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Archaeozoological Studies at Konoplyanka, the Southern Trans-Urals

Konoplyanka is a fortified settlement associated with the Sintashta culture and dating to 1920–1745 cal BC. The faunal sample was studied with regard to standard traits and pathology analysis, rather recently adopted in Russian archaeozoological studies. The results are relevant not only to ancient herd composition and age at slaughter but also to the animals' states of health. The analysis of pathologies provides information about the herders' skills and the housing of domestic ungulates. Ethnographic data relating to the modern grazing management system in the same area and information received from herdsmen are widely used. This makes it possible to assess the carrying capacity of the land, and to arrive at a more accurate reconstruction of the pastoral economy. Osteophagy among the domestic ungulates is analyzed, and the phenomenon is discussed in the context of settlement archaeology. The study has shown that animal husbandry was the predominant subsistence strategy. Results of pathology analysis indicate a high level of herding skills. The cattle were used as draft animals. Osteophagy attests to places where animals were kept. The predominant system was homestead herding, all or most animals being likely kept within the settlement throughout the year.

Keywords: *Bronze Age, Sintashta culture, archaeozoology, animal pathology, ungulate osteophagy, draft cattle.*

Introduction

The Konoplyanka site is one of 22 settlements of the Sintashta culture discovered in the Southern Trans-Urals (Soldatkin, 2018: 210). Many aspects of herding by the population of this culture have been thoroughly studied in recent years (Kosintsev, 2000; Kosintsev, Gasilin, 2009; Kosintsev, Bachura, 2013; Rassadnikov, Kosintsev, Koryakova, 2013). But a number of other issues have not so far been the focus of archaeozoological research, including the analysis of pathological markers, reconstruction of the type of herding, and the radius of the economic (herding) zone of settlements.

This study sets out to reconstruct the pastoral economy at Konoplyanka, employing archaeozoological material from the site (excavations of 2012–2013). The study of this settlement is carried out as a part of a Russian-German joint project aimed at studying the Bronze Age sites located in the Karagaily-Ayat River valley (Koryakova, Krause, 2013: 1). One of our main aims is to reconstruct the subsistence strategy and ways this ancient group interacted with their environment. Archaeozoological methods were complemented by the employment of ethnozoological data in order to attain the purposes of the study most effectively.

Material and methods

The fortified settlement of Konoplyanka is located in the Kartalinsky District of the Chelyabinsk Region, at the headwaters of the Karagaily-Ayat River, approximately

2 km northwest of a homonymous village (Sharapova et al., 2014: 102). This one-layer site contains predominantly materials of the Sintashta-Petrovka time, and is preliminary dated to 1920–1745 BC (Ibid.: 107–108). The excavation covered 96 m^2 and unearthed parts of a fortification, including ramparts, ditch, internal wall, and part of an adjacent construction (Ibid.: 104).

The osteological sample comprises 779 bones*. The sample was studied according to the protocol adopted at the Laboratory of Paleoecology of the Institute of Plant and Animal Ecology (UB RAS). The age at slaughter of cattle and *Ovicapridae* (sheep and goat) was identified on the basis of state of eruption of buccal teeth and the epiphyses (Silver, 1969). Bone measurements were taken following the protocol by Driesch (1976). Sizes of the domestic ungulates were reconstructed using the coefficients for calculating the height at the withers from metapodial and talar dimensions (Tsalkin, 1960: 119; 1970: 162). The protocol adopted at the Laboratory of Natural Science Methods of the Institute of Archaeology (RAS) was employed for the reconstruction of food-meat composition (Antipina, 2013: 139).

Taphonomy and taxonomic composition of the sample

More than a half of the bone fragments display a perfect preservation (stage 0 after (Behrensmeyer, 1978)). All these well-preserved bones were excavated from the filling of the ditch. The rest of the sample was collected inside construction 1, and exhibits traces of weathering (stage 1–2 after (Ibid.)). Almost all complete bones and large bone fragments were found in the filling of the ditch.

Bones identifiable to a particular species compose a substantial part of the sample (80 %). Most of these belong to domestic ungulates (Table 1). Cattle (*Bos taurus*) and *Ovicapridae* (sheep and goat), horses (*Equus caballus*), pigs (*Sus scrofa domesticus*), and dogs (*Canis familiaris*) are present in the sample. Approximately ten coprolites of dogs, consisting mostly of bone chips, were found in the filling of the ditch as well. Among the bones of small cattle, only sheep bones (*Ovis aries*) were identified, while goat bones were not detected. However, this observation can be most likely explained by the low sample size. Wild species are represented by single bones of roe deer (*Capreolus pygargus*), fox (*Vulpes vulpes*), and beaver (*Castor fiber*). In the complex of bones unidentifiable at the species level, fragments of large ungulate bones are prevalent (*Mammalia indet*.).

*The collection is curated at the Laboratory of Paleoecology of the Institute of Plant and Animal Ecology, Ural Branch of the RAS (Yekaterinburg).

Age distribution of slaughtered domestic ungulates

The number of fragments of the lower and upper jaws of cattle and *Ovicapridae* is low: 17 and 16 specimens, respectively. Horse bones cannot be employed in the analysis, owing to their scarcity: only 3 teeth from young, 1 tooth from a semi-adult, and 4 teeth from adult animals were excavated. According to the state of the dentition, more than a half of the slaughtered cattle were adult (Table 2). Fragments of jaws of senile individuals (i.e. with severely worn teeth crowns) were observed in the sample as well. The proportion of young animals to adult among the small cattle was equal (Table 2).

Our sample does not provide a lot of data regarding epiphyseal fusion. The most representative samples of the bones of cattle were obtained only for the distal part of the radius (6 spec.), both ends of the tibia (5 and 7 spec., respectively), calcaneus (5 spec.), and metapodials (11 spec.). Analysis shows that if epiphyses accrete at the age of 2 to 2.5 years, then a significant preponderance of slaughtered individuals with fused epiphyses is observed; but if at the age of 3.5 to 4 years, then with separated epiphyses. Such an observation suggests that the majority of animals were

Table 1. **Taxonomic composition of the archaeozoological collection**

Species	Number	%
Cattle – *Bos taurus*	392	50.3
Ovicapridae – Ovis/Capra	137	17.6
Sheep – *Ovis aries*	20	2.6
Horse – *Equus caballus*	46	5.9
Pig – *Sus scrofa domesticus*	5	0.6
Dog – *Canis familiaris*	20	2.6
Roe deer – *Capreolus pygargus*	1	0.1
Fox – *Vulpes vulpes*	1	0.1
Beaver – *Castor fiber*	1	0.1
Unidentified – *Mammalia indet*.	156	20.1
Total, NISP	779	100

Table 2. **Age at slaughter of the domestic ungulates**

Dentition development	Age, months	Cattle, %	*Ovicapridae*, %
M3 erupted	>30	58	43
M2 erupted, M3 not erupted	18–30	30	44
M1 erupted, M2 not erupted	6–18	0	13
M1 not erupted	< 6	12	0

slaughtered at between 2 and 4 years of age. The horse bones and bones of small cattle are not considered, owing to their scarcity.

Prevalence of various skeletal elements of domestic ungulates, and modifications of bones

The only relatively representative bone sample is that of the cattle. It shows an equal ratio between bones of the head, corpus, fore and hind limbs. In the sample of small cattle, bones of the head and forelimbs are prevalent; while among the horse bone fragments, hind limbs predominate.

One hundred seventy two bones with various modifications were detected in the sample. The most prevalent types of modification are gnawing-marks and signs of the impact of gastric enzymes of dog – 51.1 %. This is followed by cutting and chopping marks – 15.1 %; and signs of thermal effects – 12.7 %. Single bones displaying gnawing-marks and manifestations of contact with gastric enzymes of cattle and *Ovicapridae* were also identified. Several bone crafts and blanks were found during the work with the osteological sample. All these artifacts are burnishing tools made from talar bones of cattle (1 spec.) or sheep (3 spec.).

Skeletal metrics of domestic ungulates

Only a small number of the bones of sheep and cattle were suitable for measurement (Tables 3 and 4). Among the bones of cattle, both cow and bull remains were found. At least two metacarpals, several fragments of the lower diaphyses of the humeral bones, and first phalanxes (judging by their robustness), belonged to bulls. The metacarpals were sexed visually, as sexual dimorphism is well pronounced in these bones (Telldahl et al., 2012).

The height at the withers of cows, reconstructed from one talus, was 115.8 cm, while metatarsals revealed higher values: 118.5–121.2 cm. Three metacarpals were detected, which presumably belonged to oxen, owing to their narrow diaphyses and massive epiphyses. The height at the withers of these animals varied from 125.6 to 132.4 cm. In a bull, the height was determined from a metatarsal bone as 134.4 cm. The height at the withers of sheep, reconstructed from 4 talar bones, varied from 65.5 to 81.3 cm.

Two fragments of horn rods and a skull from a hornless individual were identified among the bones of cattle, and fragments of horns were found among ovine remains as well. There were likely both horned and hornless individuals of both cattle and *Ovicapridae* present in the herd. The scarcity of data does not permit more detailed reconstructions.

Table 3. **Cattle skeletal metrics, mm**

Variable	*n*	Lim	M ± m
P_2–M_3	4	144.0–156.0	147.7
P_2–P_4	5	51.0–57.1	53.1
M_1–M_3	5	86.5–98.8	91.6
M_3	8	32.4–41.8	37.7
Humerus, BT	9	74.3–94.1	84.2
Tibia, Bd	5	58.5–69.7	64.8
Metacarpal, GL	3	205.0–215.0	210
Bp	3	67.4–71.6	68.9
SD	3	30.5–42.1	38.0
Bd	3	70.1–77.1	74.5
Metatarsal, GL	3	218.0–245.0	228.0
Bp	4	47.3–58.1	52.6
Bd	3	52.7–70.7	59.6
Phalanx I, Glpe	14	55.3–68.4	62.0
Phalanx II, Glpe	10	33.4–47.2	41.6

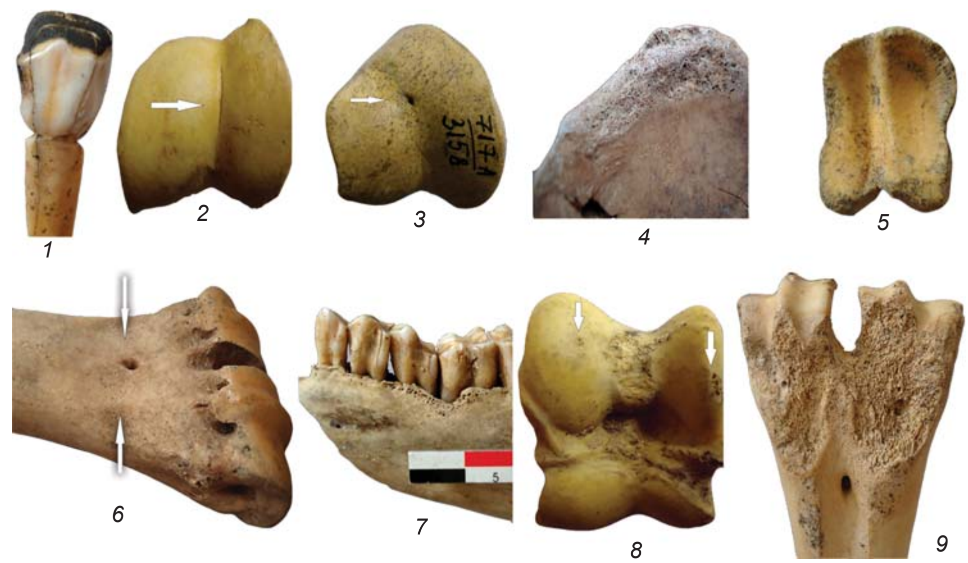
Table 4. **Sheep skeletal metrics, mm**

Variable	*n*	Lim	M ± m
M_3	6	22.3–27.9	24.9
Tibia, Bd	3	30.1–31.9	30.7
Astragalus, GLl	4	29.0–35.9	32.6
Metatarsal, GL	1	169.5	169.5
Metatarsal, Bp	2	23.0–24.0	23.5
Phalanx I, Glpe	4	41.0–45.2	43.4
Height at the withers	4	65.5–81.3	73.9

Results of the paleopathological analysis

A small number of pathological manifestations were only observed in the bones of adult cattle (18 spec.) and sheep (4 spec.).

Cattle. Of dental pathologies in the sample of cattle, one case of a wedge-shaped defect of the incisor was detected. It can be described as a V-shaped incision between the root and the crown of the tooth (see *Figure*, *1*). Depressions of articular surfaces were the most prevalent postcranial pathology (11 spec.) observed in the bovine phalanxes, metapodials, and carpal bones. These emerge as a result of local disturbances in the mineralization of subchondral bones (Thomas, Johannsen, 2011: 52). Among arthropathies, the most prevalent is Type 2 (after (Ibid.: 44)): clefts of the articular surface up to 1 mm wide and 5.0 to 10.5 mm long (see *Figure*, *2*). A depression of Type 4 (after (Ibid.: 46)); round hollow 1.0–1.5 mm in diameter and up to 1 mm deep) was also detected (see *Figure*, *3*). Two loci of eburnation were



Dental and bone pathologies of cattle (*Bos Taurus*) (*1–6*) and *Ovicapridae* (sheep and goat) (*7*, *8*), and an example of bone gnawing (osteophagy) by domestic ungulates (*9*).

1 – wedge-shaped defect of an incisor; *2* – depression of the 2nd type on the distal articular surface of the first phalanx; *3* – depression of the 4th type on the distal articular surface of the second phalanx; *4* – eburnation and proliferation of a pelvic bone; *5* – deformation and widening of the proximal articular surface of the first phalanx; *6* – depression on the volar surface of a metacarpus; *7* – precocious wear of P_4 and M_1 and an inflammation of the alveolus of a mandible; *8* – arthropathies of a sheep's talar bone; *9* – metatarsus gnawed by cattle.

found: in the central tarsal bone and in a fragment of the pelvic bone. In the latter, a proliferation of the periarticular surface was observed (see *Figure*, *4*). A marked widening and deformation of the proximal articular surface was identified in a first phalanx of a bull (see *Figure*, *5*). Two oxen metacarpals studied are of particular interest, as they display a number of pathological changes simultaneously. In both bones, subtle deformations and widenings of the articular facets of the distal epiphysis were observed. One of the bones, in addition, exhibits a marked depression (hollow) on the volar surface near its lower end (see *Figure*, *6*) and an arthropathy in the ridge of the lateral trochlea. This metacarpus also demonstrates a pronounced asymmetry between the 3rd and 4th metacarpal bones.

Ovicapridae. In an ovine mandible, manifestations of an inflammatory process of an alveolus were detected in the area of the P_4 and M_1, as well as a strong precocious wear of these teeth (see *Figure*, *7*). Two types of arthropathy were observed in the ovine postcranial skeleton. A depression of Type 2, similar to the one described above, was found on the distal articular surface of a second phalanx. On the medial surface of both ridges of a sheep's talus, we identified the second stage of the *Laesio circumscripta tali* arthropathy (after (Zimmermann et al., 2018: 20)). This lesion is a microscopic locus of osteonecrosis, which was formed as a result of insufficient blood supply (see *Figure*, *8*).

The interpretation of the observed dental pathologies of cattle (*Bos taurus*) and *Ovicapridae* (sheep and goat) is quite straightforward. The wedge-shaped defect can be related to congenital fragility of the cementum of the tooth neck in some individuals, but also to periodontal disease, the effect of salivary acids, or tough feed (Lukyanovsky, 1984: 150). The ovine dental pathology is likely a result of osteophagy found at the settlement (Caceres et al., 2013: 3113).

The etiology of the depressions on the articular surfaces is not yet known precisely, but it is established that causes of this pathology are different in different species. Depressions in the bones of cattle and *Ovicapridae* are manifestations of *osteochondritis dissecans* or *osteochondrosis dissecans* (Stevanovic et al., 2015: 7). However, some researchers suggest that the Type 2 depression is the least related to osteochondrosis. It is probably of developmental origin, and may not affect the functionality of the joint (Thomas, Johannsen, 2011: 53).

The eburnation and deformations of articular surfaces observed in the bones of cattle are not related to the use of the latter as draft animals, but are likely a result of age changes and occasional trauma. Similar lesions were observed in the bones of modern non-working cattle from the Karagaily-Ayat River valley. Pronounced asymmetry of the metacarpals are found in the modern cattle as well. However, the marked depression on the volar surface of the metacarpus of an ox, accompanied by a general asymmetry, may suggest that it was used as a draft animal. Such changes in the metapodials of cattle are typically viewed as markers of heavy physical exercise

(Bartosiewicz, 2008: 158–159). The most probable cause of the ovine talar arthropathies is housing of the animal in a stall, which can lead to a biomechanical stress to the joint (Zimmermann et al., 2018: 22).

Osteophagy of domestic ungulates

Several bone fragments with gnawing-marks caused by domestic ungulates were detected in the sample: three caused by cattle (see *Figure*, *9*), and two by *Ovicapridae*. A survey of modern cow and sheep pens in the Karagaily-Ayat River valley revealed exactly the same type of modified bone fragments, which has helped to explain the modifications observed in the Konoplyanka sample. A thorough description of the types and stages of the modifications may be found elsewhere (Rassadnikov, 2017).

Osteophagy can be viewed as an innate and typical feature of non-nutritional behavior of all ungulates and a marker of mineral deficiency in animals, since plant food cannot completely fulfill the animal's demand for minerals (Caceres et al., 2013: 3115; Hutson, Burke, Haynes, 2013: 4139). An important work by A.A. Kabysh describes a case of mass osteodystrophy of cattle, in the 1950s, in the Bredinsky District of the Chelyabinsk Region, i.e. in the Karagaily-Ayat River valley. The Konoplyanka settlement is located at the northern periphery of that district. A special commission was created to fight the osteodystrophy outbreak. The commission found that the Bredinsky District was an unusual biogeochemical province where the absorption of phosphorus and calcium in ungulates was disrupted, owing to the mineral composition of the soil (Kabysh, 1967: 334). Osteodystrophy is absent in the cattle of the Karagaily-Ayat River valley today, but cases of cattle and *Ovicapridae* eating bones and soil are observed despite mineral feeding of the animals. The probable cause of osteophagy by the cattle and *Ovicapridae* at Konoplyanka may be a combination of factors, including the specific features of the soils of the area, the peculiarities of all ungulates, and seasonal stress in some individuals. Intense dairy exploitation of cattle can be excluded from the list of potential reasons, because osteophagy is widespread among the modern beef cattle of the region.

The study of modern cow and sheep pens near the site has shown that, irrespective of the number of osteophagy markers found, such modified bones are suggestive of two important moments. First, they undoubtedly point to a homestead pattern of herding, since gnawed bones have been found exclusively inside the fence or its closest perimeter in moderns pens. If osteophagy is considered as a manifestation of general physiological stress, it is of note that in most ungulates such stress is observed in late winter to early spring, or during hot summer months (Niven, Egeland, Todd, 2004: 1789). The proclivity of ungulates for eating bones during periods of hot and dry weather has been documented in giraffes, for instance (Langman, 1978). Further, the modern system of pens where most markers of osteophagy have been found is used only during the snowless time of year. We also interviewed a number of herdsmen, who confirmed that osteophagy by domestic ungulates peaks in the summer. Thus, the markers of osteophagy may indirectly point to the season when they emerged. However, this issue requires further research.

Structure of meat food

Only indicators of the osteological spectrum for sheep, horse, and cattle were employed for the calculation of the amount of various kinds of meat consumed. Pig was not taken into account, since at present there is not enough evidence to believe that this domestic animal was bred for meat during the Bronze Age of the Southern Trans-Urals (Kosintsev, 2000: 41). The ratio of meat consumption demonstrates that beef was the main source of animal protein for the Konoplyanka population (Table 5). According to the data on dental eruption and fusion of epiphyses, young animals were consumed along with individuals older than 4–5 years of age. The second most popular type of meat was horsemeat, the third, mutton. Meat of young and adult sheep was consumed in almost equal amounts.

Probable pattern of herding

Reconstruction of the most probable type of herding at Konoplyanka is the most challenging task in this study. First, there are no data on the isotopic composition

Table 5. **Meat food composition**

Indicator	Beef	Mutton	Horsemeat	Total
Osteological spectrum, %	65.9	26.4	7.7	100 (595 bones)
Multiplicity of the weight of cattle carcasses in respect to a sheep carcass	6	1	5.5	–
Amount of meat products in standard units	394.8	26.3	42.3	463.4
Proportion of various types of meat, %	85.2	5.7	9.1	100

of bone collagen for the domestic ungulates, which could have helped to reconstruct the pattern of housing and feeding. Second, in the south of the Chelyabinsk Region, it is not possible to find a direct analogy of the homestead, transhumant, or homestead-transhumant herding, which are believed to have existed at several settlements of the Sintashta culture (Kosintsev, 2000: 44; Bachura, 2013: 287). In order to solve this problem, a number of data sources were employed, including the age distribution of the sample of cattle, the markers of osteophagy in domestic ungulates, and observations on the modern system of grazing management for cattle and *Ovicapridae* in the Karagaily-Ayat River valley. The age distribution of the slaughtered animals is indicative of a milk and meat type of husbandry. Thus, it can be hypothesized that at least a part of the herd was kept near the settlement for milking. The markers of osteophagy may suggest indirectly that the whole herd, or part of it, might have stayed near the settlement during the warm time of the year. Our observations on the modern grazing management system near the site have shown that even a small area of a river valley can, for decades, support the daily grazing of several small herds (100–150 heads) of domestic ungulates during the snowless period. Notably, steppe vegetation is resistant to grazing of mixed herds including cows, sheep, goats, and horses, and does not manifest signs of overgrazing. The hay for winter stall housing is harvested in the area adjacent to the river that is not used as a pasture. Summing up, it can be reasonably hypothesized that the area (2–3 km in radius) of the river valley surrounding the settlement could have supported the demands of the settlement's inhabitants for a pasture and foraging base for many years.

Conclusions

Unfortunately, not all aspects of the results of this study can be discussed thoroughly, owing to space limitations. We only discuss the main findings of the archaeozoological analysis of the Konoplyanka sample. In general, they show that a developed homestead herding was typical of the Sintashta cultural traditions. Husbandry appears to have been the main source of food for that population. This conclusion is also corroborated by the results of paleobotanical studies that failed to identify microscopic remains of agricultural plants in the site's cultural layer (Stobbe et al., 2016). Fishing probably did not play an important part in the subsistence strategy of the inhabitants of the settlement, since fish bones have been found neither in the ditch (which provides good conditions for the preservation of small bones) nor in the dog coprolites.

The domestic type of husbandry is confirmed by observations on the modern system of grazing management for cattle (*Bos taurus*) and *Ovicapridae* in the Karagaily-Ayat River valley, and also by paleobotanical data showing that the surrounding landscape was suitable for domestic herding (Ibid.). Judging by the same data, the areas of the valley located at the distance of 5 to 15 km from the settlement were presumably used for grazing. A number of observations point towards a high level of herder's skills in the inhabitants of the settlement. First, the low prevalence of skeletal pathologies is indicative of satisfactory conditions for housing the cattle. Second, manifestations of the castration of bulls were detected. Finally, oxen were used as draft animals. The signs of osteophagy in the domestic ungulates suggest that the herd was held near the settlement during the cold and, presumably, even warm (cows) part of the year. A number of bone lesions identified (i.e. arthropathies of the articular surfaces—a manifestation of restricted mobility of the joint) may be interpreted as indirect evidence of stall-housing of the animals. The reconstructed meat food composition of the settlement's inhabitants, and the fact that the oxen were used as draft animals, show that cattle were the most important kind of domestic ungulates.

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References

Antipina E.E. 2013
Modeli drevnego skotovodstva na Kavkaze: Arkheozoologicheskiye issledovaniya na poselenii Kabardinka 2. In *Analyticheskiye issledovaniya laboratorii yestestvenno-nauchnykh metodov*, iss. 3. Moscow: IA RAN, pp. 126–141.

Bachura O.P. 2013
Season and age of the slaughter of cattle (*Bos taurus*) and sheep (*Ovis aries*). In *Multidisciplinary Investigations of the Bronze Age Settlements in the Southern Trans-Urals (Russia)*. Bonn: Verl. Dr. Rudolf Habelt GmbH, pp. 285–291.

Bartosiewicz L. 2008
Bone structure and function in draft cattle. In *Limping Together Through the Ages: Joint Afflictions and Bone Infections*. Rahden: Verl. Marie Leidorf GmbH, pp. 153–164.

Behrensmeyer A. 1978
Taphonomic and ecologic information from bone weathering. *Paleobiology*, vol. 4 (2): 150–162.

Caceres I., Esteban-Nadal M., Bennasar M., Monfort D., Pesquero M.D., Fernandez-Jalvo Y. 2013
Osteophagia and dental wear in herbivores: Actualistic data and archaeological evidence. *Journal of Archaeological Science*, vol. 40: 3105–3116.

Driesch A. 1976
A Guide to the Measurement of Animal Bones from Archaeological Sites. Cambridge, Massachusetts: Peabody

Museum of Archaeology and Ethnology. (Peabody Mus. Bull.; vol. 1).

Hutson J., Burke C., Haynes G. 2013

Osteophagia and bone modifications by giraffe and other large ungulates. *Journal of Archaeological Science*, vol. 40: 4139–4149.

Kabysh A.A. 1967

Endemicheskaya osteodistrofiya krupnogo rogatogo skota na pochve nedostatka mikroelementov. Chelyabinsk: Yuzh.-Ural. kn. izd.

Koryakova L., Krause R. 2013

General remarks of multidisciplinary research in the Kamennyi Ambar microregion on the first phase of the project. In *Multidisciplinary Investigations of the Bronze Age Settlements in the Southern Trans-Urals (Russia)*. Bonn: Verl. Dr. Rudolf Habelt GmbH, pp. 1–21.

Kosintsev P.A. 2000

Kostniye ostatki zhivotnykh iz ukreplennogo poseleniya Arkaim. In *Arkheologicheskiy istochnik i modelirovaniye drevnikh tekhnologiy: Trudy muzeya-zapovednika Arkaim*. Chelyabinsk: Inst. istorii i arkheologii UrO RAN, pp. 17–44.

Kosintsev P.A., Bachura O.P. 2013

Kostniye ostatki zhivotnykh iz poseleniya Ustye. In *Drevnyeye Ustye: Ukreplennoye poseleniye bronzovogo veka v Yuzhnom Zauralye*. Chelyabinsk: Abris, pp. 363–387.

Kosintsev P.A., Gasilin V.V. 2009

Kostniye kompleksy poseleniya Sintashta. In *Etnicheskiye vzaimodeystviya na Yuzhnom Urale*. Chelyabinsk: Yuzh.-Ural. Gos. Univ., pp. 34–38.

Langman V. 1978

Giraffe pica behavior and pathology as indicators of nutritional stress. *Journal of Wildlife Management*, vol. 42 (1): 141–147.

Lukyanovsky V.A. 1984

Bolezni kostnoy sistemy zhivotnykh. Moscow: Kolos.

Niven L.B., Egeland C.P., Todd L.C. 2004

An inter-site comparison of enamel hypoplasia occurrence in Bison: Implications for paleoecology and modeling Late Plains Archaic subsistence. *Journal of Archaeological Science*, vol. 31: 1783–1794.

Rassadnikov A.Y. 2017

Osteofagiya domashnikh kopytnykh na poseleniyakh bronzovogo veka Yuzhnogo Zauralya (po arkheozoologicheskim i etnozoologicheskim materialam). *Vestnik arkheologii, antropologii i etnografii*, No. 2 (37): 163–168.

Rassadnikov A., Kosintsev P., Koryakova L. 2013

The osteological collection from the Kamennyi Ambar settlement. In *Multidisciplinary Investigations of the Bronze Age Settlements in the Southern Trans-Urals (Russia)*. Bonn: Verl. Dr. Rudolf Habelt GmbH, pp. 239–285.

Sharapova S.V., Krause R., Molchanov I.V., Stobbe A., Soldatkin N.V. 2014

Mezhdistsiplinarniye issledovaniya poseleniya Konoplyanka v Yuzhnom Zauralye: Predvaritelniye rezultaty. *Vestnik Novosibirskogo gosudarstvennogo universiteta*. Ser.: Istoriya, filologiya, vol. 13 (3): 101–109.

Silver I. 1969

The ageing of domestic animals. In *Science in Archaeology: A Survey of Progress and Research*. London: Thames and Hudson, pp. 283–302.

Soldatkin N.V. 2018

Zhilaya arkhitektura ukreplennykh poseleniy sintashtinsk-petrovskogo tipa: Obzor istochnikov. *Nauchniy dialog*, No. 1: 209–220.

Stevanovic O., Janeczek M., Chroszcz A., Markovic N. 2015

Joint diseases in animal paleopathology: Veterinary approach. *Macedonian Veterinary Review*, vol. 38 (1): 5–12.

Stobbe A., Gumnior M., Ruhl L., Schneider H. 2016

Bronze Age human-landscape interactions in the southern Transural steppe, Russia – evidence from high-resolution palaebotanical studies. *The Holocene*, vol. 26 (10): 1692–1710.

Telldahl Y., Svensson E., Gotherstrom A., Stora J. 2012

Osteometric and molecular sexing of cattle metapodia. *Journal of Archaeological Science*, vol. 39: 121–127.

Thomas R., Johannsen N. 2011

Articular depressions in domestic cattle phalanges and their archaeological relevance. *International Journal of Paleopathology*, vol. 1: 43–54.

Tsalkin V.I. 1960

Izmenchivost metapodiy i eye znacheniye dlya izucheniya krupnogo rogatogo skota v drevnosti. *Bulleten Moskovskogo obshchestva ispytateley prirody*. *Otd. biol.*, vol. LXV (1): 109–126.

Tsalkin V.I. 1970

Drevneishiye domashniye zhivotniye Vostochnoy Evropy. Moscow: Nauka.

Zimmermann M.I., Pollath N., Ozbasaran M., Peters J. 2018

Joint health in free-ranging and confined small bovids – implications for early stage caprine management. *Journal of Archaeological Science*, vol. 92: 13–27.

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