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Change of tack? The English eleventh-century horse-tack explosion in context

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ABSTRACT

The eleventh century marked a significant transformation in English horse equipment, characterized by an unprecedented proliferation of copper-alloy horse tack. Analysing 3086 finds from the Portable Antiquities Scheme (PAS), this research reveals a nearly 30-fold increase in copper-alloy horse equipment from the tenth to eleventh centuries, with 62% of finds being stirrup components. This study examines this 'explosion' through technological, economic and social lenses. Copper-alloy horse tack emerged amid complex developments in urban metalworking, equestrian culture and status signification. While often associated with Viking and Norman conquests, the material shift reflects broader cultural negotiations rather than simple technological transfer. Notably, the research unveils a robust north–south divide in horse tack distribution, with the North East showing significantly fewer copper-alloy finds. This regional variation challenges assumptions of cultural uniformity and suggests localized material culture dynamics. The results highlights how decontextualized archaeological artefacts can provide profound insights into socio-political and economic changes, offering a sophisticated understanding of human–horse relationships in Medieval England.

Introduction

The eleventh century marked a profound period of transformation in Medieval England, characterized by complex military, socio-political and economic shifts that extended far beyond the often-simplistic narrative of the Norman Conquest (Hadley and Dyer 2017). These transformations were not limited to human populations but encompassed their domesticated companions, with horses playing a particularly significant role. While the nearly 200 horses embroidered on the Bayeux Tapestry might symbolize the Conquest, the most intriguing equestrian development of the eleventh century predates 1066: an unprecedented proliferation – an 'explosion' – of copper-alloy horse tack that challenges our understanding of human–horse relationships in Pre-Conquest England.

First identified by Prof Graham-Campbell (1992), this material shift towards copper alloys offers a window into the nuanced transformations of human–horse relationships

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during a period of intense social reconfiguration, one that has implications for the transition between the 'Early' and 'Later' Medieval periods. The surge intersects with broader developments in medieval warfare, social stratification and economic production, making it a critical lens through which to examine eleventh-century English society.

Faced with this archaeological puzzle, this research article examines five key questions:

(1) What was the nature and extent of this copper-alloy horse equipment proliferation? Just how 'explosive' was it?
(2) What types of horse tack are represented in the eleventh-century copper-alloy 'explosion'?
(3) How does the 'explosion' fit into longer-term trends of Early Medieval horse exploitation?
(4) To what extent does this shift in material preference reflect changing attitudes towards status display versus practical technological advancement?
(5) Were there regional variations in the pattern? And, if so, might they relate to the broader political and social changes of eleventh-century England?

To address these questions, this study employs a comprehensive analysis of Portable Antiquities Scheme (PAS) data, integrated with excavated finds, historical sources and broader archaeological context. First, quantitative evidence for this material shift is established by analysing temporal patterns in over 3000 PAS finds. Second a detailed typology of horse equipment categories are developed to understand which forms were most prevalent. Third, this surge is contextualized within longer-term trends by examining horse equipment patterns across the entire Early Medieval period. Fourth, the relationship between practical and status-oriented functions are evaluated through analysis of decorative elements, material choices, and contemporary literary/legal sources. Finally, spatial analysis of PAS data is undertaken to identify significant regional variations, particularly a striking north–south divide, and to explore how these patterns relate to broader social and economic developments in eleventh-century England. Evidence from faunal remains will be considered in a later paper.

Background

The eleventh-century horse tack 'explosion' needs to be situated in its archaeological research context. Metal-detected finds have already contributed much to our understanding of Medieval horse equipment (Geake 2001; Lewis, Andrew, and David 2011; Libby 2022; Webley 2020), and this research builds on previous studies from PAS data by offering a more expansive survey covering the entire Early Middle Ages in England and Wales. Much previous research has been rightly framed in typological and chronological analysis, so this paper advances these approaches by critically integrating PAS data into broader research themes such as cultural exchange across the North Sea (e.g. Pedersen 1999; Seaby and Woodfield 1980), medieval warhorses (Davis 1989; Dibon-Smith 2017; Hyland 1994; Pluskowski, Seetah, and Malty 2009), and the consequences of urban workshops on economic production (Ottaway 2020; Ten Harkel 2018).

In particular, the material innovations in English horse equipment must be understood against the backdrop of broader European equestrian culture, in which horse ownership was a critical signifier, if not a necessary component, of superior status (Goetz 2008). The innovation of the stirrup, which provided greater stability and control (Dibon-Smith 2017; Littauer 1981; Roland 2003; Seaby and Woodfield 1980), and possibly new selective breeding practices (Davis 1989), ostensibly enabled medieval cavalry and therefore reinforced the association between horsemanship and military elite identity. Probably starting in the Carolingian world (Costambeys, Innes, and MacLean 2011), horse ownership in the eighth and ninth centuries was tied to the emergence of a mounted warrior class known as '*milites*' (Reuter 1991). Later, from the ninth to twelfth centuries, this elite-equestrian association apparently unfolded into the institution of medieval knighthood (Gassmann 2022), in which military service was tied to land obligations (Harvey 2019) and cavalry became central to warfare (Hyland 1994).

Early Medieval elite equestrian culture has received corresponding archaeological attention. Perhaps not coincidentally, it was in the Carolingian period when material horse tack, including spurs and bridles, became focal points for artistic expression along with other martial metalwork like swords (Le Jan 2000, 282; Thomas 2012, 489). In Francia, the conferring of weapons (including spurs) to young men created a paternal vassalage, either literally or through 'adoption by arms' (Le Jan 2000, 291–293), emphasizing the physical importance of spurs in constituting status. Carolingian spurs are often recovered from hoards (e.g. Zuyderwyk and Besteman 2010) or furnished burials at the fringes of the empire (or beyond), with gold and silver examples suggesting their potency as status symbols (Thomas 2012, 489–490).

Methodological framework

While providing an unprecedented corpus of material evidence, a PAS dataset requires careful methodological nuancing. Previous studies have highlighted the potential biases in metal-detected finds (Daubney 2015; Robins 2012; Webley 2020), including issues of preservation, regional variation in detection practices, and the inherent limitations of unstratified surface finds. This research addresses these challenges through statistical analysis and cross-referencing with other archaeological and historical sources, as detailed below.

Theoretical approaches

The eleventh-century transformation of horse tack cannot be understood in isolation, and this paper therefore bridges different scholarly approaches, most critically the excellent typological work done by D. Williams (1995, 1997a, 1997b, 2007) as well as by Dr Ellis (2002) and Dr Geake (2016), whose findings are the basis of this investigation. The research also connects to recent theoretical developments in material sciences (Libby 2022; Webley 2020) and material culture studies (Karkov 2022). It examines how material innovations reflect social changes and the critical role that objects like horse tack can play in social relationships, such as signifying and constituting status (Coss 2002; McDonnell 2023).

Production context

All of this eleventh-century copper-alloy tack had to be produced somewhere, and thus metalwork is critical for understanding this 'explosion'. Generally, the two most frequently worked metals in Early Medieval England were iron and copper alloys, each comprising different economies of production. Between the two, iron was more readily available, with increased iron production evident after c. 700 (Ottaway 2020, 190). By contrast, there are no known Early Medieval copper mines in England, and it is regularly argued that copper-alloy production relied heavily on recycling, which is consistent with metallurgical analyses (Blakelock, Matinon-Torres, and Scull 2022; Libby 2022). That importation was necessary to maintain copper-alloy working is further suggested by the discovery of brass ingots, probably dating to the tenth century, from Kingsway in London (Bayley et al. 2014).

As far as the archaeological record can attest, iron was used for a broader range of everyday items, especially as urban production matured (Ottaway 2020). Copperworking was a more specialist craft, requiring sophisticated knowledge of metallurgy (Libby 2022, 48–50). However, copper alloys were by no means rare or exclusive to the elite, and conversely iron was used to manufacture privileged products like swords. Copper-alloy workshops produced a wide range of items (pins, strap ends, rings, etc.), and copper-working in Viking-Age Lincoln suggests standardized techniques and workshop-based production, producing both elite and mass-market items (Ten Harkel 2018).

Iron workshops were probably more widespread, being found in 'village smithies' (e.g. Goodall and Clark 2005; Payne 2020; Woolhouse 2023) and, increasingly from the tenth century, in urban centres like Winchester or York (Hinton 2006; Ottaway 2020). Copper-alloy workshops were probably scarcer, primarily located only in urban centres like Lincoln or London (Ten Harkel 2018; Weetch 2017) or at elite rural sites (Blakelock et al. 2022; Fairbrother 1990; Libby 2022). It was in towns that crafts could intersect, as neatly evidenced by a tenth-century workshop at Coppergate that combined iron and non-ferrous metalworking at a complex of hearth arrangements (Ottaway 2020, 188). This emerging urban manufacturing capability was crucial to the technological context of eleventh-century horse tack proliferation.

Materials and methods

Dataset

My dataset includes 3086 portable metal 'horse tack' finds from England and Wales dating to c. 410–1100 recorded in the PAS. Horse tack encompasses equipment and accessories used to control horses or to supplement their symbolic/social significance such as bridles, stirrups, saddles, harnesses, and associated metal fittings such as pendants. Data have been selected to acquire the largest reasonably confident scope of horse-related PAS finds, including those of any material type. A complementary corpus of excavated iron horse tack supports the analysis (Fairbrother 1990; Lagane 2010; Ottaway 1989; Webley 2020).

Data is taken from across the Early Medieval period to provide a long-term perspective on the eleventh-century proliferation, but data limitations must be

acknowledged forthright. Unstratified metal finds are difficult to date. Many are typologically dated to broad periods: 'Early' (c. 410–600), 'Middle' (c. 600–900), or 'Late' (c. 900–1066) Anglo-Saxon. Decorated items allow for more precise stylistic-based dating, such as eleventh-century stirrup strap mounts featuring Scandinavian Ringerike and Urnes styles (Graham-Campbell 1992; D. Williams 1997a, 8). Helpfully, the metallic compositions of such examples align with other eleventh-century English horse tack, at least in Lincolnshire (Libby 2022, 202–203).

Furthermore, broad dating periods and corrosion of ferrous materials prevent a representative sample of all Early Medieval horse tack (Historic England 2016; Huisman and Ineke 2009; Robins 2012), instead revealing only those periods and types that were most popularly manufactured with copper alloys. While all material types were considered, preservation conditions necessarily leave archaeologists with a corpus very much dominated by copper alloys. Nonetheless, the temporal and regional patterns presented here are robust enough for discussion and exploration. In some ways, it is precisely this bias that has allowed this proliferation of copper-alloy tack to become so apparent. Interesting regional and typological patterns from the same dataset and methods but examining the Middle Anglo-Saxon period will be explored in a later paper.

Temporal and regional analysis

For temporal analysis, artefacts are categorized by century and type, with quantities compared as simple histograms. Spatial analysis employs a GIS (ArcGIS) to plot PAS findspots and tally per county. Spatial randomness is tested using the 'average nearest neighbour' (ANN) tool – calculating a ratio of observed to expected mean distances to the nearest neighbour – and validated through 100 Monte Carlo iterations.

Spatial analysis limitations include unequal material preservation (Blackburn 2003; Daubney 2015; Pestell 2003), and PAS findspots are first and foremost an indicator of where the public have searched, and only secondly an indicator of any historical pattern. Factors like urban environment, soil chemistry, and metal detecting popularity are considered. To control for preservation and detection biases, horse tack finds are calculated as a proportion of total PAS finds per county:

$$\text{Percentage of horse tack in a county} = \frac{\text{number of PAS horse tack finds (Date A} - \text{Date B)}}{\text{number of total PAS finds (Date A} - \text{Date B)}}.$$

Types of horse tack and their possible uses

Data are categorized into three groups: *certain*, *probable* and *possible* (Table 1). Probable horse tack includes highly fragmented artefacts or artefacts with potential non-equestrian use.

'Possible' examples are fragmented pieces that somewhat resemble tack, had various potential uses or are extremely corroded (e.g. Figures 1e,f). Of 3086 artefacts, 2384 are categorized as 'certain' and thus sufficient for analysis (Table 1).

Table 1. Classification of certain, probable and possible horse tack.

Type	Examples	Quantity (n = 3086)
Certain	Complete bit links, cheekpieces, spurs, spur pricks, strap links, stirrup mounts	2384
Probable	Undiagnosed artefacts with knobbed lozengiform loops, ambiguous straps, spur pricks, incomplete stirrup mounts	313
Possible	Non-loop junctions, incomplete strap links, decorations	389

Items that would have been made of perishable materials like saddles and headstalls are not much represented in the PAS (or broader archaeological record), though a possible tenth-century wooden saddle bow is known from Coppergate (Owen-Crocker 1991, 233). This study identifies five main groups of horse tack from the PAS record, largely derived from PAS nomenclature: looped terminals, cheekpieces, spurs, stirrups and bridle/harness mounts. The types of horse tack are summarized in Table 2.

'Looped terminals'

Looped terminals – or, more accurately, objects bearing looped terminals – were classified by D. Williams (2007) and are among the most frequently identified examples of bridle/harness equipment. Typically lozengiform with three knobbed protrusions at each cardinal point (Figure 2b), most are undecorated, but some bear Ringerike or Urnes styles (which date to the eleventh century). Because Ringerike and Urnes looped terminals have the same form, and their metallic composition aligns with other eleventh-century material (Libby 2022), lozengiform terminals are securely dated to the eleventh century.

Oval terminals are less prevalent and square terminals are rarer still; both may be of an earlier date. For this study, strap links were further classified by the number of terminals, symmetry, length, terminal diameter and decoration into categories: 'harness links' (two- or four-way), bit links and cheekpieces. Most PAS examples are copper-alloy, with some iron examples supported by excavated iron finds.

Harness link

Harness links, or 'strap distributors', comprised at least two terminals connected by a straight, often D-shaped, bar (Figure 2) (Geake 2016; D. Williams 2007, 4). These artefacts are typically symmetrical from the central boss and likely served to connect straps, possibly on browbands, nosebands, breaststraps or elsewhere (or versatilely between several of these), which means that 'harness links' could be equipped to either harnesses or headgear.

Most harness links are recovered broken, likely entering the archaeological record where they broke in use. Two-way links are most common, with 531 examples (369 certain) in the PAS. Complete lengths range from 50 to 100 mm, averaging 70 mm, with decorated terminals usually belonging to the large end of the spectrum.

Four subtypes are identified: bit links, two-way links, four-way links and riveted links. The PAS database has 117 probable (86 certain) bit links. 'Bit links' are asymmetrical, with one end characteristically knobbed and the other larger and

Figure 1. Examples of a selection of horse tack categories: (a, b) two-way bit links, (c) decorative harness pendant, (d) non-loop junction, (e) harness link with integrated plate, (f) possible strap link terminal, (g) loop fragment. (a) NMGW-A7BF76, (b) DEV-60C3E5. (c) WILT-E84E30, (d) SUSS-800EA1, (e) NMS-840EB5, (f) GLO-0840EC, (g) HESH-DD7A35. Images to scale.

Table 2. Summary of horse tack classifications and uses in this article.

Horse tack	Finds group style guide	Use
Loop terminals	Anglo-Scandinavian Horse Harness Fitting: harness link (D. Williams 2007)	Connect straps to other straps or to bridle bits; for a wide range of possible equipment (bridles, saddles, etc.)
Bit links	Anglo-Scandinavian Horse Harness Fitting: bit links (D. Williams 2007)	Connect bit to cheekpiece
Cheekpieces	Anglo-Scandinavian Horse Harness Fitting: cheekpieces (D. Williams 2007)	Connect bit to bridle
Spurs	Prick spurs (700–1700) (Ellis 2002)	Urge a horse forward, turn quickly, or signify status
Stirrup straps and stirrup terminals	Stirrup mounts (D. Williams 1995) or Stirrup strap mounts (D. Williams 1997a); Stirrup terminals (D. Williams 1997b)	Support the rider's foot, secure a warrior to mount, or assist the rider in mounting/dismounting
Harness mounts	Harness pendants and related fittings (Baker 2017; Geake 2016)	Ornamentation, probably to signify status

Figure 2. (a) SOM-81FFD2. (b) GLO-20C016. Note also the reddish colour typical of Viking Age copper alloys. Images to scale.

often ovular (D. Williams 2007, 4) (Figures 1a, b). The bit link would hang at the larger loop from the mouthpiece, with the lozengiform loop connecting to the reins (Dickinson, Fern, and Hall 2006; Geake 2016). D. Williams (2007) argues for this functional attribution because the oval loops were fragmented, which is conceivably the result of wearing through as it hung and abraded against the bit while the rider tugged at the reins. Such bit links are mostly associated with the Viking Age, but see Prof Campbell (2015, 78) for a possible eighth/ninth-century example. Mouthpieces themselves are rare in the PAS record, though several good examples survive from excavations at York (Ottaway 1989, 465), Winchester (Waterman 1959, 74) and Hesket, Cumbria (Cowen 1934, 175), all of which are single-jointed snaffle bits. So far all of the excavated mouthpieces are iron and their scarcity in the PAS record could be due to material preservation biases. The consequence of this is that many

Figure 3. (a) Four-way strap link, (b) harness link with integrated riveted plate. (a) BERK-DC0252, (b) NMS-891D61. Images to 1 cm scale.

eleventh-century bits would have been a mix of ferrous mouthpieces with non-ferrous bit links and cheekpieces.

Two-way and four-way links are the most common types. Unlike bit links, two-way links are reflectively symmetrical from the central boss to the loop (Figure 3), while four-way links are often rotationally symmetrical with one loop radiating from a central boss in each cardinal direction (Figure 3a). The latter might have correlated in size and function (but not construction) with Merovingian four-way junctions (Oxele 1992, Teffel 50,105), and D. Williams (2007, 2) identified these as junctions between the browband of the bridle with the cheekpiece. Four-way loops are associated with eleventh-century styles, with 43 examples (three unverified) in the PAS as of 2022. Riveted harness links (Figure 3b) incorporate integral plates with rivet holes, sometimes with a rusted rivet *in situ*, presumably for fastening to straps, though precise locations on the headgear/harness remain uncertain.

Cheekpieces

Cheekpieces are distinguished from other harness links by their certain use on bridles for riding (D. Williams 2007, 2–4). These flat plates sat over the bit, with

Figure 4. Cheekpiece. (a) SUR-1BFD2C. (b) PAS-5B678F. Images to 1 cm scale.

a terminal attaching to the bridle strap that ran up the horse's cheek to the browband (Figure 4) (Geake 2016). Many feature Ringerike and Urnes style decorations (Graham-Campbell 1992; D. Williams 2007) and share a metallic composition with strap mounts (Libby 2022, 202), suggesting an eleventh-century date. Of 237 cheekpieces in the PAS archive, only 41 are certain, with intact loop terminals.

Spurs

English spurs before the thirteenth century were exclusively prick spurs with straight necks and typically conical goads (Ellis 2002, 1–2; Fern 2005, 61–63; Lagane 2010; Webley 2018). It is usually the goad that survives, identifiable only because they are often sheathed in cast copper alloy (Figure 5a). Complete spurs (Figure 5b) are less common but usually consist of a goad on a central platform with arms extending outwards and downwards for attachment to the rider's heel. Many Early Medieval spurs are identified by their necks alone, but those where the heel survives (e.g. NMS-E138B0) are more certain.

Spurs are more likely than other iron tack to be recovered by detectorists, probably due to protective copper-alloy coatings (e.g. HAMP-370443, BERK-843F85, GLO-961A93). Only 31 total examples (15 certain) have so far been recovered, possibly suggesting either a preference for iron production or that spurs were rare. In support of the former, Dr Lagane (2010, 60) observed that 79% of 328 sixth–twelfth-century spurs from across non-Mediterranean Europe were iron only. Spurs were used to urge a horse forward or turn it quickly and thus were useful in battle (Ellis 2002, 1; Fern 2005, 61–63), but might also signify status as in the Carolingian world.

Stirrups

Complete stirrups, like wrought iron WAW-989551 (Figure 6) with an integral collar and rectangular saddle strap loop, are rarely recovered by detectorists. Instead, stirrups are mainly represented by two categories of associated fittings, both copper-alloy: strap mounts and terminals. This suggests that many eleventh-

Figure 5. Spurs. (a) iron goad in copper alloy sleeve (NLM-48A1E4). (b) complete copper-alloy prick spur (BUC-D21882). Images to scale. Note the relative size of the sheathed goad to that on the complete spur.

Figure 6. Stirrup WAW-989551.

stirrups, like the spurs, were composite iron and copper-alloy items. Terminals connected the base to each of the stirrup's two legs, characterized by hollow and open-backed sheaths (into which a stirrup plate could be slotted) and ledges that would have supported the plate (Figures 7a,b). Many (e.g. SF-2D7710) are cast in the shape of an animal head. These ledges are typically angled at 30° from the bottom plane of the terminal, consistent with the arched bases found in complete tenth- and eleventh-century stirrups (see Figure 6; Graham-Campbell 1992; Seaby and Woodfield 1980). Many (e.g. NMS-35AB33) retain solder traces on the interior of the sheath from bonding to metal plates, probably at the base of the stirrup.

Stirrup-strap mounts are the single most prevalent Early Medieval horse-related artefact class recovered. These are cast plates with an angled flange on the bottom and one or more fixing loops at the top (Figure 7c), though on many examples the bottom flange has broken off (Figure 7d). Some examples have iron rivets *in situ* (Figure 7e) and decorations, including openwork, are not uncommon. Of 1448 examples of stirrup mounts, 623 are convex to the front and 710 of the remaining examples – though flat – included evidence of integral flanges. Their interpretation as horse tack is supported by Scandinavian (Arbman 1935–1937; Robinson 1992) and Winchester (Robinson 1992; D. Williams 1997a) parallels. Moreover, the common metallic composition between stirrup mounts with cheekpieces from Lincolnshire suggests that they were manufactured by the same process (Libby 2022, 202–203).

Not all stirrup straps would have required these copper-alloy mounts. Stirrups could have been attached to the strap by buckles or simple riveted plates. Mounts would have ameliorated wear to the stirrup strap but were not strictly necessary. Additionally, alternatives could have been constructed from iron or non-metals, suggesting the total number of Early Medieval stirrups likely far exceeded that of recorded mounts.

Stirrups could certainly have facilitated cavalry warfare, but also served other purposes including long-distance riding, mounting/dismounting assistance, and status signification in reference to stirrups worn by an elite equestrian class in continental Europe (see G. Williams 2021), though the extent of Early Medieval horseback fighting is debated (Graham-Campbell 1992; Hill 2012; Hyland 1994, 73; G. Williams 1991, 2017, 2021).

Harness mounts

'Harness mounts' mainly encompass decorative mounts like discs, disc-like mounts, bar mounts and pendants. Most are associated with horses through their presence in fifth/sixth-century equestrian burial suites, though there are exceptions, with the main class of harness mount relevant to the eleventh century being pendants. These would have hung from either a rivet or hinge (Figure 8) (Geake 2016; Graham-Campbell 1992, 87), likely attached at the breaststrap, rear strap or browband (cf. Psychomachia [MS Cleopatra] f.5 r, f.18 r; Old English Hexateuch f.51 r). Only 47 probable Early Medieval examples are in the PAS archive, of which 30 bear eleventh-century decorative styles. In signifying status, these may have been predecessors to twelfth/thirteenth-century armorial pendants (Baker 2017, 35–43), several of which are decorated without heraldry (Ashby 2002, 4).

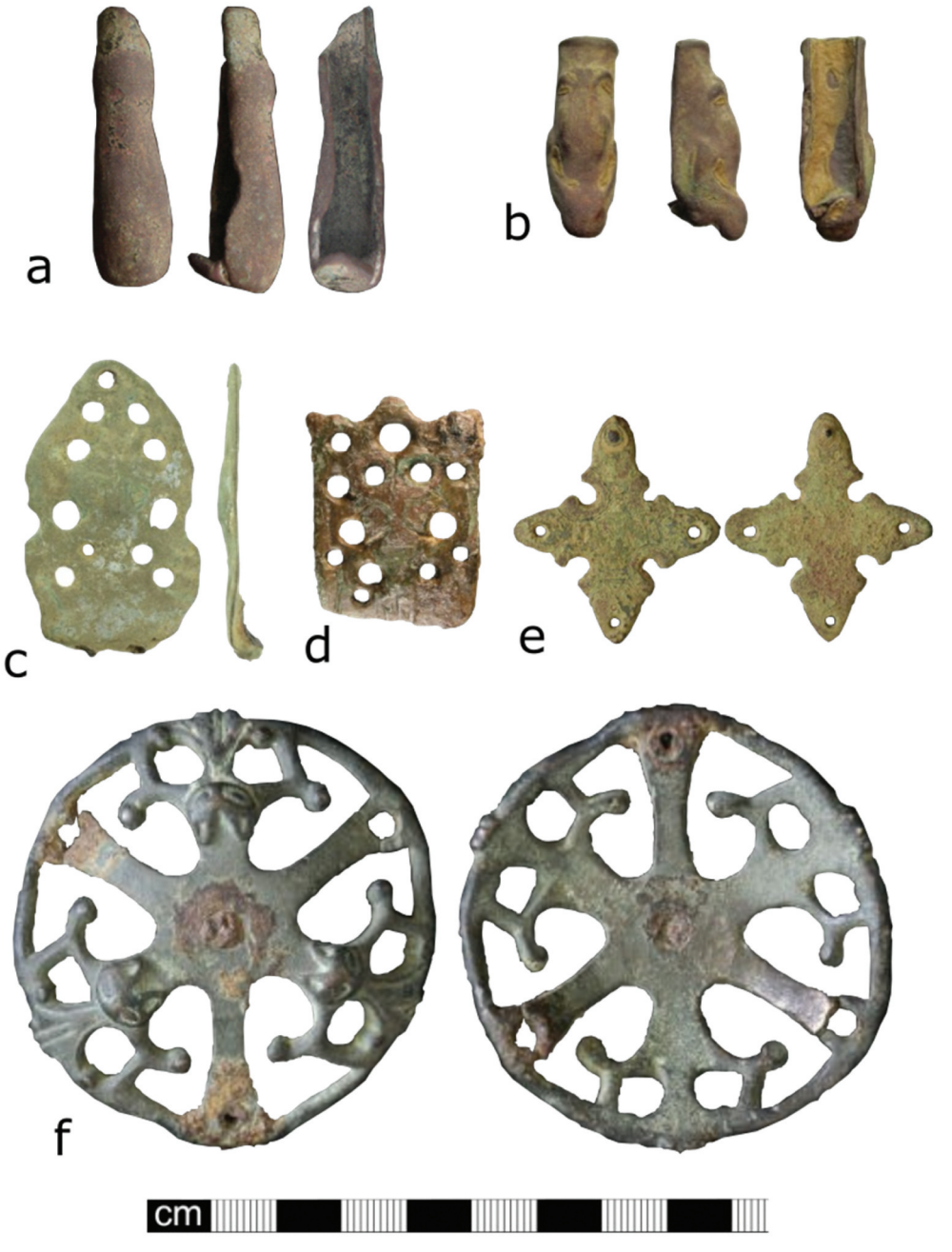

Figure 7. A selection of stirrup terminals and disc harness mounts: (a, b) stirrup terminals, (c) stirrup strap mount (Williams Class A), (d) stirrup strap mount (Williams class B), (e) quatrefoil mount, (f) Borre style tenth-century openwork disc. Images to scale. (a) HAMP-554207, (b) BERK-32CAEC, (c) NLM-ABAACC, (d) WMID-721A28, (e) NMS-4208E5, (f) NMS-FEADE4.

Figure 8. Early Medieval pendants. Left: SWYOR-64EC05. Right: NMS-8B7CAB, NB the rivet holes suggesting that it was riveted to a strap after the hinge broke. Images not to scale.

Results

Temporal analysis

Of 3086 horse tack finds, about 94% date to the eleventh century (Figure 9; Table 3), showing a marked increase in all object types from the tenth. A significant minority of these are more precisely dated to the first half of the eleventh century, identified either by the Ringerike animal style or specific stirrup morphology (D. Williams 1997a, 8). Among the eleventh-century finds, 62% are components of stirrups. These patterns remain consistent considering only 'certain' finds or all probable horse tack.

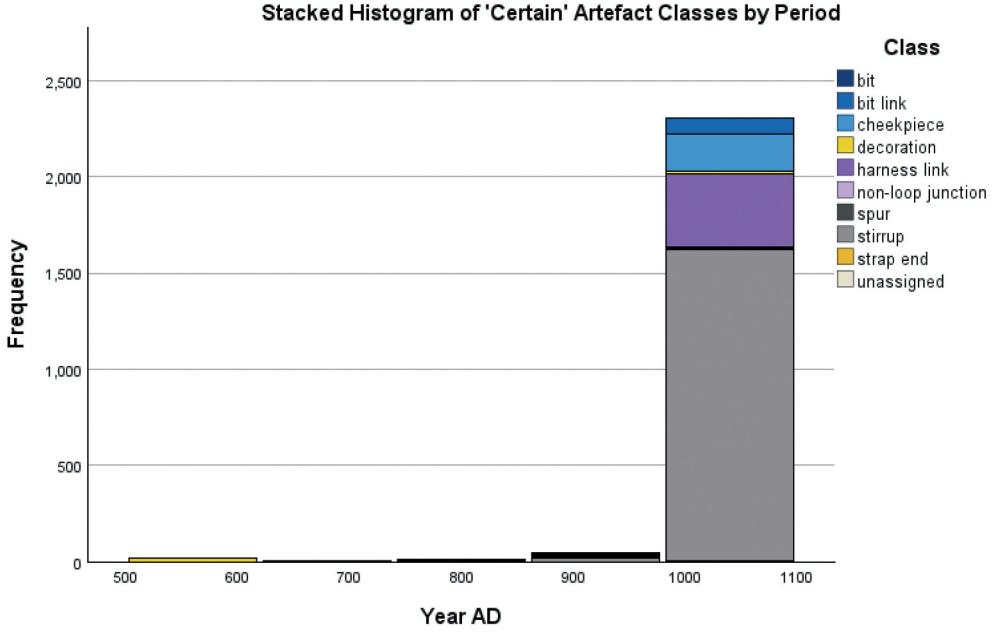

Figure 9. Histogram of artefact classes by period ('certain' only). Eleventh-century examples are predominantly stirrups. The increase in finds from the tenth to the eleventh century is nearly 30-fold.

Table 3. Frequency of horse tack finds by approximate century.

Date	Count (including probable horse tack)
Sixth century	34
Seventh century	18
Eighth century	5
Ninth century	16
Tenth century	81
Eleventh century	2915 (2264 certain)

Regional analysis

The distribution of Early Medieval horse tack in England and Wales reveals significant regional variations. Statistical analysis indicates that both Early/Middle Anglo-Saxon (ANN median expected = 1024.7, ANN observed = 799.9, $p < 0.0001$) and Late Anglo-Saxon (ANN median expected = 1012.1, ANN observed = 513.9, $p < 0.0001$) finds are more clustered than would be expected from a random distribution. This clustering can be primarily attributed to a concentration in eastern England and a relative scarcity in western, predominantly upland regions (cf. Blair 2018). Contemporary patterns in preservation and detection are sufficient to explain much of local clusters. Figure 11 includes the distribution of high-status thegnly sites identified by Dr Holmes (2011), but no spatial correlation was detectable between these and the PAS horse tack finds.

Norfolk (673) and Suffolk (294) have the highest frequencies of finds, again reflecting a broader pattern of PAS finds distribution. Gloucestershire had the highest relative frequency (52%) of horse tack among countries with over 100 Early Medieval finds, while the East Riding of Yorkshire had the lowest (1%). Mapping reveals a scarcity of Late Anglo-Saxon horse tack finds in northern England and an abundance in southern and eastern England (Figure 10; Table 4). On average, about $21.6 \pm 6.1\%$ of Early Medieval PAS finds from a given county are horse tack. A very important, and unexpected, regional pattern did emerge from this analysis: a relative scarcity of horse tack finds from eastern England north of the Humber.

North–South divide in eleventh-century finds

There is a scarcity of eleventh-century horse tack in the North East, including Yorkshire, despite the prevalence of metal detecting and Early Medieval PAS finds in the region overall. Horse tack represents less than 3% of Early Medieval PAS finds in Yorkshire (Table 4), matching a pattern of fewer non-ferrous cheekpieces and bridle pieces north of the Humber, as observed by Dr Webley (2020, 233–236, 287). In contrast, eleventh-century copper-alloy horse tack is ubiquitous in the south, extending to the West Country as far as western Cornwall. In fact, the counties with the highest relative percentage of horse tack finds are from the South West, though these likely result from the low frequency of PAS finds overall. The pattern of scarcity of horse tack in the North East is much more robust. The consistent scarcity of northern horse tack cannot be fully explained by formation processes or selection bias, unless horse tack in the North East (but not elsewhere) was predominantly made of rope, leather, or iron even into the eleventh century. Notably, this north–south divide does not correspond to the boundaries of the Danelaw.

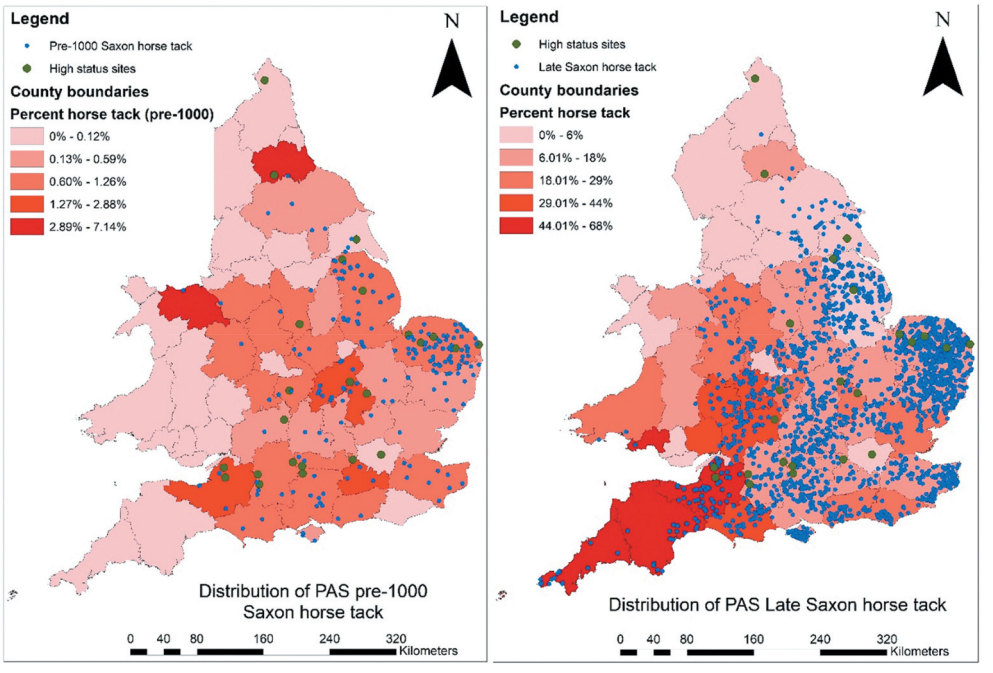

Figure 10. Dot distributions of Anglo-Saxon PAS horse tack. Left: before AD c. 1000. Right: eleventh century. Choropleths of percentage of horse tack finds per county. High-status sites identified by Holmes (2011). County boundary data by OS.

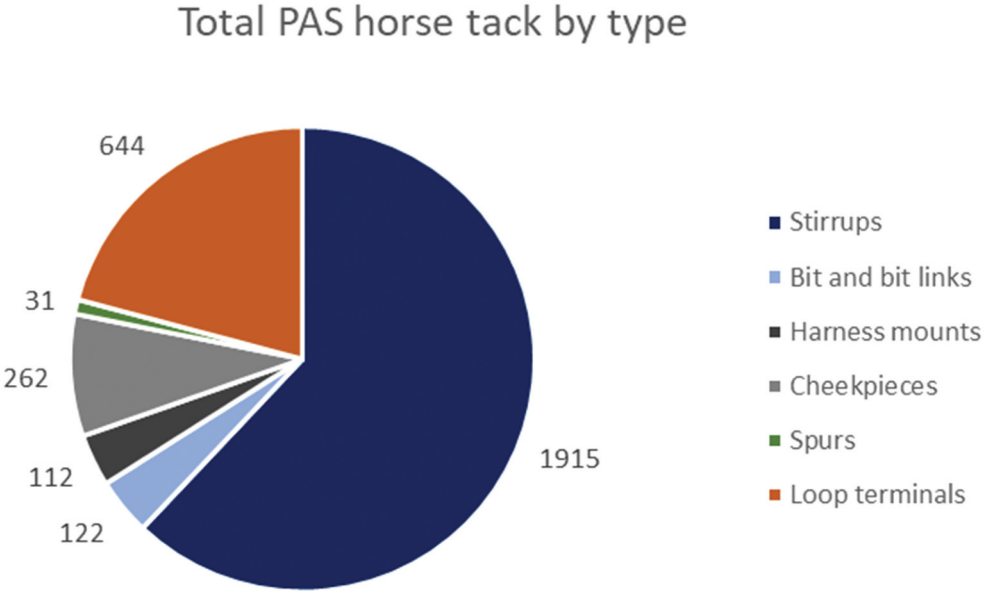

Figure 11. Pie chart of percentages of horse tack type out of sum PAS horse tack.

Table 4. Count of 'certain' PAS horse tack finds per region of England and Wales.

Region	Count (certain only)	Total PAS finds (%)
East Midlands	331	6133 (5.4%)
East of England	966	6964 (10%)
North East	2	104 (1.9%)
North West	16	83 (19.3%)
South East	591	3951 (15%)
South West	234	877 (26.7%)
Wales	10	45 (22.2%)
West Midlands	140	669 (20.9%)
Yorkshire	84	3173 (2.6%)
Total	2374	24,729 (9.6%)

Typological analysis

Of 3086 horse tack finds, 62% were stirrup artefacts (mounts or straps), and 21% were looped terminals (Figure 11), half of those being two-way links (Figure 12). Pieces that would have directly facilitated riding include loop terminals that held straps together (21% of the assemblage), cheekpieces that connected the bit to the bridle (8% of the assemblage), and bit links that connected the mouthpiece to the reins (4%). Together these comprise 33% of the assemblage. Only about 1% of PAS finds were spurs.

For the eleventh century, horse tack types are mostly evenly distributed, with some regional clustering (Figure 13). The exception was Lincolnshire, which had significantly fewer looped terminals ($t = -8.54$, $p < 0.0001$) and a higher concentration of stirrups ($t = 2.81$, $p = 0.424$) than would be expected from a random distribution.

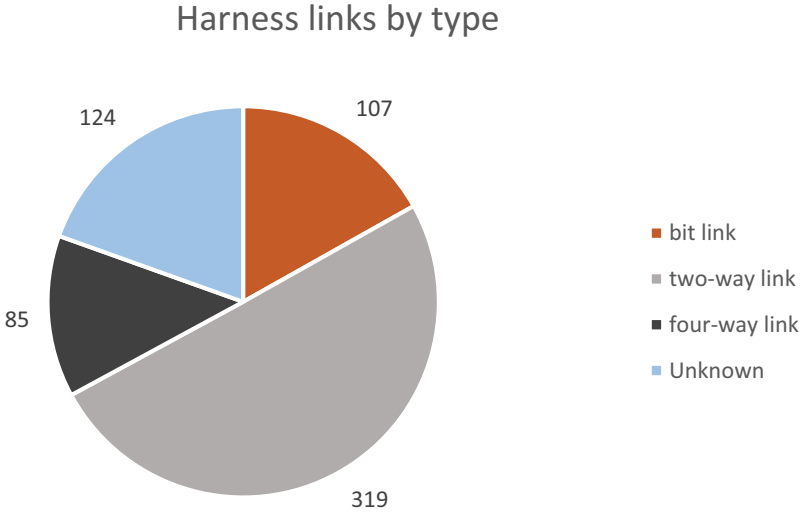

Figure 12. Pie chart of percentages of harness link types. NB: 'unknown' refers to fragments from which the total number of loops cannot be determined.

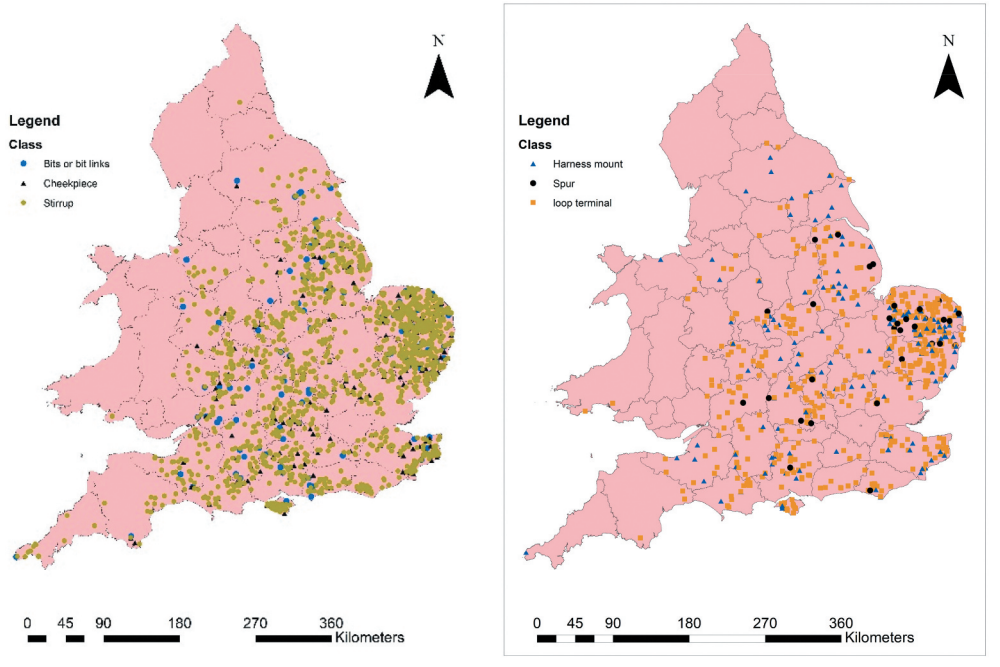

Figure 13. Dot distributions of eleventh-century PAS horse tack ($n = 3014$). Left: bits and bit links, cheekpieces, and stirrups. Right: harness mounts, spurs, and loop terminals.

Discussion

Temporal variation

A majority of finds date to the eleventh century, confirming and strengthening Graham-Campbell's (1992) identification of a surge of copper-alloy horse tack in late Pre-Conquest England. A likely explanation is an increased uptake in copper-plated tack rather than an increase in tack use overall. As archaeologists, we lack a solid baseline for the amount of iron tack that was in existence, so most horse tack in use before and during the eleventh century might have been ferrous, with the evidence long corroded away. Furthermore, many stirrup terminals and spurs studied here are composite objects of iron with copper-alloy fixtures, and bridle mouthpieces seem to have remained ferrous even as other components transitioned to copper alloys. A dramatic change in preference for copper alloys alone could explain this surge. It must be emphasized that this pattern is more-or-less unique in the PAS record to horse tack and does not coincide with a general increase in copper-alloy finds overall. Focused examinations on any other copper-alloy type of PAS find (brooch, hooked tag, pin, strap end, vessel) reveal no similar trends, though buckles did see a gradual increase from the late eighth century, peaking in the eleventh century.

Compared to earlier Anglo-Saxon periods, PAS data have significantly expanded the corpus of eleventh-century horse tack, confirming their expanded use. Turning to excavated finds, tenth-century examples remain rarer but include three iron loop junctions and a spur from a late ninth- or early tenth-century context at Middle

Harling (Margeson 1986, 77–79) and an iron bit link from a tenth-century deposit at Faccombe Netherton (Fairbrother 1990). Much horse tack has been excavated from contexts that could date to either the eleventh or tenth centuries. From Coppergate, Dr Ottaway (1992, 237) identified 12 bits, nine bit links, two loop junctions, and one cheekpiece, all iron and all dating to 900–1050. Horse-related evidence from Period 5 (850–1100) at Stratton (Bedfordshire) includes two iron spurs, five iron buckles, one copper-alloy-plated ferrous strap distributer and another strap guide (Shotliff 2022, 64). An unstratified triangular looped junction similar to that at Coppergate is also known from Riby Cross (Lincolnshire) (Ottaway 1989, 253). Iron bits or bit links from Thetford (Goodall 1984) and Riby Cross (Steedman 1993) could date to either the tenth or eleventh century. Due to dating tendencies, the possibility that this 'explosion' of horse tack began in the tenth century cannot be entirely excluded. Excavated finds from Coppergate (Ottaway 1989, 367, 594) support a gradual increase in ferrous horse tack from six (<1%) from the late ninth century to 13 (1.5%) in c. 900–975, and to 47 (20%) from c. 975 to the middle to late eleventh century, with the later percentages matching that of eleventh-century PAS finds.

The prevalence of *ferrous* tack in excavations highlights the importance of material. The roughly 2000 copper-alloy PAS horse tack finds from the tenth and eleventh centuries therefore indicate a potentially far larger volume of material now lost to (or made unidentifiable by) corrosion. Ferrous loop junctions from Coppergate, Thetford, and Middle Harling, otherwise identical to copper-alloy examples, powerfully show that horse tack could be made of either material (Goodall 1984, 258–261; Margeson 1986, 77–78; Waterman 1959, Figure 2).

While alternatives should be explored, it is proposed here that the surge in eleventh-century copper-alloy tack likely reflects a qualitative shift in the preferred material of equipping horses rather than a quantitative increase in the number of equipped horses. However, this invites questions about how and why horse exploitation changed so that more horses were tacked in copper alloy. Below, this article explores three interrelated factors that could help understand this archaeological pattern: technology and economics, the impact of conquests and social status.

Technology and economic factors

Historically, horse equipment was not exclusively metal. Probably some of the earliest tack in prehistory were made of leather, rope, antler or straw (Levine 1999; Scott 2019, 17–19; Seager-Smith 2000, 230). Organic materials likely remained common for many in the Middle Ages for their flexibility, adaptability and ease of repair, as demonstrated by a rope halter preserved in a Viking Age boat grave from Uppland (Sundqvist 2001, 71, fig. 4:1) and recent experimental reconstructions of a workable Early Medieval Irish straw harness made entirely without metal (Maguire and Johnston 2024). In fact, straw harnesses are well attested as recently as the Early Modern Period in Ireland and Scotland (Davis 1989; Holliday 2017; Maguire 2022; Maguire and Johnston 2024). Of course, metal horse tack, offering greater durability and ductility, had been used in some form in Britain since the second millennium BC (Harding 2000, 169–172) and Iron Age and Roman British horses were variously equipped with bronze (e.g. terrets) and iron (e.g. mouthpieces, bits) (Crummy 2011).

Even against this deep historical background, the eleventh-century uptake in copper alloys is noticeable.

Why the abrupt transition in material? It is tempting to view this in terms of technological innovation. Certainly, the earliest evidence of English stirrups is from the Late Anglo-Saxon period, following Scandinavian forms (Seaby and Woodfield 1980) with perhaps the earliest known example dating from the late tenth century at Winchester (Goodall 1990, 1042, fig. 332). If stirrup strap mounts indicate the number of stirrups, we can assume they were swiftly adopted and widespread in England by the eleventh century. Their military importance could give justification for their abrupt uptake.

However, the introduction of stirrups cannot explain all of the copper-alloy 'explosion', in part because horse tack of all classes increased in the eleventh century. Furthermore, medieval English stirrups did not need to be made of copper alloy and it is possible that stirrups themselves, if made of other materials, were adopted or even proliferated earlier. Seaby and Woodfield (1980, 91) have argued persuasively that twisted iron bars of Viking Age stirrups were skeuomorphs of earlier organic rope stirrups, and the word 'stirrup' itself descends from Old English '*stirap*' or '*stigrap*' (*stige* – to climb; *rap* – rope) (Seaby and Woodfield (1980, 87), suggesting rope might have well predated metal examples and could even have remained common into the eleventh century. An interesting parallel to England's eleventh-century 'explosion' can be found in Ireland, where Maguire (2025) has argued that the puzzling scarcity of metal horse tack in the Irish Bronze Age and Early Christian Period was because equestrian equipment was at those times primarily made from plant materials. In Ireland, it is the Late Iron Age (AD c. 1–400) that stands out as an exception with an abundance of sophisticated metal tack, perhaps suggesting a divergence from traditional practices. Such archaeological patterns illustrate the importance of changing material preferences to archaeological visibility.

Therefore, it is the material shift itself that requires investigation in eleventh-century England. Copper alloys offered compelling advantages over iron or organic materials: they are easier to work and, because they can be cast, are easier to manufacture into complex decorative pieces. Copper alloys require lower temperatures and less specialized equipment, and they are more resistant to corrosion.

Sophisticated copper-alloying was not a new technology in the eleventh century, so why the change in preference then? Emerging urban workshops may have played a crucial role. The capability of both ferrous and non-ferrous metalworking in the same workshop, as exemplified at Coppergate (Ottaway 2020), is notable because much of the complete eleventh-century horse tack (e.g. bridles, stirrups, spurs) would have been composites of both materials. Urban workshops likely benefitted from greater access to resources through trade, perhaps leading to more efficient production (and production costs). In towns like Lincoln, workshops were apparently capable of serving both elite and mass-market demands, suggesting an emerging 'middle market' for copper-alloy items (Ten Harkel 2018).

The material properties of copper alloys were not merely practical but potentially symbolic. Prof Karkov (2022, 18) emphasized that materials were believed by Early Medieval people to have intrinsic qualities and agencies, physically connecting crafted items to their natural origins. While art historians like Karkov usually detail works of

precious metal, skilled manufacture of copper-alloy could fit the same framework, since the distinction between 'fine' and 'applied' art is a modern one. We can only speculate like a prehistoric archaeologist as to what agencies copper alloys might have embodied, but these might have included transformative or visual properties. The golden hue of bronze might have carried some of gold's associations with divine light (Karkov 2022,18), but in a more earthly or mediated form, while colour change and patination over time could have symbolized living qualities in the metal. As an alloy, the material literally embodies the combination of different metals into something new (particularly relevant given Dr Letty Ten Harkel's 2018 research into cultural hybridity in 'Anglo-Scandinavian' designs from Lincoln). Its resistance to corrosion compared to iron could have symbolized endurance or protection, qualities that might have been particularly meaningful to safeguarding horse and rider. With further research, this framework might help explain why copper alloys were adopted beyond purely practical or social considerations.

Notably, most eleventh-century horse tack innovations involved altering existing technologies rather than introducing new ones. Stirrups of wood and rope can serve just as well as metal ones, and even metal stirrups do not strictly require mounts. Even with the eleventh-century introduction of ornate copper-alloy cheekpieces, standard snaffle bits appear to have remained the main bridle mechanism. Instead, the change was more nuanced, reflecting broader socio-political transformations.

Impact of conquests

Archaeological evidence of equestrian influence from the First Viking Age (e.g. Fairbrother 1990; Margeson 1986, 77–79; Ottaway 1989, 367, 594) is scarce, despite numerous historical accounts of horses in that period. In contrast, the surge in eleventh-century horse tack in England can be convincingly linked to the Second Viking Age. Unlike the Viking Great Army of the ninth century, Sweyn Forkbeard and Cnut decisively conquered all of England within a few years, which might – with some caveats – be reflected in the relatively abrupt and widespread distribution of the copper-alloy equestrian material.

The largest part of the surge was in stirrup fittings that followed Scandinavian forms (Seaby and Woodfield 1980, 94–101). Furthermore:

(1) much of the copper-alloy horse tack in the PAS bears Scandinavian style decoration,
(2) horses were included in heriots (customary death taxes) in Cnut's (r. 1016-1035) law codes (G. Williams 2021), perhaps reflecting commonalities across the North Sea and
(3) a parallel eleventh-century uptake of copper-alloy horse tack is visible in the Danish archaeological record. While tenth-century Danish horse burials featured iron tack, the eleventh century saw the introduction of pieces with copper-alloy embellishment (Pedersen 1999, 133). As in England, copper-alloy tack like cheekpieces and stirrups in Denmark were produced with intricate designs, often featuring animal motifs in the Ringerike or Urnes styles.

However, this last point complicates an attribution of copper-alloy tack proliferation to the Danish conquests. The contemporaneous appearance of a very similar type of copper-alloy horse tack in both England and Denmark suggests a broader cultural and material connection across the 'North Sea Empire', rather than England necessarily just adopting Danish styles (Pedersen 1999, 155). Even if one assumes that copper-alloy tack was indeed a 'cultural import' from Denmark, the mechanism of its adoption by the English population requires interrogation.

An argument could be made that the English adopted the stirrup after witnessing its military effectiveness in the hands (or feet) of the victorious Danes. However, the eleventh-century proliferation comprised more than just stirrups, and – because stirrups could be made of iron without the copper-alloy mounts – the adoption of stirrups does not necessitate a large-scale uptake of copper-alloy tack. One could imagine that, because they were adopting Danish examples that happened to use copper-alloy elements, the English deployed copper alloys for the rest of the material too. There are good reasons for military belligerents to adopt material culture from their rivals. Nevertheless, archaeologists should remain cautious in assuming a straightforward introduction of copper-alloy tack by Danish conquerors, as dating stylistic elements remains imprecise.

Turning to 1066, there is limited evidence suggesting the introduction of the curb bit to England immediately following the Norman Conquest. This technology was well established in eleventh-century France, as evidenced by finds from sites like Colletière (Rhône-Alpes), Andone (Villejoubert) and La Chapelle-Saint-Luc (Clark 2020, 178–179). The Bayeux Tapestry depicts Norman horses – but not English horses – with L-shaped bars in front of their mouths, potentially representing curb bits.

The introduction of such bits would have had significant implications for horse control, particularly in mounted combat. By creating leverage when the reins were pulled, curb bits allowed for more precise and responsive handling, which was crucial for close-quarters combat with swords or lances. This innovation also hints at the increasing importance of experienced, trained riders. The otherwise ubiquitous antecedent in England, the snaffle bit, would have been generally more forgiving of rider mistakes and have given the horse clearer, simpler signals. Modern beginner riders do not use curb bits.

Despite their potential impact, archaeological evidence for curb bits in eleventh-century England is minimal. The PAS has recorded only one additional fragmentary curb bit (GLO-61557E) from this period (Figure 14), doubling the known record but still reflecting the overall rarity of these artefacts (Goodall 2011, 373), though again ferrous examples will be underrepresented and may have been more widespread. Additionally, given that none of the 190 horses depicted on the Bayeux Tapestry are equipped in anything else resembling the body of eleventh-century PAS finds (but see Owen-Crocker 1991, 233), we are left with very faint material evidence of the immediate impact of the Norman Conquest on English horse tack.

While England's equestrian culture was undoubtedly influenced by Continental trends, key differences remain. English riders did not adopt stirrups – or at least archaeologically visible stirrups – en masse until several centuries after their continental

Figure 14. Fragment of possible gilded copper-alloy curb bit (GLO-61557E). Each tick for 1 mm. Note the D-shaped loop for the reins.

counterparts. Though stirrups have often been credited with transforming Frankish cavalry, literary and archaeological evidence suggests that horses already played a critical role in martial elite *expression* in Early Medieval England (Jenkins 1997). Rather than being late adopters of a uniform 'elite equestrianism package', the English developed a distinct form of elite equestrianism shaped by their own socio-political context, albeit with French influence.

Social status

The prevalence of copper-alloy horse tack, much of which was not strictly necessary for riding, suggests that these items were relatively high-status objects. Indeed, many examples of cheekpieces, pendants and stirrup components are finely decorated, with 93% of cheekpieces, 83% of stirrup terminals and 71% of stirrup strap mounts featuring elaborate designs where 'designs' are defined as high-relief decoration, animal heads or intricate openwork. Some (e.g. BERK-858E61) even display silver wire inlay, while at least 25 eleventh-century finds show traces of gilding (e.g. NLM-798302, WAW-F8F521). By contrast, fewer than 2% of copper-alloy harness links bear such decoration, although their association with the rest of the suite may have lent them high-status connotations. The elite signification of copper-alloy horse tack is supported by other contemporaneous high-status military objects such as gilded or decorated shields, pennants and ships' figureheads (Hinton 2006, 166). Although not usually gilded, eleventh-century copper-alloy tack might have impressed contemporaries with their shine and status-boosting appearance. In Denmark, eleventh-century copper-alloy

horse tack replaced earlier iron examples that featured silver and copper inlay (Pedersen 1999, 154), further underscoring a possible elite association.

Literary and legal evidence supports the connection between horses and status. For instance, line 62 of Maxims I in the tenth-century Exeter Book states that an '*eorl* should be on the horse's back', and by the late tenth century, horse equipment was precious enough for a bridle (*frenum*) to be fought over to the death (S 883). Cnut's laws similarly tied the number of horses in a heriot to an individual's rank, with higher-status individuals expected to maintain more horses (G. Williams 2021).

An argument for a strong association between status and copper-alloy horse tack can be persuasively made, but this leaves two important questions. First, why the change in social signification in the eleventh century? This may have been part of broader cultural shifts in how status was expressed. Prof Hinton (2006, 166) noted that jewellery and personal adornment for displaying social status mattered less by AD 1000, with far fewer small dress items being made of precious metals in the eleventh century. With estates emerging as critical units of economic and military power, the argument goes that elites increasingly tied their status to households and control of land and resources rather than to personal portable wealth (Fleming 2001, 2011; Reynolds 1999, 112–123). As a part of this, horses might have replaced personal adornment as a medium for distinction. In the changing ethos and economy of Medieval status, maintaining multiple equipped horses could demonstrate income across a household or estate rather than personal accumulated wealth. Compared to most media for expressing household status, horses were conveniently mobile. They would have made practical and visible symbols of authority, especially because – unlike regalia – copper-alloy horse tack might have been routinely used.

However, this leads to the second major question: is it not paradoxical for an elite class to be associated with such a common artefact type, given that the PAS has recorded nearly 2000 examples from this period? Interestingly, Dr Pedersen (1999, 155) described many Danish examples as 'poorly executed' and, while some PAS finds feature intricate designs, such as BERK-0F6C58 and LEIC-82FC12, others are quite basic, with simple incised lines or motifs (e.g. LEIC-534DFF, ESS-FD094F). This apparent paradox may reflect the growing aforementioned 'middle market' for copper-alloy goods (Ten Harkel 2018).

Alternatively, the resolution may lie in the changing roles of status and horses in social and military terms. G. Williams (2021) confirmed a positive association between rank and the number of horses in tenth- to eleventh-century English wills, with every 'lesser *thegn*' or above possessing at least one horse. Horses in wills, often bequeathed with their tack, became common only around the millennium, indicating that full sets of arms and horses were a recent innovation by Cnut's reign (Whitelock 2011). A further implication of these wills is that lords supplied their vassals with mounts. Even from a non-military context, the early eleventh-century *Rectitudines Singularum Personarum* detailed that beekeepers and swineherds on an estate were each to be provided with a horse to transport goods. Much of the eleventh-century copper-alloy horse tack might have been equipped to horses that belonged to a lord but were ridden by vassals or servants. Thus, the social value of being seen on an equipped horse might have declined, prompting the upper elite (e.g. the æthelings, *eorls*, bishops and upper *thegns*) to turn to more polished and ornamented tack for further distinction. The surge

of copper-alloy horse tack therefore indicates a qualitative change in status expression rather than a quantitative increase in the number of elites.

An evocative clue might be in lines 188–190 of 'The Battle of Maldon', probably composed in the late tenth or eleventh century, which features a character named Godric whose lord, the narrator tells us, has often given many a horse. Later in the poem, Godric flees the titular battle on his lord's horse 'on those trappings' ('*on þam gerædum*') he had no right to (Glen 1982). The implication being that the lord's horse was adorned in clothing or tack to signify its (and its rider's) status (though an alternative reading is that – in a cowardly act of betrayal – Godric was forfeiting the warrior's 'right' to any equipped horse). Though the poem is partly fictional, the poet would have described the martial world they were familiar with, and it is tempting to speculate that the lord's horse was equipped in the copper-alloy tack now familiar in the PAS record.

Regional variation: a north–south divide

Having explored all this, the scarcity of copper-alloy tack in the North East during the eleventh century complicates models of Norse influence, social status and equestrian military elites. Not only did the North East experience Norse influence like (if not more so than) the rest of England, but the styles of horse tack there are consistent with other regions (Campbell 2015, 87; Ottaway 1989; Richards and Haldenby 2016). Interestingly, the regional difference in horse ownership might be linked to the heriots described in Cnut's Law codes, which required fewer horses from thegns in the Danelaw than in southern England (G. Williams 2021). Unlike their southern counterparts, lesser thegns in the Danelaw were not obligated to provide horses, possibly indicating fewer equipped horses in the North East, though this would be surprising.

Alternatively, cultural differences may explain the variation. Medievalists happily accept significant regional differences in eleventh-century England (e.g. Hadley and Dyer 2017) and hitherto unexplored variation in custom may well exist around horses and elite status. Existing laws and obligations may not have been effectively enforced north of the Humber or customs varied despite the law (or copper-alloy horse tack was regionally not 'in fashion'). Riders in the North East may have conservatively chosen not to adopt new styles; indeed, such cultural continuity could even reflect an ethos of *skilled* riders who preferred early technologies just as many skilled twenty-first-century drivers prefer older manual transmissions. While G. Williams (2021) argued that heriots were generally practised, the absence of wills from the North East (Whitelock 2011) sadly limits testing of regional variation. More abstractly, the cultural expectations of elite horse ownership might have manifested differently in Yorkshire and the North East. For instance, a northern estate owner might have placed greater emphasis on breeding and exchanging their horses than simply equipping them. Though these remain necessarily speculative, such differences could result in fewer archaeological signatures of horse tack.

A second, more concrete, alternative is an economic difference. Given the possible role of urban manufacture in eleventh-century copper alloys, one has to consider the role of urbanism in the data's north–south divide. By the tenth century, towns were more developed south of the Fosse Way (e.g. East Anglia

and the East Midlands), with evidence suggesting a more robust rural hinterland and market infrastructure in these areas compared to the north (Blair 2008, 256). York, though very important, was the region's only major urban centre, and the Domesday survey records only 20 towns north of the Humber (and zero north of the River Tees) with more than 25 households, compared to over 150 in Lincolnshire alone, suggesting the north even had fewer *small* towns. Therefore, some of the regional differences could be explained if more rural northern communities maintained traditional economies of production while southern workshops were more integrated into broader trade systems, creating standardized and decorated items like stirrup mounts.

Importantly, none of the above interpretations requires there to have been less horse exploitation or even less horse tack than in other regions of England; it simply requires less use of *copper alloy* in horse tack. Organic and ferrous materials, common in earlier centuries, may have remained in use.

Conclusions

This research has illuminated several critical aspects of Early Medieval horse tack, addressing five key research questions. First, PAS data confirms the eleventh-century proliferation of copper alloy horse tack first identified by Graham-Campbell (1992), but with a much-expanded corpus. Indeed, the pattern is much more powerful than Graham-Campbell probably could have imagined at the time, with the number of horse tack finds increasing nearly 30-fold from the tenth to the eleventh centuries, a scale so significant that it can be termed as an 'explosion'. The surge does not necessarily mean more horses were used, but rather a qualitative shift in how horses were equipped, a shift that can be tied to complex social and military changes.

Considering question two, typology, much of this increase can be attributed to the introduction of the stirrup (62% of finds were components of stirrups), though other materials like iron and organic components were likely used. It is critical to note that the surge in copper-alloy encompassed all types of horse tack, with many of the finds being decorative and not strictly necessary for riding.

Addressing the third and fourth research questions, the findings suggest no monocausal explanation, but rather a complex interplay of technological, economic, and social transformations. The eleventh-century adoption of copper alloys coincided with – and was perhaps caused by – the rise of urban workshops with diversified production capabilities. Furthermore, this proliferation took place in the context of wider European phenomena, such as the development of knighthood and cavalry warfare, as well as more local transformations to status expression, including growing emphasis on estates and/or elite efforts to distinguish themselves as horse ownership expanded. Danish influence is evident through copper-alloy parallels and Viking zoomorphic decorations, while the immediate impact of the Norman Conquest was limited to one fragmentary curb bit, leaving it – perhaps surprisingly – the weakest proposed cause of the transformation of eleventh-century horse tack.

A particularly provocative finding, which addresses the fifth research question, is the robust north–south divide in material distribution, with the North East (including Yorkshire) yielding significantly fewer copper-alloy finds. This regional variation

challenges assumptions of cultural uniformity, suggesting that material culture was a dynamic process of localized negotiation rather than a monolithic phenomenon. The regional pattern cannot be solely attributed to preservation bias, and it may reflect a regional difference in urban development (and therefore economic production), though investigations into specific cultural variations could prove very fruitful.

This study also exposes critical limitations in archaeological approaches to studying Early Medieval horse equipment, namely that neither excavated nor PAS material provides a satisfactory source of information. PAS data is heavily biased against ferrous metals (not to mention organic materials), yet ferrous metals perhaps comprised the majority of Early Medieval horse tack. On the other hand, settlement and cemetery excavations are biased against the small pieces of ironwork that would have been lost on the road. Thus, the thousands of Early Medieval horse tack finds are only a tantalizing glimpse into a volume of horse-related gear that is largely lost to the archaeological record.

My findings suggest multiple promising research directions. First, further synthetic research is needed, such as analysing bridle wear on horse skulls and traction evidence on skeletons to assess regional and temporal patterns. For example, does Yorkshire's scarcity of copper-alloy tack correspond to less bridle wear in faunal evidence? Given recent debates into tracing horse-based transport through human skeletal traits (e.g. Hosek, James, and Taylor 2024), there potentially is also scope to incorporate human skeletal evidence into studies of changing human–horse relationships.

Second, this research opens a couple of possibilities for theoretical innovations. It can be taken as a reference point to investigate the symbolism and agency of copper-alloy horse tack, using archaeological, documentary and art historical evidence. This research has treated human–horse relationships as instrumental, but further exploration of interspecies co-constitution (Haraway 2007; Ward 2023), using tack as a source of evidence, could enrich our understanding of eleventh-century horses and riders.

Third, more exploration of PAS data also needs to be given to the Middle Anglo-Saxon period, some aspects of which will be explored in a follow-up paper. Additionally, these methods could be applied to study horse tack from other periods, such as the Iron Age, Roman, Later Medieval or Early Modern Eras. The inclusion of PAS data significantly enhances British archaeology and replicating this study in regions like the Low Countries, Northern France, Ireland or the broader Viking world could determine whether similar material transformations occurred elsewhere.

Beyond the specific findings about eleventh-century horse tack, this research demonstrates how decontextualized archaeological artefacts can reveal profound insights into socio-political, economic and military transformations. By treating objects not as static entities but as dynamic agents of cultural negotiation, we can develop richer, more nuanced understandings of historical change. The eleventh-century horse tack proliferation is more than an archaeological curiosity – it is a window into the intricate processes of identity formation, technological innovation and social transformation.

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