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A tale of two turkeys: Assessing the domestication status and origins of turkey remains (*Meleagris gallopavo*) from the 18th century *Machault* shipwreck through ancient DNA and stable isotope analysis

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A B S T R A C T

Launched in 1758, the *Machault* was a French privateering frigate that was scuttled in 1760 near the mouth of the Restigouche River, Canada, during the Battle of the Restigouche. Excavations of the *Machault* shipwreck have recovered a large faunal assemblage that is comprised mainly of domesticates, namely domestic cattle (*Bos taurus*) and pig (*Sus domesticus*), but also includes several piscine, wild and domestic avian, and wild mammalian taxa. Among the avian remains recovered from the wreck were two turkey (*Meleagris gallopavo*) specimens. Here, we used stable isotope and ancient mitochondrial DNA (mtDNA) analysis to determine whether these turkey specimens represent domesticated or wild individuals and explore their potential origins. Our genetic data indicate both specimens exhibit mtDNA control region haplotypes predominately found among modern domestic turkeys, and south Mexican wild turkeys (wild progenitor of domestic turkeys), suggesting they are from domesticated stocks. The isotopic data indicate the specimens have high δ^{13}C and low δ^{15}N values consistent with the consumption of human-provisioned maize. As maize was not commonly grown during the 18th century by settler populations in what is now Canada, this isotopic evidence for its consumption by the *Machault* turkeys suggests they may have originated from Anglo-American colonies to the south where the crop was an agricultural staple and were perhaps procured from seized British vessels. When taken together with zooarchaeological and textual data regarding the origins of other fauna recovered from the wreck, these data indicate the *Machault*'s crew drew on multiple supply chains for provisions.

1. Introduction

The colony of New France was dealt a serious blow when the British gained control of Québec City in 1759 following the Battle of the Plains of Abraham. In a bid to reinforce and resupply French troops in Montréal and near Québec City ahead of a planned reconquest of Québec City, King Louis XV at the behest of the Governor of New France—the Marquis of Vaudreuil—sent a supply convoy to the besieged colony. This convoy included five merchant vessels (*Bienfaisant*, *Marquis de Malauze*, *Fidélité*, *Aurore,* and *Soleil),* which were to be escorted by the *Machault* captained by François Chenard de la Giraudais (Beattie and Pothier, 1977). Launched in 1758 in Bayonne, France, and owned by Desclaux and Sons, the *Machault* was a frigate with a displacement of 550 tons and armed with 20 guns (Dagneau, 2009). The *Machault* had previously accomplished a similar mission in 1759, prior to its destruction in 1760, when under the command of Jacques Kanon, it escorted a 16-ship fleet that resupplied Québec City, served as a storehouse, and captured British vessels (Dagneau, 2009). In addition to troops, this second six-ship relief

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mission carried a cargo of weapons, including 20,000 firearms, and other essential supplies, such as 700,000 lb of flour, and 300,000 lb of lard (Dagneau, 2009). The convoy set sail from Bordeaux on April 10, 1760 (Knox 1916, 361). However, it was quickly reduced to three ships when both the *Soleil* and *Aurore* were seized by the British and the *Fidélité* sunk in a storm (Beattie and Pothier, 1977).

By mid-May the remnants of the convoy had arrived in the Gulf of St. Lawrence and on May 15 captured a British vessel near the Îles aux Oiseaux (Knox 1914–1916, 361). After learning from letters found aboard this vessel that British naval forces had already entered the St. Lawerence River and blocked access to Montréal, the convoy set sail for Chaleur Bay intending to take refuge in the bay (Beattie and Pothier, 1977; Knox 1916, 362). While enroute to Chaleur Bay, the fleet captured several British ships and upon arriving in the bay encountered Acadian refugees and a Mi'kmaq village called Tjigog (Beattie and Pothier, 1977; Knox 1916, 362; Leonard, 2002; Metallic and Chamberlin, 2006; Turnbull, 1973). The *Machault* and the other ships in the fleet spent almost two months in the Chaleur Bay area sharing food with the refugees and pursuing small British ships. In response to the continued presence of the *Machault* and the other French vessels in the region, the British dispatched a naval squadron from Louisbourg under the command of John Byron to confront the fleet. On June 22, 1760, Byron encountered the French fleet for the first time, capturing a schooner in Chaleur Bay. The British squadron then proceeded up the Restigouche River where they engaged the French in what came to be known as the Battle of the Restigouche. During this military engagement, the French were defeated, and most of their vessels, including the *Machault*, were destroyed. On July 8th, both the *Machault* and the *Bienfaisant* were sunk by explosions. Low on munitions, suffering heavy causalities, and the *Machault* taking on water, Giraudais, after having removed the bulk of their cargo, ordered that the ships be scuttled to prevent their capture (Knox 1916, 365; See Beattie and Pothier (1977) for a detailed account of the Battle of the Restigouche).

Sitting at a depth of approximately two to seven and a half meters below the surface of the Restigouche River (Fig. 1), the wreck of the *Machault* (Parks Canada site number: 2M) was first identified in 1969 during a survey of the river by the Parks Canada Archaeological Research Division Underwater Research Unit (Zacharchuk and Waddell, 1984). The shipwreck was subsequently the focus of extensive excavations by Parks Canada from 1969 to 1972 (Zacharchuk and Waddell, 1984). In addition to structural materials and artifacts (Sullivan, 1986; Zacharchuk and Waddell, 1984), many faunal remains ($n = 1413$) were recovered from the *Machault*. A zooarchaeological analysis of this assemblage by Balkwill (2007) identified a variety of avian, mammalian, and piscine taxa, with both domestic and wild species represented. Domesticates, namely domestic cattle (*Bos taurus*) and pig (*Sus*

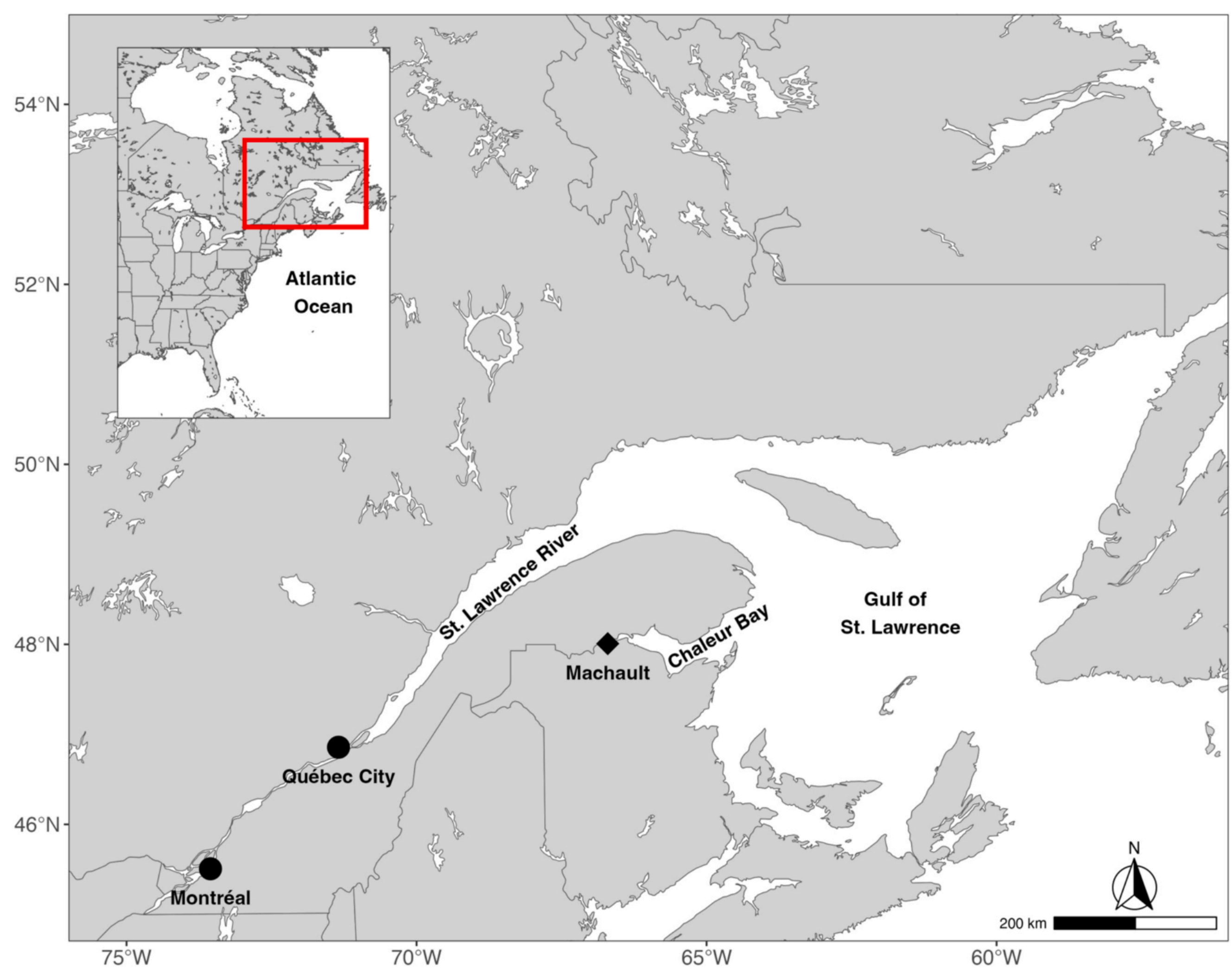

Fig. 1. Location of the Machault shipwreck and other key places mentioned in text. Basemap data from Natural Earth (2024). Map created in R version 4.4.2 (R Core Team, 2024) using the following packages: cowplot version 1.1.3 (Wilke, 2024), ggplot2 version 3.5.2 (Wickham, 2016), ggspatial version 1.1.9 (Dunnington, 2023), here version 1.0.1 (Müller 2020), rnaturalearth version 1.0.1 (Massicotte and South, 2023), openxlsx version 4.2.8 (Schauberger and Walker 2025), and sf version 1.0–19 (Pebesma and Bivand, 2023; Pebesma, 2018).

domesticus), constitute the bulk of the identified remains. Other identified domesticated taxa include cat (*Felis catus*), chicken (*Gallus gallus*), dog (*Canis familiaris*), and ovicaprids (*Ovis aries* and *Capra hircus*). Wild species recovered from the wreck included Atlantic cod (*Gadus morhua*), brown rat (*Rattus norvegicus*; Guiry et al. 2024), Canada goose (*Branta canadensis*), common merganser (*Mergus merganser*), longnose sucker (*Catostomus catostomus*), snowshoe hare (*Lepus americanus*), and white-tailed deer (*Odoceilus virginianus*).

The fauna recovered from the *Machault* likely originated from diverse geographic locales (MacLean 2016). Several of the identified species were likely obtained by the ship's crew during the period when they were sheltered in Chaleur Bay with Acadian settlers and the Mi'kmaq. For example, as they are absent from Europe but present in northeastern North America, snowshoe hare and longnose sucker might have been obtained at this time (Balkwill, 2007; MacLean, 2016). On the other hand, some of the remains likely represent barrelled provisions brought aboard before the convoy departed Bordeaux and, in part, intended to satisfy the colonial government's request for salt pork (Beattie and Pothier, 1977: 9–12). Consistent with expectations for barrelled beef products (Tourigny, 2018), few of the recovered cattle remains ($n = 532$) are from the crania ($n = 14$; 2.63 %) or feet ($n = 62$; 11.65 %) (Balkwill, 2007; MacLean, 2016). Nonetheless, the presence of feet and cranial elements suggests some of these remains might represent cuts of beef that were not barrelled (Balkwell, 2007; MacLean, 2016; Tourigny 2018). Likewise, the recovery of an oak barrel containing pig remains from the *Machault* indicates that salt pork was likely among the vessel's provisions (Sullivan, 1986: 60). A significant number of the pig remains ($n = 291$) from the wreck are cranial elements ($n = 72$; 24.74 %), with parts from the feet also well represented ($n = 49$; 16.84 %) (Balkwill, 2007; MacLean, 2016). This may indicate that some of the remains represent fresh cuts of pork. However, their presence may also reflect budgetary constraints that necessitated provisioning the ship with lower grades of salt pork, which may include heads and feet (MacLean, 2016; Tourigny, 2018). A high proportion of both the cattle ($n = 361$; 67.86 %) and pig remains ($n = 68$; 22.82 %) exhibit butchery marks (Balkwill, 2007; MacLean, 2016). This suggests that at the time of the vessel's sinking they had been already butchered and likely do not represent live individuals being held on board. Mirroring the archaeological record, manifests from the expedition the *Machault* undertook the year prior to its sinking indicate that it was carrying barrels of beef from Nantes, France, and salt pork that included heads and feet (Dagneau, 2009: 182–184).

The domestication status and geographic origins of other fauna from the *Machault*, such as the two turkey (*Meleagris gallopavo*) specimens, are more ambiguous. The turkey is a large bird species that includes a domestic subspecies (*M. g. domesticus*) and multiple wild subspecies. At present, there are six known wild turkey subspecies: eastern (*M. g. silvestris*), Florida (*M. g. osceola*), Rio Grande (*M. g. intermedia*), Merriam's (*M. g. merriami*), Gould's (*M. g. mexicana*), and south Mexican *(M.* g. *gallopavo*). While each species occupies different regions, the collective historical range of these wild subspecies encompassed large swaths of the eastern and midwestern United States, as well as parts of the American Southwest, northern Mexico, and southeastern Canada (Schorger, 1966). Currently, it is not possible to reliably differentiate turkey subspecies on the basis of bone morphology, making it difficult to discern domestication status or region of origin of specimens recovered from archaeological contexts (Thornton and Emery, 2017).

Exploring the origins of the turkeys recovered from the *Machault* requires a nuanced consideration of the potential sources for turkeys within both the regional context around the Restigouche River and the wider context of the *Machault*'s journeys during its service life. As the *Machault* had traveled to a variety of ports the turkey remains aboard could have been sourced from various locales. Both domestic and wild turkeys are historically known to have been used by French settlers in the Great Lakes–St. Lawrence Lowlands. First domesticated by Indigenous peoples in Mesoamerica and introduced to Europe by the Spanish likely via Hispaniola, domestic turkeys had spread to France by 1538 and were subsequently brought to New France by settlers during the 17th century (Manin et al., 2018; Monteagudo et al., 2013; Reitz et al., 2016; Schorger, 1966:465, 484–485; Speller et al., 2010; Thornton and Emery, 2017). By the early 19th century, turkeys were abundant in the colony's former territories in present-day Canada (Schorger, 1966: 484-485). Consequently, it is possible the *Machault* turkeys could have been domestic turkeys obtained from sources in New France or its homeport of Bordeaux, France. Eastern wild turkeys are also present in many areas of the Great Lakes–St. Lawrence Lowlands under the control of New France, including what is now southern Ontario and Québec. Long an important foodstuff for Indigenous peoples residing in the region (Orchard et al., 2023), historical accounts indicate French settlers likewise consumed wild turkeys and used their feathers (e.g., J.C.B., 1941; Kalm, 1771: 66; Nicolas, 2011:359). For example, during the 17th century, the Jesuit missionary and naturalist Louis Nicolas (2011:359) remarked that wild turkeys in New France were "very common and well known to everyone" and "much more delicate to eat… than those that have been domesticated in our Europe." Wild turkeys are not known to have historically inhabited the area around Chaleur Bay and the mouth of the Restigouche River (Schorger, 1966), making it unlikely any wild individuals aboard the *Machault* were sourced from the region. However, the vessel had visited areas of the St. Lawrence Valley in 1759 that are near the known historical range of wild turkeys (Dagneau, 2009; Schorger, 1966). It is therefore possible these specimens could represent remnants of turkeys brought aboard as provisions during this time. Other possible sources for the turkeys aboard the *Machault* include the British vessels that it and its convoy captured in the Gulf of St. Lawerence in 1760. These vessels, many of which had American homeports (Beattie and Pother, 1977), may have contained wild turkeys, which were historically widespread in the Anglo-American colonies, or domestic turkeys reared in these colonies.

In this study, we used ancient DNA (aDNA) analysis to investigate the domestication status, and geographic origins of the turkey specimens recovered from the *Machault*. Outside of domestication centers, domestic populations often exhibit mitochondrial DNA (mtDNA) lineages distinct from those found among their wild counterparts, making it possible to infer the domestication status of a specimen through aDNA analysis (e.g., Abbona et al., 2020; Cai et al., 2018; Honka et al., 2018; Wang et al., 2022; Zouganelis et al., 2014). In the case of turkeys, domesticated individuals are expected to be phylogenetically similar to turkeys from Mesoamerica given the region's status as a domestication center for the species (Reitz et al., 2016; Speller et al., 2010). The analysis of mtDNA is not limited to providing insights into the domestication status of animal specimens. Intraspecific genetic variation across space means that in some instances it is possible to ascertain a specimen's geographic origins through the analysis of mtDNA (e.g., de Flamingh et al., 2021; Kennedy et al., 2024; Royle et al., 2022; Star et al., 2018). Using mtDNA in isolation to determine whether an archaeological specimen is domesticated, however, is not without its problems. Lineage sharing between wild and domestic populations, due to short divergence times and/or introgressive hybridization, can hinder mtDNA-based assessments of domestication status (Honka et al., 2018; Wang et al., 2022). Recognizing these limitations, we also used stable carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope analysis to investigate the *Machault* turkeys' diets, which can offer clues about whether they were provisioned by humans and their potential geographic origins. As wild and managed turkeys may consume different food items, stable isotope analysis can be used to identify domesticated individuals in archaeological contexts (Guiry et al., 2021b; Manin et al., 2018; Morris et al., 2016). This is because the isotopic compositions of human-provisioned feeds can vary across space, providing an interpretive framework for using stable isotope analysis to investigate the husbandry and geographic origins of domesticated individuals (Guiry et al., 2012; Guiry et al., 2017; Kennedy and Guiry, 2023; Klippel, 2001; Guiry et al., 2020). For instance, in the study region (i.e., northern, C_3-plant dominated) the foods consumed by husbanded turkeys are expected to differ isotopically (both in terms of variation an inclusion of distinctive C_4 feed crops like maize) from those consumed by wild or free-ranging animal domesticates originating in British regions to the south. Taken together, the results of the aDNA and stable isotope analysis of the *Machault* turkey specimens suggest they were both domestic individuals that originated from regions to the south of New France.

2. Methods and materials

2.1. Specimens

Ancient DNA and stable isotope analyses were performed on two turkey specimens recovered from the *Machault* wreck. Both were identified as turkey by Balkwill (2007) through morphological comparisons with reference specimens held in the Osteology Collection at the Canadian Museum of Nature (Ottawa, Ontario, Canada). The first specimen (Zooarchaeology lab record number: 981; aDNA lab code: TUM1; stable isotope lab code: IUBC 3382) is a partial tibiotarsus consisting of the proximal end and most of the shaft (Fig. 2a and Fig. 2b). Analyses by Balkwill indicate the distal end of this specimen was likely sawn off during butchering. This element was recovered from context 2M3A2 near the bow of the ship (Fig. 3; Maclean, 2016). The second turkey specimen is a complete ulna (Zooarchaeology lab record number: 1195; aDNA lab code: TUM2; stable isotope lab code: IUBC 3387) that was recovered from context 2M48D1 (Fig. 2c and Fig. 2d). This context is located outside the wreckage and was not associated with artifacts from any particular part of the ship (Fig. 3; Maclean, 2016). To provide baseline data to contextualize our results, isotopic analyses were also performed on 16 turkey specimens from 18th- and 19th-century sites in Québec City (Supplementary Material Table S1), including Îlot des Palais ($n = 11$; time period: ca.1720–1760; Borden site number: CeEt-30; Bernard [2013]), the Assemblée nationale du Québec ($n = 4$; time period: ca. 1760–1780; Borden site number: CeEt-740; Ostéothèque de [2000]; Simoneau [2000]), and rue Saint-Vallier ($n = 1$; time period: 1784 –1835; Borden site number: CeEt-745; Rouleau [2000]).

2.2. Ancient DNA analysis

2.2.1. Decontamination and DNA extraction

All pre-PCR activities (decontamination, DNA extraction, and PCR setup) were conducted in a dedicated aDNA laboratory at the Simon Fraser University Department of Archaeology (Burnaby, British Columbia, Canada). This laboratory is positively pressurized and is equipped with a UV-HEPA air filtration system (Yang and Watt, 2005). To safeguard against contamination, personal protective equipment (double layer of gloves, coveralls, and masks) is worn by all personnel working in the laboratory, and bench surfaces and equipment are regularly cleaned with bleach and UV-irradiated distilled water (Yang and Watt, 2005). No processing of modern specimens, PCR amplifications, or handling of PCR products has ever occurred in this lab.

A small subsample of bone weighing 126 mg (TUM1 [IUBC 3382]) and 200 mg (TUM2 [IUBC 3387]) was removed from each turkey specimen with a single-use razor that prior to use was decontaminated thorough exposure to UV irradiation in a crosslinker. These subsamples were then decontaminated following the protocol described by Speller and colleagues (2012). In summary, the bone subsamples were immersed in a 100 % commercial bleach solution (≈8.25 % w/v NaOCl; Clorox Company of Canada, Brampton, Ontario, Canada) for 8 min, rinsed in distilled water for 1 min, and then rinsed a second time in distilled water for 8 min. The subsamples were then UV irradiated in a crosslinker for 15 min and then irradiated for an additional 15 min after being rotated to expose a different side. The specimens were then incubated for 18.75 h at 50 °C in a rotating hybridization oven in 4 mL of lysis buffer (0.5 M EDTA [pH 8.0], 0.25 % SDS, and 0.5 mg/mL proteinase K). Following incubation, DNA was extracted and purified using a modified silica-spin column method (Yang et al., 1998; Yang et al., 2008). A blank extraction control was processed alongside the *Machault* turkey specimens to monitor for contamination (Poinar and Cooper, 2000).

2.2.2. PCR amplification and sequencing

To assess the potential domestication status and geographic origins of the *Machault* turkeys, we sequenced a 551 bp fragment of the mitochondrial control region or D-loop spanning positions 15,506 – 16,057 of the turkey mitochondrial reference genome (GenBank accession number: NC_010195.2; Dalloul et al., 2014). A sequence for this region

Fig. 2. Photographs of turkey specimens recovered from the wreck of the *Machault*: (A) ventral view of TUM1 (IUBC 3382), (B) dorsal view of TUM1, (C) ventral view of TUM2 (IUBC 3387), and (D) dorsal view of TUM2.

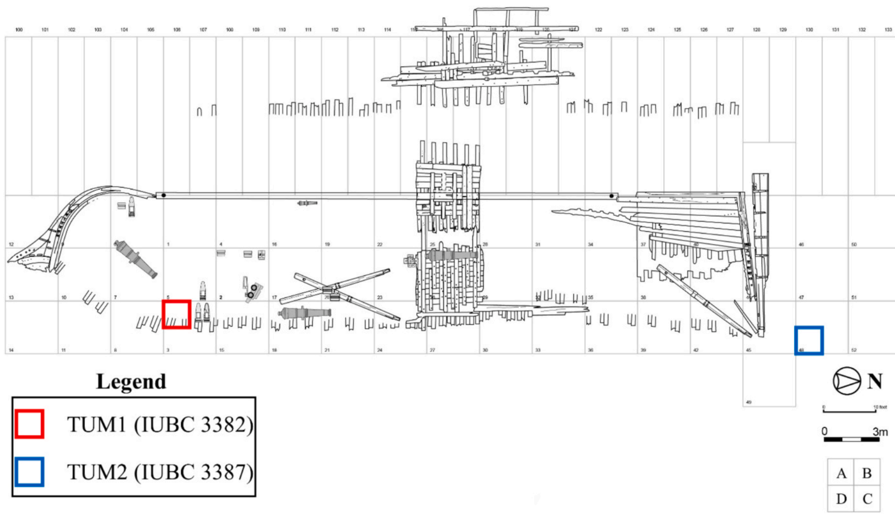

Fig. 3. Plan view of the wreck of the *Machault*. The location of the contexts from which the turkey specimens were recovered are outlined in red (TUM1 [IUBC 3382]) or blue (TUM2 [IUBC 3387]). Each three-by-three-meter unit is subdivided into four quadrants (labelled A, B, C, and D). The square in the lower right-hand corner shows the location of each quadrant in the three-by-three meter units. The solid scale bar represents 10 feet, and the checkered scale bar represents 3 m, with each subdivision representing 1 m. Basemap courtesy of Parks Canada. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

was generated by amplifying and sequencing a series of overlapping fragments with several published primer pairs (Speller et al., 2010; Supplementary Material Table S2). All PCR amplifications and post-PCR procedures were conducted in a negatively pressurized laboratory with a dedicated ventilation system and physically separated from the aDNA laboratory. PCRs were performed with a MiniAmp (Applied Biosystems, Waltham, Massachusetts, USA) or Mastercycler Gradient (Eppendorf, Mississauga, Ontario, Canada) thermal cycler in a 30–35 µl reaction volume comprised of 1.5 × PCR Gold Buffer (Applied Biosystems, Waltham, Massachusetts, USA), 2 mM $MgCl_2$, 0.2 mM per dNTP, 0.3 µM of each primer, 1 mg/mL BSA, 3 µl DNA, and 1.5–2.25 U AmpliTaq Gold (Applied Biosystems, Waltham, Massachusetts, USA). The PCR thermal cycling program consisted of an initial denaturation step at 95 °C for 12 min followed by 60 cycles at 95 °C for 30 s (denaturation), 52 °C for 30 s (annealing), and 70 °C for 40 s (extension), and a final extension step at 72 °C for 7 min. A negative control was included in each PCR run to identify instances of contamination (Poinar and Cooper, 2000).

Amplification success was assessed by electrophoresing 5 µl of PCR product pre-stained with SYBR Green I (Invitrogen, Waltham, Massachusetts, USA) on a 2 % agarose gel and visualizing any amplicons with a Dark Reader transilluminator (Clare Chemical Research, Dolores, Colorado, USA). Amplicons that were of the appropriate size were directly Sanger sequenced in the forward and/or reverse direction with the amplification primers at Eurofins Genomics (Louisville, Kentucky, USA). Before being sequenced, some amplicons were enzymatically purified with ExoSAP-IT Express (Applied Biosystems, Waltham, Massachusetts, USA) following the manufacturer's directions. We attempted to repeat amplification and sequencing for all successfully amplified fragments to assess whether the obtained sequences were the result of contamination and check if any observed single nucleotide polymorphisms (SNPs) reflect post-mortem damage, such as cytosine deamination (Poinar and Cooper, 2000; Winters et al., 2011).

2.2.3. Sequence analysis

For each specimen, the obtained sequences were visually examined, trimmed to remove the primer sequences, and assembled into a consensus sequence using ChromasPro version 2.1.8 (Technelysium, South Brisbane, Queensland, Australia; https://technelysium.com.au/wp/chromaspro). To confirm that the specimens were turkeys, the obtained consensus sequences were compared against published sequences in the GenBank Nucleotide Collection (Sayers et al., 2023) through BLASTn searches (Altschul et al., 1990). A multiple alignment of the *Machault* consensus sequences and published ancient and modern turkey sequences (Mock et al., 2002, Monteagudo et al., 2013, Speller et al., 2010, Thornton et al., 2021, Manin et al., 2018) was constructed with Clustal W (Thompson et al.,1994) as implemented in BioEdit version 7.2 (Hall, 1999). The aligned sequences were visually examined in BioEdit and trimmed to the same length. Subsequently, the 'DNA to haplotype collapser' tool in FAbox version 1.6.1 (Villesen, 2007) was used to collapse the aligned sequences into unique haplotypes. A median-joining network (Bandelt et al., 1999) was then constructed in PopART version 1.7 (Leigh and Bryant, 2015) from the collapsed alignment. Haplotype data for a total of 492 individual turkeys were used to construct the network. In addition to the *Machault* turkeys, haplotype data for ancient and modern turkey specimens from a range of wild and domestic populations were sourced from published studies (Mock et al., 2002, Monteagudo et al., 2013, Speller et al., 2010, Thornton et al., 2021, Manin et al., 2018). The nomenclature for turkey haplogroups and haplotypes used in this study follows the system described by Speller and colleagues (2010).

2.3. Stable isotope analysis

We analyzed the $\delta^{13}C$ and $\delta^{15}N$ compositions of collagen extracted from the *Machault* turkey specimens and 18th- and 19th-century turkey specimens ($n = 16$) from Québec City used to establish a baseline. Specimens with IUBC prefixes were processed (collagen extractions) and analyzed on an elemental analyzer coupled to an isotope ratio mass spectrometer (EA-IRMS) at the University of British Columbia's Archaeology Chemistry Laboratory (Vancouver, British Columbia, Canada). Specimens with HEAL prefixes were processed at the Historical Ecology and Archaeology Laboratory at the University of Leicester (Leicester, United Kingdom) and analyzed on an EA-IRMS at the Water Quality Centre at Trent University (Peterborough, Ontario, Canada). In both labs, specimens were processed and analyzed following the same protocol. Specimens were demineralized in 0.5 M HCl that was refreshed at the end of each 24 h cycle until reactions ceased and then rinsed to neutrality in Type 1 (Resistivity = 18 MΩ cm) water. Specimens were then treated in 0.1 M NaOH in an ultrasonic bath with the solution being refreshed every 10 min until it remained clear and then again rinsed to neutrality in Type 1 water. Specimens were then refluxed in 10^{-3} HCl (pH 3) for 36 h at 65 °C. Specimens were then centrifuged (1500 rpm for 10 min) and the solubilized fraction was pipetted to a fresh tube, and then frozen and lyophilized. Isotopic and elemental compositions of 0.5 mg collagen subsamples were measured on an EA-IRMS. For the IUBC specimens, isotopic and elemental compositions were measured using a Vario MICRO Cube EA coupled via continuous flow to an Isoprime IRMS (Elementar, Hanover, Germany). In the case of the HEAL specimens, isotopic and elemental compositions were measured using an EA 300 (Eurovector, Pavia, Italy) coupled via continuous flow to a Horizon IRMS (Nu Instruments, Wrexham, United Kingdom). Isotopic compositions were calibrated for carbon and nitrogen, respectively, relative to AIR and VDPB using a two-point calibration curve.

Known and long-term average isotopic compositions for calibration and check standards are provided in Supplementary Material Table S3. Average and standard deviations for calibration standards, check standards, and sample replicates (10 %) are shown in Supplementary Material Tables S3, S4, and S5, respectively. For δ^{13}C and δ^{15}N: systematic errors [$\mu_{\text{(bias)}}$] were ± 0.10 ‰ and ± 0.19 ‰; random errors [$\mu R_{(w)}$] were ± 0.07 ‰ and ± 0.16 ‰; and standard uncertainties were ± 0.12 ‰ and ± 0.25 ‰. The quality control (QC) criteria used to evaluate the isotopic data included carbon (>13.8 %) and nitrogen (>4.0 %) elemental concentrations (Ambrose, 1990) and liberal C:N criteria (Guiry and Szpak, 2021).

3. Results

3.1. Ancient DNA results

A sequence for the targeted 551 bp fragment of the mitochondrial control region was successfully generated for both *Machault* turkeys. The consensus sequences for TUM1 (IUBC 3382) and TUM2 (IUBC 3387) have been deposited in GenBank under accession numbers OQ865412 and OQ865413, respectively. For both specimens, amplification success rates varied with the size of the targeted fragment (Table 1). While it was possible to amplify a 343 bp fragment from TUM1 (IUBC 3382) and 326 bp fragment from TUM2 (IUBC 3387), shorter fragments generally (but not always) had higher amplification success rates (Table 1). In the case of both specimens, the shortest targeted fragment, which was 201 bp long, had the highest amplification success rate (Table 1). No DNA was amplified from any of the blank extraction or negative PCR controls. While it was not possible to replicate the amplification of the longest fragment in the case of TUM1 (IUBC 3382) (Table 1), all other fragments were successfully reamplified and resequenced and we were able to replicate the sequence data. Except for C → T and G → A transitions associated with post-mortem cytosine deamination (Dabney et al., 2013), sequences obtained from different amplification and sequencing reactions were identical. BLASTn searches of the *Machault* consensus sequences against GenBank indicated they both matched published sequences from turkeys (100 % sequence similarity). These data support the osteological identification of these specimens as turkeys. A total of 64 distinct mitochondrial haplotypes were identified among the combined dataset consisting of previously published sequence data from ancient and modern turkeys and the sequences from *Machault* turkeys (Fig. 4). As shown in the median-joining network (Fig. 4), TUM1 (IUBC 3382) and TUM2 (IUBC 3387) exhibit haplotype mHap1 and mHap2, respectively. Both haplotypes have been previously documented among ancient and modern turkey populations and belong to the previously defined Haplogroup 3 (H3; Fig. 4). The fact that the two *Machault* turkey specimens possess different haplotypes indicates they represent different individuals.

Table 2
Amplification success rate by specimen for each primer pair. The expected size of the fragment amplified '#/#' denotes the number of successful amplifications and attempted amplifications, respectively.

Specimen	Primer Pairs and Fragment Sizes			
	TK-F2/TK-R261 (260 bp)	TK-F2/TK-R405 (343 bp)	TK-F143/TK-R405 (201 bp)	TK-F315/TK-R670 (326 bp)
TUM1 (IUBC 3382)	3/4 (75 %)	1/2 (50 %)	3/3 (100 %)	5/6 (83.3 %)
TUM2 (IUBC 3387)	4/5 (80 %)	0/1 (0 %)	3/3 (100 %)	3/4 (75 %)

3.2. Stable isotope results

Isotopic and elemental compositions for the analyzed turkey specimens are presented in Fig. 5b and Supplementary Material Table S1. Specimens from the *Machault* as well as baseline specimens from 18th and 19th-century sites in Québec City produced elemental concentrations and C:N values that met the outlined QC criteria (Supplementary Material Table S1). While the baseline data (n = 16; Fig. 5b) show that on average turkeys from Québec City had low δ^{13}C (–19.4 ± 2.7 ‰) and δ^{15}N (+6.5 ± 0.7 ‰) values, three individuals (hereafter referred to as Group 2; Fig. 5b) from Îlot des Palais exhibited elevated δ^{13}C (–14.1 ± 0.4 ‰) and δ^{15}N (+7.4 ± 0.1 ‰) values. These Group 2 specimens clearly represent husbandry practices that are distinct from those used to raise the other turkeys (i.e., Group 1 in Fig. 5b) represented at all three baseline sites. Inclusion of Group 2, however, has only a minor impact on the overall Québec City turkey baseline dataset, with the exclusion of these data shifting means (n = 13, i.e., Group 1) for δ^{13}C (–19.4 ± 2.7 ‰) and δ^{15}N (+6.5 ± 0.7 ‰) by only –1.2 ‰ and –0.2 ‰, respectively. The turkeys from the *Machault* —TUM1 (IUBC 3382) and TUM2 (IUBC 3387)—produced δ^{13}C values of –13.0 ‰ and –15.9 ‰ and δ^{15}N values of + 5.0 and + 6.8, respectively (Fig. 5b).

4. Discussion

4.1. Ancient DNA data

4.1.1. Authenticity of ancient DNA sequences

Relative to modern specimens, archaeological specimens are more susceptible to contamination with exogenous DNA on account of any preserved DNA molecules being both low in quantity and poor in quality (Poinar and Cooper, 2000; Yang and Watt, 2005; Bollongino et al., 2008). However, the authenticity of the sequence data we obtained from the *Machault* turkey specimens is supported by several lines of evidence. First, all pre-PCR laboratory work was conducted in a dedicated aDNA laboratory physically separated from post-PCR and modern DNA laboratories, reducing the likelihood of contamination from sources of modern DNA and/or PCR products (Poinar and Cooper, 2000). Second, both *Machault* specimens were decontaminated prior to DNA extraction using a combination of bleach and UV irradiation (Yang and Watt, 2005). Third, no DNA was amplified from any of the blank extraction or negative PCR controls, which is indicative of a lack of systematic contamination (Poinar and Cooper, 2000). Fourth, the cytosine deamination driven C → T and G → A transitions that typify aDNA molecules were observed in sequences obtained from both *Machault* specimens (Dabney et al., 2013). Fifth, for both specimens, in general, the inverse relationship between amplification success and fragment size expected for ancient specimens was observed (Poinar and Cooper, 2000). Sixth, the sequences we obtained from the *Machault* were successfully replicated through independent amplification and sequencing reactions (Poinar and Cooper, 2000). Seventh, the fact that the specimens exhibit different haplotypes indicates cross-contamination did not occur (Speller et al., 2012). Eighth, independent evidence for the preservation of biomolecules within the *Machault* specimens is provided by the recovery of well-preserved collagen from both specimens (Poinar and Cooper, 2000).

4.1.2. Interpretation of ancient DNA data

Previous studies of control region sequence variation among turkeys

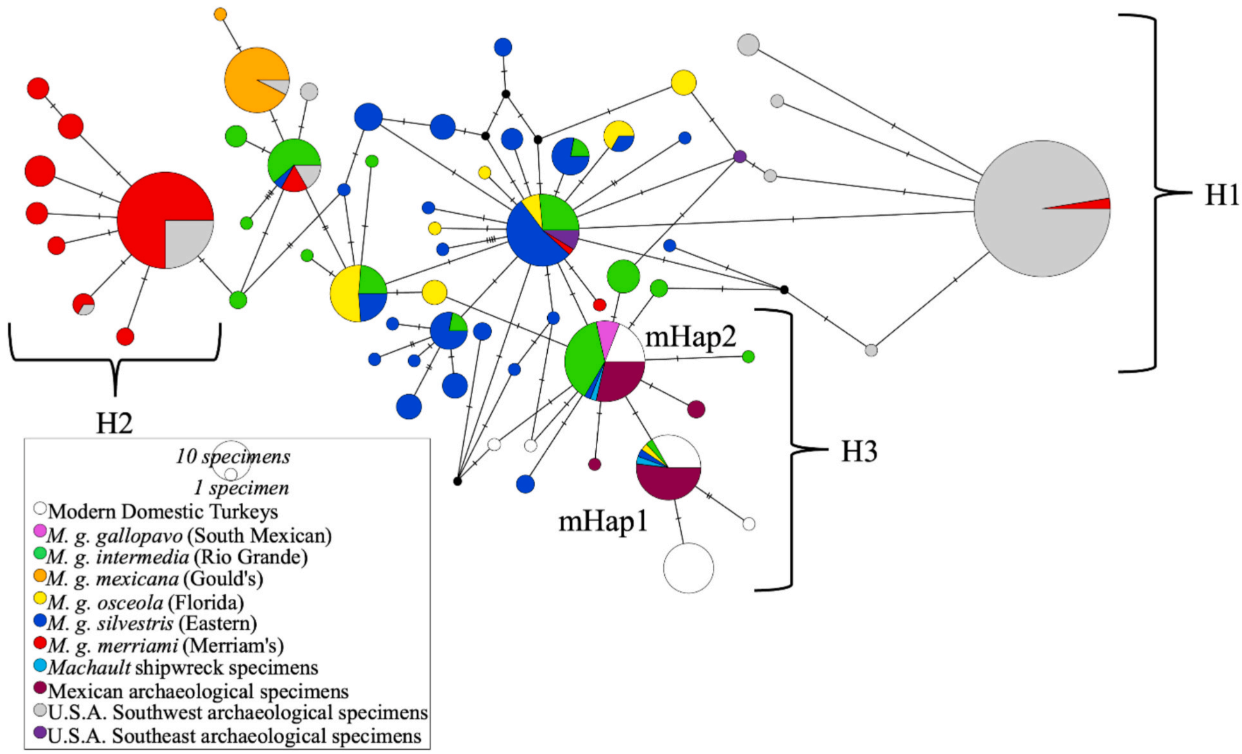

Fig. 4. Median-joining network showing the relationship between the control region sequences obtained from the *Machault* turkeys and published sequences from ancient and modern turkeys from various domestic and wild populations. Individual haplotypes are represented by circular nodes. Each node's size is proportional to the frequency of the corresponding haplotype. The proportion of individuals exhibiting a haplotype that are from a given population is represented by the slices of the nodes. Hatch marks across lines connecting nodes represents the number of mutational differences between haplotypes, with one hatch mark being equal to one nucleotide difference. Small black circles represent inferred haplotypes that were not observed among the sampled turkeys.

have documented the phylogenetic relationships of modern domestic turkey breeds (Manin et al., 2018; Monteagudo et al., 2013; Speller et al., 2010). Reflecting their Mesoamerican origins, all previously published modern domestic turkeys surveyed belong to Haplogroup 3, alongside ancient Mesoamerican turkeys and historic populations of their wild progenitor: the South Mexican wild turkey (Manin et al., 2018; Monteagudo et al., 2013; Speller et al., 2010). The membership of TUM1 (IUBC 3382) and TUM2 (IUBC 3387) in Haplogroup 3 is therefore consistent with both individuals being from domestic turkey stocks (Speller et al., 2010; Reitz et al., 2016). Additional evidence for the domestication status of the *Machault* turkeys can be gleaned from the population affinities of other turkeys with which they share a haplotype. Except for a handful of Rio Grande, Florida, and Eastern wild turkeys, most individuals that share the mHap1 haplotype with TUM1 (IUBC 3382) are modern domestic turkeys or archaeological turkeys from Mesoamerica (Fig. 4). Likewise, the haplotype exhibited by TUM2—mHap2—is predominately found among turkeys with Mesoamerican roots, including modern domestic turkeys, south Mexican wild turkeys, and archaeological turkeys from Mesoamerica (Fig. 4; Manin et al., 2018). However, the results of previous analyses indicate many Rio Grande wild turkeys, and a single eastern wild turkey possess the mHap2 haplotypes on account of hybridization events between wild and domestic individuals (Fig. 4; Mock et al., 2002). The fact that most of the individuals that share a haplotype with TUM1 (IUBC 3382) and TUM2 (IUBC 3387) are modern domestic turkeys, south Mexican wild turkeys, or archaeological turkeys from Mesoamerica lends credence to the hypothesis that both *Machault* specimens are domestic turkeys (Reitz et al., 2016). Nonetheless, as the haplotypes possessed by TUM1 (IUBC 3382) and TUM2 (IUBC 3387) belong are not unique to domestic populations the possibility that the *Machault* turkeys represent wild individuals cannot be ruled out based on the genetic data alone. In addition, as both specimens' haplotypes are present in modern domestic breeds in both the Americas and Europe (Speller et al., 2010; Monteagudo et al. 2013), it is not possible to genetically pinpoint the geographic origins of these likely domesticated individuals from the *Machault*.

4.1.3. Isotopic context

Isotopic baseline data are essential for interpreting dietary and mobility trends from the isotopic compositions of archaeological faunal remains. Stable carbon isotope compositions are passed up the food web with little change and can therefore be used to discern animals' consumption of foods deriving from different photosynthesis (C_3 and C_4) pathways (DeNiro and Epstein, 1978; Tieszen 1991). Stable nitrogen isotope compositions, by contrast, increase in a stepwise fashion from one trophic level to the next (i.e., from plant to herbivores, and from herbivore to carnivores, and so on) and are therefore useful for assessing the relative dietary contributions of plant and animal products (DeNiro and Epstein, 1981; Post 2002). Potential for spatiotemporal variation in the isotopic composition of nutrients at the base of the food web means that isotopic baseline data from potential food species (Katzenberg, 1989) should be sourced from as close in time, space, taxonomy, and cultural context as possible. While published isotopic data from historical turkeys in early British and French contexts are rare (only two specimens from Newfoundland reported in the literature [Guiry et al., 2012]), data from livestock from 19th-century sites in Upper Canada (Guiry et al., 2017), and 17th – 18th-century sites in the Canadian Maritimes (Guiry et al., 2021a) complement the baseline dataset we have generated and help constrain interpretations (Fig. 5a and Fig. 5b).

Within the wider geographical context, it is important to bear in mind that the local study region is dominated by C_3 plants, which confer lower $\delta^{13}C$ values to their consumers (Tieszen, 1991). In most areas of Canada that were colonized by early British and French settlers, naturally occurring C_4 plants, which confer higher $\delta^{13}C$ values to their consumers, are rare. Moreover, as far as we can tell, the major agricultural

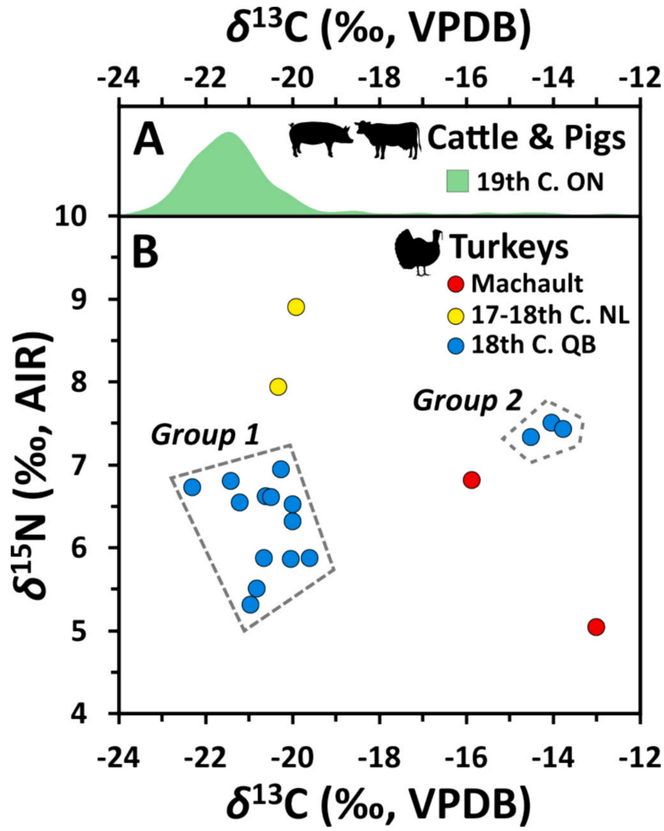

Fig. 5. Stable carbon and nitrogen isotopic compositions of the *Machault* turkeys and comparative specimens. (A) Kernel density histogram of published $\delta^{13}C$ values for archaeological 19th century livestock from Ontario (ON; Domestic cattle and pigs, $n = 268$; Guiry et al., 2017) illustrating the dominance of C_3 resources (i.e., non-maize) at inland locations (i.e., areas away from salt-marshes). (B) Isotopic compositions of the *Machault* turkeys (n = 2) and historical turkey baseline data from Québec City (QB; n = 16; this study) and Newfoundland (NL; n = 2; Guiry et al., 2012). Group 1 and 2 demarcate turkey specimens from Québec included in the baseline data that exhibit C_3 and C_4 diets, respectively. Group 1 includes specimens from the Assemblée nationale du Québec ($n = 4$), Îlot des Palais ($n = 8$), and rue Saint-Vallier ($n = 1$) sites and Group 2 is comprised of specimens from the Îlot des Palais ($n = 3$) site.

staples used to feed livestock were also mainly C_3 plants (Guiry et al., 2017). As such, it can be assumed most non-domestic and domestic terrestrial animals from the study region will have low $\delta^{13}C$ values. This is borne out by most of the baseline turkey data (Fig. 5b; Group 1, $n = 13$ of 16 turkeys) we collected from 18th-century sites in Québec as well as published data from archaeological livestock and wild animal remains recovered from historical period contexts in Canada (Fig. 5a; Guiry and Buckley, 2018; Guiry et al., 2012; Guiry et al., 2017; Guiry et al., 2021a; Tourigny et al., 2016).

Three potential sources of foods with higher $\delta^{13}C$ values are maize, salt hay, and marine resources. First, while C_4 cultivars such as maize were major agricultural staples for Indigenous peoples and their domestic animals in parts of what is now Canada (e.g., Glencross et al., 2022; Morris et al., 2016; Pfeiffer et al., 2016), colonial agriculture in these regions had shifted to C_3 crops, such as wheat (Guiry et al., 2017). However, further south, colonial agriculture in what is at present the USA, adopted maize as a staple (e.g., Ubelaker and Owsley, 2003) and, for this reason, animals traded north from these areas could provide a source of isotopically distinctive (i.e., high $\delta^{13}C$) C_4-fed animals (Guiry et al., 2017). It is also possible that small amounts of maize were imported as animal feed (Guiry and Buckley, 2018). Second, plants from salt marshes represent an economically important exception to the general rule that C_4 plants are rare in early historical contexts in northern North America (Guiry et al., 2021a). Cord grasses collectively known as salt hay (*Spartina* spp.) are C_4 plants that are naturally abundant in coastal salt marshes along the eastern coasts of North America, including the Canadian Maritimes. Salt hay was widely utilized as source of graze and fodder for domestic cattle in the study region during the early colonial period (e.g., Hatvany, 2002), leading to observations of high $\delta^{13}C$ values in domestic cattle from saltmarsh adjacent 17th and 18th century Acadian sites in what are now the provinces of Prince Edward Island, Nova Scotia, and New Brunswick. In this context, it is possible that turkeys husbanded in the study region could have been fed salt hay (or products from animals that were raised on salt hay) or naturally foraged in these areas. Lastly, foods derived from marine animals tend to have higher $\delta^{13}C$ values than their terrestrial counterparts due to baseline differences between the isotopic compositions of carbon dioxide fixed by primary production in terrestrial and marine ecosystems (Chisholm et al., 1982; Craig, 1953; Guiry 2019). However, foods derived from common, economically important marine fauna (e.g., cod, herring) also tend to have higher $\delta^{15}N$ values due to the larger number of trophic levels in marine ecosystems (Schoeninger and DeNiro, 1984; Sigman et al. 2009), providing an independent indicator for the potential influence of marine foods on turkey $\delta^{13}C$.

Before we interpret the isotopic compositions of the *Machault* turkeys, it is worth: a) evaluating the processes which likely underlie surprisingly high $\delta^{13}C$ values in a small portion of our Québec baseline data (i.e., Group 2 in Fig. 5b); and, b) considering the extent to which these turkey diets might be representative of broader turkey husbandry in New France, or instead, could reflect a special, otherwise unusual set of husbandry practices. Of the three potential high-$\delta^{13}C$ turkey food sources, maize consumption is a likely explanation for the elevated $\delta^{13}C$ values observed in our Group 2 baseline turkey data (Fig. 5b). These specimens come from the French occupation of the second Intendant's Palace at the Îlot des Palais site in Québec. During this period (ca. 1720–1760), the complex was composed not only of the palace itself, but also secondary buildings including the King's Stores as well as a barn. Archaeobotanical research at the complex has provided evidence for the presence of maize in the King's Stores (Bain et al., 2009). Meanwhile, historical textual and zooarchaeological research indicate that the turkeys from the site were likely raised and consumed locally. Specifically, a barnyard is shown within the complex in a 1732 plan by Chaussegros de Lery and is referenced specifically as having been used to raise fowl (Bernard, 2013). Furthermore, many turkey bones were recovered from a palace latrine (Bernard, 2013). Together these lines of evidence help to contextualize Group 1 baseline data, suggesting that the use of maize as fodder for domestic turkeys did occur in New France.

These maize-fed turkeys come from a place and time in which colonists in New France may have still been experimenting with crop and animal husbandry strategies. Moreover, as it housed the King's Stores, the Îlot des Palais site represents a central point to and from which resources from disparate locations were transported, housed, and redistributed. It is therefore challenging to evaluate the extent to which the evidence we have uncovered for the provisioning of turkeys with maize at Îlot des Palais represents a spatiotemporally localized or broadscale phenomenon. We believe that the balance of evidence supports the former scenario – that the use of maize to feed turkey in colonial contexts in New France was likely a rare occurrence. It is noteworthy that the archaeobotanical evidence for maize at Îlot des Palais is ephemeral (only a few kernels) and we are not aware of other, wider scale evidence for the presence of maize at colonial contexts in New France. For this reason and acknowledging that we do not have detailed records to evaluate or quantify the importance of maize in the King's Stores or the wider Îlot des Palais complex, it seems likely that maize was an occasional curiosity or, at most, a short-term minor staple. While maize consumption by domestic and wild fowl has been documented in a variety of archaeological contexts across the Americas (Manin et al., 2018; Morris et al., 2016), given the rarity of archaeological and historical evidence for the presence of maize in New France it may seem surprising that it would have been used specifically to feed turkeys at Îlot des Palais. Indeed, assuming turkeys recovered from the site's latrine were mainly husbanded within the complex (which seems justified based on the presence of a barnyard), it is clear from most specimens we have analyzed that C_4 diets are the exception rather than the rule for turkeys raised at the site. In that context, one possible explanation for why maize stores might have been diverted for use as turkey feed comes from the archaeoentomological evidence at the site, which included the recovery of insects associated with damp conditions that may have led to grain spoilage (Bain et al., 2009). It is possible to imagine a scenario in which the utility of molding, or otherwise moisture-compromised maize stores would have been salvaged as turkey feed. Therefore, while further research on this site would help to better understand patterns in the potential sources and use of maize in animal husbandry at Îlot des Palais, we do not expect maize feeding to have been widely practiced in French turkey husbandry in the region. With respect to our interpretive framework for the *Machault* turkeys, this means that, despite the small amount of evidence for maize feeding we have observed at Îlot des Palais, we expect that local husbandry in most areas of New France would likely result in turkeys with C_3 diets (i.e., reflected by low δ^{13}C values).

4.1.4. Interpretation of isotopic data

In the context of other historical fauna (Fig. 5a and Fig. 5b) and considering the above discussion of regional baselines, the relatively high δ^{13}C values observed in the *Machault* turkeys indicate diets incorporating C_4 plants to varying degrees. Relatively low δ^{15}N values suggest that these higher δ^{13}C values are not a result of marine food consumption. Determining whether these C_4 inputs reflect either a scenario in which turkeys consumed (1) agricultural food crops (e.g., maize) or (2) saltmarsh plants is challenging. Each of these potential food source scenarios would, moreover, favour a different explanation for the origins of the turkey's recovered from the *Machault*. Under scenario 1, as outlined in detail in the preceding discussion on highly unusual nature of the Group 2 baseline data, a maize-focused diet would suggest these turkeys were obtained through trade or other means from regions further south where this crop was a staple. This would also mean that these specimens are also very likely to be from domesticated turkeys. Although we cannot rule out the importation of maize as a feed, the evidence from colonial maize-based turkey husbandry we have observed in New France is scarce and we have argued is likely not representative of broader trends. In contrast, a salt-hay focused diet (either through direct consumption of *Spartina* or byproducts from animals fed on salt hay) proposed by scenario 2 would be consistent with locally available feeds (though salt hay would also be available further south) and possibly also with diets of wild birds living in nearby saltmarsh habitats.

The balance of evidence, we believe, favours the first option –imported turkeys foddered on maize – as the most parsimonious explanation. While salt hay could potentially be used to feed turkeys, we are not aware of historical evidence suggesting that *Spartina* grasses were harvested and processed in ways that would make them suitable feed for domestic fowl. We are also not aware of historical evidence for wild turkeys living in local saltmarsh habitats. It is worth reiterating that, although Group 2 samples (Fig. 5b) show turkeys were likely raised on maize in New France, in the context of all published archaeological domestic faunal data from regions of Canada colonized by France and Britain (Fig. 5a and Fig. 5b), these data represent outliers and what was likely an extremely rare husbandry practice associated with a high-status site. In other words, while we cannot categorically exclude the possibility that the turkeys recovered from the *Machault* could have originated in New France, and acknowledge that this remains a distinct possibility, based on their C_4 diets we believe that it is likely that these turkeys were raised in another region of North America. We note that while there is limited historical evidence for significant maize use in 18th-century New France, there is considerable evidence for its production and use in Anglo-American colonies, including as an animal feed (Stavely and Fitzgerald, 2004). This aligns well with published δ^{13}C values from 17th- and 18th-century archaeological rats—animals with diets broadly reflecting foods available in and near human settlements—which show no evidence for C_4 food use in New France, but widespread availability of C_4 foods in Anglo-American colonial settlements, such as Jamestown and Charleston (Guiry and Gaulton, 2016; Guiry et al., 2024). Isotopic studies of human remains paint a similar picture. Individuals from Anglo-American settlements as far north as Connecticut consumed significant amounts of C_4 foods, whereas those in New France made limited use of these resources (France et al, 2014; Vigeant et al., 2017). It therefore seems more likely that during her three-years of service the *Machault*'s crew had obtained domestic turkeys raised in the Anglo-American colonies where maize was a common livestock feed.

We cannot say with certainty how turkeys from Anglo-American colonies wound up on the *Macahult*, but one plausible scenario based on the ship's known actions and movements is that they were seized from captured British vessels. Historical documents indicate that *Machault*-led convoy captured a British vessel off the Îles aux Oiseaux near the mouth of the St. Lawrence River (Knox 1916, 362). This was followed by the capture of four British vessels on May 16th off the Gaspé Peninsula and one or two British vessels near the mouth of Chaleur Bay on May 17th (Knox 1916, 362; Beattie and Pothier, 1977:13). Among the captured vessels were ships with homeports in the Anglo-American colonies, including Casco Bay, Halifax, and New York, as well as a vessel originating from New London, but whose most recent port of departure was Louisbourg (Beattie and Pothier, 1977:13). Since several of these vessels originated from Anglo-American colonies where maize was a common crop, it is possible some may have been provisioned with maize-fed turkeys, which were subsequently taken by the *Machault*'s crew upon their capture. While the historical record makes no mention of the *Machault* seizing provisions from these captured vessels, such actions were commonplace at the time. During the early modern period, provisions were often among the booty taken from captured vessels and were used to replenish their captor's food supplies (MacDonald, 2014; Migaud, 2011). For instance, one account by William Funnell (1707:45–46), a mate to the 18th-century English privateer William Dampier, notes that their capture of a vessel "deeply laden with Flower, Sugar, Brandy, Wine, about 30 Tuns of Marmalet of Quinces, a considerable quantity of Salt with some Tuns of Linnen and Woollens Cloth" came as a great relief as "it might supply our selves with Provisions for four or five Years." Non-faunal materials recovered from the *Machault* provide additional support for the hypothesis that its crew seized goods from these captured vessels. The artifact assemblage from the wreck includes various items of English or Anglo-American origin, including muskets, glassware, candle paraphernalia, bottles, spigots, and ceramics (Sullivan, 1986; Wade, 1980). These artifacts have been interpreted by some as booty from the British vessels captured by the *Machault* (McNally, 1977; Wade, 1980). Alternatively, these items of English origin may represent trade goods brought aboard prior to the ship's departure from Bordeaux, and the muskets may have been taken by the French during an earlier military engagement and reissued to the *Macahult*'s crew (McNally, 1977; Sullivan, 1986; Wade, 1980; Dagneau, 2009).

5. Summary and conclusion

In this study, we used aDNA and stable isotope analysis to provide new insights into the domestication status and origin of the two turkey specimens recovered from the the *Machault*. Consistent with expectations for domesticated individuals, both turkeys exhibit haplotypes (mHap1 and mHap2) originating in Mesoamerica that are common in modern domestic turkeys, south Mexican wild turkey (the wild progenitor of domestic stocks), and archaeological turkeys from Mexico. The hypothesis that the *Machault* turkeys were domesticated is further supported by their high δ^{13}C and low δ^{15}N values, which we argue are most parsimoniously interpreted as reflecting the consumption of human-provisioned maize. As cultivation and use of maize as a livestock feed was extremely rare in what is now Canada, we suggest that this isotopic evidence for maize consumption by the *Machault* turkeys points to an origin in Anglo-American colonies to the south, where during this period it was an agricultural staple. In the future, genomic analyses of the *Machault* turkeys and comparative data from modern and archaeological specimens from potential source regions could help further pinpoint the origins of these turkeys (cf. Star et al., 2017; Star et al., 2018). The likely American origin of these turkeys coupled with zooarchaeological data suggesting its crew were consuming game from the Chaleur Bay area and salt meat from Europe (Balkwill, 2007; MacLean, 2016), indicate the provisioning pathways for the *Machault* were complex and drawing on multiple sources. Genetic and/or isotopic provenancing of other taxa (e.g., Atlantic cod) from the wreck could provide additional details about these pathways.

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CRediT authorship contribution statement

Luke S. Jackman: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tom Vaughan:** Writing – review & editing, Writing – original draft. **Thomas C.A. Royle:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Eric J. Guiry:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Charles Dagneau:** Writing – review & editing, Resources. **Camilla F. Speller:** Writing – review & editing, Resources. **Stéphane Noël:** Writing – review & editing, Resources. **Dongya Y. Yang:** Writing – review & editing, Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2025.105291.

Data availability

The DNA sequences from the *Machault* turkeys have been submitted to GenBank (https://ncbi.nlm.nih.gov/genbank) under accession numbers OQ865412 and OQ865413. The code for the R script used to generate Fig. 1 is available on GitHub (https://github.com/tcaroyle/Machault_tale_of_two_turkeys) and archived on Zenodo (https://doi.org/10.5281/zenodo.15640070). All other relevant data are presented in the article text or contained within the supplementary material.

References

Abbona, C.C., Adolfo, G.N., Johnson, J., Kim, T., Gil, A.F., Wolverton, S., 2020. Were domestic camelids present on the prehispanic South American agricultural frontier? An ancient DNA study. PLoS One 15 (11), e0240474. https://doi.org/10.1371/journal.pone.0240474.

Altschul, S.F., Gish, W., Miller, W., Myers, E.W., Lipman, D.J., 1990. Basic local alignment search tool. J. Mol. Biol. 215 (3), 403–410. https://doi.org/10.1016/S0022-2836(05)80360-2.

Ambrose, S.H., 1990. Preparation and characterization of bone and tooth collagen for isotopic analysis. J. Archaeol. Sci. 17 (4), 431–451. https://doi.org/10.1016/0305-4403(90)90007-R.

Bain, A., Bouchard-Perron, J.-A., Auger, R., Simoneau, D., 2009. Bugs, seeds and weeds at the Intendant's Palace: a study of an evolving landscape. Post-Medieval Archaeology 43 (1), 183–197. https://doi.org/10.1179/007942309X12457508844242.

Balkwill, D., 2007. Unpublished report. Report on file at Underwater Archaeology Team, Parks Canada, Ottawa, Canada.

Bandelt, H.-J., Forster, P., Röhl, A., 1999. Median-joining networks for inferring intraspecific phylogenies. Mol. Biol. Evol. 16 (1), 37–48. https://doi.org/10.1093/oxfordjournals.molbev.a026036.

Beattie, J., Pothier, B., 1977. The Battle of the Restigouche. Canadian Historic Sites: Occasional Papers in Archaeology and History 16, 5–34.

Bernard, J., 2013. Étude zooarchéologique d'un assemblage faunique provenant des latrines ouest du palais de l'Intendant (CeEt-30) vers 1722-1775. Centre interuniversitaire d'études sur les lettres, les arts et les traditions (CELAT), Québec.

Bollongino, R., Tresset, A., Vigne, J.-D., 2008. Environment and excavation: Pre-lab impacts on ancient DNA analyses. C.R. Palevol 7 (2–3), 91–98. https://doi.org/10.1016/j.crpv.2008.02.002.

Cai, D., Zhang, N., Zhu, S., Chen, Q., Wang, L., Zhao, X., Ma, X., Royle, T.C.A., Zhou, H., Yang, D.Y., 2018. Ancient DNA reveals evidence of abundant aurochs (*Bos primigenius*) in Neolithic Northeast China. J. Archaeol. Sci. 98, 72–80. https://doi.org/10.1016/j.jas.2018.08.003.

Chisholm, B.S., Nelson, D.E., Schwarcz, H.P., 1982. Stable-carbon isotope ratios as a measure of marine versus terrestrial protein in ancient diets. Science 216 (4550), 1131–1132. https://doi.org/10.1126/science.216.4550.1131.

Craig, H., 1953. The geochemistry of the stable carbon isotopes. Geochim. Cosmochim. Acta 3 (2–3), 53–92. https://doi.org/10.1016/0016-7037(53)90001-5.

Dabney, J., Meyer, M., Pääbo, S., 2013. Ancient DNA damage. Cold Spring Harb. Perspect. Biol. 5 (7), a012567. https://doi.org/10.1101/cshperspect.a012567.

Dagneau, C., 2009. La culture matérielle des épaves françaises en Atlantique nord et l'économie monde capitaliste, 1700-1760. Unpublished Ph.D. dissertation. Université de Montréal, Montréal, Canada. https://hdl.handle.net/1866/6426.

Dalloul, R.A., Zimin, A.V., Settlage, R.E., Kim, S., Reed, K.M., 2014. Next-generation sequencing strategies for characterizing the turkey genome. Poult. Sci. 93 (2), 479–484. https://doi.org/10.3382/ps.2013-03560.

DeNiro, M.J., Epstein, S., 1978. Influence of diet on the distribution of carbon isotopes in animals. Geochim. Cosmochim. Acta 42 (5), 495–506. https://doi.org/10.1016/0016-7037(78)90199-0.

DeNiro, M.J., Epstein, S., 1981. Influence of diet on the distribution of nitrogen isotopes in animals. Geochim. Cosmochim. Acta 45 (3), 341–351. https://doi.org/10.1016/0016-7037(81)90244-1.

de Flamingh, A., Coutu, A., Sealy, J., Chirikure, S., Bastos, A.D., Libanda-Mubusisi, N.M., Malhi, R.S., Roca, A.L., 2021. Sourcing elephant ivory from a sixteenth-century Portuguese shipwreck. Curr. Biol. 31 (3), 621–628.e4. https://doi.org/10.1016/j.cub.2020.10.086.

Dunnington, D., 2023. ggspatial: Spatial data framework for ggplott (Version 1.1.9) [software]. CRAN. https://doi.org/10.32614/CRAN.package.ggspatial.

France, C.A.M., Owlsey, D.W., Hayek, L.-A.-C., 2014. Stable isotope indicators of provenance and demographics in 18th and 19th century North Americans. J. Archaeol. Sci. 42, 356–366. https://doi.org/10.1016/j.jas.2013.10.037.

Funnell, W., 1707. A Voyage Round the World: Containing an Account of Captain Dampier's Expedition Into the South-Seas in the Ship St. George, in the Years 1703 and 1704. With His Various Engagements, &c. And a Particular and Exact Description of Several Islands in the Atlantick Ocean, the Brazilian Coast, the Passage Round Cape Horn, and the Coasts of Chili, Peru, and Mexico. Together With the Author's Voyage From Amapalla on the West Coast of Mexico, to East India. His Passing by Three Unknown Islands, and Thro' a New-Discover'd Streight Near the Coast of New-Guinea; His Arrival at Amboyna: With a Large Description of That and Other Spice Islands; As Also of Batavia, the Cape of Good Hope, &c. Their Rivers, Harbours, Plants, Animals, Inhabitants, &c. With Divers Maps, Draughts, Figures of Plants and Animals. W. Botham for James Knapton, London.

Glencross, B., Warrick, G., Smith, T., Prowse, T.L., 2022. Estimating ancient Huron-Wendat diet in southern Ontario using stable isotopes from dogs. J. Archaeol. Sci. Rep. 41, 103324. https://doi.org/10.1016/j.jasrep.2021.103324.

Guiry, E., 2019. Complexities of stable carbon and nitrogen isotope biogeochemistry in ancient freshwater ecosystems: implications for the study of past subsistence and environmental change. Front. Ecol. Evol. 7, 313. https://doi.org/10.3389/fevo.2019.00313.

Guiry, E., Buckley, M., 2018. Urban rats have less variable, higher protein diets. Proc. R. Soc. B: Biol. Sci. 285 (1889), 20181441. https://doi.org/10.1098/rspb.2018.1441.

Guiry, E.J., Gaulton, B.C., 2016. Inferring human behaviors from isotopic analyses of rat diet: A critical review and historical application. J. Archaeol. Method Theory 23 (2), 399–426. https://doi.org/10.1007/s10816-015-9248-9.

Guiry, E., Kennedy, R., Orton, D., Armitage, P., Bratten, J., Dagneau, C., Dawdy, S., deFrance, S., Gaulton, B., Givens, D., Hall, O., Laberge, A., Lavin, M., Miller, H., Minkoff, M.F., Niculescu, T., Noël, S., Pavao-Zuckerman, B., Stricker, L., Teeter, M., Welker, M., Wilkoski, J., Szpak, P., Buckley, M., 2024. The ratting of North America: A 350-year retrospective on *Rattus* species compositions and competition. Sci. Adv. 10 (14), eadm6755. https://doi.org/10.1126/sciadv.adm6755.

Guiry, E., Noël, S., Fowler, J., 2021a. Archaeological herbivore δ^{13}C and δ^{34}S provide a marker for saltmarsh use and new insights into the process of ^{15}N-enrichment in coastal plants. J. Archaeol. Sci. 125, 105295. https://doi.org/10.1016/j.jas.2020.105295.

Guiry, E., Orchard, T.J., Needs-Howarth, S., Szpak, P., 2021b. Isotopic evidence for garden hunting and resource depression in the late Woodland of Northeastern North America. Am. Antiq. 86 (1), 90–110. https://doi.org/10.1017/aaq.2020.86.

Guiry, E., Szpak, P., Richards, M.P., 2017. Isotopic analyses reveal geographical and socioeconomic patterns in historical domestic animal trade between predominantly wheat-and maize-growing agricultural regions in eastern North America. Am. Antiq. 82 (2), 341–352. https://doi.org/10.1017/aaq.2016.34.

Guiry, E.J., Noël, S., Tourigny, E., Grimes, V., 2012. A stable isotope method for identifying transatlantic origin of pig (*Sus scrofa*) remains at French and English fishing stations in Newfoundland. J. Archaeol. Sci. 39 (7), 2012–2022. https://doi.org/10.1016/j.jas.2012.03.004.

Guiry, E.J., Orchard, T.J., Royle, T.C.A., Cheung, C., Yang, D.Y., 2020. Dietary plasticity and the extinction of the passenger pigeon (*Ectopistes migratorius*). Quat. Sci. Rev. 233, 106225. https://doi.org/10.1016/j.quascirev.2020.106225.

Guiry, E.J., Szpak, P., 2021. Improved quality control criteria for stable carbon and nitrogen isotope measurements of ancient bone collagen. J. Archaeol. Sci. 132, 105416. https://doi.org/10.1016/j.jas.2021.105416.

Hall, T.A., 1999. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symp. Ser. 41, 95–98.

Hatvany, M.G., 2002. The origins of the Acadian aboiteau: An environmental-historical geography of the northeast. Hist. Geogr. 30, 123–131.

Honka, J., Heino, M.T., Kvist, L., Askeyev, I.V., Shaymuratova, D.N., Askeyev, O.V., Askeyev, A.O., Heikkinen, M.E., Searle, J.B., Aspi, J., 2018. Over a thousand years of evolutionary history of domestic geese from Russian archaeological sites, analysed using ancient DNA. Genes 9 (7), 367. https://doi.org/10.3390/genes9070367.

Kalm, P., 1771. Travels into North America; Containing Its Natural History, and a Circumstantial Account of its Plantations and Agriculture in General, with the Civil, Ecclesiastical and Commercial State of the Country, the Manners of the Inhabitants, and Several Curious and Important Remarks on Various Subject, Volume 3. William Eyres, London.

J.C.B. (Ed.), 1941. Travels in New France. Pennsylvania Historical Commission, Department of Public Instruction, Commonwealth of Pennsylvania, Harrisburg.

Katzenberg, M.A., 1989. Stable isotope analysis of archaeological faunal remains from southern Ontario. J. Archaeol. Sci. 16 (3), 319–329. https://doi.org/10.1016/0305-4403(89)90008-3.

Kennedy, J.R., Guiry, E.J., 2023. Exploring railroad impacts on meat trade: An isotopic investigation of meat sourcing and animal husbandry at Chinese diaspora sites in the American West. Int. J. Hist. Archaeol. 27 (2), 393–423. https://doi.org/10.1007/s10761-022-00663-6.

Kennedy, J.R., Royle, T.C.A., Jackman, L.S., Tran, C.N.H., Yang, D.Y., 2024. Zooarchaeological and ancient DNA identification of a non-local gopher tortoise (*Gopherus polyphemus*) in New Orleans, Louisiana, USA. J. Archaeol. Sci. 172, 106094. https://doi.org/10.1016/j.jas.2024.106094.

Klippel, W.E., 2001. Sugar monoculture, bovid skeletal part frequencies, and stable carbon isotopes: Interpreting enslaved African diet at Brimstone Hill, St Kitts, West Indies. J. Archaeol. Sci. 28 (11), 1191–1198. https://doi.org/10.1006/jasc.2000.0636.

Knox, J., 1916. An Historical Journal of the Campaigns in North America for the Years 1757, 1758, 1759, and 1760, Volume III–Appendix. The Champlain Society, Toronto.

Leigh, J.W., Bryant, D., 2015. POPART: Full-feature software for haplotype network construction. Methods Ecol. Evol. 6 (9), 1110–1116. https://doi.org/10.1111/2041-210X.12410.

Leonard, K., 2002. Archaeology of the Restigouche River, New Brunswick: A summary. Report on file at Parks Canada, Ottawa, Canada.

Macdonald, J., 2014. Feeding Nelson's Navy: The True Story of Food at Sea in the Georgian Era. Frontline Books, London.

MacLean, K., 2016. Analysis of the faunal remains from the *Machault*. Unpublished Master's thesis. University of Southern Denmark, Esbjerg, Denmark.

Manin, A., Corona-M, E., Alexander, M., Craig, A., Thornton, E.K., Yang, D.Y., Richards, M., Speller, C.F., 2018. Diversity of management strategies in Mesoamerican turkeys: Archaeological, isotopic and genetic evidence. R. Soc. Open Sci. 5 (1), 171613. https://doi.org/10.1098/rsos.171613.

Massicotte, P., South, A., 2023. rnaturalearth: World map data from Natural Earth (Version 1.0.1) [software]. CRAN. https://doi.org/10.32614/CRAN.package.rnaturalearth.

McNally, P., 1977. Table glass from the wreck of the *Machault*. Canadian Historic Sites: Occasional Papers in Archaeology and History 16, 35–44.

Metallic, A., Chamberlin, A., 2006. Maintaining Peace and Friendship in Gespe'gewa'gi, Mi'gma'gi: The Matnaggewaqan of 1760. Report on file at Parks Canada, Ottawa, Canada.

Migaud, P., 2011. A first approach to links between animals and life on board sailing vessels (1500–1800). Int. J. Naut. Archaeol. 40 (2), 283–292. https://doi.org/10.1111/j.1095-9270.2011.00315.x.

Mock, K.E., Theimer, T.C., Rhodes, O.E., Greenberg, D.L., Keim, P., 2002. Genetic variation across the historical range of the wild turkey (*Meleagris gallopavo*). Mol. Ecol. 11 (4), 643–657. https://doi.org/10.1046/j.1365-294X.2002.01467.x.

Monteagudo, L.V., Avellanet, R., Azón, R., Tejedor, M.T., 2013. Mitochondrial DNA analysis in two heritage European breeds confirms Mesoamerican origin and low genetic variability of domestic turkey. Anim. Genet. 44 (6), 786. https://doi.org/10.1111/age.12080.

Morris, Z., White, C., Hodgetts, L., Longstaffe, F., 2016. Maize provisioning of Ontario late Woodland turkeys: Isotopic evidence of seasonal, cultural, spatial and temporal variation. J. Archaeol. Sci. Rep. 10, 596–606. https://doi.org/10.1016/j.jasrep.2016.06.017.

Müller, K., 2020. here: A simpler way to find your files (Version 1.0.1) [software]. CRAN. https://doi.org/10.32614/CRAN.package.here.

Natural Earth, 2024. Natural Earth. https://www.naturalearthdata.com/ (accessed 11 June 2025).

Nicolas, L., 2011. The Codex Canadensis and the Writings of Louis Nicolas: The Natural History of the New World=Histoire naturelle des Indes occidentales. Gilcrease Museum, Tulsa, and McGill-Queen's University Press, Montréal and Kingston.

Orchard, T.J., Needs-Howarth, S., Hawkins, A.L., Lesage, L., Guiry, E.J., Royle, T.C.A., 2023. Considering passenger pigeon abundance and distribution in the late Woodland zooarchaeological record of southern Ontario, Canada. Int. J. Osteoarchaeol. 33 (4), 608–618. https://doi.org/10.1002/oa.3163.

Ostéothèque de, M., 2000. Étude zooarchéologique des restes osseux provenant de la place du Parlement de Québec (CeEt-740). Report on file at Bibliothèque numérique en archéologie, Québec, Canada.

Pebesma, E., 2018. Simple features for R: Standardized support for spatial vector data. The R Journal 10 (1), 439–446. https://doi.org/10.32614/RJ-2018-009.

Pebesma, E., Bivand, R., 2023. Spatial data science: With applications in R. Chapman and Hall/CRC, New York.

Pfeiffer, S., Sealy, J.C., Williamson, R.F., Needs-Howarth, S., Lesage, L., 2016. Maize, fish, and deer: Investigating dietary staples among ancestral Huron-Wendat villages, as documented from tooth samples. Am. Antiq. 81 (3), 515–532. https://doi.org/10.7183/0002-7316.81.3.515.

Poinar, H.N., Cooper, A., 2000. Ancient DNA: Do it right or not at all. Science 289 (5482), 1139. https://doi.org/10.1126/science.289.5482.1139b.

Post, D.M., 2002. Using stable isotopes to estimate trophic position: Models, methods, and assumptions. Ecology 83 (3), 703–718. https://doi.org/10.1890/0012-9658(2002)083[0703:USITET]2.0.CO;2.

R Core Team, 2024. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

Reitz, E.J., Speller, C., McGrath, K., Alexander, M., 2016. A sixteenth-century turkey (*Meleagris gallopavo*) from Puerto Real, Hispaniola. J. Archaeol. Sci. Rep. 10, 640–646. https://doi.org/10.1016/j.jasrep.2016.05.050.

Rouleau, S., 2000. Fouilles archéologiques du site de la tannerie Robitaille-Gauvreau en 1999. Ville de Québec, Division design et patrimoine, Québec.

Royle, T.C.A., Guiry, E.J., Zhang, H., Clark, L.T., Missal, S.M., Rabinow, S.A., James, M., Yang, D.Y., 2022. Documenting the short-tailed albatross (*Phoebastria albatrus*) clades historically present in British Columbia, Canada, through ancient DNA analysis of archaeological specimens. Ecol. Evol. 12 (8), e9116. https://doi.org/10.1002/ece3.9116.

Sayers, E.W., Cavanaugh, M., Clark, K., Pruitt, K.D., Sherry, S.T., Yankie, L., Karsch-Mizrachi, I., 2023. GenBank 2023 update. Nucleic Acids Res. 51 (D1), D141–D144. https://doi.org/10.1093/nar/gkac1012.

Schauberger, P., Walker, A., 2025. openxlsx: Read, qrite and edit xlsx files (Version 4.2.8) [software]. CRAN. https://doi.org/10.32614/CRAN.package.openxlsx.

Schoeninger, M.J., DeNiro, M.J., 1984. Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. Geochim. Cosmochim. Acta 48 (4), 625–639.

Schorger, A.W., 1966. The Wild Turkey; Its History and Domestication. University of Oklahoma Press, Norman.

Simoneau, D., 2000. Rapport d'interventions archéologiques: Colline parlementaire 1999-2000. Ville de Québec, Division design et patrimoine, Centre de développement économique et urbain, Québec.

Sigman, D.M., Karsh, K.L., Casciotti, K.L., 2009. Nitrogen isotopes in the ocean. In: Steele, J.H. (Ed.), Encyclopedia of Ocean Science, second ed. Academic Press, San Diego, pp. 4139–4152. https://doi.org/10.1016/B978-012374473-9.00632-9Sl.

Stavely, K.W., Fitzgerald, K., 2004. America's Founding Food: The Story of New England Cooking. University of North Carolina Press, Chapel Hill.

Speller, C.F., Hauser, L., Lepofsky, D., Moore, J., Rodrigues, A.T., Moss, M.L., McKechnie, I., Yang, D.Y., 2012. High potential for using DNA from ancient herring bones to inform modern fisheries management and conservation. PLoS One 7 (11), e51122. https://doi.org/10.1371/journal.pone.0051122.

Speller, C.F., Kemp, B.M., Wyatt, S.D., Monroe, C., Lipe, W.D., Arndt, U.M., Yang, D.Y., 2010. Ancient mitochondrial DNA analysis reveals complexity of indigenous North American turkey domestication. PNAS 107 (7), 2807–2812. https://doi.org/10.1073/pnas.0909724107.

Star, B., Barrett, J.H., Gondek, A.T., Boessenkool, S., 2018. Ancient DNA reveals the chronology of walrus ivory trade from Norse Greenland. Proc. R. Soc. B Biol. Sci. 285 (1884), 20180978. https://doi.org/10.1098/rspb.2018.0978.

Star, B., Boessenkool, S., Gondek, A.T., Nikulina, E.A., Hufthammer, A.K., Pampoulie, C., Knutsen, H., André, C., Nistelberger, H.M., Dierking, J., Petereit, C., Heinrich, D., Jakobsen, K.S., Stenseth, N.C., Jentoft, S., Barrett, J.H., 2017. Ancient DNA reveals the Arctic origin of Viking Age cod from Haithabu, Germany. PNAS 114 (34), 9152–9157. https://doi.org/10.1073/pnas.1710186114.

Sullivan, C., 1986. Legacy of the Machault: A collection of 18th-century artifacts. National Historic Parks and Sites Branch, Parks Canada, Environment Canada, Ottawa.

Thompson, J.D., Higgins, D.G., Gibson, T.J., 1994. CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Res. 22 (22), 4673–4680. https://doi.org/10.1093/nar/22.22.4673.

Thornton, E.K., Emery, K.F., 2017. The uncertain origins of Mesoamerican turkey domestication. J. Archaeol. Method Theory 24 (2), 328–351. https://doi.org/10.1007/s10816-015-9269-4.

Thornton, E.K., Peres, T., Chase, K.L., Kemp, B.M., Frome, R., Manin, A., Basnett, L., McGrath, K., Speller, C., Reitz, E.J., 2021. Testing for Mississippian period turkey management in the archaeological record of the southeastern United States. Am. Antiq. 86 (4), 794–814. https://doi.org/10.1017/aaq.2021.58.

Tieszen, L.L., 1991. Natural variations in the carbon isotope values of plants: Implications for archaeology, ecology, and paleoecology. J. Archaeol. Sci. 18 (3), 227–248. https://doi.org/10.1016/0305-4403(91)90063-U.

Tourigny, E.D., 2018. Eating barrelled meat in Upper Canada: Cultural and archaeological implications. Int. J. Hist. Archaeol. 22 (4), 843–864. https://doi.org/10.1007/s10761-017-0450-1.

Tourigny, E., Thomas, R., Guiry, E., Earp, R., Allen, A., Rothenburger, J.L., Lawler, D., Nussbaumer, M., 2016. An osteobiography of a 19th-century dog from Toronto. Canada. International Journal of Osteoarchaeology 26 (5), 818–829. https://doi.org/10.1002/oa.2483.

Turnbull, C.J., 1973. Old Mission Point Excavations 1972. Report on file at Parks Canada, Ottawa, Canada.

Ubelaker, D.H., Owsley, D.W., 2003. Isotopic evidence for diet in the seventeenth-century colonial Chesapeake. Am. Antiq. 68 (1), 129–139. https://doi.org/10.2307/3557036.

Vigeant, J., Ribot, I., Hélie, J.-F., 2017. Dietary habits in New France during the 17th and 18th centuries: An isotopic perspective. Am. J. Phys. Anthropol. 162 (3), 462–475. https://doi.org/10.1002/ajpa.23129.

Villesen, P., 2007. FaBox: an online toolbox for FASTA sequences. Mol. Ecol. Notes 7 (6), 965–968. https://doi.org/10.1111/j.1471-8286.2007.01821.x.

Wade, B., 1980. Summary of the artifact distributions from *Le Machault*. Parks Canada Research Bulletin 133, 1–13.

Wang, Y., Sun, Y., Royle, T.C.A., Zhang, X., Zheng, Y., Tang, Z., Clark, L.T., Zhao, X., Cai, D., Yang, D.Y., 2022. Ancient DNA investigation of the domestication history of pigs in Northeast China. J. Archaeol. Sci. 141, 105590. https://doi.org/10.1016/j.jas.2022.105590.

Wickham, H., 2016. ggplot2: Elegant graphics for data analysis. Springer-Verlag, New York.

Wilke, C.O., 2024. cowplot: Streamlined plot theme and plot annotations for 'ggplot2'(Version 1.1.3) [software]. CRAN. https://doi.org/10.32614/CRAN.package.cowplot.

Winters, M., Barta, J.L., Monroe, C., Kemp, B.M., 2011. To clone or not to clone: Method analysis for retrieving consensus sequences in ancient DNA samples. PLoS One 6 (6), e21247. https://doi.org/10.1371/journal.pone.0021247.

Yang, D.Y., Eng, B., Waye, J.S., Dudar, J.C., Saunders, S.R., 1998. Improved DNA extraction from ancient bones using silica-based spin columns. Am. J. Phys. Anthropol. 105 (4), 539–543. https://doi.org/10.1002/(SICI)1096-8644(199804)105:4<539::AID-AJPA10>3.0.CO;2-1.

Yang, D.Y., Liu, L., Chen, X., Speller, C.F., 2008. Wild or domesticated: DNA analysis of ancient water buffalo remains from North China. J. Archaeol. Sci. 3 (10), 2778–2785. https://doi.org/10.1016/j.jas.2008.05.010.

Yang, D.Y., Watt, K., 2005. Contamination controls when preparing archaeological remains for ancient DNA analysis. J. Archaeol. Sci. 32 (3), 331–336. https://doi.org/10.1016/j.jas.2004.09.008.

Zacharchuk, W., Waddell, P.J., 1984. The Excavation of the *Machault*, An 18th-Century French Frigate. National Historic Parks and Sites Branch, Parks Canada, Environment Canada, Ottawa.

Zouganelis, G.D., Ogden, R., Nahar, N., Runfola, V., Bonab, M., Ardalan, A., Radford, D., Barnett, R., Larson, G., Hildred, A., Jones, M., Scarlett, G., 2014. An old dog and new tricks: Genetic analysis of a Tudor dog recovered from the Mary Rose wreck. Forensic Sci. Int. 245, 51–57. https://doi.org/10.1016/j.forsciint.2014.10.001.