Rebuttal of Taylor and Barrón-Ortiz 2021 *Rethinking the evidence for early horse domestication at Botai*

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Taylor and Barrón-Ortiz[1] present a reconsideration of the evidence for early horse husbandry in the Eneolithic Botai Culture of Northern Kazakhstan[2-4]. However, their critique misrepresents key methodologies applied in the original analyses[2], demonstrates fundamental scientific misunderstanding of the stable isotopic evidence, omits key details about recent proteomic evidence[5] and underplays or ignores a raft of other evidential lines[4]. Additionally, the only primary evidence presented[1], relating tooth wear patterns in North American wild horses, if correctly presented, adds more empirical weight to the conclusion that Botai-type wear patterns[2] are only seen in bitted animals.

Regarding bit wear, the primary morphological characteristic used to identify bridling is the parallel-sided wear on the anterior edge of the mandibular P2 tooth[6], but specifically in the absence of other enamel exposure around the tooth. Taylor and Barrón-Ortiz[1] present a specimen of a wild horse that they claim has features 'nearly identical to those attributed to bit wear at Botai, along with visible cementum banding'. However, it does not match the criteria laid down by Bendrey[6] and applied to the Botai tooth[2]. Their specimen has uneven dietary wear all around the tooth that extends well down the crown (see Fig 1a, left and right). This type of wear is not uncommon in older horses such as this, and is thus explicitly excluded as bit wear in Bendrey's methods[6]. The Botai tooth (Fig 1a centre, 1b) is from a younger animal with a clear vertical band of wear that terminates at the jaw line, in the absence of any buccal or lingual dietary wear. Bendrey's original methodological development included examining a range of bitted and unbitted horses to establish that the Botai-type wear was not seen in unbitted specimens. What Taylor and Barrón-Ortiz[1] have, in fact, achieved is the detailed analysis of a further 72 lower P2s from wild horses that do not display bit wear as defined by our methods, thus extending the empirical basis for our original conclusions.

Taylor and Barrón-Ortiz additionally attempt to argue that the wear on the Botai tooth represents 'two adjoining, oval-shaped areas of exposure. These exposed areas of enamel correspond with two well-defined bands of reduced cementum deposition'[1]. This is simply incorrect. Figure 1B shows the continuous nature of the wear, and that deeper areas of wear on the Botai tooth are actually poorly correlated with banding, particularly in the case of the upper two pits that are not aligned with any such bands. Taylor and Barrón-Ortiz[1] invoke these cementum bands in an attempt to find an alternative explanation for the wear on the Botai specimen, whereas Figure 1B rules out any correlation. The argument that bands of reduced cementum have thus allowed hypoplastic lesions to become visible rests on a desire to present a comparison to their wild specimen that, in fact, only bears some superficial resemblances, which as shown above, are not relevant to bit wear identification[2, 6]. Cementum banding is very common in horses and it is not a determinant factor of different wear patterns; as such, teeth display the full range of diagnostic patterning. All three teeth presented in Figure 1 display two cementum bands. Taylor and Barrón-Ortiz's specimen displays old age dietary wear, the Botai tooth displays bit wear on the anterior only and the feral Exmoor specimen shows no abnormal wear at all. Such banding presents an uneven surface that might impact depth of wear but not the defining criteria we applied[2,6].

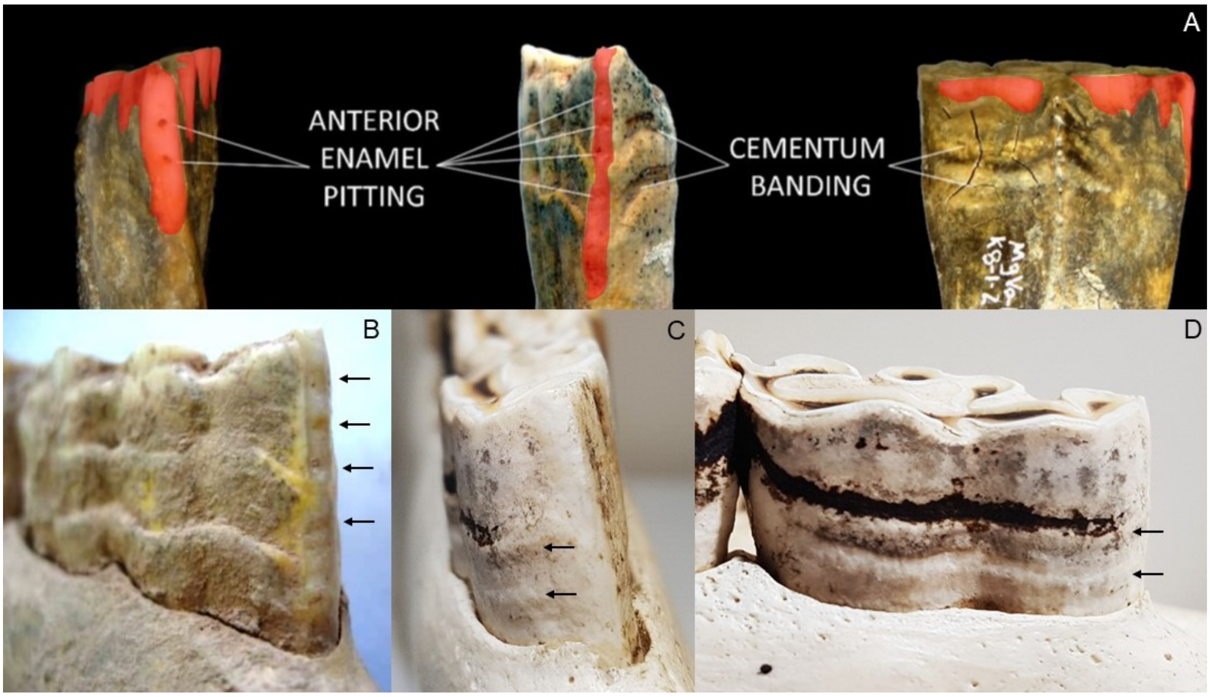

Fig 1. (A) Taylor and Barrón-Ortiz's[1] original image with enamel exposure on the crown highlighted in red. The Pleistocene wild horse is on the left and right, and the Botai horse in centre. (B) The Botai specimen in its mandible showing the clear parallel band of wear on the anterior. The arrows point to deeper areas of wear. (C & D) A feral, unbitted Exmoor pony displaying no anterior, buccal or lingual wear. The arrows point to the cementum bands.

Taylor and Barrón-Ortiz[1] totally dismiss the key evidence for mare's milk in pottery based upon fundamental errors of understanding related to the formation of the stable isotopic record. They argue that the summer deuterium signals found likely indicate repeated summer season hunting rather than milking mares. However, horses killed in summer do not produce a 'summer' signal in their meat/adipose fats. Due to turnover rates, they produce an integrated signal for the year, whilst milk produces a pure summer signal because it is synthesized instantly in the season it is let down. This was empirically validated by sampling both summer meat and milk from traditionally kept horses (Fig 2a). Eliminating the possibility of confusing milk with summer meat was in fact the entire foundation of the method originally published[2]. Outram et al.[2] found pots displaying both the signals for meat and milk at Botai in two groupings (Fig. 2b). This pattern could not be produced in any event by pure summer hunting for meat, even in the case of foals being consumed, as lengthy gestation would integrate the seasonal signals and pottery would have to be reserved only for the consumption of foal meat. However, the archaeological and ethnographic record provide ubiquitous evidence for vessels dedicated to dairy processes. Fig. 2c shows the deuterium values for bison fats in ceramics at the Plains Village site of Mitchell, South Dakota[7]. This completely sedentary site had comparable extreme continental weather and exploited bison year-round, including neonates, yet the δD values closely cluster as an integrated signal of adipose fat without outliers.

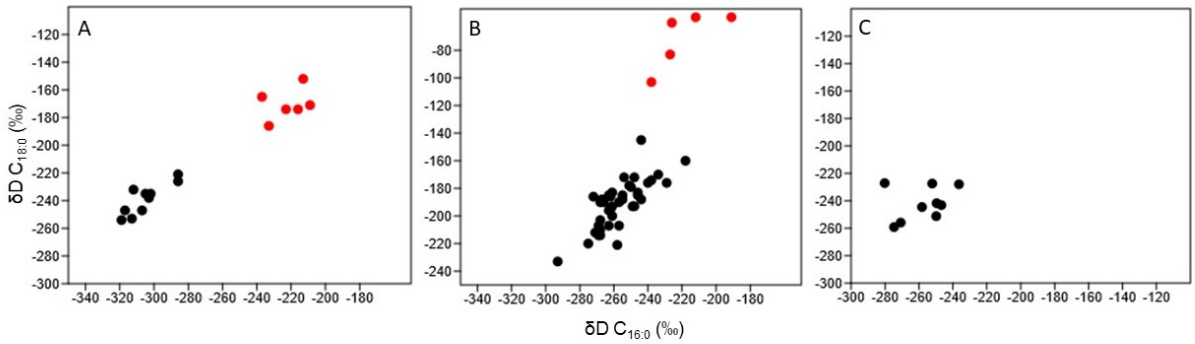

Fig 2. Compound-specific δD values in $C_{16:0}$ and $C_{18:0}$ fatty acids from (A) reference fats of summer meat (black) and summer milk (red) taken from traditionally kept modern horses in Kazakhstan[1], (B) Botai pottery showing an equivalent seasonal shift, with red points identified as milk[2] (only equine fats, as identified by regionally established $\delta^{13}C$, values are included to ensure the pattern relates to horses specifically), (C) Original data from hunted bison at Mitchell, SD, USA. Note that absolute δD values vary over time due to climate change or geographical location, thus relative position of clusters is the relevant criterion.

Taylor and Barrón-Ortiz[1] also refer to an unpublished human dental calculus proteomic paper[5] as evidence that the Botai people did not drink milk, but that there was later horse milking in the 3rd millennium BCE in the Pontic Steppe. They neglect very important details about these results. The 3rd millennium result is based upon only 2 positives out of 17 samples (frequency = 11.7%), meaning that 15 were negative. The Botai negative result is based upon the only 2 samples available, provided by Outram, and with such a frequency, the binomial probability of observing 2 negative drawings is equal to 0.7785. Therefore, Taylor and Barrón-Ortiz's conclusion is not statistically supported. They also fail to note that the positive samples are from the very early 3rd Millennium BCE Yamnaya Culture, which chronologically overlaps with the late Botai Culture, thus demonstrating the potential for early horse husbandry far earlier than the Sintashta horizon they refer to, when the modern lineage of domestic horses is known to become more widespread[8].

Taylor and Barrón-Ortiz[1] deliberately omit or poorly represent other multiple lines of evidence. They misrepresent the evidence for corral enclosures by reducing it to 'posthole structures raised the possibility of corrals' [1] when, in fact, enclosures have been evidenced by extensive geophysics at two Botai Culture sites[3,9], phosphate enhancements and have been ground-truthed by excavation revealing continuous trench features and post-holes that have been radiocarbon dated to Botai date[3]. A myriad of other evidence is simply ignored, such as poleaxing marks on crania, lack of schlepp effect in element transport, lack of a substantial hunting toolkit, coat colour changes, etc.[4] They also fail to evidence or explain their own hunting hypothesis. How and why did the ceramic using Botai people become able to settle in large villages, with enclosures, and exploit purely wild horses at a time when population genetics[3] suggest wild horse populations were crashing? Even at the height of Palaeolithic horse hunting, when horse populations were much higher and human populations lower, such total specialism in conjunction with settlement never occurred.

Taylor and Barrón-Ortiz[1] fail to grasp the possibility that there could be earlier incipient phases of local, subsistence-based horse husbandry[4] in both the European and Central Asian steppe prior to the widespread use of the DOM2 lineage[8] across Eurasia for equestrian purposes. They do not appreciate that many lineages of domestic animals do not survive into the modern day due to extinction, loss by mass introgression, intensive inbreeding or feralization. The Przewalksi's horse is an important lineage that deserves conservation whatever its deep past was. Its traditional status as a pure wild horse has only ever been an unevidenced assumption from very recent times. We suggest that it went through a period of husbandry in the early processes of horse domestication, and, due to their misrepresentation and misunderstanding, Taylor and Barrón-Ortiz's paper does not serve to weaken the evidence we have presented for that husbandry.

The authors declare no competing interests.

AKO wrote this paper with contributions from RB, RPE, LO and VFZ.

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