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HOW 'PASTORAL' IS PASTORALISM? DIETARY DIVERSITY IN BRONZE AGE COMMUNITIES IN THE CENTRAL KAZAKHSTAN STEPPES*

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Steppe communities have traditionally been viewed as pastoralist groups with similar herd-based economies. Recent scholarship, however, warns against assumptions of homogeneity and new scientific techniques are providing a more nuanced approach to steppe archaeology, with increasing indications of diversity. This recent evidence further suggests that considering these communities as primarily pastoralist may hide a variety of subsistence strategies, such as fishing and cultivation. Here, we consider direct evidence for diet (in the form of stable isotope analysis) from Bronze Age communities from central Kazakhstan, in the semi-arid steppe zone. We find that the diversity recently suggested for communities across the steppe zone can be found within sites in the Karaganda region. This suggests that individuals exercised choice in their dietary habits that led to dietary differences large enough to be detectable isotopically. The results also highlight the inclusion of fish in the diet of these 'pastoral' populations, with indications that some individuals in the Final Bronze Age consumed notable amounts of millet. This shows that these 'pastoralist' economies also engaged in fishing throughout the Bronze Age, with millet cultivation becoming increasingly important in the Final Bronze Age. As such, our understanding of what it means, in this context, to be a pastoralist requires further consideration.

KEYWORDS: PALAEODIET, CARBON, NITROGEN, STEPPE

INTRODUCTION

Stretching from Hungary to eastern Russia, the steppe ecological zone has played a vital part in past world events, and understanding the archaeology of the steppe is crucial to a full understanding of world prehistory. A central theme in the archaeology of the steppe has been the idea of Bronze Age pastoralists, and the role their ranging lifestyle played in the spread of a variety of attributes, including horse husbandry, metal technology and Indo-European language (cf., Gimbutas 1973; Renfrew 1987; Anthony 2007). However, the cultures populating the steppes were, until relatively recently, described by large-scale models that lacked good connections to local adaptations, socio-economic change and the mosaic of environments that characterize the steppes (Hanks 2010: cf., Frachetti 2006; Bendrey 2011). Nevertheless, within the past 20 years international interest and research into steppe archaeology has significantly increased, and new archaeological techniques are allowing a more nuanced understanding of steppe archaeology.

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Several recent projects have focused on the Bronze Age (such as Frachetti and colleagues in South Eastern Kazakhstan: Frachetti 2002, 2006), a particularly dynamic period that saw the emergence of large-scale patterns of movement, interaction and trade between regional communities and polities, as well as key technological developments such as spoke-wheeled chariots (Hanks 2010). These projects have tended to highlight the diversity of human adaptation to the steppe environments, and provide some indications that viewing these communities as simply pastoralist may limit our awareness of other aspects of their subsistence. For example, Bendrey (2011) found that herd composition varied across the steppes influenced by regional climatic, topographical and ecological conditions, while Frachetti and colleagues (2010) have found evidence for domesticated plants, indicating that terrestrial animals were not the sole focus of food production.

Here, we use stable carbon and nitrogen isotope analysis to consider the diversity of human diets in Bronze Age central Kazakhstan and to assess critically what it meant, in dietary terms, to be a 'pastoralist' in this semi-arid steppe zone. Through the use of this technique we will provide independent and direct dietary evidence at the site, regional and, through comparison to published research, international levels. We will also consider the consumption of resources other than domesticated animals, such as fish and cultivated plants (specifically C_4 plants), which may be absent from the archaeological record of these communities.

BACKGROUND

Kazakhstan archaeology and evidence for diet

The Bronze Age in central Kazakhstan is divided into a number of cultures represented in this study: the Late Bronze Age Andronovo culture, divided into Alakul and Fedorovo sub-types (mid-second millennium BC); and the Final Bronze Age Begazy–Dandybai culture (1300–900 BC: Hanks *et al*. 2007; Koryakova and Epimakhov 2007; Svyatko *et al*. 2009). All of these cultures are thought to have subsistence practices focusing on pastoralism. Zooarchaeological remains are increasingly studied, and a limited amount of lipid residue analysis has been carried out, but flotation for archaeobotanical evidence remains uncommon.

Throughout the Bronze Age, the animal bone evidence indicates that the economy was based upon caprids, cattle and horses, with limited use of large wild animals (Vadetskaya 1975, as cited in Frachetti 2002; Kuzmina 2003 and references therein; Outram *et al*. 2012). By the Andronovo period there is also evidence for pigs and dogs. Sieving has been limited, but was carried out at Andronovo Temirkash (sampled in this study), indicating that bird and fish bones can be found but are present in very low proportions (1.1% and 1.5%, respectively; Outram *et al*. 2012). Lipid residue and herd structure analyses from the Andronovo site of Lisakovsk (in the forest-steppe zone of north-west Kazakhstan) and the Begazy–Dandybai proto-city Kent (analysed in this study) indicates that, at these sites at least, ruminant dairy products were utilized, particularly from cows (Outram *et al*. 2012).

As noted above, archaeobotanical studies are rare; however, Bronze Age plant remains have been recovered from Begash in south-east Kazakhstan and included two types of domesticated grains, broomcorn millet (*Panicum miliaceum*) and free-threshing wheat, directly dated to 2460–2150 cal BC (Frachetti *et al*. 2010; Spengler *et al*. 2013, 2014). While this indicates that domesticated crops may be present, they were largely absent from domestic contexts, which suggests ritual rather than subsistence use. Spengler and colleagues (2014) also report a small number of wheat grains from Tasbas in south-eastern Kazakhstan, dated using charcoal to

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2840–2500 cal BC, while Late Bronze Age flotation samples from Tasbas contained much higher seed densities, including naked barley, broomcorn millet and peas, with barley grains directly dated to 1450–1250 cal BC. The only other early finds of wheat and millet are from the Middle Bronze Age sites of Arkaim and Alandskoe (*c.*2200–1800 BC) in the trans-Ural region (Gayduchenko 2002); however, the report lacks species identification, direct chronology and morphological information (Frachetti *et al*. 2010). In the Iron Age, there is well-dated evidence for domesticated plant use in the form of millet, wheat and barley phytoliths from Tuzusai and Tseganka 8 in southeastern Kazakhstan (Chang *et al*. 2003).

Stable isotope analysis

Stable isotope analysis provides individual, quantitative evidence about past diets. As the body is made from the food and drink consumed during life, chemical differences in diets are transmitted through the food chain and recorded in bone collagen. The technique is relatively insensitive to minor dietary components, and it is estimated that 20% of the protein consumption must derive from an isotopically distinct source in order for it to be detectable isotopically (Hedges 2003). This means that when isotopic differences are found, they reflect real differences during life.

Stable carbon isotope ratios ($\delta^{13}C$) can be used to distinguish between diets based upon two different types of plant (C_3 and C_4), which follow different photosynthetic pathways (Vogel and Van der Merwe 1977). Most economically important plants, including wheat, barley, rice and potatoes, are C_3, but maize, millet, sorghum and sugar cane use the C_4 photosynthetic pathway. At this time, millet is the only C_4 staple crop that would have been available to people living in central Kazakhstan. However, it is not necessarily the only C_4 plant entering the human food chain. The steppe zone includes numerous C_4 plants present in relatively small proportions (Pyankov *et al*. 2000; Toderich *et al*. 2004). While it is difficult to imagine a scenario whereby direct consumption of these plants by humans would notably influence their $\delta^{13}C$ values, it is possible that animals ate isotopically detectable amounts of wild C_4 plants. Stable carbon isotope ratios can also be used to distinguish between marine and terrestrial food chains (Schoeninger and De Niro 1984), but marine foods are unlikely to have been available to people in prehistoric central Kazakhstan.

Stable nitrogen isotope ratios ($\delta^{15}N$) provide an indication of the amount of animal protein consumed by an individual, as the $\delta^{15}N$ value increases by 3–5‰ with each step in a trophic chain, although the mechanism that causes this is not clearly understood (O'Connell and Hedges 1999; Bocherens and Drucker 2003; Hedges and Reynard 2007). Aquatic ecosystems tend to have long food chains, which leads to higher $\delta^{15}N$ values than in terrestrial food chains (Schoeninger and De Niro 1984).

In this study, bone collagen (protein) was analysed, which reflects diet over the majority of adult life, and small dietary inputs or changes in diet may not be detectable (Hedges *et al*. 2007). As nitrogen is only present in dietary protein, the nitrogen isotope values reflect only the protein component of the diet. Carbon in bone collagen is mainly taken from the protein part of the diet, although some carbon may reflect other dietary fractions (Ambrose and Norr 1993; Tieszen and Fagre 1993; Howland *et al*. 2003; Jim *et al*. 2006). Infants tend to have higher $\delta^{15}N$ values than adults due to a tropic level effect associated with breastfeeding (Fuller *et al*. 2006). Pathological conditions and starvation can lead to increases in body $\delta^{15}N$ values (Katzenberg and Lovell 1999; Mekota *et al*. 2006). When conducting stable isotope analyses on human populations, it is beneficial to sample contemporaneous fauna, as the isotopic ratios at the base of the food chain vary through space and time (Stevens and Hedges 2004).

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MATERIALS AND METHODOLOGY

Eighty-eight human bone samples and 76 animal samples (horse, ovicaprid, cattle and dog) were taken from sites in central Kazakhstan (Fig. 1 and Table 1). Full sample details and isotope results are presented in Supplementary Appendices 1 and 2. The human samples span the Late to Final Bronze Age, with three samples dated to the Early Iron Age. The samples are dated on the basis of associated material culture (for details, see the references in Table 1) and, in the absence of direct dating, it remains possible that some of the individuals are misdated, particularly as the kurgans could have been reused in later time periods (potentially without any associated material culture to signify this). The majority of the animal samples date to the Andronovo period; that is, the later Bronze Age.

Collagen was extracted following the method described in Privat *et al*. (2005). All collagen samples were analysed in triplicate, using a Costech elemental analyser coupled in continuous-flow mode to a Thermo Finnigan MAT253 mass spectrometer. Carbon and nitrogen stable isotope values are expressed as delta values (e.g., $\delta^{13}C$) relative to international standards (VPDB and AIR, respectively) in units of per mille (parts per thousand, ‰: Hoefs 2004). Repeated measurements on international and in-house standards showed that the analytical error was less than <0.2‰ for both carbon and nitrogen.

Measured collagen is deemed to be of good quality if it fulfils the following criteria: an atomic C : N ratio of 2.9 to 3.6 (De Niro 1985); a 'collagen' yield of >1% by mass; final carbon yields of >13%; and final nitrogen yields of >4.8% (Ambrose 1990). Three human and six animal samples failed to yield reliable collagen. All of the remaining samples yielded reliable collagen: the C : N ratios of all samples fell within a range of 3.1 to 3.4; and all collagen yields were greater than 1%.

Statistical analyses were performed using SPSS 21.0 for Mac. Samples were tested for normality using histograms, and Kolmogorov–Smirnoff and Shapiro–Wilk tests, and for equality of variance using Levene's tests. The parametric data were investigated using independent samples *t*-tests. The non-parametric tests employed were Kruskal–Wallis tests. All statistical data are given in Table 2. Outliers are identified as samples that lie more than 1.5 times the interquartile range (IQR) below quartile 1 (Q1) or above quartile 3 (Q3). The minimum sample size for statistical analysis was five.

RESULTS

Animal results

The animal results have been grouped into herbivores and carnivores and are shown in Figure 2. The herbivore values (horse, ovicaprid and cattle) have a mean $\delta^{13}C$ value of −19.2‰ (± 0.7‰) and $\delta^{15}N$ of 7.5‰ (± 1.6‰), and range from −20.6 to −17.9‰ in $\delta^{13}C$ and from 4.8‰ to 13.3‰ in $\delta^{15}N$. While there are no statistically identified outliers in $\delta^{13}C$, two of the caprid samples (KZF44 and KZF56, from Temirkash and Tashik, respectively) have relatively high $\delta^{13}C$ values (both $\delta^{13}C = -17.9$‰), which may suggest a small C_4 component to their diets or the consumption of (C_3) plants with high $\delta^{13}C$ values due to aridity (O'Leary 1988; Farquhar *et al*. 1989; Hartman 2012). Three samples are identified as statistical outliers in $\delta^{15}N$ (lying more than 1.5 times the IQR above Q3; KZF46, KZF47 and KZF50), with values greater than 12.5‰. These individuals could be: young animals exhibiting a weaning effect; subject to extreme stress, such as starvation (Mekota *et al*. 2006); imported from an area with very high $\delta^{15}N$ values; or

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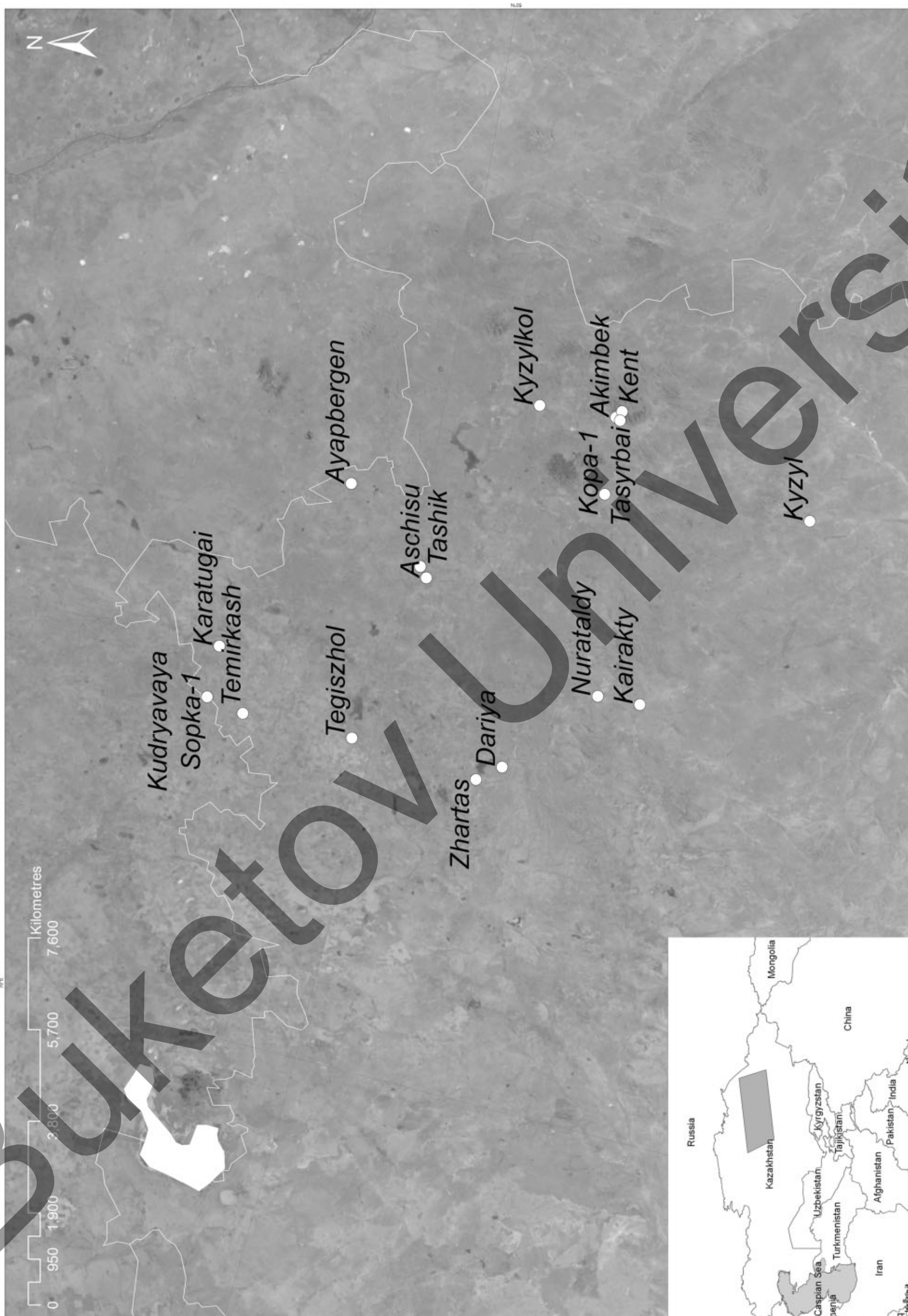

Figure 1 *A map of the analysed sites.*

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Table 1 *A brief description of the analysed sites*

Site	*Culture/period*	*Date*	*Comments*	*Number of samples*	*Reference(s)*
Tegiszhol (Тегисжол)	Andronovo (Atasu–Alakul, Nura–Fedorovo, Begazy–Dandybai) and Tasmola/Bronze Age and Early Iron Age	1800–700 BC	Kurgan cemetery associated with Temirkash; different dates for different kurgans	29 humans (2 failed) 4 animals	Outram *et al.* (2011, 2012), Varfolomeev (2007a,b, 2011b)
Temirkash (Темиркаш)	Andronovo/Middle and Late Bronze Age Могилъник Темиркаш (cemetery)/Final Bronze Age Поселение Темиркаш/ Middle Bronze Age Andronovo–Fedorovo/Final Bronze Age	Mid-second millennium BC and beginning of first millennium BC	Settlement associated with Tegiszhol; located north-west of Karaganda, in semi-arid steppe	2 humans (могилъник) 40 animals (поселение)	Outram *et al.* (2011, 2012), Varfolomeev (2007a)
Nurataldy (Нураталды)	Early Andronovo – early Alakul)	18th to 16th centuries BC	Buried in stone box, with pot of sheep bones	1 human 1 sheep	Unpublished
Dariya (Даръя)	Andronovo–Fedorovo			3 humans	Loman and Kukushkin (2012)
Tashik (Ташик)	Andronovo–Alakul/Middle Bronze Age			15 humans 20 fauna	Unpublished
Aschisu (Ащису)	Early Andronovo – early Alakul)	End of third, beginning of second millennium BC	One individual buried with a copper bowl	9 humans 4 fauna	Kukushkin (2007, 2010, 2012), Kukushkin and Loman (2011)

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Table 1 *(continued)*

Site	*Culture/period*	*Date*	*Comments*	*Number of samples*	*Reference(s)*
Ayap-bergen (аяп-берген)	Early Andronovo – early Alakul)	18th to 17th centuries BC		1 human	Kukushkin (2006)
Kopa-1 (Копа-1)	Andronovo–Alakul		Cemetery	1 human	Unpublished
Akimbek (Акимбек)	Andronovo–Fedorovo			5 humans 1 horse	Unpublished
Tasyrbai (Тасырбай 2)	Andronovo–Fedorovo			2 humans	Unpublished
Kudryavaya Sopka-1 (Кудрявая Сопка-1)	Sargarinsko–Alekseevsk/Final Bronze Age			2 humans 1 sheep	Loman and Kukushkin (2009)
Kyzylkol (Кызылколъ)	Andronovo – early Alakul	18th to 17th centuries BC	Woman buried with seven children	8 humans	Unpublished
Kyzyl (Кызыл)	Final Bronze Age	By analogy, 9th to 8th centuries BC		2 humans	Beisenov and Varfolomeev (2008)
Karatugai (Каратугай)	Sargarinsko–Alekseevsk/Final Bronze Age	By analogy, 9th to 8th centuries BC		5 humans	Unpublished
Zhartas (Жартас)	Early Iron Age			1 human	Kukushkin and Loman (2004)
Kairakty (Кайракты)	Andronovo–Fedorovo		Sacrificial victim	1 human	Loman and Kukushkin (2011)
Kent (Кент)	Begazy–Dandybai/Final Bronze Age	12th to 8th centuries BC	Proto-city	1 human	Outram et al. (2011, 2012), Varfolomeev (2011a, 2013)

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Table 2 *Statistical data*

Comparison	*n*	$\delta^{13}C$				$\delta^{15}N$			
		Test	*Degrees of freedom*	*Test statistic*	*P*	*Test*	*Degrees of freedom*	*Test statistic*	*P*
Temirkash versus Tashik animal results	40, 16	*t*-test	54	(*t*) 0.041	0.967	*t*-test	54	(t) –0.455	0.651
Temirkash animal results MBA versus LBA	19, 21	*t*-test	38	(*t*) 0.124	0.902	*t*-test	38	(t) –0.231	0.818
Comparison of human results by site (with $n > 4$)	26, 15, 9, 5, 8, 5	Kruskal–Wallis	5	(*H*) 9.584	0.088	ANOVA	5, 62, 67	(F) 3.512	0.007
Comparison of human results by culture ($n > 4$)	19, 27, 15, 16	ANOVA	3, 73, 76	(*F*) 7.382	<0.001	Kruskal–Wallis	3	(H) 4.649	0.199

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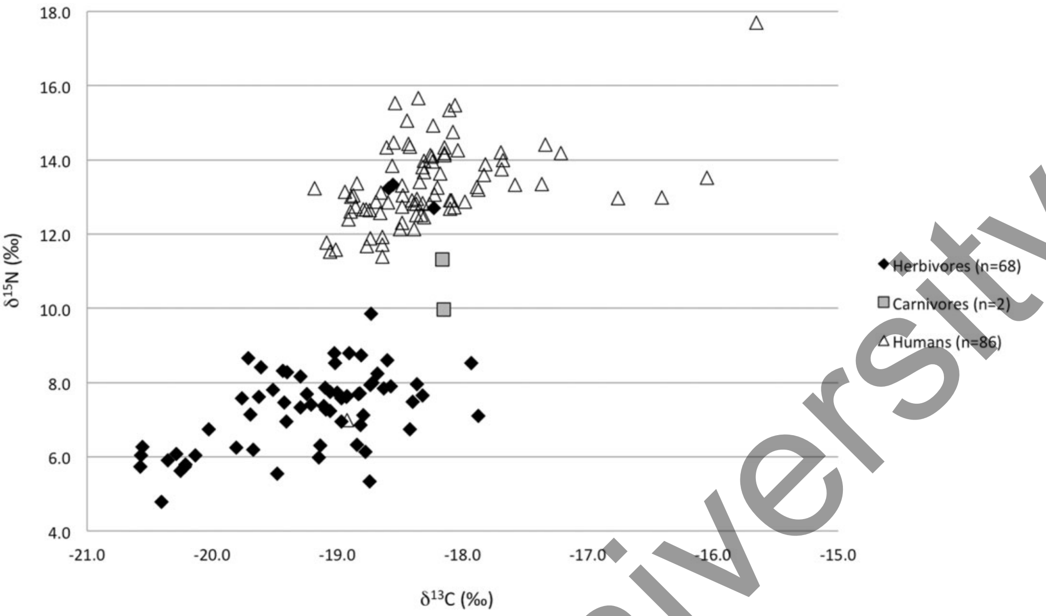

Figure 2 *A scatter plot of the human and animal $\delta^{13}C$ and $\delta^{15}N$ results.*

misidentified (this latter hypothesis is particularly likely for sample KZF47, which was taken from a rib). Further, sample KZF53 has a high $\delta^{15}N$ value compared to the remaining herbivores—in this case, the sample was identified as a juvenile at the time of sampling and therefore probably exhibits a weaning effect. These four outliers have been excluded from subsequent analyses. With these outliers excluded, the mean values are −19.2‰ (± 0.6‰) in $\delta^{13}C$ and 7.2‰ (± 1.0‰) in $\delta^{15}N$ (ranging from −20.6‰ to −17.9‰ in $\delta^{13}C$ and from 4.8‰ to 8.9‰ in $\delta^{15}N$).

The two carnivore values are notably higher in $\delta^{15}N$ than the mean herbivore value ($\delta^{15}N$ = 11.3‰ and 10.0‰) and have relatively high $\delta^{13}C$ values ($\delta^{13}C$ = −18.2‰ for both).

Animal samples were available from seven sites, but only two of those sites have a herbivore sample size greater than five: Temirkash ($n = 39$) and Tashik ($n = 15$, with two outliers identified above excluded). Statistical analyses show that there is no difference between the sites in either mean $\delta^{13}C$ or $\delta^{15}N$.

It is difficult to compare the faunal results through time, as the majority of the samples date to the Andronovo period (see Supplementary Appendix 2). The samples from Temirkash can, however, be divided into Middle and Late Bronze Age. Statistical analyses indicate that there is no difference in either mean $\delta^{13}C$ or $\delta^{15}N$.

Although the data are limited, there seems to be little variation in the environmental baseline through space and time in Bronze Age central Kazakhstan. The animal data presented will therefore be combined and used, with caution, as a baseline for all of the human values.

Human results

The human results are shown in Figure 2 and have a mean $\delta^{13}C$ value of −18.3‰ (± 0.6‰) and a mean $\delta^{15}N$ value of 13.3‰ (±1.3‰). However, there is one sample with a very low $\delta^{15}N$ value

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that is statistically identified as an outlier (lying more than 1.5 times the IQR below Q1; KZ006 $\delta^{15}N = 7.0‰$). This value is more typical of the herbivore than human data in this study. We suggest that this (rib) sample was misidentified and thus we exclude it from further analysis. A second sample also stands out as unusual: sample KZ053 has the highest $\delta^{15}N$ and $\delta^{13}C$ values of any sample in this study ($\delta^{13}C = -15.7‰$, $\delta^{15}N = 17.7‰$) and is a statistical outlier in both $\delta^{13}C$ and $\delta^{15}N$ (lying 1.5 times the IQR above Q3 for both isotopic values). In order to prevent this sample from skewing the means and statistical tests, we exclude it from statistical analyses but include it in the discussion below. With these two samples excluded ($n = 83$), the mean $\delta^{13}C$ value is −18.3‰ (± 0.6‰, range from −19.2‰ to −16.1‰) and the mean $\delta^{15}N$ value is 13.3‰ (± 1.0‰, range from 11.4‰ to 15.7‰, although note that this includes juvenile individuals—when identified juveniles are removed, mean $\delta^{15}N = 13.2‰$). When these mean human values are compared to the herbivore data presented above, the mean human–herbivore offset values are 1.0‰ in $\delta^{13}C$ and 6.1‰ in $\delta^{15}N$. The herbivore–human difference at Tegiszhol and Temirkash (which are a settlement and an associated cemetery) is 1.0‰ in $\delta^{13}C$ and 5.9‰ in $\delta^{15}N$ (1.1‰ and 6.0‰, respectively, with juveniles removed), while that at Tashik is 0.8‰ in $\delta^{13}C$ and 6.0‰ in $\delta^{15}N$ (0.7‰ and 5.7‰, respectively, with juveniles removed).

Six sites have human sample sizes greater than four: Tegiszhol ($n = 26$), Tashik ($n = 15$), Aschisu ($n = 9$), Akimbek ($n = 5$), Kyzylkol ($n = 8$) and Karatugai ($n = 5$). As can be seen in Figure 3, there is no trend in values with site; rather, there are a range of isotopic values within each site. There are no statistical differences between sites in $\delta^{13}C$, and the only statistical differences in $\delta^{15}N$ are that Aschisu has lower values than Akimbek and Kzyzlkol.

Finally, the results are compared by culture (and period). As can be seen in Figure 4, in general there is very little difference between periods, with the exception that the Final Bronze Age has more samples with high $\delta^{13}C$ values. Statistical tests were run on the Early Alakul ($n = 19$), Alakul ($n = 27$), Fedorovo ($n = 24$, excluding sample KZ053 discussed above) and Final Bronze

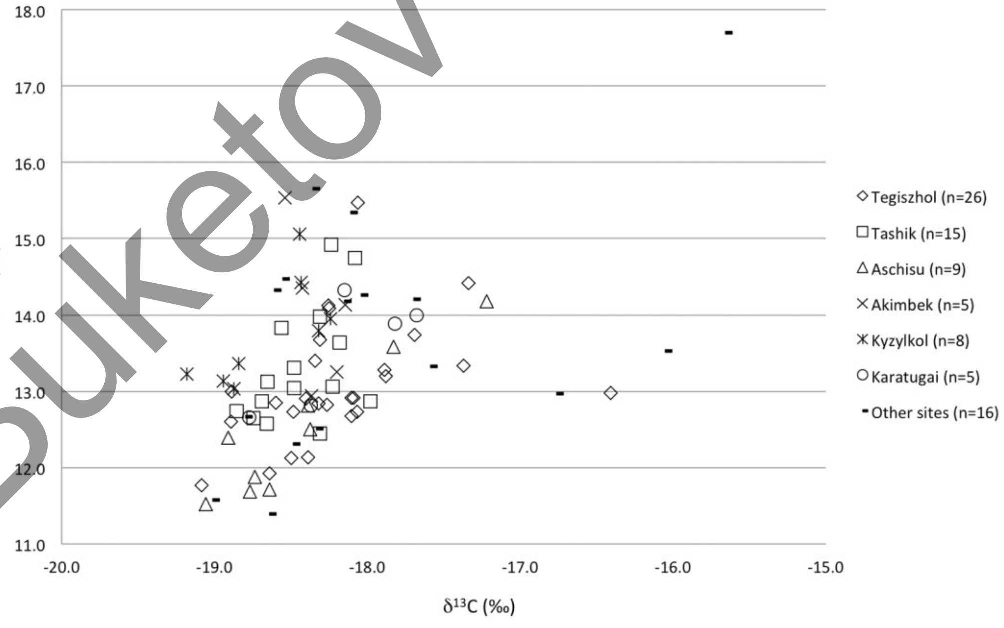

Figure 3 *A scatter plot of the human $\delta^{13}C$ and $\delta^{15}N$ results, separated by site.*

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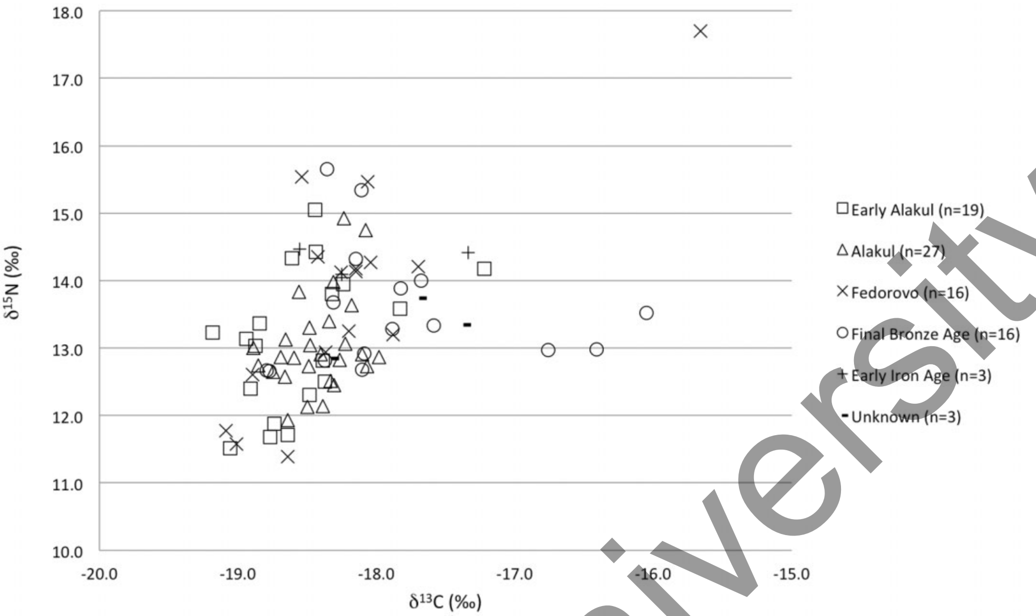

Figure 4 *A scatter plot of the human $\delta^{13}C$ and $\delta^{15}N$ results, separated by culture/period.*

Age (n = 17) groups. No statistical differences were found in δ^{15}N. In δ^{13}C, the Final Bronze Age was different to all of the other groups, having higher δ^{13}C values.

DISCUSSION

Animals

The herbivore δ^{13}C values are typical for Holocene C_3 environments, showing that the majority of the herbivore diets consisted of C_3 foodstuffs. There are two caprid results, noted above, with relatively high δ^{13}C values, which may indicate either a small C_4 input to the diet or more arid conditions at that time. That these two caprids are from different sites indicates that this C_4 plant(s) and/or aridity effect was present at more than one location. Both samples date to the Andronovo period.

The herbivore δ^{15}N results (mean δ^{15}N = 7.3‰) are higher than those found in the Minusinsk basin (n = 18, mean δ^{15}N = 5.4‰; Svyatko *et al*. 2013) and than Eneolithic horses from northern Kazakhstan (n = 4, δ^{15}N = 2.7‰), but comparable to herbivores from Liskavosk (n = 5, δ^{15}N = 7.5‰) and Bestamak (n = 3, δ^{15}N = 6.7‰) in northern Kazakhstan (Ventresca Miller *et al*. 2014), and to those from sites in southern Siberia (n = 4, δ^{15}N = 7.5‰; Murphy *et al*. 2013). High δ^{15}N values can be associated with manuring (which adds high δ^{15}N biomass to the soil; Bogaard *et al*. 2007), but given the ecological context of the steppes this seems unlikely. Rather, we suggest that aridity is a more likely cause, as aridity has been shown to increase δ^{15}N values in plants and animals that feed upon them (Heaton *et al*. 1986). The herbivores in this study have a 4‰ range of variation, larger than would be expected. This is partly accounted for by the different species considered, but it may also be a reflection of a range of local environmental conditions,

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either spatially or temporally, associated with different aridities and local micro-environments. However, the comparison of the results from Temirkash and Tashik show that the mean values for these two sites are similar.

The two dogs have stable isotope results indicating diets at a trophic level intermediate between the herbivores and humans, consistent with the diet expected for domestic dogs.

Humans

In general, the human isotope values suggest a diet largely based on a C_3 terrestrial food chain; however, the results indicate that other food sources with different isotopic values were consumed in varying proportions. The mean differences in $\delta^{13}C$ between the herbivore and human values (1.0‰ for all individuals, 1.0‰ for Tegiszhol and Temirkash, and 0.8‰ for Tashik) are within the 0–2‰ estimated increase for a trophic level (Bocherens and Drucker 2003). This suggests that the majority of people consumed diets with little or no C_4 input. There are four individuals with notably high $\delta^{13}C$ values (KZ025 $\delta^{13}C = -16.4$‰, KZ053 $\delta^{13}C = -15.7$‰, KZ092 $\delta^{13}C = -16.8$‰ and KZ104 $\delta^{13}C = -16.0$‰) suggestive of the addition of C_4 foodstuffs to their diets (although see comments on KZ053 below). Given the faunal data discussed above, it is likely that this C_4 foodstuff was consumed directly by humans, and therefore this probably represents millet consumption and, presumably, cultivation. There are also 11 individuals with intermediate $\delta^{13}C$ values (between −18.0‰ and −17.0‰), although it is not clear if these data represent a small proportion of C_4 foodstuffs in their diets (either through direct consumption or via animals) or if these data represent particularly arid conditions at the time of collagen formation and/or natural variation in human $\delta^{13}C$ values. On the basis of the human isotopic results presented here, it is not possible to comment on the cultivation and consumption of C_3 plants.

In terms of $\delta^{15}N$, even with juveniles removed, the human–animal offset values are higher than that commonly associated with a trophic level enrichment (i.e., 3–5‰; Bocherens and Drucker 2003). The mean human–herbivore offset value of 6.1‰ (5.9‰ at Tegiszhol and Temirkash, and 6.0‰ at Tashik) shows that some of these individuals were consuming some protein from a higher trophic level than the sampled animals. These data strongly indicate that there was a small component of the diet of many individuals with a higher $\delta^{15}N$ value than the analysed herbivores. The most parsimonious explanation for this is the consumption of a small amount of freshwater fish (or animals that eat freshwater fish). A small number of fish bones have been found at Temirkash through sieving, but the proportion was only 1.5% (unfortunately, these bones were not available for isotopic analysis) and no evidence for fish processing has yet been found through residue analysis of ceramics. Nevertheless, the location of many of the sites along rivers suggests that the inhabitants would have had access to riverine fish. It is possible that fish were treated in such a way that they rarely became part of the archaeological record, such as being prepared and dried or smoked away from the depositional contexts. In general, then, the isotopic evidence indicates that Bronze Age diet in central Kazakhstan was more diverse than traditionally believed. While diet was likely largely based upon domestic herds (note that isotopic analyses cannot distinguish between meat and dairy products), fish formed a notable but varying part of the diet, while some individuals consumed millet.

The statistical analyses above show that this dietary diversity cannot be accounted for by dietary differences between sites. Indeed, the only site with significantly different isotope results was Aschisu, where the proportion of fish consumption was lower than at the other large sites, and fish may not have been consumed at all (particularly by the four individuals with $\delta^{15}N$ values less

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than 12‰). On the other hand, the temporal comparison does account for some of the dietary diversity, in that $\delta^{13}C$ values are higher in the Final Bronze Age than the preceding periods. This suggests that the consumption of C_4 plants, presumably millet, became more important to the diet in this period. It does not necessarily indicate the first consumption of millet in central Kazakhstan but, rather, the first time that it was consumed on a significant scale (cf., Lightfoot *et al.* 2013). Indeed, the presence of carbonized millet remains (see references above) shows that millet was probably present in this Central Asian region in earlier time periods, but infrequently eaten in quantities sufficient to significantly enrich the isotopic signal.

There is one interesting individual, sample KZ053 (Tasyrbai, Fedorovo culture), who has the highest $\delta^{13}C$ and $\delta^{15}N$ values found in this study, while the other individual analysed from this site has more typical values (KZ066; $\delta^{13}C = -18.6‰$ and $\delta^{15}N = 11.4‰$). These results may reflect: an aridity effect combined with C_4 plant consumption (and perhaps migration from a more arid area); a diet very high in freshwater aquatic protein and C_4 plants; or a diet including large amounts of marine protein (and long-distance migration).

Comparison to other studies

While isotopic research in Central Asia is relatively limited, there are a number of isotopic studies to which the results presented here can be compared. The first isotopic analyses of steppe pastoralists were carried out by O'Connell *et al.* (2003) and suggested that the Eneolithic and Iron Age people sampled consumed significant quantities of fish or other aquatic animals, although the sample size was limited. The study by Svyatko *et al.* (2013) of the Eneolithic to Early Iron Age (2700–1 BC) of the Minusinsk Basin, Russia, also showed that freshwater fish were an important resource throughout this period, and that millet became important in the Late Bronze Age. Murphy *et al.* (2013) have also found isotopic evidence that millet and fish were important dietary components in Early Iron Age southern Siberia. Ventresca Miller and colleagues have used stable isotope analysis and dental analyses (Ventresca Miller *et al.* 2014; Ventresca Miller *et al.* in press) to study diet at Middle Bronze Age Bestamak and Late Bronze Age Lisakovsk in northern Kazakhstan. These analyses suggest that some individuals supplemented their diets with freshwater fish, with little change in diet between the two periods considered. In further support of the consumption of freshwater fish, Privat *et al.* (2007) have used nitrogen and sulphur isotopes to show that freshwater fish were consumed at the Late Bronze Age site of Chicha in Novosibirsk, Russia. The combination here of nitrogen and sulphur isotopic evidence is particularly powerful and convincing. To the east of the study area, Zhang and colleagues (Zhang and Li 2006; Zhang and Zhu 2011; Zhang et al. 2009, 2010) have demonstrated that millet consumption was common in Xinjiang, western China, although Bronze Age communities in Xinjiang did not rely on millet as heavily as those in central China.

In summary, although the number of studies is limited, the isotopic data show that fish, and sometimes millet, were part of the diet of steppe 'pastoralists' (who are often assumed to consume mainly terrestrial animal protein), and thus strongly support the interpretations presented here. The true picture of human subsistence in Central Asia is far from clear. However, together with previous studies, this investigation provides a glimpse into the Bronze Age lifestyle in the steppes. The current isotopic evidence suggests that these communities were not as homogeneous in their diets as previously assumed, fitting well with other archaeological evidence for dietary diversity across the steppes (e.g., Frachetti *et al.* 2010; Bendrey 2011; Outram *et al.* 2012; Spengler *et al.* 2014).

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CONCLUSION

The data presented here have shown that the subsistence strategy in Bronze Age central Kazakhstan was not solely focused on terrestrial animals. Instead, fishing and cultivation were notable, if small, parts of the subsistence strategy, with the relative importance of these three dietary components varying for different people and at different times. This dietary diversity can be seen even within sites, indicating that people had real choice in their subsistence strategies. Change can be seen through time, with millet consumption becoming increasingly important in later periods. Through comparison with published research, we have shown that this pattern was not unique to central Kazakhstan—the, admittedly limited, isotopic and archaeobotanical evidence indicates the importance of these resources at various times and locations cross the steppes.

The importance of fishing and cultivation requires the economic basis and daily lives of these communities to be reconsidered. Fishing and cultivation would have required considerable inputs of time, energy and resources on a (semi-?)regular basis. This has important implications for our understanding of what it means to be a pastoralist. We suggest that the use of domestic herds does not preclude the procurement of other food resources—millet, for example, requires relatively little human input between sowing and harvesting (Rachie 1975; Rao 1989), and the evidence presented here and elsewhere shows that these pastoralist communities were responding in diverse ways to the opportunities presented by the world around them.

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Appendix 1.
Appendix 2.

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