Sledge runners made of cattle mandibles? – Evidence for jawbone sledges from the Late Iron Age and the Roman Period in Switzerland and Austria

Barbara Stopp and Günther Karl Kunst

During the Late Iron Age and Roman periods in Switzerland and Austria, cattle mandibles with artificial modifications can be observed. About 70 worked cattle mandibles are known from the eastern part of the Roman *vicus* of Mautern-Favianis (Lower Austria; 1st–4th c. AD), and 141 mandibles have been found to date in the Late Iron Age settlement of Basel-Gasfabrik (Switzerland, 150–70/80 BC). Generally, the artefacts are identified by the presence of polished and abraded areas along the lower margin (*margo ventralis*) of the jaws. It is suggested here that these mandibles were used as runners of makeshift sledges pulled across snow, dry ground or grass, with most of the weight resting upon the posterior parts and a rope being attached to the anterior ends.

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Introduction

When working with the Late Iron Age and Roman material from the *vicus* of Vitudurum-Oberwinterthur (Switzerland) at the end of the 1980's, the late Philippe Morel discovered some cattle mandibles with heavily polished and abraded corpus bases (Morel 1991, 130 ff.). The abrasion of some was so pronounced that even the marrow cavity became exposed. But the use of these artefacts remained unknown.

During the following years more sites yielded this type of artefact. Interestingly enough the artefacts seemed to be found only in Switzerland. Inquiries about similar finds in other countries were without result until recently, when the same type of artefact was also discovered in the Roman *vicus* of Mautern-Favianis in Lower Austria.

Description of the material

Nearly all of the mandibles used are from cattle, occasionally also from horse. Most of them were found in single halves, only on some sites were both hemi-mandibles found together. When the latter occurred, the two halves showed corresponding alterations, an indication of their use while still connected with each other.

The jawbones identified as artefacts are characterized by a set of surface marks and other traits almost identical in all the sites (Fig. 1). Generally, there are little, if any, indications of initial manufacture. The rostral part of the mandibles with the diastema remains more or less intact, whereas the ramus, especially the ascending part, is often broken off, sometimes also chopped off by transverse blows. It seems that the cheek teeth have never been removed or manipulated deliberately, a complete set of premolars and molars being a rather normal feature of the worked objects. Superficial blade marks can be found on the lateral surface of the corpus and the angular area. As the same modifications do appear on unworked specimens as well, they may not be linked to the subsequent use of the mandibles at all but rather indicate their detachment

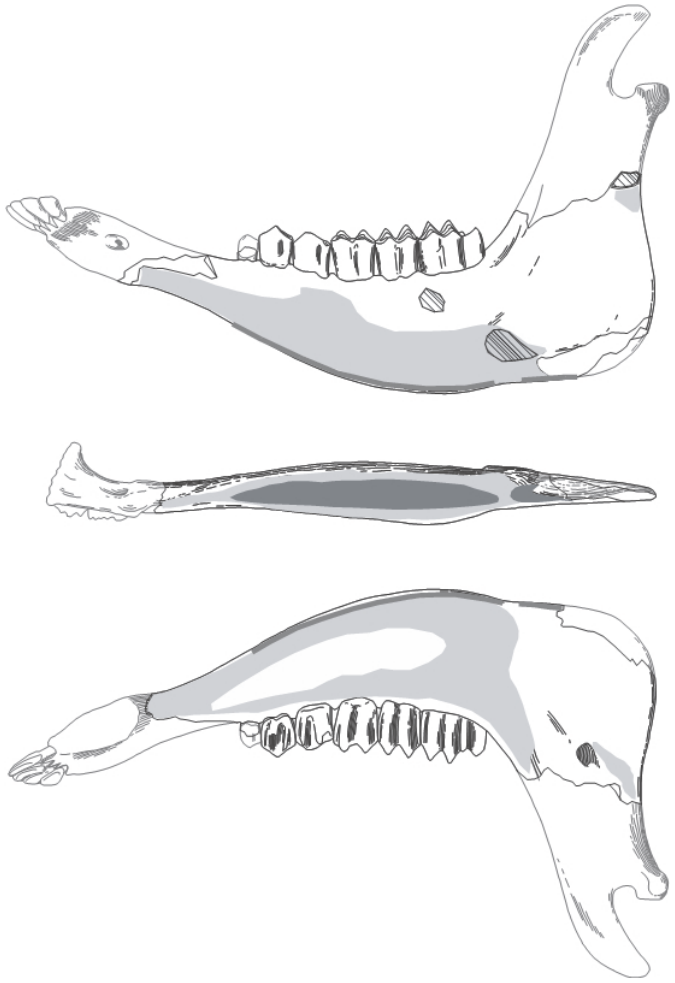

Fig. 1. *Schematic drawing of a moderately worn and fragmented worked cattle mandible, in lateral, basal and medial view, largely based upon 1133/4 from Mautern-Favianis, eastern* vicus *area; strong lines indicate delimitation of specimen against a complete mandible (stippled line); light shading – polish, dark shading – abrasion, hatched areas – chopmark.The diastema area, broken here, remains intact in many other specimens.*

from the skull and defleshing. But there are also perfectly complete specimens (except for the incisors), which would not stand out in any comparative collection, if it were not for their abraded bases. Other types of fracture on the ramus, corpus or diastema area might have occured during or after use. Some mandibles display rounded edges where the ramus is broken. At least these objects were obviously in use after the breakage occurred.

The part which displays the main alteration, is the base of the mandibles. The modifications vary strongly in intensity, starting with slight polish and ending up with abraded surfaces, which may attain a breadth of 15 mm and more. It seems justified to interpret them as a wear sequence (Figs. 2, 3).

Fig. 2. *Wear sequence on four left cattle mandibles from the* vicus *of Mautern-Favianis, basal view; from top to bottom: polish only; abrasion on basal part of corpus; abrasion on basal part of corpus and on the angular process; heavy abrasion on corpus and angular process, angular area partly fractured (photo R. Gold).*

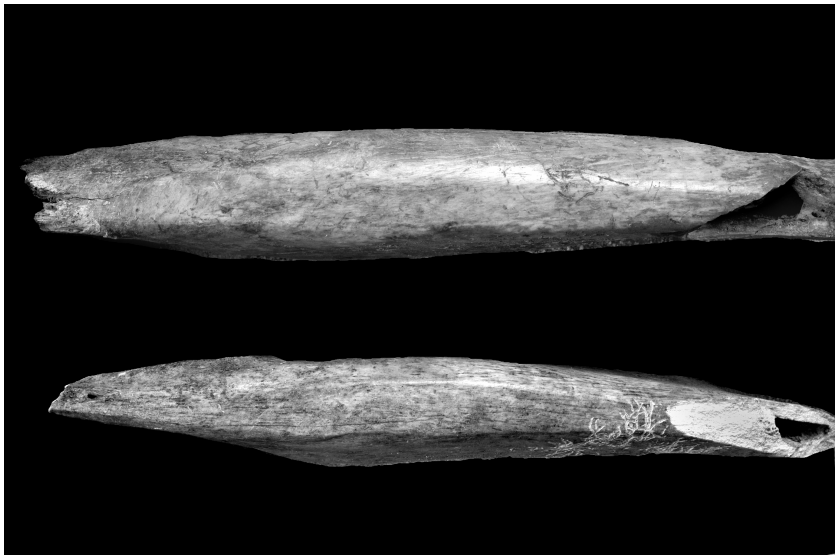

Fig. 3. *Two fractured, right cattle mandibles from the* vicus *of Mautern-Favianis, basal view; heavy abrasion marks on basal parts (photo R. Gold).*

The first signs of utilisation are scratches, followed by a light polish. A smoothed area becomes established, starting somewhere in the middle part of the corpus and extending distally onto the angular corner. Experience has shown that these lesser worked mandibles in particular are only recognized when specifically looked for.

Later on the developing of abrasions on the base can be observed, their spreading follows the same pattern as the polish. Because in cattle mandibles the *Margo ventralis* is separated by a more or less accentuated natural incision, the *Incisura vasorum facialium*, the abraded surface tends to be bipartite at the beginning and may remain so even in advanced stages of wear. Despite some individual variation, a general spatial distribution of the abraded surfaces becomes apparent by superimposing their outlines, indicating a "core area" between the basal corpus below P_4/M_1 and the angular part of the mandible, only rarely going orally beyond the toothrow and reaching the diastema (Fig. 4). Cancellous tissue is usually exposed in the angular (distal) part only. The smoothed surface usually retains a somewhat curvilinear outline in side view, following more or less the natural bone contours and only exceptionally approaching a perfect plane. In this stage the polish sometimes also extends to the sides of the corpus, especially to the buccal one.

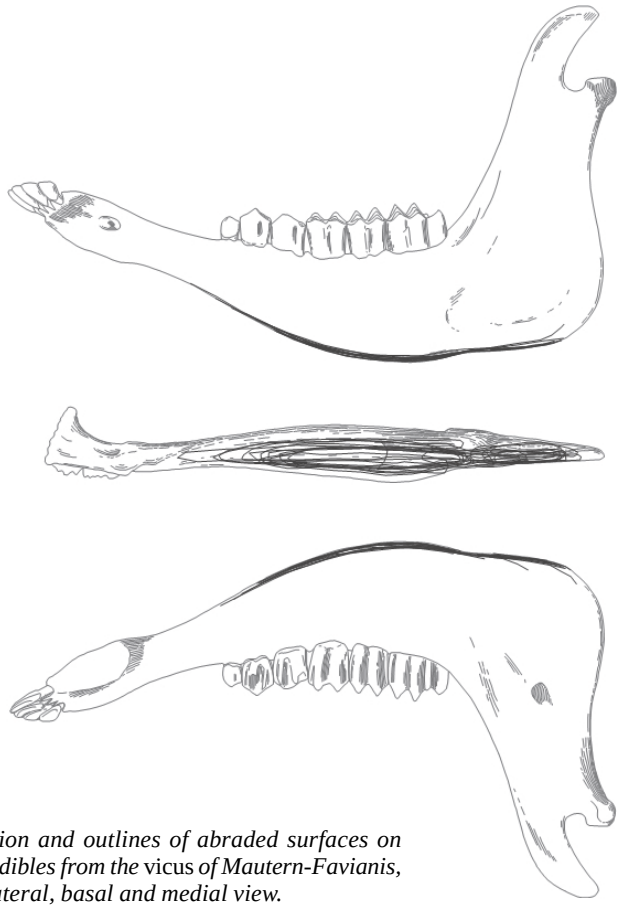

Fig. 4. *Distribution and outlines of abraded surfaces on twelve cattle mandibles from the* vicus *of Mautern-Favianis, superimposed; lateral, basal and medial view.*

The final stage shows such highly abraded bases, that the marrow cavity becomes exposed. Up to now this stage has only been observed in one site in Switzerland (Oberwinterthur). Even at this stage the abrasions are solely restricted to the middle and posterior part of the corpus base and the angular part of the ramus. The diastema is hardly ever affected by alterations, except in heavily used mandibles where a light polish can be observed.

In most cases, the preservation conditions of the bone surfaces allow for an identification of the microwear of the abraded areas. These tend to be densely covered with fine striations, usually already visible to the naked eye and exhibiting a more or less pronounced preferred orientation (Figs. 5, 6). By and large, they run parallel to the longitudinal axis of the mandible, or rather slightly diagonally, from laterally/orally to medially/aborally. However, random scratches or groups of differently, even transversally directed marks are common. Apparently, a more stable orientation pattern becomes established after prolonged use. Altogether, there seems to be less uniformity regarding a strictly longitudinal orientation than in bone skates (MacGregor 1985, Fig. 75), and the fineness of the wear marks may differ considerably. Both polish and scratchmarks may extend to surface areas outside of the abraded areas. Most commonly, the protruding parts of the medial and lateral sides of the basal corpus and sometimes of the diastema are slightly polished. The exact assessment of the distribution of the polish is largely dependent on the general preservation conditions of the bones. The relationship between the intensity of basal wear and the distribution of polish may vary: there are specimens with overall polish and only initial signs of abrasion on the base, and *vice versa.*

Fig. 5. *Detail of the basal corpus area of a cattle mandible from Mautern-Favianis, initial stage of wear (topmost specimen from Fig. 2); although the main direction of the striations is longitudinal, there are also some transversal marks; length of bone area in the picture about 20 mm (photo Ch. Baal).*

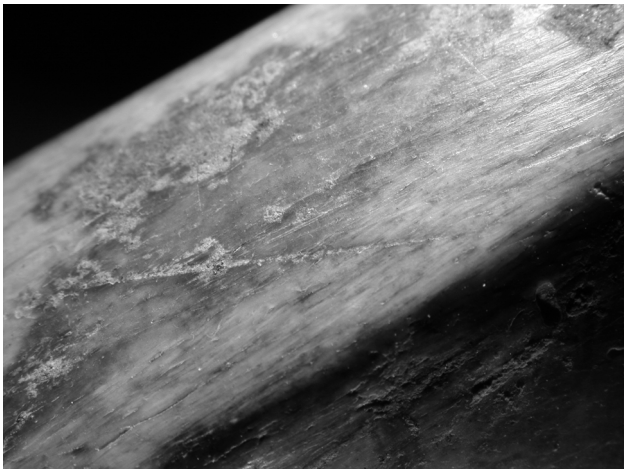

Fig. 6. *Detail of the basal corpus area of a cattle mandible from Mautern-Favianis, advanced stage of wear; main direction of striations longitudinal, some irregular scratchmarks; breadth of abraded surface about 13 mm (photo Ch. Baal).*

Geographical and chronological distribution

Because the traces of use-wear can be easily overlooked when in their first stages, a distribution of the mandible artefacts is difficult to assess. As already mentioned before, for many years these artefacts were only found in Switzerland (Fig. 7). Up to now only one site in Lower Austria is known to have yielded the same type of artefact (Fig. 8).

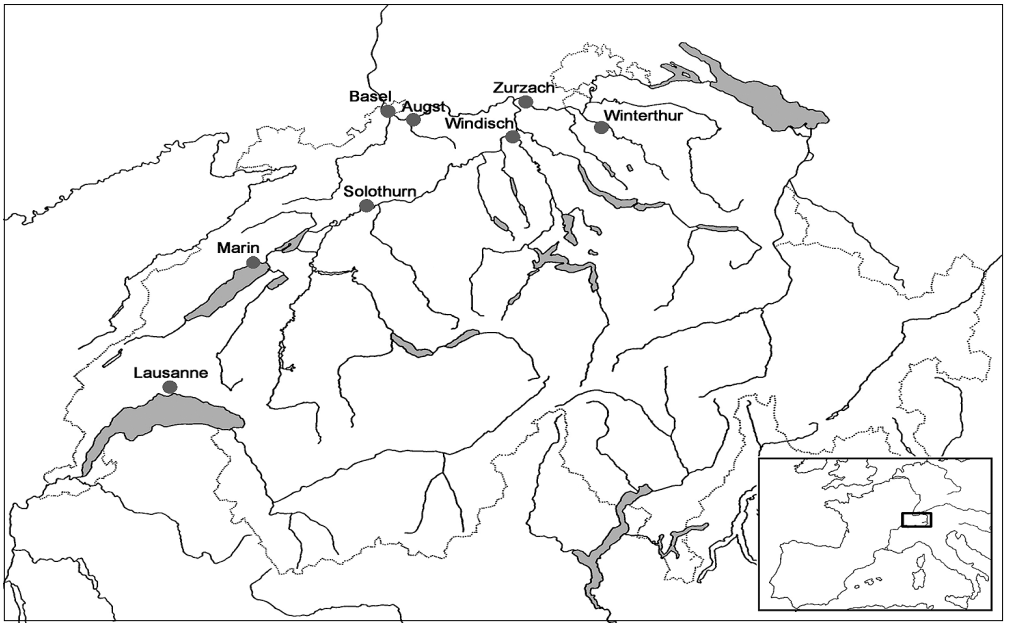

Fig. 7. *Late Iron Age and Roman time sites in Switzerland with cattle mandibles displaying alterations on the base (for details see Table).*

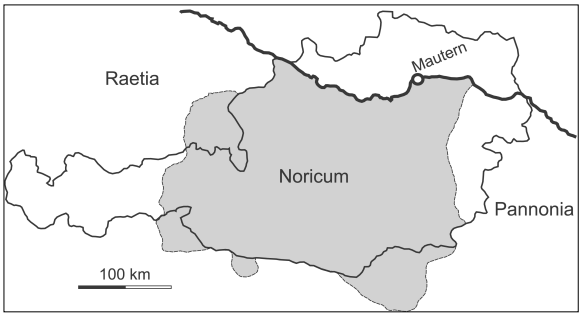

Fig. 8. *Map of Austria in the 2nd century AD with the location of Mautern-Favianis; shaded area – province of Noricum; thick line – river Danube.*

In Switzerland the mandible artefacts are present in the archaeological material from the Late Iron Age onwards (ca. 150 BC) and can be found till the end of the 1st century AD, maybe even later (Table). Their main occurrence in Mautern-Favianis (A) is during the 1st and 2nd century AD.

In most of the sites the mandible artefacts are only represented by single finds, but in the late Iron Age settlement of Basel-Gasfabrik their proportion is more than 5% of all the cattle mandibles, in Oberwinterthur there are nearly 4%.

Table. *Late Iron Age and Roman sites from Switzerland and Austria with used cattle mandibles.*

Site	Dating	Type	n cattle mandible artefacts	Literature
Basel-Gasfabrik (CH, BS)	150–80/70 BC	settlement (pits)	141	Stopp, unpublished
Marin-les-Bourgignonne (CH, NE)	Lt D1	*"enceinte quadrangulaire"* (ditch)	10 (+ 1 Equid)	Reynaud, unpublished
Basel-Münsterhügel (CH, BS)	60/70–20 BC 20 BC–20 AD	settlement (street) settlement (street)	2 2	Stopp, unpublished
Windisch-Breite (CH, AG)	25 BC–40 AD	*castrum*	4 (+ 1 Equid)	Pfäffli & Schibler 2003
Zurzach (CH, AG)	0–50 AD	*castellum* or *vicus*	1 (Equid)	Morel 1994
Augst (CH, BL)	40/50–70 AD	town (*insula*)	2	Breuer, unpublished
Solothurn-Vigier (CH, SO)	1st c. AD	*vicus*	1	Breuer, unpublished
Lausanne-Vidy (CH, VD)	1st c. AD?	*vicus*	1	Anderes, pers. comm.
Oberwinterthur-Unteres Bühl (CH, ZH)	1st–3rd c. AD	*vicus* (pits, ditches, layers)	53 (+ 1 Mule)	Morel 1991
Mautern (Lower Austria)	1st – 4th c. AD	*vicus* (pits, ditches, house foundations)	ca 70 (+1 Pig)	Kunst in preparation

Interpretation

The uniformity of the marks observed both on Swiss and Austrian mandibles, regardless of their chronological affiliation, strongly suggests a common interpretation. The main arguments are the consistency observed in the choice of anatomical elements and species and in the location of the abraded surfaces on the mandibular bases. There is no doubt that these abrasions resulted from the repeated friction of the mandibles against some kind of surface. Philippe Morel, who first discovered these artefacts in Oberwinterthur (CH), wrote that the common interpretation for this type of alterations was either their use as skates or sledge runners or in the tanning trade as scrapers of some sort. Morel excluded their use as skates or sledge runners. His arguments were that first the abraded surface was never flat (as in the radii and metapodials used as skates) but always remained convex. Secondly the abrasion traces were displayed in two main directions, straight and angled, whereas in skates or sledge runners one would only find them straight or angled (MacGregor 1985, Fig. 75). An assumption is made that the mandibles could have been used by hornworkers to flatten the horn.

Bone skates and sledge runners made of horse or cattle radii and metapodials are quite well known, especially from medieval times (e.g. MacGregor 1985, 141 ff.; Becker 1990). In places such as Eastern and Northern Europe, long bone skates and sledge runners were even used up to modern times (e.g. Balfour 1898; Herman 1902). But occurences of the use of mandibles are rare, the best known examples are probably the ones displayed on paintings by Pieter Brueghel the Elder from the 16th century.

The archaeological record for these so-called jaw-bone sledges is scant, and they were all made from equid mandibles. Few are known from medieval or post-medieval contexts from Britain and the Netherlands (Ijzereef 1974; MacGregor 1985, 144 ff.; Albarella *et al.* 1997), and a singular find is known from a Late Neolithic pit from Lower Bavaria (Germany; Kunst 2001). For this latter specimen, however, a radiocarbon determination is not yet available.

The use of cattle mandibles for similar purposes is only known from ethnographical sources from the 19th century. Virchow (1887) mentions their use in the former Prussian provinces of Brandenburg and Pomerania and depicts one example from the region between Arnswalde/ Choszczno and Pyritz/Pyrzyce, now in the West Pomeranian Voivodship (Poland; Fig. 9, left). Herman (1902, Fig. 146; Fig. 9, right) provides a further picture of a sledge made from a pair of cattle mandibles from Arnswalde ("*Arnswalder Kieferschlitten*"), but it remains unclear if it is meant to be an original drawing (of the same object?) or a modified replica from a different angle after Virchow's figure. In Virchow's drawing two cattle hemi-mandibles are nailed or pegged in an upright position onto two opposing sides of a wooden board, with the mandible bases working as sledge runners. Virchow states that the smooth and slightly curved bases of the mandibles were used in order to reduce friction when these somewhat clumsy objects were moved across snow or ice.

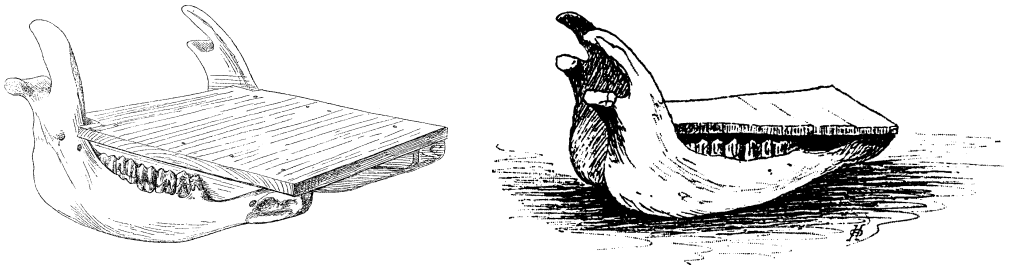

Fig. 9. *The Arnswalde sledge after Virchow (1887), left, and Herman (1902), right.*

Neither Virchow nor Herman provide data on the wear marks of the cattle mandibles used, but it can be guessed that abrasion must have been rather regular on fixed objects like these. The issue of regularity of the abraded surfaces, being one of Morel's main arguments against the interpretation of the cattle mandibles from Oberwinterthur as sledge runners, deserves some further discussion. Obviously, it is omnipresent on equid jaw-bone sledges, but only exceptionally so on the cattle mandibles from Mautern, Basel and the other Swiss sites. Certainly, anatomy dictates the shape of the artefacts. Compared with bovines, the base of an equid mandibular corpus appears straight and regular in its oral section and concave in the aboral part, owing to the development of the angular corner. Furthermore, in adult equids, both hemi-mandibles are fused in the symphysis, whereas they remain only loosely connected in ruminants and will separate after maceration. A pair of equid mandibles, therefore, is provided with an innate stability that keeps it in a fixed position on any flat surface. A load put on this sort of sledge was evenly distributed across the whole length of the bone. If moved across the ground, the wear pattern on its base will develop in a regular and predictable way. Similar conditions are found in pigs, and indeed, the only worked pig mandible from Mautern presents a rather evenly abraded base. On the other hand, ruminant hemi-mandibles, even if strictly tied together in their symphysis, do not represent a very stable entity unless their convex base is artificially flattened or some constructive elements (like in the Arnswalde sledge) are added. Due to the more curved anatomy of the base of

cattle mandibles, the main load was resting upon the aboral two thirds of the bone, leaving the oral part with the diastema and the symphysis largely unaffected by any abrasions. The frequent fracturing of the angular corner points in a similar direction. This section of the *Margo ventralis* would be most prone to damage during use if the oral part of the mandible is lifted up. It is also rather thin-walled. The distribution of the abraded surfaces beneath the toothrow and on the angular area is the most consistent feature of our material (Fig. 4), and we suggest that these objects were pulled across the ground, at least sometimes tied together in anatomical pairs at the symphysis, with a traction rope attached at the same spot. This would keep the oral parts of the mandibles constantly above the ground. As the mandibles exhibit no really conclusive marks indicating the presence of additional stabilizing devices (such as transverse holes in the rami or corpora), these makeshift sledges were probably of a rather unstable design. The hemi-mandibles would be in a constant jerking and rocking movement, especially when pulled across an uneven surface. It would be expected that the wear pattern on the base would develop in an irregular fashion initially and only become stabilized after prolonged use. The accompanying polish, which extends in heavier used specimens up the sides of the corpora, can also be found on sledge runners and skates made of long bones.

Our knowledge of the microwear of the abraded surfaces is still incomplete and needs further study, but the results obtained so far are not at odds with the interpretation suggested above. The slightly oblique directions of the striations present in many specimens was also observed on the horse mandible from Dordrecht (Ijzereef 1974) and may be a simple consequence of the mandibles having been used as anatomical pairs: scratchmarks, then, would not appear in a strictly longitudinal direction of the mandible, but cut it at an acute angle from buccal/oral to lingual/aboral.[1] Irregular scratch marks are easily explained by actions such as braking or redirecting the sledge, and differences in fineness and density of the striations may simply be related to variations in the surface across which these objects were moved. Apart from snow and ice, sledges like these could as well have been used on grass or even on dry ground, depending on the type and weight of the load.

On the basis of these arguments, we propose that cattle mandibles with the basal abrasions described above were used as sledge runners. But there is further research necessary on this subject (e.g. microwear). There is also the question of reconstructing sledges, using different methods of attachment.

Worked mandibles found as anatomical pairs indicate that different types of fastening may have been used. Apart from small sledges of the Arnswalde type, constructed with single pairs, it is also conceivable that several mandibles were arranged in one row, in a catamaran fashion, as suggested by Ijzereef (1974).

Leaving the technical details, the function of these sledges, most of all the objects eventually transported by them, remains obscure. If they are not simply explained as childrens' playthings, light but bulky materials like hay, chaff or twigs could be regarded as a potential load.

Finally, some more clues may be provided by contextual information from the archaeological sites. Two of the sites shall be cited as examples here: The Late Iron Age settlement of Basel-Gasfabrik as the oldest site and currently the one with the most finds and the Roman *vicus* of Mautern-Favianis as the youngest one and the one with the second most finds.

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[1] In horse mandibles used as single pairs, the amount of deviation should be around 7,5°, equalling the angle between one hemi-mandible and the centre-line (Ijzereef 1974, 183).

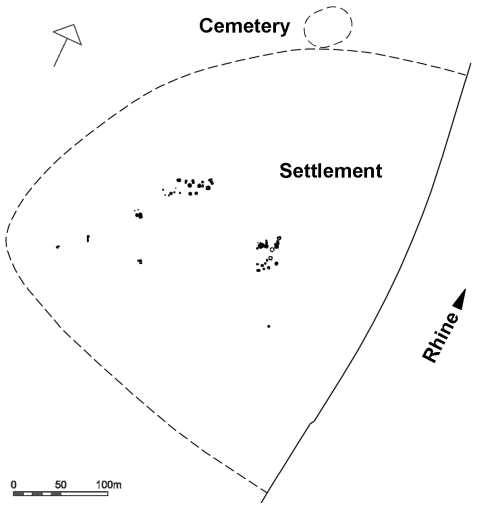

Fig. 10. *The Late Iron Age settlement of Basel-Gasfabrik. Dotted lines: boundary of the settlement and the cemetery; black dots: archaeozoologically analysed pits (D. Miesch, Archäologische Bodenforschung Basel-Stadt).*

Fig. 11. *Both halves of a Late Iron Age cattle mandible with alterations of the base from Basel-Gasfabrik. The ascending rami were broken away and display rounded edges (photo B. Stopp).*

Basel-Gasfabrik

The Late Iron Age settlement of Basel-Gasfabrik, which dates from c. 150 to 80/70 BC, is situated on the left bank of the river Rhine, less than 2 km from Basel's modern city centre in the north-west of Switzerland (Kamber *et al*. 2002). The unfortified settlement with a small cemetery to its north, occupied an area of about 15 hectares (Fig. 10). To date, the settlement is essentially represented by more than 350 pits. Other archaeological structures, such as cultural layers and postholes of houses, are rare. The original function of the pits is unknown. Very diverse in shape and depth, they are thought to be either former storage- (cellars, silos) or workplaces (smithy). After being abandoned they were refilled. Apart from sediments of different origins, the pits contain kitchen refuse and potsherds, parts of house structures and the remains of craftsmen's activities. Although there is a cemetery nearby, in many of the pits, fragments of human bones are found, some of the pits even contain a number of human skeletons.

In 31 out of the 55 archaeozoologically analysed structures, mostly pits, 141 cattle mandibles or fragments thereof with alterations of the base were found. This equals a proportion of 5.4% of all cattle mandibles. For the following analysis only the most complete mandibles, 83 in all, were chosen.

There is no preference for either the left or the right side to be observed. 39 (47%) of the 83 mandibles belong to 21 pairs (Fig. 11). The high proportion of pairs, which is matched at no other site is possibly due to the fact that nearly all of the finds are from pits. If both halves of the mandibles were not only used but also discarded together, the chances of finding both halves in pits is higher than in cultural layers, where disturbances occur more often. Most of the mandibles are from adult animals, only 5 (6%) are from young ones.[2] About 60% of the mandibles bear "butchering" marks. The high proportion is not astonishing, since the

[2] The average proportion of young cattle in Basel-Gasfabrik is around 13%.

mandibles had to be defleshed in order to be used. On 18% of the broken off rami rounded edges can be observed, which proves their ongoing utilisation after the breakage. But it is inconclusive whether it was an ongoing use because of, or despite the breakage. Since most of the mandibles were obviously thrown away as soon as the break occurred, the latter is more probable.

Being by far the largest settlement of the region in the Late Iron Age, Basel-Gasfabrik held an important position in regional trade and handcraft production. Farming, except grassland management used for making hay,[3] probably played a minor role and a lot of the foodstuffs, especially cereals and even some of the animals, had to be imported from the surrounding villages and farmsteads. The location of the settlement on the riverbank and imported products such as amphorae also provide evidence of trading with regions farther away, maybe even the presence of a reloading point or staging post. All this might be an indication as to the potential load of the sledges (bringing in hay?) or why a lot of them were needed (transport of wares over relatively short distances?).

Mautern-Favianis

Mautern-Favianis is located in central Lower Austria, about 600 km to the east of the Swiss site. In the second half of the 1st century AD, a Roman auxiliary fort was erected on the southern, right-hand shore of the river Danube, close to the lower entrance of the narrow Wachau valley. This fort formed part of the so-called Danubian limes in the province of Noricum, a system of defensive structures along the northern border of the Roman empire, coinciding here with the river Danube and extending into the provinces of Pannonia to the east and of Raetia to the west (Fig. 8; Gassner *et al.* 2002). A summary of earlier investigations and a detailed site-report of excavations inside the fort and discussion of its chronology have been published recently (Gassner *et al.* 2000; Groh & Sedlmayer 2002). From the end of the 1st century AD onwards, a civilian settlement/*vicus* developed to the west, south and east of the fort. It was inhabited by a highly Romanized population supplying the local army unit through livestock-breeding, agriculture and specialized crafts like pottery and some metal, textile, bone and antler working. The material discussed here is from extensive rescue excavations carried out from 1997–1999 in the eastern *vicus* area, yielding over 3000 archaeological features and huge amounts of potsherds, animal bones and other kinds of objects. Only deep and sunken structures survived, including the foundations of wooden buildings, sunken huts, pits, wells, latrines and fence ditches. Six phases from the 1st century AD until AD 450 could be discerned (Groh & Sedlmayer in preparation). Faunal remains have been analyzed from selected contexts only, but all the material has been checked for worked specimens. Worked mandibles occur throughout phases 1 to 5, but the majority seem to belong to the earlier periods of occupation (second half of 1st and first half 2nd century AD). Apart from one pair of pig mandibles, they are all from cattle, 35 left and 30 right hemi-mandibles, including all types of fragments. Most of them can be attributed to adult specimens, but 4 are from mature subadults with some milk dentition still present. There are only 4 to 5 matching pairs. In the course of the present investigations, four worked cattle mandibles, including one pair, could be identified from the animal bone material of a single closed context from the southern *vicus* area, a cellar backfilled in the 2nd century AD (Adam 2001, 62 ff.).

It is clear from the archaeozoological material that cattle carcasses were regularly processed in the *vicus*, probably also as part of the smoking or salting processes. This activity would provide a constant amount of waste parts like mandibles, making them available for an opportunistic usage as artefacts. Although residuality may be an issue, the long-term use of these artefacts can be traced over a period of more than two hundred years.

[3] This activity is indicated by the archaeobotanical results (Stopp *et al.* 1999).

References

Adam, A. 2001. Tierknochen. – St. Groh. Die Grabung 1998 im Kastellvicus Süd von Mautern an der Donau/Favianis. Ergänzungshefte zu den Jahresheften des Österreichischen Archäologischen Institutes, 1. Wien, 62–84.

Albarella, U., Beech, M. & Mulville, J. 1996. The Saxon, Medieval and Post-Medieval Mammal and Bird Bones Excavated 1989–1991 from Castle Mall, Norwich, Norfolk. Ancient Monuments Laboratory Report, 72/97.

Balfour, H. 1898. Sledges with bone runners in modern use. – The Reliquary and Illustrated Archaeologist, 4, 242–254.

Becker, C. 1990. Bemerkungen über Schlittknochen, Knochenkufen und ähnliche Artefakte, unter besonderer Berücksichtigung der Funde aus Berlin-Spandau. – J. Schibler, J. Sedlmeier & H. Spycher (eds.). Festschrift für Hans R. Stampfli. Beiträge zur Archäozoologie, Archäologie, Anthropologie, Geologie und Paläontologie. Basel, 19–30.

Gassner, V., Groh, St., Jilek, S., Kaltenberger, A., Pietsch, W., Sauer, R., Stiglitz, H. & Zabehlitzky, H. 2000. Das Kastell Mautern-Favianis. Der Römische Limes in Österreich, 39. Wien.

Gassner, V., Jilek, S. & Ladstätter, S. 2002. Am Rande des Reiches. Die Römer in Österreich. Österreichische Geschichte 15 v.Chr. – 378 n.Chr. Ueberreuter. Wien.

Groh, St. & Sedlmayer, H. 2002. Forschungen im Kastell Mautern-Favianis. Die Grabungen der Jahre 1996 und 1997. Der Römische Limes in Österreich, 42. Wien.

Groh, St. & Sedlmayer, H. in preparation. Forschungen im Vicus Ost von Mautern-Favianis. Die Grabungen der Jahre 1997–1999. Der Römische Limes in Österreich. Wien.

Herman, O. 1902. Knochenschlittschuh, Knochenkufe, Knochenkeitel. Ein Beitrag zur näheren Kenntnis der prähistorischen Langknochenfunde. – Mitteilungen der Anthropologischen Gesellschaft in Wien, 32, 217–238.

Ijzereef, G. 1974. A medieval jaw-sledge from Dordrecht. – Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek, 24. Amersfoort, 181–184.

Kamber, P., Hecht, Y., Spichtig, N. & Rissanen, H. 2002. Stadt der Kelten. Geschichten aus dem Untergrund (Ausstellungskatalog). Schriften des Historischen Museums Basel, 13. Basel.

Kunst, G. K. 2001. Die Tierreste von Pilsting-Ganacker (Die Tierreste aus der jungneolithischen Grube in der der Trasse der B20 bei Ganacker, Gemeinde Pilsting.). – Archäologie im Landkreis Dingolfing-Landau, 1. Dingolfing-Landau, 282–316.

Kunst, G. K. in preparation. Zoologie. – St. Groh. & H. Sedlmayer in preparation.

MacGregor, A. 1985. Bone, Antler, Ivory and Horn. The Technology of Skeletal Materials Since the Roman Period. London.

Morel, Ph. 1991. Untersuchung des osteologischen Fundgutes aus dem *vicus* Vitudurum-Oberwinterthur. – H. F. Etter, R. Fellmann Brogli, R. Fellmann, St. Martin-Kilcher, Ph. Morel & A. Rast (eds.). Beiträge zum römischen Oberwinterthur – Vitudurum 5. Berichte der Zürcher Denkmalpflege, Archäologische Monographien, 10. Zürich, 79–176.

Morel, Ph. 1994. Die Tierknochenfunde aus dem Vicus und den Kastellen. – R. Hänggi, C. Doswald & K. Roth-Rübi (eds.). Die frühen römischen Kastelle und der Kastell-Vicus von Tenedo-Zurzach. Veröffentlichungen der Gesellschaft pro Vindonissa, XI, 395–410.

Pfäffli, B. & Schibler, J. 2003. Appetit auf Fleisch: Ein Schlüssel zur sozialen und kulturellen Gliederung – Die Grosstierreste. – A. Hagendorn, H. W. Doppler, A. Huber, H. Hüster Plogmann, S. Jacomet, Ch. Meyer-Freuler, B. Pfäffli & J. Schibler (eds.). Zur Frühzeit von Vindonissa. Auswertung der Holzbauten der Grabung Windisch-Breite 1996–1998. Veröffentlichungen der Gesellschaft pro Vindonissa, XVIII: 1–2, 244–279; 493–499.

Stopp, B., Iseli, M. & Jacomet, S. 1999. Die Landwirtschaft der späten Eisenzeit. Archäobiologische Überlegungen am Beispiel der spätlatènezeitlichen Siedlung Basel-Gasfabrik. – Archäologie der Schweiz, 22: 1, 27–30.

Virchow, R. 1887. Einige Ueberlebsel in pommerschen Gebräuchen. – Verhandlungen der Berliner Anthropologischen Gesellschaft (Zeitschrift für Ethnologie), 19, 361–362.