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CORRECTION

Correction to: Pasture usage by ancient pastoralists in the northern Kazakh steppe informed by carbon and nitrogen isoscapes of contemporary floral biomes

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As part of our paper we evaluated differences between stable isotope ratios of geographic units as well as between livestock taxa. We incorrectly used ANCOVA (analysis of covariance) when we should have used ANOVA (analysis of variance) which compares variation between groups. We have re-analysed all of the datasets and found that the significance of our results changed slightly, leading to an increase in significant differences between groups (see bold text). However, our overall discussion has not changed and these findings offer further support for our previous conclusions.

Results

The floral base of the food web

Bestamak:
Significant differences were identified in average $\delta^{15}N$ values between all units at the site of Bestamak (ANOVA, $p = 1.45 \times 10^{-11}$; Correction Supplemental Table 3). Units were then combined into three vegetation communities including the open steppe (OS), areas of anthropogenic activity (AA) and riverine, salt lake, and marsh (RSL). Significant differences in $\delta^{15}N$ values were identified between the plants in the open steppe and those in areas of anthropogenic activity and near water (ANOVA, $p = 1.45 \times 10^{-11}$; Correction Supplemental Table 3). No statistically significant isotopic variation was evident in carbon isotope values between units or vegetation communities (Correction Supplemental Table 3).

Lisakovsk:
Isotopic variation between collection units at Lisakovsk ($n = 4$) indicates that significant differences were identified in average $\delta^{15}N$ values between unit 5013 and the other units (ANOVA, $p = 5.43 \times 10^{-6}$) and statistically significant isotopic variation was evident in carbon isotope values (ANOVA, $p = 0.04$; Correction Supplemental Table 3). Unit 5013 has a significantly lower average nitrogen isotope composition than other units by 3.2‰ (Correction Supplemental Table 3).

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Isotopic values of ancient livestock

Domesticated livestock, including horses, cattle, sheep, and goats were recovered from the Bronze Age sites of Kamennyi Ambar, Bolshekaragansky, Bestamak and Lisakovsk. Different livestock taxa from these sites yield different average values with significant differences in average $\delta^{13}C$ and $\delta^{15}N$ values by taxa (Fig. 4; Table 5; ANOVA, $\delta^{13}C$ $p = 4.79 \times 10^{-9}$, $\delta^{15}N$ $p = 3.98 \times 10^{-4}$) (see Correction Supplemental Table 4). Inter-species carbon isotopic distinctions were visible across sites where horses were depleted in ^{13}C on average by 0.7 to 1.5‰ relative to cattle (Tukey post-hoc HSD, $p < 0.0005$) and by 1.2 to 2.3‰ relative to sheep/goat (Tukey post-hoc HSD, $p < 0.0005$). We further found significant differences between cattle and sheep/goat when all sites were combined, with sheep/goat enriched ^{13}C on average by 0.6‰ relative to cattle (Tukey post-hoc HSD, $p = 0.0059$). Kamennyi Ambar livestock exhibited the widest range of $\delta^{13}C$ values from −20.8 to −17.1‰, while at Bolshekaragansky, $\delta^{13}C$ values ranged from −19.7 to −18.5‰. At Bestamak, $\delta^{13}C$ values ranged from −20.0 to −17.7‰, and at Lisakovsk, livestock had $\delta^{13}C$ values ranging from −20.8 to −18.7‰. At Lisakovsk (ANOVA, $p = 2.18 \times 10^{-6}$), a significant 0.9‰ depletion in ^{13}C is visible in horses relative to cattle (Tukey post-hoc HSD, $p < 0.0005$) and a 1.2‰ depletion relative to sheep/goat (Tukey post-hoc HSD, $p < 0.0005$). Carbon isotope differences between species were also significant at Kamennyi Ambar, (ANCOVA, $p = 4.31 \times 10^{-6}$), with significant differences identified between sheep/goat and horses, as well as horses and cattle (Table 5; Correction Supplemental Table 4). Horses were depleted in ^{13}C, on average by 1.1‰ compared to cattle (Tukey post-hoc HSD, $p = 0.0048$) and by 1.9‰ relative to sheep/goat (Tukey post-hoc HSD, $p < 0.0005$).

Significant nitrogen isotopic differences were also visible between taxa and between sites (ANOVA, $p = 3.98 \times 10^{-4}$) (see Correction Supplemental Table 4). Horses were depleted in ^{15}N relative to cattle at all sites, on average from 0.7 to 2.2‰ (Tukey post-hoc HSD, $p = 0.0047$), and horses were depleted in ^{15}N by 0.8 to 2.8‰ compared to sheep/goat (Tukey post-hoc HSD, $p < 0.0005$). Kamennyi Ambar livestock exhibited $\delta^{15}N$ values from 3.2 to 9.8‰ and $\delta^{13}C$ values ranging from 4.7 to 6.9‰. A similarly low range of nitrogen isotopic variation was visible at Lisakovsk, with $\delta^{15}N$ values ranging from 4.3 to 8.3‰. At Bolshekaragansky, livestock exhibit $\delta^{15}N$ values ranging from 4.7 to 6.9‰, while at Bestamak, $\delta^{15}N$ values range from 6.2 to 8.4‰. Significant differences were evident in nitrogen values between species at Kamennyi Ambar (ANCOVA, $p = 0.0035$) but not at Lisakovsk (ANCOVA, $p = 0.176$). Comparatively, livestock from Kamennyi Ambar had a wider range of carbon and nitrogen isotope values than those from Lisakovsk (Table 4; Fig. 4). ***At Kamennyi Ambar, horses were depleted in ^{15}N relative to cattle, on average by 2.1‰ (Tukey post-hoc HSD, $p = 0.0426$), and horses were depleted in ^{15}N by 2.8‰ compared to sheep/goat (Tukey post-hoc HSD, $p = 0.0031$).***