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SHORT REPORT

A Possible Case of 'Poll-Evil' in an Early Scythian Horse Skull from Arzhan 1, Tuva Republic, Central Asia

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ABSTRACT Occipital bone lesions on an Iron Age horse cranium from the burial mound of Arzhan 1, Tuva, Central Asia, are described and interpreted. Cavitations around the nuchal ligament attachment site on the skull are interpreted as foci of inflammation and necrosis following local infection. It is suggested that the pathology represents a case of 'poll-evil', most likely due to a bacterial infection. The significance of such an interpretation is discussed, including its implications for disease ecology and the possible infection risks to contiguous animal and human communities of the first millennium BC in Central Asia. Copyright © 2009 John Wiley & Sons, Ltd.

Key words: palaeopathology; horse; 'poll-evil'; Iron Age; Central Asia; disease ecology; pastoral nomadism

Introduction

The primacy of horses within Scythian life in Central Asia in the first millennium BC is evident from some of the rich archaeological finds of this period (Alexeev *et al.*, 2001). The elite associations of horses from high status barrow burials are highly visible in the archaeological record (e.g. Francfort *et al.*, 2000; Čugunov *et al.*, 2003), but the significance of horses would have permeated throughout the society. Horses would have formed an essential component of the nomadic lifestyle, as movement to seasonal pastures would have been essential for the success of subsistence strategies (Shnirelman *et al.*, 1996; Koryakova & Hanks, 2006). Information from skeletal remains on equine health and on how these animals were used by humans can supply valuable information about prehistoric society and its economy (e.g. Levine *et al.*, 2000; Bendrey, 2007a,b; Bendrey *et al.*, 2008).

This article describes and interprets lesions on the occipital bone of a horse skull from the site of Arzhan 1, in the Tuva Republic, Central Asia (Figure 1). Arzhan 1 is a complex funerary monument; a 'royal' barrow containing over 160 horse skeletons (Gryaznov, 1980; Bourova, 2004; Bokovenko, 2006). The barrow is considered to be the earliest 'Scythian', or 'pre-Scythian', monument in Eurasia, dating to the boundary of the 8th and 9th centuries BC (Zaitseva *et al.*, 2007). Only a small part of the original collection of horse skeletal material excavated from Arzhan 1 has been retained. This is now curated by the Institute for the History of Material Culture of the Russian Academy of Sciences, St Petersburg. Given that the bones of the retained skeletons have become mixed in this collection it is not possible to identify the bones of individual horses. It is thus not possible to interpret information relating to

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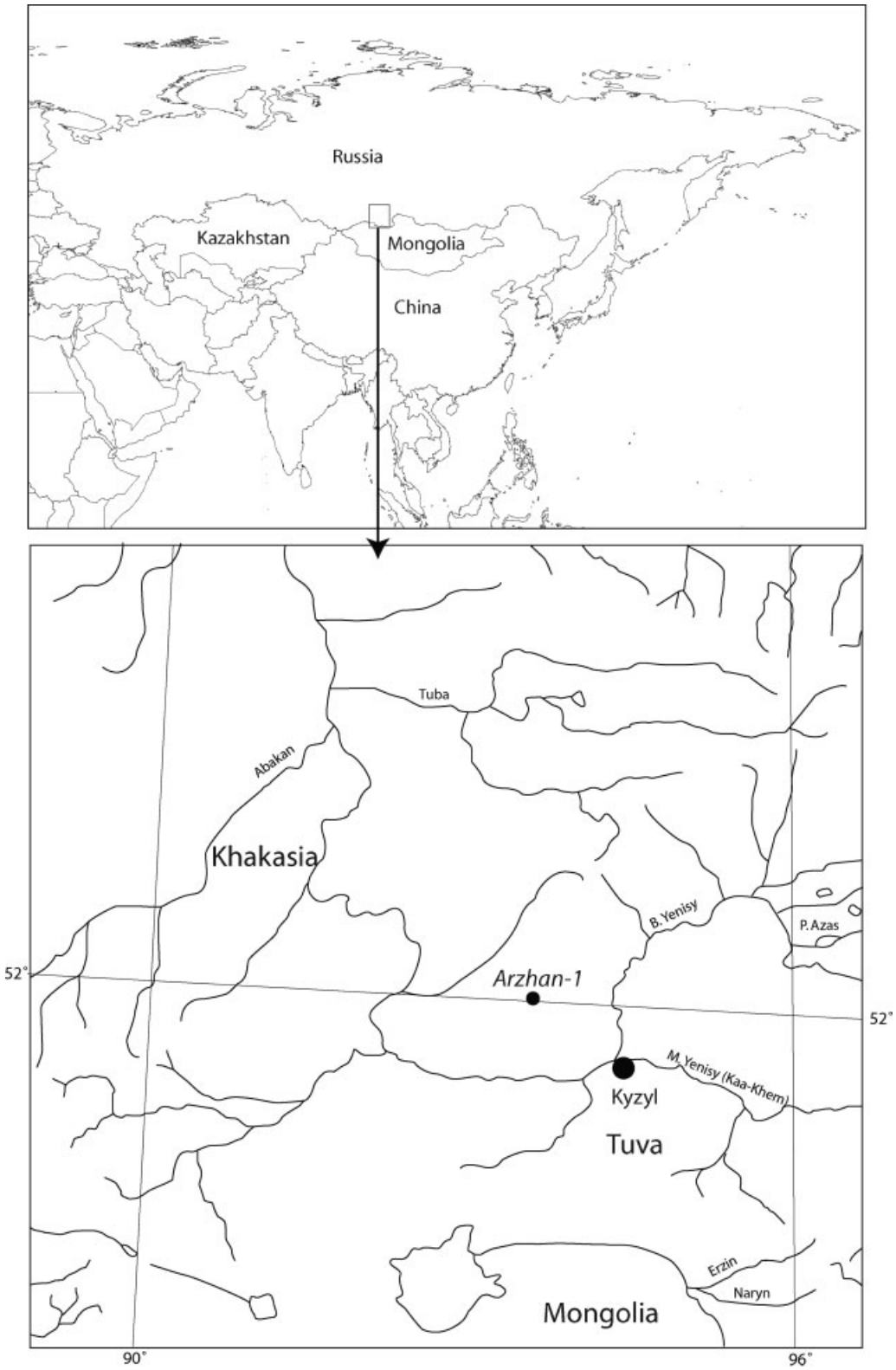

Figure 1. Map showing the location of Arzhan 1.

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health status gleaned from the skull examined here with that animal's post-cranial skeleton or mandible. The cranium described here is from chamber 2 of the barrow (Figure 2).

The horse skull

The horse skull is that of an adult male. The age of the horse is difficult to define precisely. The cranium retained no incisors for age estimation. Permanent cheek teeth were retained within the upper maxilla, but it was possible to make a rough estimate of the height of the crown of the right upper second premolar of *ca*. 30–35 mm. This would suggest an age of around 10–12 years at death (following Levine, 1982). According to Gryaznov (1980; cited in Bourova, 2004, 323) all the horses from the barrow were stallions older than 12–15 years. Crown height measurements from eight right lower third molars from chamber 2 (again taken following Levine, 1982) gave various age estimations

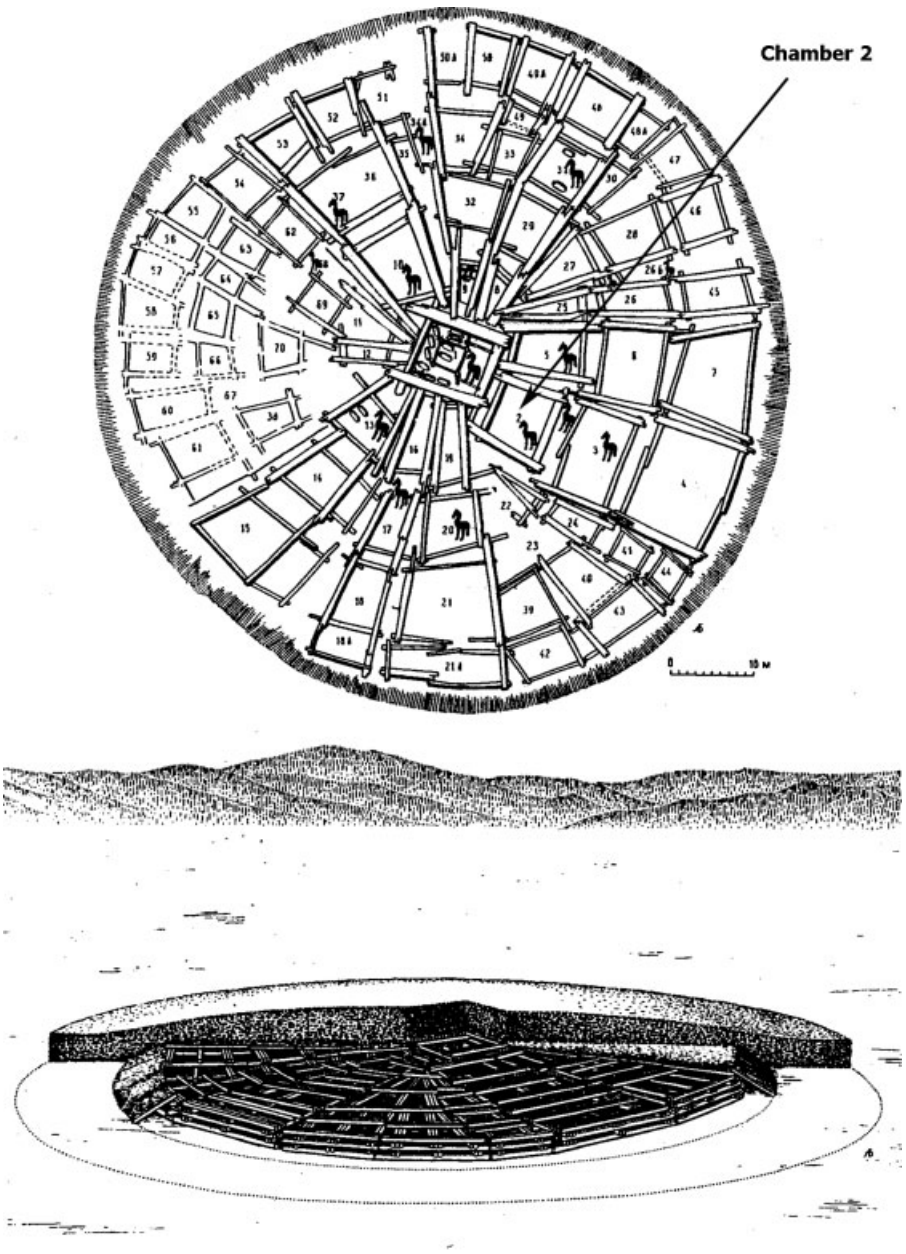

Figure 2. Reconstruction of the barrow of Arzhan 1 by Gryaznov. Locations of multiple horse burials are marked. Chamber 2 is marked.

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within the range of *ca*. 9–14 years. The rough age estimation of the horse skull is in broad agreement with this other age data, and it seems possible that the horse was probably towards the start of its second decade of life when it died.

Occipital bone lesions

There is a highly irregular, hypertrophic projection at the external occipital protuberance (EOP) (the site of the nuchal ligament attachment – see Bendrey, 2008a). This has broken-off post-excavation (this can be seen by the lighter shade of the bone in Figure 3A) and it is not possible to fully assess its size and shape. The cross-sectional dimensions of the bone at its break are *ca*. 13 mm in height and *ca*. 9 mm in width (Figure 3).

There is extensive bone loss, resulting in cavitations around the site of the EOP, which is encircled by depositions of new bone (Figure 3B). The width of the cavity (the distance from the EOP to the encircling new bone varies from *ca*. 7 to 10 mm, but also projects caudally several millimetres, ventral to the encircling hypertrophic bone. The cavity was of a depth up to *ca*. 8 mm below the bone surface. At the base of the feature, thin bony 'walls' (<1 mm in cross-section) subdivide the cavity to the left and right (Figure 4C). This feature has also broken, and it is not possible to define its full form.

Figure 3. Posterior view of occipital bone of the horse skull from Arzhan 1, chamber 2. 'A' indicates attachment site of the nuchal ligament; 'B' indicates area of necrosis.

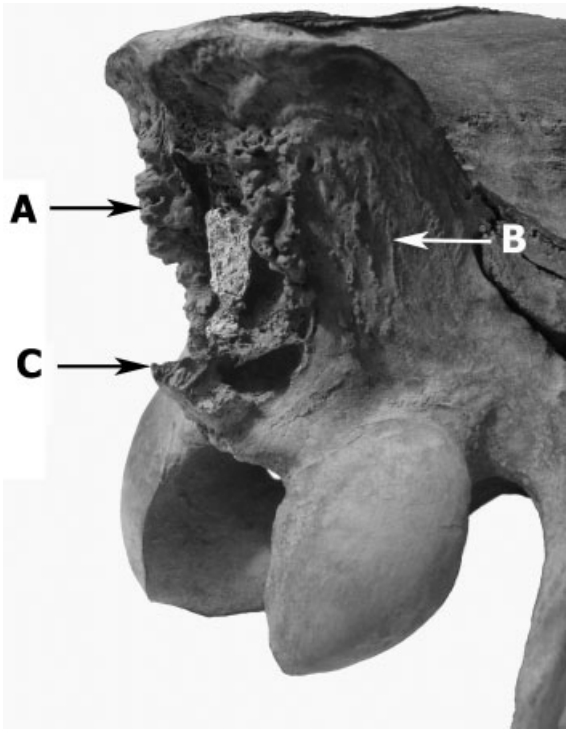

Figure 4. New bone formations (A–C) around the area of necrosis on the posterior wall of the horse skull from Arzhan 1, chamber 2 (see text for discussion).

As stated, irregular bony projections extend out from the occipital bone around the cavity, mainly lateral to the cavity. This is most pronounced to the left and right at the top half of the feature (Figure 4A). These two larger projections cover an area of *ca*. $23 \times 10\,mm^2$, and project out from the bone some 8–9 mm. Smaller bony projections of somewhat linear distribution are observed on either side of the larger exophytic formations (Figure 4B). These occur over an area of *ca*. $31 \times 11\,mm^2$ on each side, and project outwards by approximately 2 mm in height (maximum). These new bone formations either side of the cavity are relatively dense in character and are not typical of the reactive bone typically associated with infection and inflammation, but rather with the hypertrophy associated with enthesial developments. This interpretation is supported by the symmetrical expression of these lesions.

Further interpretations

The central hypertrophic projection (Figure 3A) represents an enthesopathy due to osteon remodelling

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at the ligament attachment site, the development of which is normally affected by age and muscle movements linked to the habitual activity of the horse (Bendrey, 2008a).

The cavitations around the attachment site (Figure 3B) are interpreted as foci of inflammation and necrosis following local bacterial infection. Inflammation, the body's response to such insult, triggered in such circumstances can result in the formation of enzyme- and free-radical-rich pus which can cause extensive local tissue injury and remodelling, including cavitation, periosteal proliferation and new bone formation (Ackermann, 2007, 153–157; Thompson, 2007).

Given the localisation of the described changes around the site of attachment of the nuchal ligament, there is a strong possibility that these features indicate that the horse had been suffering from 'poll-evil'. This lesion results from bacterial infection and consequent inflammation of the supra-atlantal bursa, a small, fluid-filled sac lined with synovial membrane that lies immediately caudal to the occipital bone of the skull providing a cushion between the nuchal ligament and the dorsal aspect of the first cervical vertebrae, the atlas (e.g. see Figure 5) (Sisson, 1975). Such supra-atlantal bursitis is described in horses and mules following direct trauma to the area and the local introduction of infection or following the localisation of haematogenous infection to a previously traumatised bursa. The inflammation typically results in bursal distension and rupture may follow with fistulation to the skin surface and in some cases the induction of a destructive osteitis of the adjacent bones (Baker & Brothwell, 1980, 64 and 127–128; Thompson, 2007).

The new bone formations either side of the cavity (Figure 4A and B) may represent enthesopathies developed as a response to infection compromising the functioning of the nuchal ligament. A number of the cervical muscles relate to the nuchal ligament and several have insertions on the occipital bone (Sisson, 1975; Budras *et al.*, 2003, 52–3 and 89–90).

Figure 5. The horse skull from Arzhan 1, chamber 2, with schematic outlines added to show the approximate positions of the atlas vertebra, the supra-atlantal bursa and the nuchal ligament.

Discussion

The position and character of the described changes on the occipital bone of an equine cranium is likely the consequence of the extension of destructive inflammation from an adjacent infected supra-atlantal bursa, a condition of equidae known as 'poll-evil'. Making such a presumptive diagnosis is of some significance given that in palaeopathological research 'poll-evil' has previously only been suggested from lesions on the atlas (Baker & Brothwell, 1980, 72). The publication of a detailed description is therefore of importance in furthering palaeopathological studies of horse remains and in facilitating the identification or interpretation of similar lesions in remains from other sites.

'Poll-evil' and its implications

Supra-atlantal bursitis is described in horses and mules following direct trauma to the area and the local introduction of infection or following the localisation of haematogenous infection to a previously traumatised bursa. The inflammation typically results in bursal distension and rupture may follow with fistulation to the skin surface and in some cases, the induction of a destructive osteitis of the adjacent bones (Baker & Brothwell, 1980, 64 and 127–128; Thompson, 2007). Bacteria associated with 'poll-evil' include *Brucella abortus* and *Actinomyces bovis*, particularly where horses are exposed to cattle, and *Streptococcus zooepidemicus*.

B. abortus infection has commonly been associated with 'poll-evil' in horses (Denny, 1973) and its putative presence in the Arzhan 1 animal would have important implications for disease ecology, and for infection risks to contiguous animals and human communities (Bendrey, 2008b; Bendrey *et al.*, 2008). Taylor has identified *Brucella* DNA from a human skeleton from Iron Age Tuva, along with several cases of *Mycobacterium bovis* DNA in human skeletons (Taylor *et al.*, 2007; Bendrey *et al.*, 2008, 1588). Taylor *et al.* (2007) suggest that as bovine tuberculosis is not thought to be self-maintaining in man the *M. bovis* infections reflect continued exposure of the population to an infected animal reservoir host/s. *B. abortus* infections in horses are normally associated with contact with cattle (Denny, 1973; Weese, 2002; Thompson, 2007). Brucellosis in humans can be acquired from drinking infected milk and eating poorly cooked, contaminated meat (Ortner, 2001, 229), and Herodotus refers to the Scythian practice of consuming horses' milk (Barguet & Roussel, 1964, 288). Transmission of infectious diseases to the pastoral nomadic groups of

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the first millennium BC in Central Asia may thus have occurred through both their close contact with their herds and also consumption of infected food products. Brucellosis also has economic implications, being responsible for abortion, infertility and drops in milk production (Schlafer & Miller, 2007).

In addition to bacteria, migratory activity of the nematode parasite *Onchocerca cervicalis* within the nuchal ligament and its environs has been implicated in provoking inflammation of the supra-atlantal bursa (Thompson, 2007). This parasite is spread by biting midges of the genus *Culicoides* but its significance as a cause of 'poll-evil' has been questioned given that where the prevalence of *O. cervicalis* is high, the prevalence of bursitis is not (Thompson, 2007). Furthermore, although insects capable of transmitting this nematode are found in climates such as those prevailing in Siberia (Mirzaeva, 1964) and Northern Canada (Downes, 1965; Polley, 1984) their lower population density in such locations must reduce the likelihood of *O. cervicalis* being the significant aetiological agent in this case (Polley, 1984). Furthermore given the severity of the induced osseous change in this case, infection with bacteria such as *B. abortus*, *A. bovis* or *S. zooepidemicus* appears more likely than an infestation with *O. cervicalis*.

Selection of the horse for burial

The pathology may have affected the condition and behaviour of the horse. In cases of 'poll-evil', because of the discomfort, horses become difficult to halter or bridle and tend to hold their heads in an extended position which can lead to difficulties prehending food (Amman & Wintzer, 1986). Did the infection contribute to the selection of this particular horse for inclusion in the burial?

The advanced age of the animals and high frequency of osseous pathologies (often on vertebrae) in the horses from some kurgans has been argued as reasons for their slaughter (Bökönyi, 1968). Animals would be targeted for sacrifice because they were lame and too weak to ride. However, Levine (1999, 53) remarks that it has not been demonstrated that the abnormalities rendered the animals unsound. In contrast to the interpretation of Bökönyi, we argue that the horses are (sometimes) old, and thus sometimes sick, because they were used for a long time by their owners (who are not necessarily the deceased), and that this long companionship may have developed a strong emotional relationship between rider and horse. These animals can thus have had a high symbolic value, an importance which may be reflected in the context of their role in the funerary ritual of these high status barrows.

The enthesopathy as evidence for 'use'

A comparative study of the enthesopathy at the EOP in modern equids indicated that its expression is to a large degree age related, but is also more pronounced in highly trained racehorses (Bendrey, 2008a). Can the degree of development of the hypertrophy at the EOP of the Arzhan 1 specimen be argued as evidence for persistent fast or excessive riding? The hypertrophy at the site of the EOP is broken and it is not possible to fully assess the size of the enthesopathy; also the enthesopathy is accentuated by the cavity around the attachment site. Considering the likely scenario that the ligament was also infected, and the long-standing nature of the problem, it is uncertain to what extent the use of the horse or the infection affected bone proliferation at the EOP.

Evidence for the use of the Arzhan 1 horses from their skeletal remains does exist in the form of bitting damage on the mandibular diastema and the lower second premolars (see Bendrey, 2007a; although this was not systematically recorded). This is not surprising since bits have been recovered from the site (Bokovenko, 2000; Čugunov *et al.*, 2003, 117). More detailed understanding of the use of the horses will have to await further detailed analyses.

Conclusions

It is suggested that the lesion on the occipital bone adjacent to the point of insertion of the nuchal ligament of the Arzhan 1 horse cranium is likely the result of the disorder known as 'poll-evil'. This interpretation may be significant given that this disease has previously only been suggested from lesions on horse atlas vertebrae recovered from archaeological sites. As discussed, 'poll-evil' is associated with a variety of organisms, including *B. abortus*, *A. bovis* or *S. zooepidemicus* and to a lesser extent, the nematode *O. cervicalis* (Thompson, 2007).

Evidence of the presence of infectious diseases, such as brucellosis, in both humans and animals can build-up a picture of the disease epidemiology within and between animal and human communities (Taylor *et al.*, 2007; Bendrey *et al.*, 2008). Close association between animals and humans in the Central Asian pastoral societies of the first millennium BC would have facilitated disease transmission, as would the con-

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sumption of infected food products. It will only be through the palaeopathological study of human and animal skeletal remains, and improvements in the methodologies for identifying any lesions present, that a better understanding of these processes will be achieved.

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