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On the diet of Tycho Brahe and his wife: did they consume fish from stagnant pools?

Johannes van der Plicht[1,2], Sylva Drtikolová Kaupová[3], Petr Velemínský[3], Jiří Smolík[4], Jan Kučera[5], Jan Kameník[5], Vladimír Havránek[5], Jaroslav Brůžek[6,7], Jens Vellev[8] and Kaare Lund Rasmussen[9*]

Abstract

Radiocarbon dating has been performed on cortical femoral tissue samples from Tycho Brahe (1546–1601) and his wife Kirsten Barbara Jørgensdatter (1549–1604). No discernible reservoir effect has been observed in either skeleton. This combined with unusually high $\delta^{15}N$ values and seemingly terrestrial $\delta^{13}C$ values, makes us suggest that a large fraction of their protein intake came from freshwater fish raised in stagnant pools.

Keywords: Tycho Brahe, Kirsten Jørgensdatter, Diet, ^{13}C, ^{15}N, Radiocarbon

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Main text

In 2010 Tycho Brahe's grave in the Church of Our Lady before Týn in Prague was opened by a Czech-Danish research team. Cortical femoral samples were sequestered from the Tycho Brahe (TB) and his wife Kirsten Barbara Jørgensdatter (KBJ) [1–3]. Collagen from thoroughly decontaminated cortical bone samples from both individuals were extracted in Prague and have now been radiocarbon dated and measured for stable isotope ratios of C and N in Groningen. The results of the analyses are listed in Table 1.

Both samples were measured in duplicate; the table shows the averaged values. The bone samples showed excellent quality (see Additional file 1). The rationale behind the radiocarbon dating was to derive reservoir effects, age offsets between samples of terrestrial and aquatic origin. The latter are usually depleted in ^{14}C causing apparently older radiocarbon ages. Tycho Brahe and his wife represented a relative unique opportunity, since humans with a known time of death are rarely ^{14}C-dated. A reservoir effect was expected based on the elevated $\delta^{15}N$ value [3–5].

Surprisingly, the ^{14}C-dates for both individuals were consistent with their time of death, *i.e.* no significant age offset was observed. Graphs of the calibrated dates are shown in Additional file 1. At the 2-sigma level, they show a bimodal probability distribution for this time range, around 1500 and 1600 AD for both TB and KBJ. The latter is consistent with the historical time of death. The older age cannot be excluded; it shows a higher probability but that can be an artefact caused by the shape of the curve. Both dates are possible, showing either no reservoir effect, or a relatively small one of about 100 years.

Furthermore, it is seen that the $\delta^{13}C$ and $\delta^{15}N$ values of this study and those reported by Kacki et al. [3] are in excellent agreement. The $\delta^{13}C$ values indicate that the individuals did not receive any appreciable part of their protein intake from the marine food chain during the last decade of their lifetime. The $\delta^{15}N$ values, on the other hand, are strongly elevated: 14.7‰ for TB and 13.4‰ for KBJ.

In the thorough analysis by Kacki et al. [3], these $\delta^{15}N$ values are matched by medieval samples of cod and seal. However, both cod and seal would exhibit a distinct marine character in their $\delta^{13}C$, which was not observed for TB and KBJ, so these food items cannot have been a major part of an important protein intake. The only other

*Correspondence: klr@sdu.dk
[9] Cultural Heritage and Archaeometric Research Team (CHART), Institute of Physics, Chemistry and Pharmacy, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark
Full list of author information is available at the end of the article

Table 1 ^{14}C dates, stable isotope ratios and relevant parameters bone collagen from Tycho Brahe and his wife

	Lifetime AD	Laboratory code	^{14}C BP	δ^{13}C ‰	δ^{15}N ‰	Source	Calibrated age 1 sigma, AD	Calibrated age 2 sigma, AD
TB	1546–1601	GrM- 14103/14800	389 ± 15	− 19.0	14.7	This study	1456–1490	1451–1506, 1595–1618
KBJ	1549–1604	GrM- 14105/14107	362 ± 15	− 19.4	13.4	This study	1476–1512, 1592–1619	1460–1523, 1574–1626
TB				− 19.0	14.7	Kacki et al.		
KBJ				− 19.4	13.4	Kacki et al.		

data showing comparable δ^{15}N values are those of Bohemian freshwater fish [3].

We suggest that a plausible explanation for the peculiar combination of high δ^{15}N values and no measurable radiocarbon reservoir effects was a diet rich in freshwater fish. Fish from freshwater systems are known to have large positive values of δ^{15}N [3, 4, 6 and references therein]. Normally, a diet rich in freshwater fish will result in significant reservoir effects [6, 7], but that is not seen in this case. One likely combination of the observed isotope ratios is that the fish came from freshwater lakes with stagnant water, *i.e.* lakes with no or negligible water throughput and little erosion. In such waterbodies, CO_2 equilibrium between water and atmosphere can occur by exchange [8]. The ^{14}C-content of the dissolved bicarbonate in the lake can become equal or close to that of the atmospheric CO_2. Indeed, absence of a reservoir effect has been observed under such conditions [6].

Cases where terrestrial/historic comparisons between (calibrated) ^{14}C dates and known ages are very rare. Cook et al. [7] describe a famous prehistoric case: a pelvic human bone, embedded with an arrow made from deer bone. The deer obviously is purely terrestrial, the human is a fish consumer (also witnessed by archaeological fishing gear). This presents a direct measurement of the reservoir effect, combined with stable isotopes of the bone collagen. The averaged value for the derived reservoir effect is 455 years in this case, for the prehistoric Donau river. The Donau is a flowing river where there is no equilibrium of CO_2 between water and atmosphere. The stable isotope values are comparable with those of TB and KBJ. Therefore, it is justified to expect reservoir effects of similar size for TB and KBJ.

Stagnant ponds were actually close by, both on Hven and near Prague. On the island of Hven, where Brahe and his wife spent most of their time from 1576 to 1597, Valentin Spangenberg constructed almost 60 interconnected freshwater ponds with all sort of fish [9–13]. From 1597 to 1598 they spent a year at the castle of Brahe's friend Heinrich Rantzau in Wandesburg outside Hamburg, and then they moved for a while to Wittenberg, where they stayed in the former home of Philip Melanchthon. In 1599 Brahe and his wife lived for 1 year near a newly adapted observatory in a castle in Benátky nad Jizerou, 50 km from Prague. From 1600 until Brahe's death in 1601, they lived in Prague. His wife died in Prague in 1604.

Freshwater fish farming flourished in Bohemia during the sixteenth century. It is estimated that by the end of that century there were up to 75,000 breeding ponds in Bohemia and Moravia, producing some 4000–6000 tons of freshwater fish every year [14]. For example, near the town of Třeboň in South Bohemia the Rožmberk fishpond was designed and built under guidance of Jakub Krčín, working for the Bohemian aristocratic family of Rosenberg (=Rožmberk). The average depth of this pond was ca. 6 m and it extended over almost 5 km^2. It was finished in 1590, so timewise it is possible that fish from this pond were on the Brahe's dinner table while in Prague [14, 15]. Freshwater fish were an essential part of the menu at the time of Emperor Rudolf II, where both freshwater and marine fish came to the tables of the noble [16, 17].

This means that for ca. 25 years Brahe and his wife lived rich lives with immediate access to fish from stagnant freshwater ponds. This is a sufficiently long timespan to make the major fraction of their remodeled cortical femoral bone having been turned over and recoding the special δ^{15}N of the fish from such ponds [18, 19]. In addition to this diet, meat of young milk-fed mammals, if this would have been consumed, would also elevate the δ^{15}N [3], while keeping an unaltered radiocarbon date.

Conclusion

Radiocarbon dating of cortical femoral tissue samples obtained from Tycho Brahe and his wife Kirsten Barbara Jørgensdatter revealed that no reservoir effects can be observed. However, the bones did show enrichment in δ^{15}N. This led to the conclusion that whatever source caused the elevated δ^{15}N, it must have been close to equilibrium with the atmospheric carbon reservoir. The δ^{13}C values reduce the possibility of saltwater fish or seal as a dominant protein intake. It is suggested that the important protein intake for both Brahe and his wife for many years was freshwater fish from pools with stagnant water.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s40494-020-00399-8.

Additional file 1. Details of the radiocarbon dating.

Abbreviations
TB: Tycho Brahe; KBJ: Kirsten Barbara Jørgensdatter.

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Authors' contributions
Conceived and designed the experiments: KLR and JP. Performed the chemical analyses: SDK and JP. Analysed the data: JP and KLR. Contributed in the acquisition of the samples in the field PV, JS, JKu, JKa, VH, JB and JV. Contributed to the interpretation of results and acquisition of references: PV, JS, JKu, JKa, VH, JB, JV, JP and KLR. Wrote the paper, with comments from other participants: KLR and JP. All authors read and approved the final manuscript.

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Author details
[1] Center for Isotope Research, Nijenborgh 6, 9747 AG Groningen, The Netherlands. [2] Faculty of Archaeology, Leiden University, P.O. Box 9515, 2300 RA Leiden, The Netherlands. [3] Department of Anthropology, National Museum, Václavské náměstí 68, 115 79 Prague 1, Czech Republic. [4] Institute of Chemical Process Fundamentals Czech Academy of Sciences, Rozvojová 135, 165 02 Prague 6, Czech Republic. [5] Nuclear Physics Institute, Czech Academy of Sciences, CZ-250 68 Řež 130, Czech Republic. [6] Department of Anthropology and Human Genetics, Faculty of Science, Charles University, Albertov 6, 128 43 Prague 2, Czech Republic. [7] CNRS, UMR 5199 PACEA, Laboratoire d'Anthropologie des Populations du Passé, Université Bordeaux 1, Talence 33405, France. [8] Department of Culture and Society, Section for Medieval and Renaissance Archaeology, Moesgaard Alle 20, 8270 Højbjerg, Denmark. [9] Cultural Heritage and Archaeometric Research Team (CHART), Institute of Physics, Chemistry and Pharmacy, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark.

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