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ORIGINAL PAPER

Isotopic dietary patterns of monks: results from stable isotope analyses of a seventeenth–eighteenth century Basilian monastic community in Vilnius, Lithuania

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Abstract

The aim of the research focuses on reconstructing diet of the seventeenth–eighteenth century Basilian monks who were buried in the crypt beneath the Holy Trinity Uniate Church in Vilnius, Lithuania. For this aim, stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope analyses of human bone collagen samples ($n = 74$, of which 39 yielded reliable isotopic data) were performed. In order to establish the isotopic dietary baseline for the Basilian monks, we sampled faunal bones ($n = 47$, of which 34 yielded reliable isotopic data) recovered during archaeological investigations in the area around the Vilnius Lower Castle and the Palace of the Grand Dukes of Lithuania. Faunal samples were comprised of various domestic and wild terrestrial animals, freshwater and anadromous fish, and migratory and non-migratory birds. In total, 121 human and faunal samples were analysed. The isotopic data collected in our study suggest that C_3 plant and domestic animal products were the main components in the diets of the Basilian monks, while freshwater fish played a noticeable, yet a much smaller dietary role. However, historical sources describe a reverse dietary picture, i.e. a higher dietary contribution from fish and a lower from animal products. The potential reasons for this incongruity between isotopic and historical dietary evidence were also explored. Finally, the isotopic data of the Basilian monks were compared with that of contemporary Lithuanian nobles and commoners. The comparisons indicate that monastic dietary patterns were more similar to those of the nobility than those of the commoners.

Keywords Lithuania · Basilian monks · Monastic diet · Seventeenth–eighteenth century · Bone collagen · $\delta^{13}C$ · $\delta^{15}N$

Introduction

The Union of Brest in 1596 created a new Greek Catholic, or Uniate, church in the territories of the Polish-Lithuanian Commonwealth. The Uniates maintained their Byzantine-Slavonic rites but accepted the primacy of the pope. After the union, by 1617, most Orthodox churches and monasteries in the Polish-Lithuanian Commonwealth were converted into Uniate ones which were subsequently incorporated into a new Order of St. Basil the Great (Ordo Sancti Basilii Magni). The members of this new Uniate monastic order – the Basilian monks – combined the ascetical and contemplative traditions of Eastern monasticism with activities typical to Catholic religious orders.

The dietary behaviour of Basilian monks was in certain ways similar to that of other Christian monks in that their food choices were restricted by the rules imposed by their monastic order (e.g. Silvas 2013). One such rule was the obligation for monks to observe periodic fasts on particular days of the week

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(e.g. Mondays, Wednesdays, and Fridays) and during liturgical seasons, such as Advent, Lent, and others (Adamson 2004; Dembinska 1999; Krachkovskiy 1900). During fasting seasons, the consumption of meat was prohibited, and monastic meals featured various species of fish instead (Dembinska 1999; Adamson 2004; Laužikas 2014; Dambrauskaitė 2018). Considering this fact, it can be hypothesised that the isotopic data of monks should provide a strong aquatic signal related to the high dietary contribution from fish. However, even though fish was an important component of monastic meals (especially on fast days), the actual dietary proportions of terrestrial animal and fish products in the monks' diets could have varied significantly between individuals and populations across different time periods due to the complicated relationship between the monastic lifestyle and consumption of meat.

On the one hand, almost all traditional Eastern and Western Christian rules prohibited the consumption of meat, as this restriction was considered to be the best way to strive for the ideals of the apostolic life (Bynum 1988; Albala 2011). As such, in the 1620s and in the 1630s, the newly founded Basilian order also repeatedly issued prohibitions against meat consumption, breaching of which was even considered a grave offence and a sign of disobedience. Consumption of meat was limited to only 3 days a week even for ailing monks. On the other hand, as the zeal of the reforms abated, the Basilian order gradually relaxed its restrictions, and, already in 1667, all monks were allowed to eat meat 3 days a week, except during fast seasons (Krachkovskiy 1900). Since this study deals with the Basilian monks from the seventeenth and eighteenth century, when the monastic dietary restrictions were supposedly more lenient, it is more likely that their isotopic data may reflect a higher dietary proportion of terrestrial animal products than fish. And if that was the case, it may even be possible that the dietary composition/isotopic data of the Basilian monks would not be that different from secular individuals, which was actually observed in many previous isotopic studies (Sarkic et al. 2018; Quintelier et al. 2014; Gregoricka and Sheridan 2013; Yoder 2012; Müldner and Richards 2007).

In this paper, we have combined the analyses of isotopic and historical data with the aim of reconstructing the diet of Lithuanian seventeenth–eighteenth century Basilian monks from the Vilnius Holy Trinity Church-Monastery complex which was an important centre of religious and cultural life within the Uniate church. By using both isotopic and historical analyses, we not only provide new evidence on Basilian monks' diets but also evaluate whether the Basilians' diets conform with what would have been expected in the Eastern monastic tradition (more fish, less meat in the diet), or did the monks already enjoy greater freedom in their food choices (more meat, less fish in the diet) by the seventeenth–eighteenth century. Also, the comparisons between isotopic data of the Basilian monks and two contemporary Lithuanian secular populations, the first representing the nobility and the second, the commoners, enabled us to determine whether monastic dietary patterns were similar or different to any of the other social groups.

Materials

For this study, we performed stable isotope analyses on 74 human and 47 animal bone collagen samples, each representing a separate individual. Both human and faunal material came from Vilnius, Lithuania (Fig. 1). The faunal osteological material, which was analysed in order to establish the isotopic dietary baseline for the Basilian monks, was selected from various animal species (Tables S1 and S3), remains of which were recovered from the area around the Palace of the Grand Dukes, a part of the former Vilnius Lower Castle complex and dated to the sixteenth–eighteenth century (S1).

The human osteological material represents the monastic population of Basilian monks (Tables S2 and S4), whose remains were buried and later discovered during the 2015 and 2016 interdisciplinary archaeological, anthropological, and historical investigations of the crypt and its contents beneath the main altar of Vilnius Holy Trinity Church (Fig. 2; S1; Kuncevičius et al. 2017; Piombino-Mascali et al. 2017; Kuncevičius et al. 2016). In total, 74 well-preserved human remains were discovered in the crypt. The crypt is dated to the second half of the seventeenth to the beginning of the eighteenth century based on the written sources about the crypt and the inscriptions that were present on some of the coffins which indicated an individuals' birth and death dates (Kuncevičius et al. 2017). Since from the historical sources we know the exact period (Kuncevičius et al. 2017) when the crypt was used as a burial place for Basilian monks, it was decided not to perform radiocarbon analyses on human bones which in this case wouldn't have given an accurate chronology for this site.

Methods

Bone collagen extraction was performed at the Archaeological Research Laboratory (Stockholm University, Sweden) following procedures of the modified Longin (1971) method (Brown et al. 1988; S2; Tables S1-S2). Next, the 0.4–0.6 mg of extracted bone collagen from each sample ($n = 111$), which had a sufficient collagen yield (≥ 1%), were submitted to the Stable Isotope Lab (SIL) at the Department of Geological Sciences in Stockholm University. There, the EA-IRMS analysis was performed by combusting collagen samples in a Carlo Erba NC2500 elemental analyzer, which was connected via a split

Fig. 1 The localisation of Vilnius (Lithuania) from where both human and faunal material were derived (modified from Piličiauskas et al. 2017, Fig. 1)

Fig. 2 (**a**) D The Vilnius Holy Trinity Church-Monastery (Image taken from: http://www.bernardinai.lt/straipsnis/2014-06-03-vilniaus-svenciausiosios-trejybes-baznyciai-500-metu/118410, accessed 10 October 2019); (**b**) The altar beneath which the Basilian burial crypt is located (Kuncevičius et al. 2016, 1 pav.); (**c**) inside the Basilian burial crypt before the investigation (Kuncevičius et al. 2016, 2 pav)

Table 1 Isotopic data of animals from the lower castle of Vilnius and The Palace of the Grand Dukes of Lithuania (Vilnius, Lithuania)

Sample #	Common name (species)	Chronology	Element	δ^{13}C (‰)	δ^{15}N (‰)	Collagen yield (%)	%C	%N	C/N
ŽPVR 10	Bream (*Abramis brama*)	16–17 c.	Praeoperculare	− 26.3	7.9	4.0	41.2	14.9	3.2
ŽPVR 11	Zander (*Sander lucioperca*)	16–17 c.	Dentary	− 27.5	7.8	3.2	41.0	15.1	3.2
ŽPVR 12	Zander (*Sander lucioperca*)	16–17 c.	Dentary	− 23.4	11.0	2.4	42.0	15.4	3.2
ŽPVR 13	Pike (*Esox lucius*)	16–17 c.	Operculare	− 25.0	6.8	3.7	41.1	14.9	3.2
ŽPVR 14	Pike (*Esox lucius*)	16–17 c.	Operculare	− 25.4	12.1	4.5	40.7	15.0	3.2
ŽPVR 17	Sturgeon (*Acipenser* sp.)	16–17 c.	Suboperculare	− 17.1	9.6	6.9	36.4	13.3	3.2
ŽPVR 18	Sturgeon (*Acipenser* sp.)	16–17 c.	Suboperculare	− 18.7	10.7	5.7	32.4	11.8	3.2
ŽPVR 19	Grey partridge (*Perdix perdix*)	15 c.	Ulna	− 20.8	7.3	2.2	35.7	12.8	3.3
ŽPVR 20	Grey partridge (*Perdix perdix*)	15 c.	Ulna	− 21.5	6.5	1.7	34.1	12.1	3.3
ŽPVR 21	Greylag geese (*Anser anser*)	15 c.	Humerus	− 22.9	5.0	8.6	38.6	14.0	3.2
ŽPVR 22	Greylag geese (*Anser anser*)	15 c.	Humerus	− 23.0	9.4	6.5	40.1	14.4	3.3
ŽPVR 23	Mallard (*Anas platyrhynchos*)	15 c.	Humerus	− 27.1	10.8	3.3	39.3	14.1	3.2
ŽPVR 24	Mallard (*Anas platyrhynchos*)	15 c.	Humerus	− 25.8	9.6	5.7	37.6	13.6	3.2
ŽPVR 25	Elk (*Alces alces*)	16–17 c.	Cranium	− 22.1	4.3	5.8	34.1	12.0	3.3
ŽPVR 26	Elk (*Alces alces*)	16–17 c.	Cranium	− 22.2	2.9	5.2	40.5	14.4	3.3
ŽPVR 27	Wisent (*Bison bonasus bonasus*)	16–17 c.	Ulna	− 23.8	3.7	5.0	41.9	15.2	3.2
ŽPVR 28	Wisent (*Bison bonasus bonasus*)	16–17 c.	Ulna	− 22.9	5.4	6.9	40.4	14.7	3.2
ŽPVR 29	Dog (*Canis lupus familiaris*)	16–17 c.	Cranium	− 20.1	9.1	5.1	40.1	14.3	3.3
ŽPVR 30	Dog (*Canis lupus familiaris*)	16–17 c.	Vertebra	− 20.5	11.5	4.2	39.2	14.2	3.2
ŽPVR 31	Cattle (*Bos taurus*)	16–17 c.	Metatarsus	− 21.6	7.3	7.1	40.8	14.8	3.2
ŽPVR 32	Pig (*Sus scrofa domesticus*)	16–17 c.	Mandible	− 21.3	8.5	5.8	35.1	12.6	3.2
ŽPVR 33	Sheep (*Ovis aries*)	16–17 c.	Cranium	− 22.2	9.9	11.3	37.9	13.8	3.2
ŽPVR 34	Boar (*Sus scrofa*)	16–17 c.	Tibia	− 21.7	5.9	4.4	41.3	14.7	3.3
ŽPVR 35	Wisent (*Bison bonasus bonasus*)	16–17 c.	Metacarpus	− 24.1	4.5	6.8	39.4	14.3	3.2
ŽPVR 36	Red deer (*Cervus elaphus*)	16–17 c.	Metacarpus	− 22.3	3.6	1.9	32.1	11.7	3.2
ŽPVR 37	Elk (*Alces alces*)	16–17 c.	Humerus	− 22.4	3.4	6.4	37.1	13.3	3.2
ŽPVR 38	Chicken (*Gallus gallus domesticus*)	15 c.	Ulna	− 21.0	8.1	6.7	38.4	13.9	3.2
ŽPVR 41	Bream (*Abramis brama*)	16–17 c.	Operculare	− 27.8	8.6	5.3	44.4	15.8	3.3
ŽPVR 42	Zander (*Sander lucioperca*)	16–17 c.	Dentary	− 27.3	11.9	1.0	41.3	14.9	3.2
ŽPVR 43	Pike (*Esox lucius*)	16–17 c.	Dentary	− 24.9	9.3	2.5	42.1	15.7	3.1
ŽPVR 45	Perch (*Perca fluviatilis*)	16 c.	Dentary	− 21.4	7.9	5.2	42.9	15.6	3.2
ŽPVR 46	Perch (*Perca fluviatilis*)	17 c.	Operculare	− 25.4	12.1	2.3	37.2	13.8	3.2
ŽPVR 48	Calf (*Bos taurus*)	17 c.	Mandible	− 22.1	6.6	4.9	43.5	15.8	3.2
ŽPVR 49	Calf (*Bos taurus*)	17 c.	Mandible	− 21.9	7.9	3.1	41.2	14.8	3.2

interface to a Thermo Delta V Advantage mass spectrometer. The precision of the measurements for both δ^{13}C and δ^{15}N was ± 0.15‰. Ten samples were submitted to the Mass Spectrometry Laboratory at the Department of Nuclear Research, at the Center for Physical Sciences and Technology (FTMC; Vilnius, Lithuania). There, the EA-IRMS analysis was performed by combusting collagen samples in a Thermo Flash EA 1112 elemental analyzer, which was connected to a Thermo Scientific Delta V Advantage mass spectrometer. The analytical precision for δ^{13}C and δ^{15}N was ± 0.1‰ and ± 0.2‰, respectively.

In order to ensure that the collagen in bone samples is of sufficient quality for further data interpretations, three different parameters were also measured: carbon and nitrogen concentrations (%C and %N, respectively) and the atomic carbon to nitrogen (C/N) ratio (see also S2).

In this paper, we also graphically and statistically compared individuals based on their social and health status in order to determine if there are any correlations between these attributes and human isotopic values. For statistical comparisons, we also used two different techniques. Grubbs' test for outliers was used in order to determine whether the analysed human population contains individuals who are significant outliers in terms of their δ^{13}C and/or δ^{15}N. Also, a non-parametric Kruskal-Wallis test was used to compare the isotopic data of the

Basilian monks with the data sets of two different secular populations (nobles and commoners; see Discussion).

Results

Animal isotope values

Out of the 47 analysed animal bone collagen samples, 34 yielded reliable isotopic data (Tables S3; S2). Isotopic data of the analysed animal samples are provided in Table 1 and Fig. 3. From these faunal isotopic values, the human palaeodietary baseline, which enables us to determine the main animal protein sources consumed by the Basilian monks, was created. To create the isotopic baseline, we grouped all of the analysed species into separate animal categories, based on similarities in habitat, dietary, and/or mobility patterns. As a result, seven different animal groups were distinguished, six of which are referred to as food groups, since they comprise species that can be considered as potential food sources for human consumption and a single non-food group that was comprised of dogs. The food groups are as follows: (1) domestic herbivores/omnivores, (2) wild herbivores/omnivores, (3) freshwater fish, (4) anadromous fish, (5) migratory birds, and (6) non-migratory birds (Fig. 4). For more detailed interpretations of the isotopic values of each animal group see S3.

After identifying these food groups, we generated a scatter plot diagram, in which the isotopic expectancy ranges were marked out for each food group as areas of different shape and colour by connecting all animal isotopic values from a single group. Also, δ^{13}C and δ^{15}N values of each animal were elevated by + 1‰ and + 4.5‰, respectively, in order to account for the isotopic ratio fractionation of each element occurring between the food and the consumer (for more details see S4). The purpose of this was to show where human isotopic values would be placed in the diagram if their diets were based on the consumption of animals from a specific food group. For example, if an individual's isotopic data point was inside the area of the freshwater fish food group, then that would be a strong indication that this food group comprised the major portion of his/her diet.

Human isotopic results

Out of the 74 human bone collagen samples, 40 yielded reliable isotopic data (Table S4; S2). Isotopic data of the analysed human samples are provided in Table 2 and Fig. 5. The average δ^{13}C value for all human samples that met all collagen quality criteria is − 20.1 ± 0.3‰ ranging from − 20.6‰ to − 19.4‰, while the average δ^{15}N value is 12.3 ± 0.8‰ ranging from 9.8‰ to 14.1‰. No statistically significant outliers were detected (Grubbs' test: all individuals' $p > 0.05$ for both δ^{13}C and δ^{15}N; Table S5), which suggests relatively homogenous diets among the Basilian monks. However, slight isotopic variations are visible (Fig. 5), which may indicate minor dietary differences between individuals, and which might have been caused by the varying proportions of terrestrial versus aquatic protein sources. For example, the most noticeable difference in δ^{15}N found between individuals STC73 (14.1‰) and STC28 (9.8‰) could indicate a higher proportion of aquatic protein in the diet of the former and a more terrestrial dietary composition of the latter (Fig. 5). Similarly, the largest difference in δ^{13}C between individuals STC72 (− 19.4 ‰) and STC50 (− 20.6 ‰) suggest a slightly higher dietary contribution from marine and/or C_4 plant sources in the former's diet (Fig. 5).

Human isotopic data do not show any correlation with the age of the individuals (Fig. 6; Table S6), nor any isotopic differences between individuals with various diet-related bone pathological lesions and those without (Fig. 7; Table S7; also see S5 for more information on the bone pathological lesions detected on the monks' remains). Therefore, despite some potential minor variations between individuals, the overall human isotopic data indicate a diet based mainly on terrestrial C_3 plant and domestic animal protein sources (Fig. 4).

Discussion

Historical data on the Basilian diet

The main historical source that reveals some features of the Basilians' diets is the account book kept by the Holy Trinity Monastery from 1765 to 1781 (hereafter the account book[1]; Tables 3–4). However, this document provides a rather limited and therefore only partially useful information about the diet of the Basilians. For example, the quantities of purchased foodstuffs are usually not specified, which makes it difficult to approximate the serving size of each type of food for every monk.

Furthermore, not all the purchased food items were consumed by monks. In few cases, the account book specifies that the food item in question was bought for special guests (usually, secular nobles) or for the ailing monks or secular people who were nursed in the monastery's infirmary, although it must be emphasized that these are rare cases and the vast majority of food items listed in the account book were purchased for the consumption by the Basilian monks themselves. Therefore, the account book mostly reflects at least some portion of the monastic diet.

However, not all foodstuffs were mentioned in the account book, since not all foods were purchased at the market but

[1] lit: Švč. Trejybės bažnyčios-vienuolyno pajamų ir išlaidų knyga (1765–1781). Lithuanian State Historical Archives, f. 1178, ap. 1, b. 1

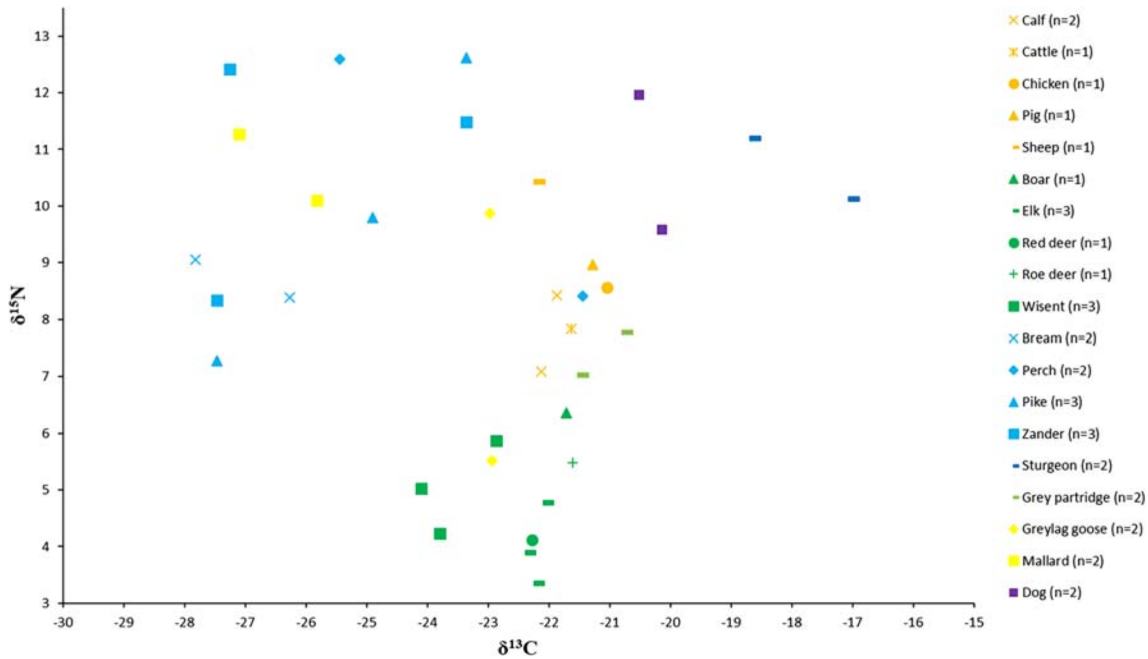

Fig. 3 Stable isotope values of animal bone collagen samples

instead were obtained from the villages and estates owned by the Basilians, while bread and ale were produced in the monastery (Kuncevičius et al. 2017). Since these transactions were not recorded in the account book or any other written sources, it is impossible to define more accurately the composition of the monastic diet based on this evidence alone. Although the historical evidence about diets of the Basilian monks tells us only one side of the story, it reveals what foods were available to them. This can help to narrow down the range of animal species that could have been the highest contributors of protein to human bone collagen.

Based on the account book, the main components of protein in the diets of the Basilian monks were various species of fish, mainly pike (Table 3). This finding is not surprising, considering that fish was the main course on fast days (Dembinska 1999; Adamson 2004; Laužikas 2014; Dambrauskaitė 2018), which were frequent in the monastic calendar (Adamson 2004; Dembinska 1999; Krachkovskiy

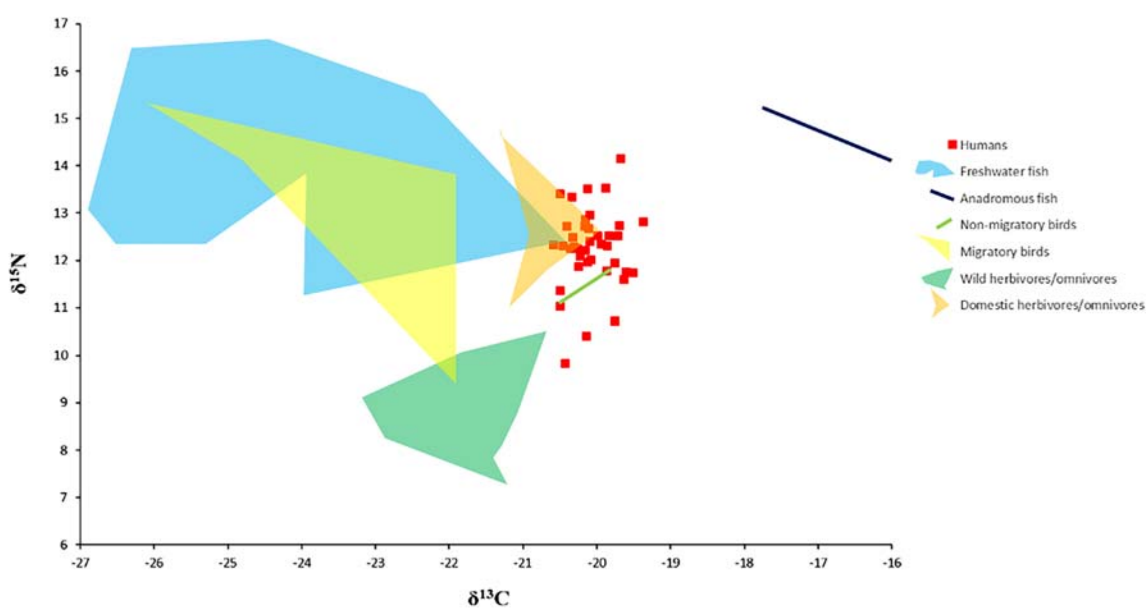

Fig. 4 The isotopic expectancy ranges (the coloured areas) of six distinguished food groups. The isotopic expectancy ranges were created after adding + 1‰ and + 4.5‰ to each animal's $\delta^{13}C$ and $\delta^{15}N$ values, respectively, in order to account for each element's isotopic fractionation between food and its consumer (See S4)

Table 2 Isotopic data of male* humans from the Holy Trinity Church/Monastery (Vilnius, Lithuania)

Sample #	Grave no.	Age at death	Element	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	Collagen yield (%)	% C	% N	C/N
STC 11	K 66	30–39	Right femur	− 19.9	11.8	12.8	43.2	15.6	3.2
STC 12	c C/2	25–35	Right femur	− 20.1	12.0	5.0	39.2	14.1	3.2
STC 13	K 45	20–25	Right femur	− 20.5	11.4	9.6	39.6	14.4	3.2
STC 14	K 29	25–30	Right femur	− 20.3	12.3	7.9	38.7	13.9	3.3
STC 15	K 37	30–35	Right femur	− 19.9	12.3	13.6	42.0	15.1	3.2
STC 20	K 38	35–40	Right femur	− 20.2	12.9	11.0	41.0	14.8	3.2
STC 21	K 33	25–30	Right femur	− 20.5	11.0	12.0	41.5	15.0	3.2
STC 22	K 23	35–45	Right femur	− 20.1	13.5	13.7	38.0	13.8	3.2
STC 23	K 67	20–25	Right femur	− 20.2	12.1	12.3	39.6	14.4	3.2
STC 24	K 4	45–50	Right femur	− 20.1	12.4	9.7	37.4	13.5	3.2
STC 25	K 54	40–49	Right femur	− 19.8	11.9	9.6	36.9	13.3	3.2
STC 26	K 48	50 +	Right femur	− 19.8	12.5	6.7	41.1	14.8	3.2
STC 27	K 51	40–45	Right femur	− 19.6	11.7	9.8	39.4	14.1	3.3
STC 28	K 25	25–35	Right femur	− 20.4	9.8	8.2	43.5	15.2	3.3
STC 29	K 61	35–44	Right femur	− 20.5	13.4	9.7	40.1	14.6	3.2
STC 30	K 56	30–40	Right femur	− 19.8	10.7	9.9	38.8	14.1	3.2
STC 31	K 70	40–49	Right femur	− 20.1	12.0	10.8	41.0	14.7	3.2
STC 32	K 35	30–40	Right femur	− 20.2	11.9	12.0	39.7	14.3	3.2
STC 33	K 60	40–49	Right femur	− 19.9	12.3	8.8	40.7	14.8	3.2
STC 34	K 71	30 +	Right femur	− 19.7	12.5	10.0	43.6	15.7	3.2
STC 47	K 27	40–45	Right femur	− 19.6	11.6	7.5	41.3	14.7	3.3
STC 50	K 52	50 +	Right femur	− 20.6	12.3	10.8	43.2	14.4	3.5
STC 55	K 21	50 +	Right femur	− 20.1	13.0	10.4	43.5	15.8	3.2
STC 57	K 11	50 +	Right femur	− 20.3	12.5	8.8	41.8	15.1	3.2
STC 58	K 1	30–40	Left femur	− 20.1	10.4	12.6	45.0	16.4	3.2
STC 59	K 12A	40–50	Left femur	− 20.5	12.3	11.1	44.7	16.1	3.2
STC 60	K 41	40–45	Left femur	− 20.4	12.7	12.4	45.0	16.2	3.2
STC 61	K 44	50 +	Left femur	− 20.1	12.7	9.5	45.1	16.2	3.2
STC 62	K 64	35–45	Left femur	− 20.2	12.7	7.9	45.6	16.5	3.2
STC 64	K 34	40 +	Right rib	− 20.4	12.3	10.5	42.0	15.2	3.2
STC 65	K 32	50 +	Left metacarpal	− 19.7	12.7	9.2	37.5	13.5	3.2
STC 66	K 46	25–35	Right metatarsal	− 19.5	11.7	7.6	43.0	15.5	3.2
STC 67	K 13	50 +	Left metatarsal	− 20.2	12.2	10.1	41.5	15.0	3.2
STC 68	kv. 2/D	40–49	Right metatarsal	− 20.3	13.3	8.9	39.1	13.9	3.3
STC 70	K 49	50 +	Right metatarsal	− 20.0	12.5	9.8	38.6	13.9	3.2
STC 71	K 47	35–45	Right rib	− 19.9	13.5	10.4	43.2	15.6	3.2
STC 72	K 7	50 +	Cervical vertebra	− 19.4	12.8	12.1	44.7	16.2	3.2
STC 73	K 18	40 +	Left rib	− 19.7	14.1	11.7	40.6	14.5	3.3
STC 74	K 65	40–49	Right humerus	− 20.3	12.3	9.1	43.5	15.8	3.2

*The sex of three individuals (STC33, STC34, STC64) is less certain but based on contextual data of their burials they more likely were also males

1900). Fresh pike of large size was expensive, very liked among the Lithuanian and Polish nobles (Piličiauskienė and Blaževičius 2019), and, according to the account book (Table 3), the Basilians were probably no different in this regard. Although types and quantities of the purchased fish are not always specified, it is certain that the Basilians consumed fresh as well as preserved fish. However, according to menus of the nobility, fresh pike was consumed more often than dried or salted fish (Piličiauskienė and Blaževičius 2019). Every week the monastery purchased several varieties of fresh, locally sourced fish, such as pike or perch. Another common dish on fast days was salted herring, usually imported from the Netherlands and bought in barrels greater than 100 l (The Account Book).

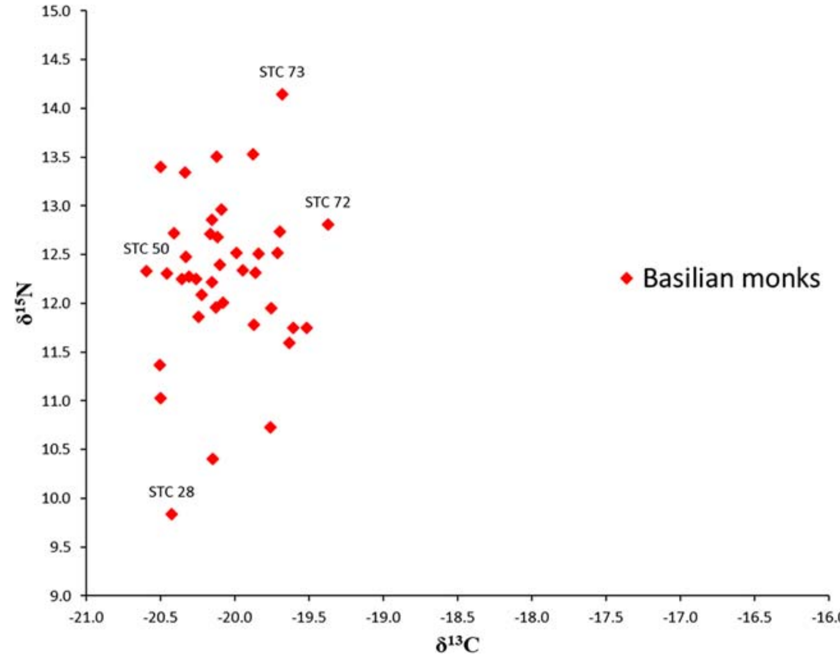

Fig. 5 Stable isotope values of human bone collagen samples. The individuals with highest and lowest $\delta^{13}C$ and $\delta^{15}N$ values are indicated on the graph

Concerning the consumption of animal products, it is known that the villages and estates owned by the Basilian monastery supplied various amounts of fresh and preserved (usually smoked or salted) pork, veal, poultry, and other meat for daily consumption. However, the community was not entirely self-sufficient in this regard, and fresh meat was sometimes bought from the local market as well (see Table 4). Entries in the account book clearly indicate that meat was usually purchased in the months of spring and summer when the provision from the monastery's estates was limited, as well as on feast days or upon the reception of honourable guests (The Account Book). Meat was also consumed as nutrition for the sick: In 1772–1773 and 1780 alone, meat was purchased 176 times for the sick prior (who eventually died) and other ailing monks (The Account Book).

The account book reveals that veal, mutton, and, to a much lesser extent, varieties of game were usually served on feast days, whereas chicken and hen were consumed by the weaker monks. Although the account book does not provide specific information on the patterns of meat consumption, the monastery's purchases most likely indicate what kinds of meat were usually served in the refectory.

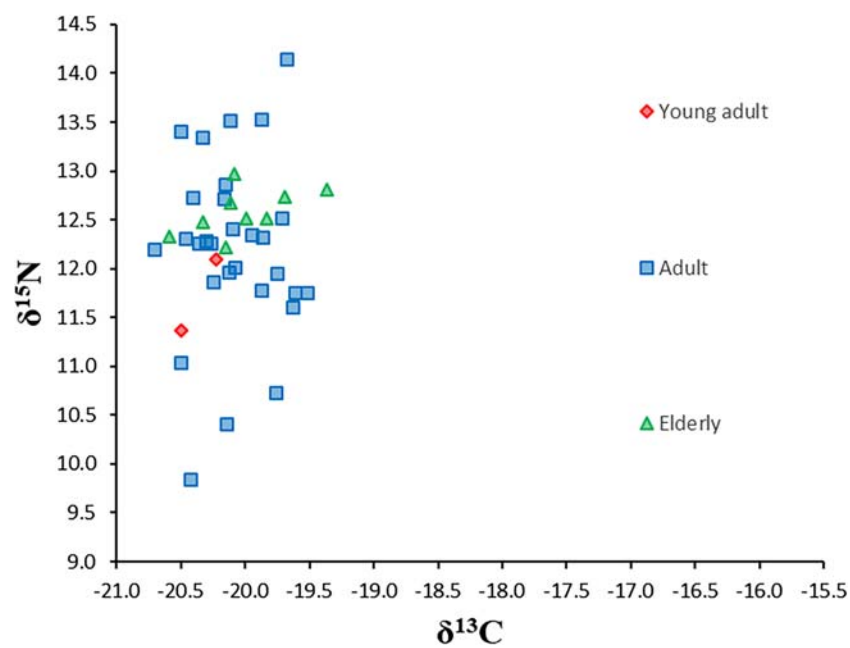

Fig. 6 The distribution of isotopic values between individuals of different age groups: young adults (18–25 years), adults (25–50 years), elderlies (50 + years)

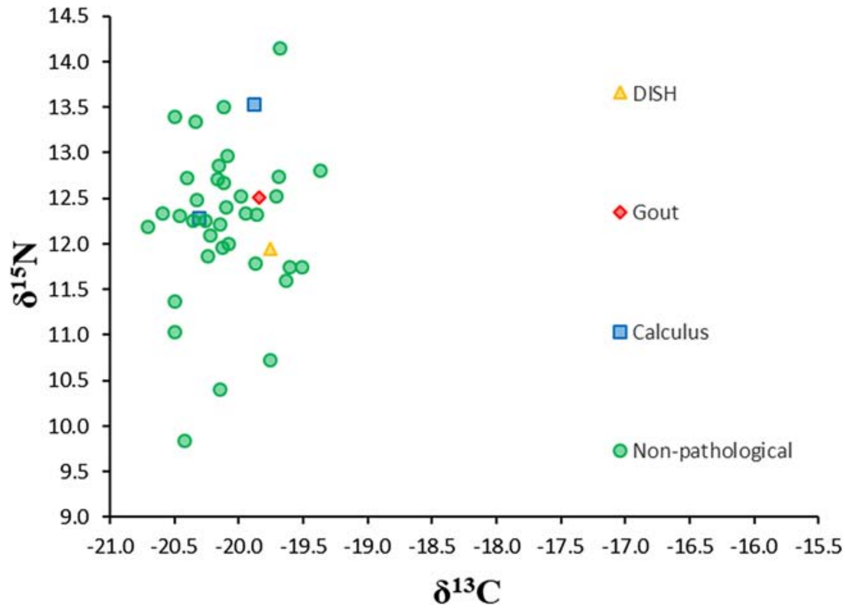

Fig. 7 The distribution of isotopic values between individuals with vs those without a diet-related bone pathology

Thus, historical sources show that the quotidian diet of the Basilian monks was quite simple. It was based on fresh as well as preserved fish, meat, bread, vegetables, dairy, and ale. The stable revenues received by the monastery ensured that the consumption habits of the monks remained the same throughout the year. Ideally, members of the monastic community should have shared the same food in the same amounts. However, the sources indicate that the size of the meals was determined by the monk's age and position in the monastery. While younger monks and seminary students complained about insufficient portions, the elders criticized the quality of the food (Kuncevičius et al. 2017).

Table 3 Types of fish purchased by the monastery, 1765–81[a]

Type of fish	Number of mentions
Unspecified "fish"	820
Pike	142
Perch	48
Bream	39
Salmon	33
Eel	31
Vendace	27
Herring	25
Sturgeon	21
Other varieties (carp, flatfish, etc.)	76
Total of all fish types	1262

[a] The Account Book. Lithuanian State Historical Archives, f. 1178, ap. 1, b. 1

Reconstructing diets of the Basilian monks

Based on Fig. 4, we can see that human isotopic values most closely cluster towards the isotopic expectancy range of the domestic herbivore/omnivore food group (Fig. 4), which

Table 4 Types of meats purchased by the monastery, 1765–81[a]

Type of meat	Number of mentions
Veal	194
Unspecified "meat"	162
Mutton	34
Beef	6
Pork	3
Chicken and hen	120
Total domestic animal meat	519
Hazel grouse	22
Black grouse	13
Grey partridge	1
Goose	6
Mallard	2
Other varieties (turkey, wood grouse)	4
Unspecified "poultry"	5
Total poultry (excluding chicken and hen)	53
Hare	12
Other varieties (beaver, roe, boar)	7
Total game	19
Total of all meat types	591

[a] The Account Book. Lithuanian State Historical Archives, f. 1178, ap. 1, b. 1

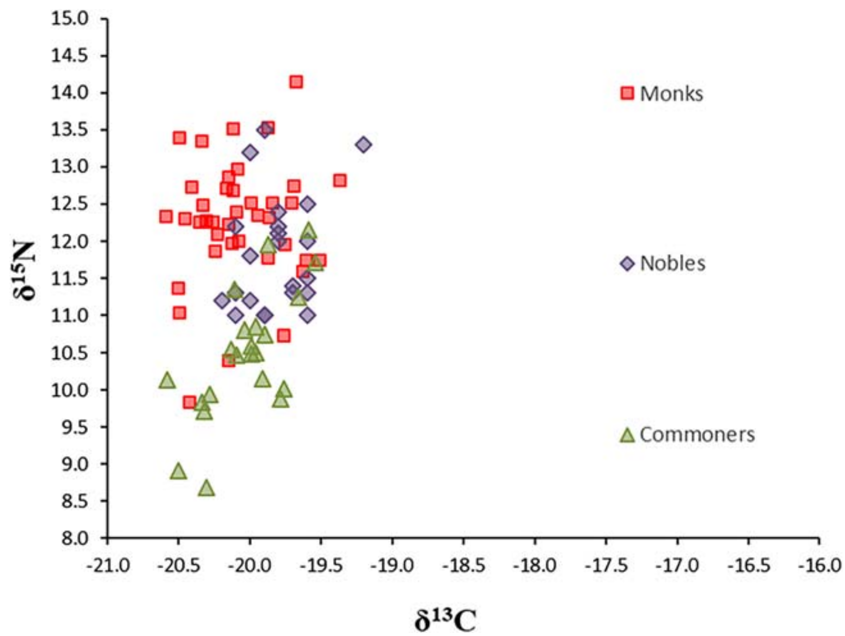

Fig. 8 The distribution of isotopic values between 3 different Lithuanian social groups of similar periods: Basilian monks (Vilnius, seventeenth–eighteenth century), noblemen (Vilnius, sixteenth–seventeenth century; Reitsema et al. 2015), and commoners (Alytus, fourteenth–eighteenth century; Whitmore 2014)

suggests these animals were the main protein source for the Basilian monks. This indication agrees somewhat with the information from the account book, where the most frequently mentioned terrestrial animal food sources (Table 4) include species from the domestic herbivore/omnivore food group (particularly, cattle and chicken). Meanwhile, the same interpretation cannot be used to explain the human isotopic values that are outside the domestic herbivore/omnivore food group expectancy range (Fig. 4). These particular individuals might have consumed a broader variety of protein sources, which may have included freshwater and/or marine fish, as well as some portion of terrestrial domestic animal species.

The dietary contribution from freshwater fish protein to the diets of the Basilian monks is much more difficult to determine due to the high variation of freshwater fish isotopic values, an observation also made in other isotopic studies (Katzenberg and Weber 1999). Since none of the human isotopic values is found inside the freshwater fish isotopic expectancy range (Fig. 4), it would be tempting to suggest that this food group was not the main protein source in the diets of the Basilian monks. However, such observation would contradict the information from the account book, which clearly indicates that fish was the most frequently purchased food by the Basilian Monastery (Table 3; The Account Book).

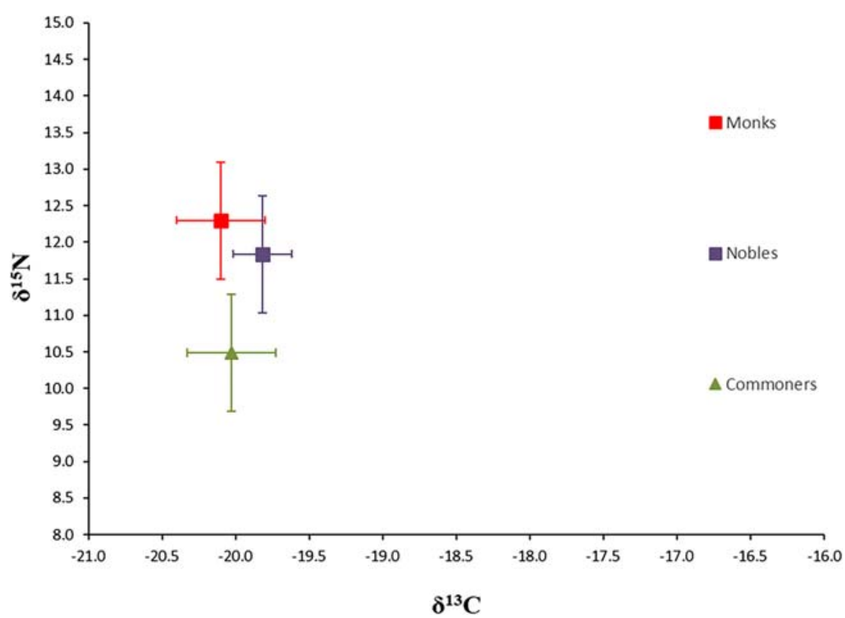

Fig. 9 The averages and standard deviations for each Lithuanian social group: Basilian monks ($\delta^{13}C$ − 20.1 ± 0.3; $\delta^{15}N$ 12.3 ± 0.8); nobles ($\delta^{13}C$ − 19.8 ± 0.2; $\delta^{15}N$ 11.8 ± 0.8); commoners ($\delta^{13}C$ − 20.0 ± 0.3; $\delta^{15}N$ 10.5 ± 0.8)

Table 5 Statistical comparison of $\delta^{13}C$ values of individuals belonging to different social strata: monks ($n = 39$), nobles ($n = 22$; Reitsema et al. 2015), commoners ($n = 22$; Whitmore 2014). Mann-Whitney pairwise with Bonferroni corrected p values. The p values in bold indicate statistically significant ($p < 0.05$) isotopic differences between social groups

	Monks	Nobility	Commoners
Monks		0.004628	1
Nobility	0.004628		0.09118
Commoners	1	0.09118	

One potential reason for the incongruity between two different types of evidence is the aforementioned limitations of this particular historical source, namely, that not all foodstuffs available to the Basilians were recorded in the account book, which only listed the products purchased at the market, whereas the food obtained from other sources (estates, villages, etc.) would not have been mentioned in this document. The other possible reason why isotopic and historical data attribute different dietary significance of this food group is that the number of the analysed fish samples in this study may not be large enough to provide the full extent of isotopic variability among freshwater species. If that is the case, then the insufficient sample size of freshwater fish could be one of the explanations as to why the current isotopic data significantly underestimate the true extent of freshwater fish contribution to the diets of the Basilian monks.

Alternatively, it may be that the isotopic data do not show a significant freshwater fish contribution to the diets of the Basilian monks simply because foods from aquatic sources were not consumed by the Basilians as frequently as one might expect from individuals following a monastic lifestyle, which, among other things, is supposed to include adherence to certain forms of dietary restrictions.

However, we should also consider that the number of mentions of a certain foodstuff in this historical source may not directly correspond to the actual amount of the food in question being consumed. For example, since a single domestic animal (especially cattle or veal) can provide much more food than one individual fish, this could explain why fish was mentioned in the account book more frequently than meat, even though isotopic data indicate that animal products played a more significant dietary role than aquatic sources. Moreover, other historical sources on the diet of contemporary Lithuanian nobility also suggest that meat was consumed in much larger amounts than fish on non-fast days, whereas on fast days, it was the other way around (Dambrauskaitė 2017; Piličiauskienė and Blaževičius 2019).

Table 6 Statistical comparison of $\delta^{15}N$ values of individuals belonging to different social strata: monks ($n = 39$), nobles ($n = 22$; Reitsema et al. 2015), commoners ($n = 22$; Whitmore 2014). Mann-Whitney pairwise with Bonferroni corrected p values. The p values in bold indicate statistically significant ($p < 0.05$) isotopic differences between social groups

	Monks	Nobility	Commoners
Monks		0.1683	0.000000004905
Nobility	0.1683		0.0008064
Commoners	0.000000004905	0.0008064	

Another food group that, based on the observations from Fig. 4, seems to have been an important protein source for at least one Basilian monk (STC 21) is non-migratory birds, grey partridges (*Perdix perdix*). However, historical sources do not reflect a significant dietary input of this food group: only one mention of a grey partridge in the account book (Table 4; The Account Book) indicates that the Basilians did not purchase these birds as often as other animal foods. Additionally, partridge is a very small bird, from which only a very small amount of meat can be extracted. Therefore, it seems doubtful that the isotopic value of the individual STC 21 was an exceptional case of high dietary intake from grey partridges. This similarity is, therefore, most likely coincidental, and the actual main protein sources of the individual STC21 were probably different but had similar isotopic values to those of non-migratory birds.

The other food groups—wild herbivores/omnivores, migratory birds, and anadromous fish—do not seem to have been important protein sources for the Basilian monks, since all human isotopic data are well outside these isotopic expectancy range areas (Fig. 4). This observation seems to agree fully with the information from the account book, which rarely mentions any species from these food groups (Tables 3–4; The Account Book).

Dietary characterization of monks versus secular male population

In order to determine whether the dietary patterns of the Basilian monks were similar or different to those of Lithuanian secular populations, the isotopic data of the monks were compared with that of contemporary Lithuanian nobility and commoners. The individuals belonging to the sixteenth–seventeenth century nobility of the Polish-Lithuanian Commonwealth come from various Lithuanian church burial sites (Reitsema et al. 2015; Table S8), whereas the data for members of the lower social stratum, commoners, are represented by individuals who were excavated from the fourteenth–eighteenth century cemetery which was located near the Lithuanian town of Alytus (Whitmore 2014; Table S8).

The comparison of these three different social groups was carried out in two ways: (1) graphically, by generating a scatter plot diagram in which the isotopic values of the Basilian monks, nobles, and town commoners were plotted; (2) statistically, by using the Kruskal-Wallis test[2] in order to compare the isotopic values of the Basilian monks with those of the nobles and town commoners. Because the investigated Basilian monk group was comprised exclusively of males, we decided to include only male samples from both nobles' and town commoners' classes in the following analyses and discussions, to avoid the potential skewing of the comparative results due to possible isotopic discrepancies caused by intersexual dietary differences.

After plotting the isotopic values (Fig. 8) and their averages and standard deviations (Fig. 9) of the monks, nobles, and town commoners on both diagrams, we can clearly see that the members of the monastic order of St. Basil are closer to the individuals of the higher social status than to those of the lower status (Fig. 8–9), which indicates a potential dietary similarity between the monks and the nobility. It is known from previous isotopic studies that the diet of the nobles was rich in terrestrial meat and freshwater fish products, reflected by their significantly elevated $\delta^{15}N$ values (indicating aquatic food sources) and relatively depleted $\delta^{13}C$ values (which were within the terrestrial range) (Reitsema et al. 2015). The fact that the same pattern is observed in the isotopic data of the Basilian monks suggests that these two different social groups had a similar diet, which was based on terrestrial C_3 plant/animal and fish products.

The statistical analysis of individuals from different social groups demonstrated a couple of things. One notable finding of the statistical analysis is that the nobles on average had significantly different $\delta^{13}C$ values compared with the monks, but not to the commoners (Table 5). This could be interpreted as an indication of a higher dietary input of marine and/or C_4 plant food sources (such as millet) in the nobles' diet compared with that of the monks. However, since millet or any other C_4 plants were not cultivated in Lithuania throughout all historical periods (Laužikas 2014), it is unlikely that C_4 plants were important dietary sources. Meanwhile, the fact that the $\delta^{13}C$ values of the monks show a lesser marine input in their diets suggests that sea foods were not common ingredients in their meals. This interpretation is also supported by historical and zooarchaeological data, which indicate that consumption of marine fish, especially cod, was not popular in Lithuania, unlike in Poland (Piličiauskienė and Blaževičius 2019; Laužikas 2014). Compared with the nobility, the Basilian monks consumed more freshwater fish instead of the marine species, which would explain their lower $\delta^{13}C$ values.

Another interesting pattern was detected from the statistical comparison of $\delta^{15}N$ values between the three social groups. It was observed that the town commoners had much lower $\delta^{15}N$ values compared with both the nobility and the monks and that these differences are statistically significant (Table 6). These results could be an indication that diets of the town commoners did not contain less fish (both freshwater and marine) compared with the diets of the monks and nobles. The possible explanation for this is that the diets of the town commoners were comprised of a larger portion of terrestrial plant foods, which would account for their significantly lower $\delta^{15}N$ values compared with those of the monks and nobles. It is the most likely scenario, considering that due to their poorer status, meat and some of the fish products (such as sturgeon) were too expensive for the town commoners to consume on a more frequent basis (Dambrauskaitė 2017; Piličiauskienė and Blaževičius 2019).

Overall, the isotopic results of the monks, nobles, and commoners and the statistical comparisons between these three datasets suggest that the Basilian monks and nobles had similarly diverse diets, which were richer in animal and/or fish foods compared with the commoners. The diets of both the Basilian monks and nobles were comprised of larger portions of terrestrial animal and aquatic products, although the monks probably consumed more freshwater fish. This observation is also supported by the comparison of the isotopic and historical data between the Lithuanian and Polish elites. Despite the fact that both nations were part of the same Commonwealth in the Early Modern Period, due to historical circumstances and, therefore, different dietary traditions, the Lithuanian elite and commoners consumed fewer marine fish compared with their Polish counterparts. Polish nobility enjoyed more marine foodstuffs in their diet. It is worth noting that similar tendencies in the monastic diets have also been observed in other isotopic studies, which demonstrated that, from the Late Middle Ages onwards, the members of monastic communities increasingly consumed the types of food that were also present on nobility's dinner tables (Yoder 2012).

Conclusions

Isotopic data derived from this study suggest that the diet of the Basilian monks consisted mainly of terrestrial C_3 plant (most likely rye, barley, wheat, and other cereals) and domestic herbivore/omnivore (mainly cattle and chicken) food sources. Freshwater fish seemingly comprised a smaller portion in the diet of the Basilian monks, although due to the potentially insufficient number of analysed freshwater samples, it is possible that the current isotopic data underestimate the significance of this food group. Other food groups (anadromous fish, migratory birds, wild herbivores/omnivores) were consumed in much lower quantities.

The picture of the Basilian monks' dietary practices gleaned from historical sources is slightly different compared

[2] The reason for choosing the Kruskal-Wallis test was that this non-parametric method allows inclusion, analysis, and comparison of groups of small and unequal sample sizes (Madrigal 2012, p. 153).

with that inferred from isotopic data. Based on the information from the account book, various species of fish and its products should have been the staples in the diets of the Basilian monks. However, products from terrestrial animals (meat, dairy, eggs) played a seemingly lesser dietary role in the Basilians' daily lives, since these foodstuffs were only reserved for special occasions (e.g. the reception of important guests) and were prescribed to ailing monks.

The incongruities in information about monastic diet between isotopic and historical evidence could be explained either as a result of certain biases present in the analysed written source (e.g. that not all food items consumed by Basilian monks were listed in the account book) or as a consequence of the insufficient number of the analysed faunal samples (particularly those of freshwater fish). However, considering the known history of this monastic community, the results of this research, despite the aforementioned potential biases and/or scarcity of the current data, most likely suggest that these seventeenth–eighteenth century Basilian monks consumed more meat than fish which could have been related to the gradual relaxation of dietary restrictions from 1667 onwards.

Nevertheless, more studies need to be done in order to confirm or reject the conclusions of this research. Particularly, stable isotope analyses of the higher number of freshwater fish samples could give a more accurate picture of the full range of their isotopic variation. Also, the analyses of other elements' isotopic ratios (e.g. $\delta^{18}O$ and $^{87}Sr/^{86}Sr$) would give some information on human provenance and mobility which could potentially explain the dietary status of some of the Basilian monks as suggested by $\delta^{13}C$ and $\delta^{15}N$ values.

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