turkeys there did not consume maize. In fact, their carbon isotopic compositions are lower than those of the Early Woodland Bruce Boyd (700 to 900B.C.) and Princess Point (~A.D. 500 –1000) sites, and the Early Ontario Iroquoian site of Van Besien (A.D. 920). There are several possible reasons for this difference: (1) maize fields might have differed spatially in the landscape compared to the Ontario Iroquoian sites; (2) harvesting techniques may have left minimal maize behind; and/or (3) Western Basin peoples at these sites may have used different turkey hunting strategies *e.g.*, maize production and turkey hunting may have been geographically separate activities. For example, the lack of recovery of juvenile remains at these sites may reflect different garden hunting practices or Western Basin people may not have garden hunted turkey; instead turkeys may have been pursued only as a primary hunting activity. Though, it should be noted, the lack of juvenile bones could also be a result of differential preservation between adult and juvenile remains. It is also possible that Ontario Iroquoian peoples used dried maize, stored in villages, to attract turkey and other cold weather species to fields post-harvest, something that may not have been practiced at the Inland Aggregate sites.

By contrast, modern wild turkeys live in a C_3 environment but they all consume C_4 foods, probably agricultural maize waste. Their lower $\delta^{15}N_{col}$ values corroborates this assumption, as increased use of inorganic fertilizers and/or access to agricultural legumes should produce lower $\delta^{15}N_{col}$ values similar to those recorded for modern deer from the region (Cormie and Schwarcz 1994; Morris 2015). Maize-consuming insects may also be an alternative C_4 resource. However, while modern grasshoppers and crickets from southwestern Ontario have $\delta^{15}N$ values similar to regional plants, including maize, their $\delta^{13}C$ values indicate they are not a C_4 resource during the spring/early summer months, when the turkeys would prey upon them (Morris 2015). These results suggest that modern Ontario turkeys will eat maize if available. Despite the fact that they can only eat waste maize on the ground, the quantity is sufficient to alter their collagen carbon isotopic composition significantly. This finding is consistent with Groepper et al.'s (2013) and Tefft et al.'s (2005) findings that maize can constitute up to 35% of total turkey diet in areas of maize agriculture.

Modern southwestern Ontario agricultural data can provide a useful analog for understanding the relationship between maize waste in fields and agricultural intensity. The significance of maize crops in southwestern Ontario counties and the high rates of waste created by wind and precipitation and combine harvesting (Ontario Ministry of Agriculture, Food, and Rural Affairs, 2012; Sumner and Williams 2012; William 2008) indicate that there is a rich, post-harvest C_4 food source for modern wild turkeys that could provide an overwintering food supply. The amount of waste maize in today's fields is suggested to exceed the total production of ancient

Attawandaron fields (A.D. 1450 to 1650) fields (Sykes 1981, adapted from Heidenreich 1971:191). Although the amount of maize needed to sustain a healthy wild turkey has not been accurately determined, it would not come close to the amount left in fields today even if ancient humans left a large amount of maize behind after harvesting (unlikely, as hand-harvesting would leave less waste).

The mixed C_3/C_4 diet of modern turkeys overlaps with that of several archaeological turkeys (n=12) from sites north of the Grand River and west of Lake Ontario in central southwestern Ontario (Figure 2), as well as the two sites to the north analyzed by Katzenberg (1989; 2006). The dietary specialization of these ancient birds indicates a human/animal interaction wherein: (1) the landscape was altered by domestic crops, (2) humans accidently or purposefully left behind some of their domestic produce (maize) in the fields, or stored, dried maize was purposely put out creating a niche that will attract turkeys, and (3) humans then used this niche for hunting them. A similar case is made for turkeys examined by Emery and Speller (this issue) from the Maya region, where two distinct grouping of turkeys are visible, including captive *M. Gallopavo* turkeys and wild Ocellated Turkeys. The Occellated Turkeys have a similar range of $\delta^{13}C_{col}$ values (Emery and Speller; this volume) and may have utilized the agricultural fields or "maize bait" provisioned by ancient Maya hunters.

In the case of modern Ontario turkeys, maize waste may be accidental but modern hunters know that agricultural fields attract turkeys and will often hunt them near field edges. Turkeys would be most expected in maize fields during and/or harvest, and there is supporting osteological (juvenile skeletal remains with age-at-death estimates), contextual (winter house middens), zooarchaeological (Foreman 2011; Prevec and Noble 1983), and ethnohistoric (Thwaites 1896–1901) evidence of cool-weather turkey hunting.

Whether or not Ontario Late Woodland Iroquoian peoples purposefully or accidentally created this C_3/C_4 niche is a key question. In the fall, turkeys will gorge on readily available foods to fatten for the winter. While they vary their food resources seasonally, they often use the same routes to access food, which makes them vulnerable to predators, including human hunters (Schorger 1966). According to the Jesuit Relations, they were even known to venture near human settlement to find food during winter scarcity (Thwaites 1896–1901 vol. 59). The number of archaeological turkeys exhibiting high $\delta^{13}C$ values suggests access to relatively large quantities of maize. It is unlikely that accidental maize waste would provide sufficient resources for these birds to alter their bone collagen values; therefore Ontario Iroquoian peoples may have purposefully left some maize in fields after harvest, creating a cold-weather feeding space for several species, including wild turkeys. The lack of evidence for turkeys consuming maize at some coeval Ontario Iroquoian and Western Basin sites is, in itself, strong indirect support for the hypothesis that maize waste at certain sites was purposeful (Table 3). Further testing of wild turkeys from more sites across the region, including a larger number of earlier sites, would help determine whether the pattern is site specific, or whether maize access by wild turkeys represents a temporal or regional pattern. Future work could draw on previous research using laser ablation of individual osteons done from deer bone (Brady et al. 2008) as a means to better correlate C_4 resource access and seasonality.

Provision of food security for wild turkeys is found in modern contexts (New Hampshire Fish and Games and Department of Environmental Conservation 2014), and it would not be surprising if the ancient peoples of Ontario did the same thing. What might have begun as an observation of turkeys preferentially selecting maize fields for feeding during fall and winter may have shifted to provisioning them to secure a reliable hunting ground. More data from other regions of southwestern Ontario, however, are needed to determine whether turkey provisioning was limited geographically to central southwestern Ontario.

Garden Hunting and Women's Work

The practice of provisioning may have been related to gendered behavior. Tending fields and harvesting was considered women's work among the Iroquoian-speaking nations (Heidenreich 1971; Thwaites 1896–1901 vol. 65; Tooker 1991; Wrong 1939). Carr (1883:36) recounted the words of Arthur C. Parker, an Iroquois general, describing the Six Nations Iroquois:

"Among all the Indian tribes, especially the more powerful ones, the principle that a man should not demean himself or mar his dignity by cultivating the soil or gathering its product was most strongly inculcated and enforced. It was taught that a man's province was war, hunting, and fishing. While the pursuit of agriculture, in any of its branches, was by no means prohibited, yet, when any man, excepting the cripples, old men, and those disabled in war or hunting, chose to till the earth, he was at once ostracized from men's society, classed as a woman or squaw, and was disqualified from sitting or speaking in the councils of his people until he had redeemed himself by becoming a skillful warrior or a successful hunter."

As women were primarily responsible for harvesting crops, it may also have been the women, and perhaps elderly men, who created a garden hunting niche by leaving maize behind in fields. A shift to opportunistic, turkey hunting closer to fields and villages around A.D. 1200 is also suggested by the combined evidence of reduced numbers of turkeys in faunal assemblages of middens at many village sites, attributed as shift away from active turkey, and other cool weather species, hunting (Campbell and Campbell 1989; Foreman 2011; Prevec and Noble 1983; Stewart 2000) and their greater consumption of maize. Prior to A.D. 1200, turkeys may have been actively hunted in the forest by men (Dickson 1992; Engelbrecht 2003) but after that time, turkey acquisition may have been managed by women.

Wild Turkey Provisioning: Proto-domestication or Hunting Strategy?

Motivations for the shift to purposeful provisioning may have been multifactorial. The Middle Ontario phase coincides with climate change in which the Medieval Warm Period (MWP, ~A.D. 800 to 1200) was followed by cooling associated with the Little Ice Age (LIA, ~A.D. 1450 to 1800). These major climatic events would have caused a shorter growing season around the beginning of the Attawandaron phase (Bernabo 1981; Campbell and Campbell 1989; Dean 1994:7; Foster 2012; Gajewski 1988; Mullins et al. 2011; Viau et al. 2012). Variation in $\delta^{13}C$ values of Attawandaron turkeys could reflect site-specific cost-benefit decisions between needs for carbohydrates (complete maize harvesting) and protein (predictable and low energy expenditure hunting of provisioned turkeys). Nonetheless, it appears that site- and/or region-specific food provisioning of wild turkeys by Ontario Iroquoian peoples during the Late Woodland was a unique activity in North America.

Because the Middle Ontario Iroquoian phase was a time of considerable ceremonial activity (Wright 2004), the emphasis on a predictable turkey source may not have been for meat, but for feathers, which were an important component of medicine bundles, and ritual headdresses and cloaks (Olsen 1998). Researchers in the southwest and Central America have hypothesized that the ceremonial uses of turkeys led to their domestication (Breitburg 1993).

Evidence of ritually used turkeys in this study begins at the Early Woodland component (700 - 400 B.C.) of the Bruce Boyd site where turkeys from the human burial feature (Spence et al. 1978; M. Spence, *personal communications*) have unexpectedly high $\delta^{13}C_{col}$ values (mean = –20.8±0.2‰) and slightly lower than expected $\delta^{15}N_{col}$ values (mean = +5.4±0.2‰). This unusual result could be explained by a much earlier entry of maize into Ontario than was previously known or consumption of an alternate C_4 resource (*e.g.*, amaranth), but most likely reflects trade with New York or Ohio where maize was cultivated much earlier (Allegreto 2007; Capella 2005; Crawford et al. 2006; Martin 2004). Trading of turkey wings as medicinal objects, is recorded in the Jesuit Relations; *"[*Saossarinon*, a healer] taught the secrets of his art and communicated his power,—as a token of which he left them each a Turkey's wing, adding that henceforth their dreams would prove true.*" (Thwaites 1896–1901 vol. 13).

Faunal deposits characteristic of feasting events and ceremonial animal use (Hayden 2009) include burials of large numbers of birds together at the Crawford Lake and Hamilton sites, including juvenile birds estimated to be three to five months at death (Morris 2015). The combined evidence of fall turkey hunting with simultaneous disposal of multiple birds strongly suggests cool-weather feasting activity (see Hayden 1996), such as thanksgiving ceremonies (held after the harvest [Heidenreich 1971]), the White Dog Ceremony (held in mid–winter [Oberholtzer 2002]) or other cool-weather feasts (Fenton 1953). The ideological role and categorization of turkeys is important for understanding their relationship with Woodland peoples. Despite their use as food, medicine, clothing, and in ritual, wild turkeys are rarely mentioned in Great Lakes stories, mythologies or clan names. Although turkey parts may have been important, the bird might not have shared the cosmological associations of species more frequently referenced in Great Lakes mythology (*i.e.*, wolves, bears, foxes, eagles and beavers) and depicted on effigy pipes (owls, crows, ravens, ducks and eagles) (Mathews 1980; Noble 1979; Wonderley 2005). Turkeys might also have been categorized differently than the more frequently depicted aquatic and predatory bird species, particularly owls, in art and myth [(*e.g.*, Ontario pipe effigies (Mathews 1980)].

The question remains whether maize provisioning was a form of proto–domestication or simply a convenient hunting strategy for Late Woodland Ontario Iroquoian peoples. Domestic turkeys would be fully provisioned with maize year round, resulting in significantly higher mean $\delta^{13}C_{col}$ values, as seen at sites from southwestern United States, Mexico and the Maya region (McCaffrey 2014; Rawlings and Driver 2010; Emery and Speller this volume; Conrad; this volume). Only one of the Ontario Iroquoian turkeys (Hamilton site, Ham-05) shows this pattern. Ham-05 was recovered from a midden within the village, as opposed to the other Hamilton site turkeys, which were recovered from middens found outside the village (Lennox 1977). Because it must have been kept in captivity, this bird may have been raised for food or ritual purposes, or kept as a pet, a practice that has been recognized in ethnohistoric accounts of the Attawandaron (Galton 1865; Wrong 1939). The close relationship between humans and turkeys implied by the purposeful feeding of a captive bird may mark a phase of raising turkeys within the village walls, which comes close to domestication. It remains early in our investigation of the relationship between humans and turkeys. Nonetheless, these initial suggestions that wild turkeys were used for both feasting and ceremony at some Ontario Iroquoian sites may be evidence for a continuum to domestication. Although there is not enough evidence to support a hypothesis of proto-domestication, it is clear that there was a unique relationship between turkeys and humans at Ontario Iroquoian sites, which involved multiple instances of accidental or deliberate provisioning (at Pipeline, Rife, Winking Bull, Walker), at least occasional cold-weather feasting and/or ritual use (at Crawford Lake and Hamilton), and at least one instance of purposeful feeding and captivity (at Hamilton).

Conclusions

This study has demonstrated the importance of using modern species as comparative models for understanding human-animal interactions in the past. The isotopic data presented here also provide insight into: (1) dietary adaptations of turkeys to changing environments; (2) varying subsistence practices within and between past cultural groups, and (3) the complexity of the relationship between humans and animals. Cultural differences in landscape and animal management used by Ontario Iroquoian and Western Basin peoples and responses by turkeys to environmental change were also explored through an inter-regional comparison of their isotopic compositions. Although full domestication of wild turkeys is not part of the spectrum of human-animal relationships in southern Ontario, this study has shown an interaction between wild turkeys and Ontario Iroquoian people at some sites that is currently unique in the North American archaeological literature.

Turkeys from some sites in southwestern Ontario began consuming maize consistently in the Middle Ontario Iroquoian phase. This behaviour continued into the historic Attawandaron period at some sites and there is evidence of year–round, purposeful feeding of at least one turkey at the Hamilton site. Age-at-death analysis of juvenile turkeys, burial context and ethnohistoric descriptions of fall and winter hunting provided support for the direct isotopic evidence of cold-weather turkey hunting in Ontario. Beginning around A.D. 1200 an increasing number of maize-consuming turkeys combined with decreasing proportions of turkeys in midden assemblages overall may represent a shift to opportunistic, near-settlement hunting at Ontario Iroquoian sites. Turkeys hunted at some Late Woodland Ontario Iroquoian sites were likely purposefully provisioned with maize during the fall harvest. This practice would have ensured the availability of turkeys for food, feasting, ritual, and medicine during the cooler months. Because the Iroquoian maize harvest was the responsibility of women, it is proposed that they were responsible for creating the garden-hunting niche by leaving maize in fields and possibly hunting the turkeys there as well.

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