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The Upper Pleistocene Tracksite Bottrop-Welheim (Germany)

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Abstract: On the lower terraces of the Emscher river near Bottrop, a vertebrate tracksite was discovered and preserved as epoxy resin casts. The horizon with the footprints is attributed to the middle Weichselian. Roughly 600 footprints cover the cast section of about 150 m^2. From these, 30 trackways with three or more footprints could be reconstructed. Sixteen trackways represent *Rangifer tarandus,* and 12 are from large herbivores, mainly bovids. Of special interest are the two trackways of *Canis lupus* and *Panthera leo spelaea. Anser* sp. is the only bird represented. Using biomechanical equations developed for dinosaurs, stride length can be used to estimate the travelling speed of the trackmakers. All of the animals were moving at a modest pace. This suggests that the carnivores crossed the site at different times than the herbivores. The time represented by the tracksite is very short, and more likely may be counted in days than in weeks. Nevertheless, different preservation types of the tracks indicate small-scale variations in the water content of the sediment, as well as a progressive drying-up of the site.

Key words: Upper Pleistocene, footprints, trackways.

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I. INTRODUCTION

Pleistocene flood plain deposits are very widespread in Central Europe. Especially when medium to coarse sands alternate with muddy sediments, the deposits have a great potential for preserving the footprints of mammals and birds as well as those of larger reptiles, if present in the area. However, as Pleistocene flood plain deposits are not usually indurated sandstones or silt stones, footprints are only occasionally observed. Such unconsolidated deposits are preferentially studied in vertical sections, and it is rather unlikely that footprints or trackways are detected in this view. If unconsolidated deposits are exposed horizontally – as was the case in Bottrop-Welheim – impressive ichnological documents of the Pleistocene fauna may be discovered.

Only two other Pleistocene tracksites from similar unconsolidated river deposits are known to us. EBNER & GRÄF (1978) describe and figure some isolated footprints representing a large bovid and most probably a horse from a river terrace at Mutzenbach near Graz in Austria. Only a very limited horizontal area was exposed, so that the information content of this tracksite is very restricted. Its age is belived to be Late Pleistocene to Early Holocene.

SUTCLIFFE (1985) mentioned the discovery of a great number of footprints in a loamy layer of the Lower Gravel at Swanscombe, east of London. The site is famous for its rich Middle Pleistocene fauna, human remains, and artifacts. The footprints represent deer, horses, a large bovid, most probably rhinos, and a straight-tusked elephant. The site represents a trampling horizon from which only isolated footprints but no continuous trackways could be identified. Part of the trampling horizon was also cast, but has not been described in detail.

In contrast to these two sites, about 150 m^2 were exposed at Bottrop-Welheim and are now preserved as epoxy resin casts in the Museum für Ur- und Ortsgeschichte Qvadrat in Bottrop. Among the 600 footprints representing 5 mammal species and one bird, at least 30 trackways with more than 3 footprints could be identified. Of particular biological interest is the co-occurrence of herbivores and carnivores at the tracksite.

A c k n o w l e d g m e n t s . The excavation and casting of the Bottrop-Welheim tracksite was supported financially by the Landesdenkmalamt Nordrhein-Westfalen. However, the project would not have been possible without the generous support of Bakelite Gesellschaft Inc. of Duisburg and the volunteers from the Höhere Berufsfachschule für präparationstechnische Assistenten in Bochum. Thanks for the execution of the finished artwork should go to D. LAUBENSTEIN, Münster, and D. KRANZ, Bonn.

II. LOCALITY AND STRATIGRAPHIC POSITION

Bottrop-Welheim is situated in the valley of the Emscher river, a tributary of the Rhine at the northern margin of the Ruhr district. During the excavation of a new settling pond for a water treatment plant near the river bank, the deposits of the lower terrace (N i e d e r t e r r a s s e) were exposed horizontally and almost parallel to the bedding plane. The slight dip of the N i e d e r t e r r a s s e beds was caused by tectonic movements due to coal mining in the Carboniferous bedrock.

On visiting the construction site in February 1992, one of the authors (M. W.) noticed sandy patches arranged in a double row on a loamy surface. After cleaning away the sand, he discovered the deeply impressed footprints of a lion. Subsequently, more than 150m^2 of this horizon could be exposed, covered with footprints of different preservation types. In a major field effort, the Museum Quadrat at Bottrop was able to cast of most of the site. The procedure is described in detail by M. WALDERS (in KOENIGSWALD et al. 1995). Although the site itself soon was destroyed by ongoing construction, the casts could be mapped and interpreted in detail.

Based on geomorphological arguments, the lower terrace of the Emscher river is generally believed to have been deposited during the last glaciation (Weichsel). This terrace consists of several discrete stratigraphic units which can be dated biostratigraphically with the aid of the rich bone fauna collected from the area (KOENIGSWALD & WALDERS 1995).

The lowermost unit is called the K n o c h e n k i e s (gravel with bones). The mammalian fauna from this horizon contains some elements clearly attributable to the last interglacial period (e. g., *Stephanorhinus kirchbergensis* and *Capreolus capreolus*), but the majority of taxa are indicative of the last glaciation (*Mammuthus primigenius*, *Coelodonta antiquitatis*, *Megaloceros giganteus* and *Ovibos moschatus*, to name but a few). The occurrence of *Equus hydruntinus* indicates that at least some parts of the K n o c h e n k i e s were deposited in the early part of the Weichselian.

The K n o c h e n k i e s is overlain by the S c h n e c k e n s a n d e (sands with gastropods). In the past, finds from these two units were often not kept separated from one another. However, the construction site at the Bottrop-Welheim water treatment plant yielded a limited but significant fauna from the S c h n e c k e n s a n d e. The mammal fauna contains only species typical of a cold environment. *Crocuta crocuta spelaea* is represented by chewing marks on the scapula of a *Mammuthus primigenius*. In Central Europe, *Crocuta* is only present in faunas older than the maximum ice advance of the Weichselian (KOENIGSWALD & HEINRICH in prep.), indicating that the Schneckensande most probably were deposited during the middle Weichselian.

This unit in turn is covered by sediments of the Periglaziale Lössaue (periglacial flood plain deposits with loess), a sequence of muddy and sandy layers. The track horizon was discovered in one of the lowermost muddy layers of this unit. The species inventory of the tracksite indicates a cold environment as well.

The next younger biostratigraphic markers were available in a small peat deposit intercalated between the Kreuzgeschichtete Talsande (crossbedded river sands) overlying the Periglaziale Lössaue and the Ebengeschichtete Talsande (horizontally bedded river sands). The pollen spectrum of this peat is indicative of the Allerød phase of the late Weichselian (BUDDE & STEUSLOFF 1951).

It is difficult to decide whether the tracksite represents a time interval before or after the Weichselian glacial maximum. However, based on the occurrence of *Crocuta* immediately below the track horizon, we argue for a middle Weichselian age. Extensive thermoluminescence dating of the tracksite sediments by FRECHEN (1995) indicate a maximum age of 42 to 35 ka, corroborating the middle Weichselian age of the track-bearing horizon.

III. PRESERVATION OF THE FOOTPRINTS

The footprints are preserved differently, depending on the water content of the ground and the weight of the trackmakers (Fig. 1). Based on the depth of the impression and the preservation of the details of the soles, five different types were distinguished that indicate increasing dryness of the substrate (from type 1 to type 5, Fig. 2). Since some trackways vary in the type of preservation, wet and drier parts within the cast section of the tracksite can be mapped (KOENIGSWALD et al. 1995).

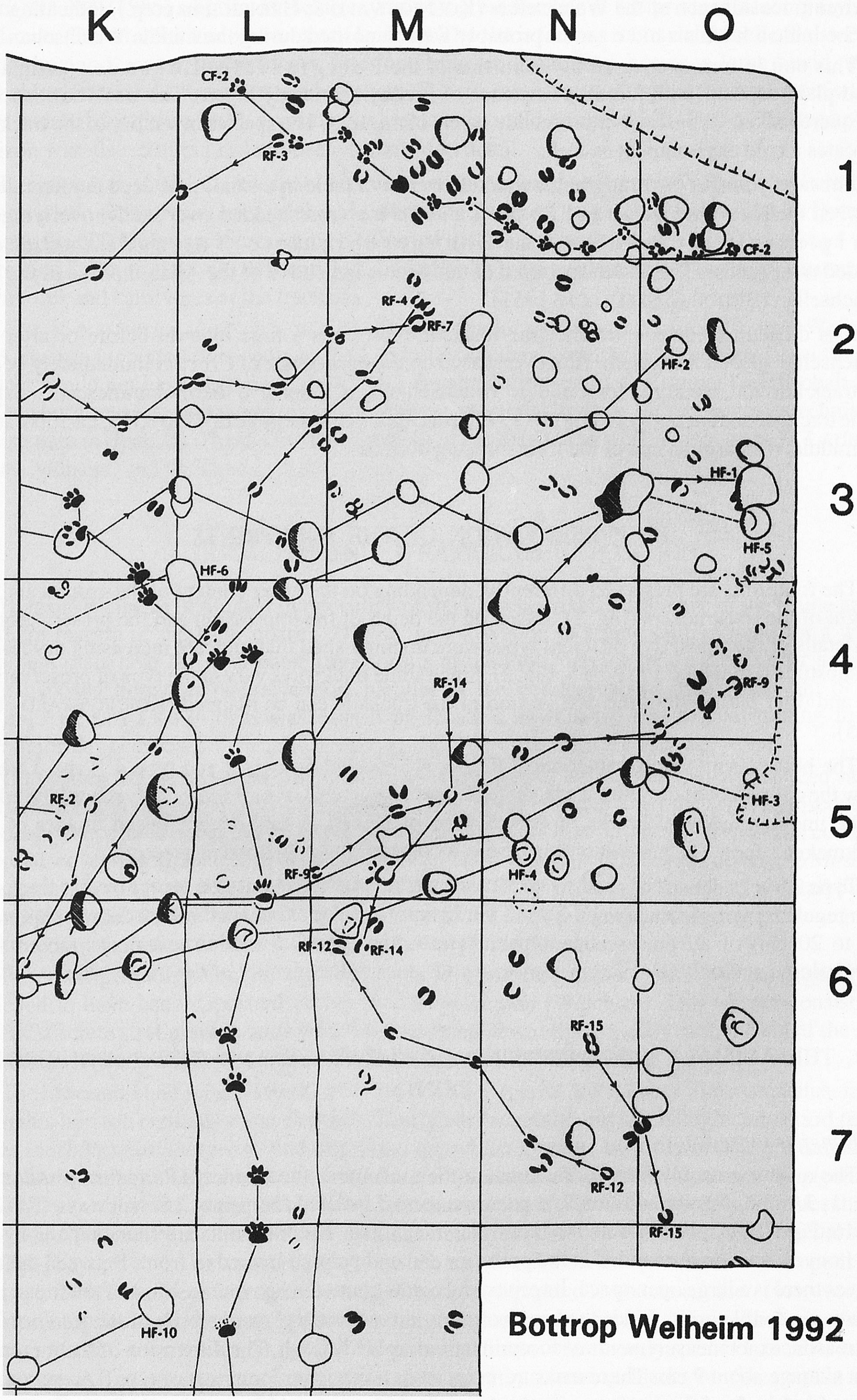
The best preservation of anatomical details is provided by type 3 and type 4. Type 3 tracks show the entire foot of the animal as a shallow impression while type 4 tracks only record the edges of the ungulate hooves. Tracks of type 5 were preserved as faithful but raised images of the trackmaker's foot. The genesis of this type is incompletely understood at present.

Type 1 tracks consist of shallow circular depressions that can only be recognized as tracks by their regular spacing in trackways. Type 2 tracks are also circular but are the most deeply impressed (up to 20 cm) of all preservation types. Type 1 and type 2 tracks almost never record foot morphology, and only trackway parameters give clues to the identity of the trackmaker.

IV. THE ANIMALS REPRESENTED BY TRACKWAYS AND INDIVIDUAL FOOTPRINTS

Rangifer tarandus

The most commonly identified animal at the tracksite is the reindeer (*Rangifer tarandus* L.) (Fig. 1, 3A, 3D, 4B). In addition to a great number of isolated footprints, 16 trackways (RF-1 to RF-16; Fig. 4B) can be attributed to this Holarctic animal. The footprints are characterized by the two hooves, which are rounded at the posterior end and pointed inward in front. Between the two hooves there is a large open space. Imprints of the dew claws are not visible. Most of the footprints, in fact, are double prints, since the hindfoot steps almost exactly into the print of the forefoot. For this reason, exact measurements of footprint size may be difficult. The dimension of the footprints is on average about 9 cm. These measurements were taken from footprints of type 3 preservation. The stride length of the trackways varies between 100 cm and 120 cm (Fig. 5). One presumably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Bottrop Welheim 1992

juvenile individual (Fig. 3D) has a stride length of 85 cm. The gait recorded in the *Rangifer* trackways is discussed below.

Bos or *Bison*

A much larger artiodactyl than the reindeer is represented by two trackways (Fig. 3E, 4A) (BF-1 and BF-2). The hooves that made these footprints were not only wider (about 12 cm) and longer, but also not turned in. The space enclosed between the two hooves is also much smaller than in *Rangifer*. This shape is typical for bovids and differs from cervids of the same size, such as *Megaloceros* and *Alces*, in the blunt tip and relatively wider hooves. Cervid prints are more slender with the anterior half of each hoof tapering to a point. However, a distinction between *Bos* and *Bison* is not possible from the Bottrop trackways, if at all. Both trackways commence with type 5 preservation and later change to type 4.

Large herbivores

Ten trackways (HF-1 to HF-10, Fig. 4A), often crossing most of the area, are preserved as type 1 and type 2, i. e., shallow circular imprints and deep circular imprints (Fig. 1). These types of preservation make identification of the trackmaker very difficult. However, stride length and track width are very suggestive of large bovids and horses. The values for the HF trackways (stride length between 130 cm and 195 cm, track width between 20 cm and 40 cm) are distinctly higher than those for the reindeer trackways. One footprint in trackway HF-1 shows probable dew claw marks, suggesting that this trackway originates from a large bovid.

?*Equus* sp.

Two trackways of the large herbivore group (HF-5 and HF-6, Fig. 4A) are tentatively attributed to horses. In one footprint of HF-5, the anterior part of a hoof is imprinted, showing an uninterrupted edge which looks more like the single hoof of a horse than the cloven hooves of a bovid. Trackway HF-6 is closely parallel to HF-5 (Fig. 4A), and stride length and footprint spacing are very similar in both. Apparently, the makers of these trackways progressed simultaneously, close to each other, and in the same direction, suggesting that they belonged to the same species, *Equus* sp.

Canis lupus

The short but well preserved trackway of a large canid crosses the northern corner of the tracksite (Fig. 1). Identification as a canid is based on the morphology of the interdigital pad and the large space between it and the toe pads (Fig. 3B). This large space, as well as the angle of divergence of the middle toes (about 20), indicates that the tracks were made by a wolf (*Canis lupus*) and not a domestic dog. Domestic dogs have essentially parallel middle toes. The size of the footprints (9-10 cm long and 6-8 cm wide) is also suggestive of a wolf, as this is very large, even exceeding that of modern wolves.

The gait of the animal is difficult to determine because fore- and hindfoot prints cannot be separated with certainty. However, the close and even spacing of the tracks suggests a relatively slow gait.

Panthera leo spelaea

The most significant find and the one that prompted the detailed excavation and casting of the tracksite is that of a lion trackway (Fig. 1, 3C and 4B). The trackway crosses the entire tracksite, initially in a northwesterly direction which later changes to westward. The trackway is very long and represents 33 footfalls, although two of these are not preserved.

Fig. 1. A representative section of the Upper Pleistocene tracksite of Bottrop-Welheim. In addition to the trackways, numerous isolated footprints, mainly of *Rangifer*, can be observed. Footprints of type 3 and type 4 preservation show a clear image of the maker's foot, while footprints in type 1 and type 2 preservation are shallow to deep depressions which appear as rounded outlines on this map.

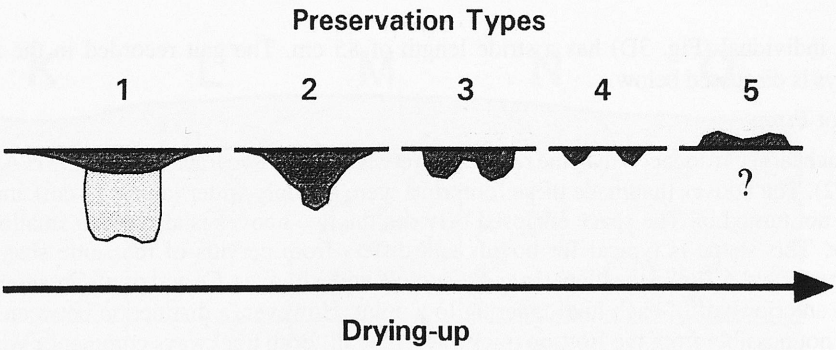

Fig. 2. Different types of footprint preservation organized according to the successive drying-up of the tracksite.

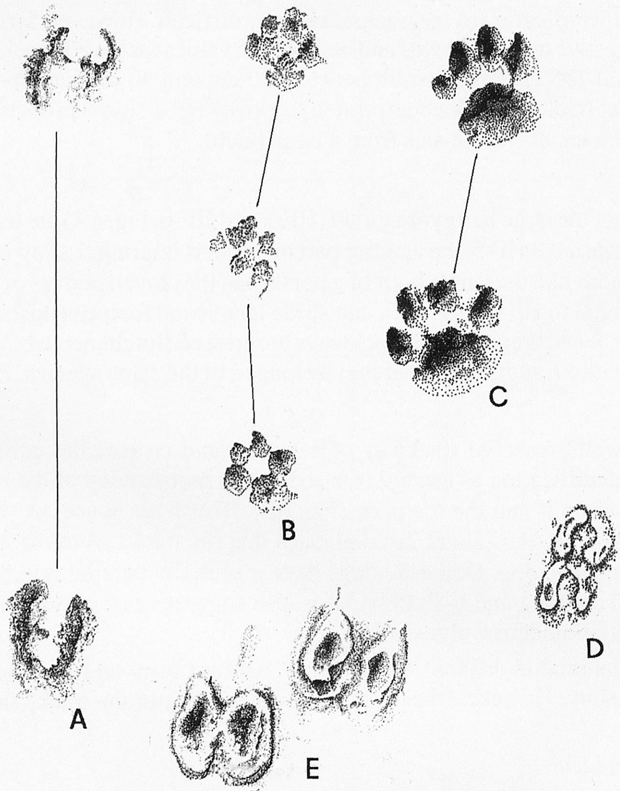

Fig. 3 Typical examples of footprints in the trackways of Bottrop-Welheim. The direction of movement is in all cases upwards. Not drawn to the same scale. A) Right and left double print of adult *Rangifer tarandus*. Note the large open space between the hooves. The hindfoot has overstepped the forefoot. This is preservation type 4, as only the edges of the hooves were impressed. B) A sequence of three prints of *Canis lupus* of preservation type 3. C) A lion footprint couplet *(Panthera leo spelaea)*. Represented are the left forefoot and left hindfoot. This is also of preservation type 3. D) Double print of a young reindeer (RF-16) in preservation type 5. E) Bovid footprints belonging to two different trackways (BF-1 and BF-2), preservation type 5.

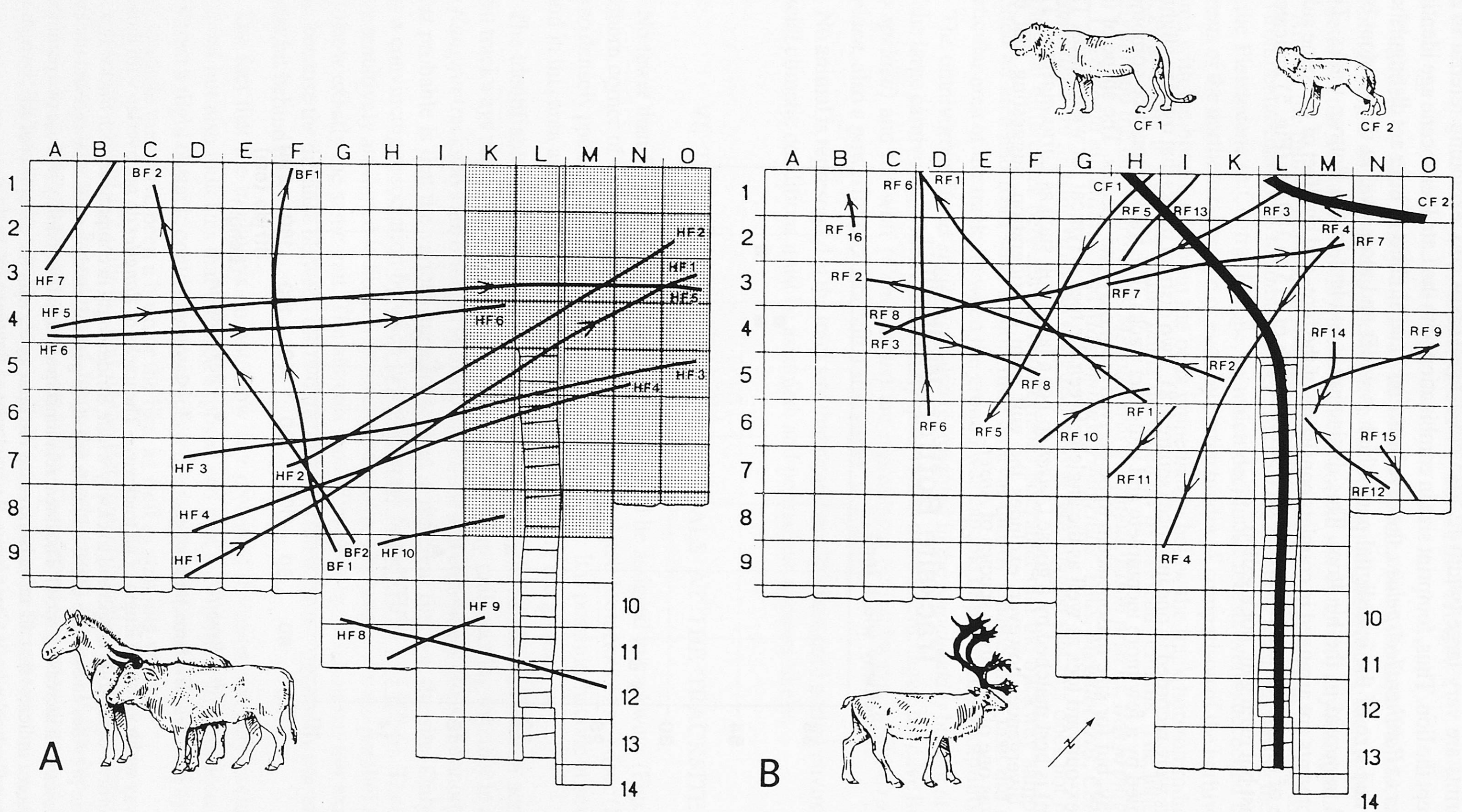

Fig. 4. Schematic overview of all identifiable trackways at the Upper Pleistocene tracksite of Bottrop-Welheim. A) Bovid (BF-1 and BF-2), horse (HF-5 and HF-6), and indeterminate, large herbivore trackways (other HF signatures) are plotted. B) *Rangifer tarandus* (RF-1 to RF-16) and carnivore trackways (CF-1 = *Panthera leo spelaea,* CF -2 = *Canis lupus*) are plotted. The direction of progress could generally be ascertained (arrows) except in some of the HF trackways. Note that there is no preferred orientation to the trackways. The shaded area in Fig. 4A corresponds to the area in Fig. 1. The grid spacing is 1 m.

The footprints are very large (width 12.5-15 cm, length 12-14 cm), excluding referral to all other cats except the lion. Thus, footprint size in combination with the Late Pleistocene age identify the track maker as *Panthera leo spelaea,* the cave lion. Fore- and hindfeet of lions are distinguished by the shape and size of the interdigital pad, which is wider and more oval in the forefoot but narrower and trapezoid in the hindfoot. This distinction is evident in the Bottrop tracks. The individual footprints are arranged in couplets consisting of the fore- and hindfeet of the same side. The sequence of footfall in combination with a stride length of 175 to 180 cm (Fig. 5) indicate a moderately fast but even gait, not a gallop.

Anser sp.

Bird tracks were recorded in one instance (square H8). Two distinct tracks that overlap slightly are accompanied by a few more incomplete and indistinct tracks. The tracks cannot be combined into a trackway, but for size reasons seem to be derived from only one species. The shape of the slightly convex-outward toes as well as the angle between the toes is typical for water birds. The size (7 × 7 cm) is best matched by a goose (*Anser* sp.) or a large gull such as *Larus marinus.* The angle of toe divergence, however, excludes the gull from consideration, suggesting that the trackmaker was one of the larger species of *Anser.*

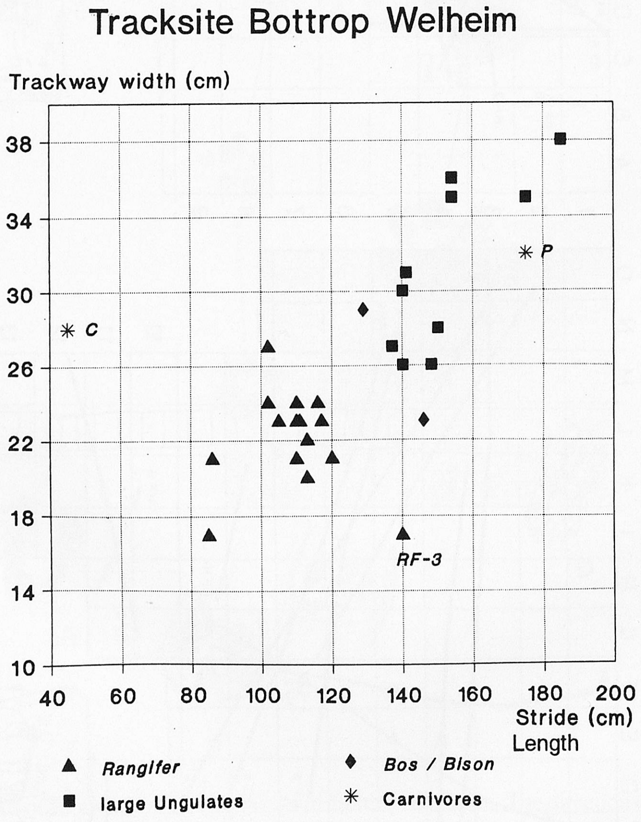

Fig. 5. Trackway width vs. stride length of all trackways. The tracks of *Rangifer* do not overlap with those of the larger herbivores in stride length and trackway width. Stride length in comparison with trackway width and body size provides an estimate of the animal's speed. In general, stride length increases and trackway width decreases with increasing speed. The linear relationship and small variability of these two parameters in the herbivores indicates that all animals moved at the same pace, with the exception of RF-3 which was slightly faster. C = trackway of *Canis lupus,* P = trackway of *Panthera leo spelaea.*

V. COMPOSITION OF THE FAUNA

The tracksite shows only a limited number of species from the Late Pleistocene inventory. Although some of the species allow some environmental inferences, the frequency of representation at the tracksite is highly incidental and should not enter into any interpretations.

Among the limited number of species, at least *Rangifer tarandus* can be used to characterize environmental conditions to some degree. This species regularly occurred during the cold periods of the Pleistocene in Central Europe, in which deciduous forests were succeeded by coniferous forests of the northern taiga type or even by barren tundra. A comparison of the herbivore trackway fauna with the bone fauna from the beds immediately below the track horizon indicates that the trackway fauna is a subset of the fauna documented by skeletal remains. The latter consists of *Rangifer* and the large herbivores *Megaloceros giganteus*, *Bison priscus*, *Bos primigenius*, *Equus* sp., *Coelodonta antiquitatis*, and *Mammuthus primigenius.* Thus, *Megaloceros*, *Coelodonta*, and *Mammuthus* are missing from the trackway record. We suggest that this does not represent true ecological differences between the two horizons but rather that the trackway sample is from so limited an area and from such a short time interval that by chance these taxa did not cross the particular area of the tracksite when the ground was capable of preserving footprints.

The omnivorous *Ursus spelaeus* is also represented in the *Knochenkies* but not at the tracksite. Of the large carnivores, which are normally quite rare in bone assemblages, the cave lion (*Panthera leo spelaea*) and the wolf (*Canis lupus*) are represented by trackways, while *Crocuta crocuta spelaea,* also a powerful predator and a scavenger, is missing.

No animal is represented at the tracksite that would not fit into a cold period environment. Thus glacial climatic conditions must be assumed, and permafrost appears likely.

VI. THE ACTIVITY OF THE ANIMALS AT THE TRACKSITE

No fewer than 50% of the footprints at the site could be assigned to trackways (Figs. 1, 4). In the northern corner of the cast area, there are numerous isolated footprints of reindeer (Fig. 1). They are so densely packed that trackways cannot be singled out. It is possible that one or several animals stood in this area and milled around on this spot, trampling the ground.

The identifiable trackways, on the other hand, document continuous motion across the area. Most trackways are isolated and do not show any hint of animals moving together in a herd. Thus, the *Rangifer* trackways are oriented in many directions and commonly cross one another (Fig. 4B). Most probable is that the various animals arrived at different times at the site. Only in one case was a convincing association between two trackways found (HF-5 and HF-6). These trackways were tentatively attributed to horses, as discussed above. The trackways are parallel to each other and show exactly the same gait. The animals moved in close association but not exactly side by side, because the distance between the two trackways is too narrow. Apparently one animal lagged a little bit behind the other.

The fact that the trackways do not show any preferred direction not only excludes herding behavior but also indicates that the area exposed and cast was open in all directions. Only in the southeast a slight obstacle could have been located, since this direction was avoided by the animals. This obstacle may have been a bush or the like, as well as standing water.

Trackways record not only the gait of the trackmaker but also its relative travelling speed. Absolute speed can also be estimated from the stride length (Fig. 5) if the hip height of the trackmaker is known (ALEXANDER & JAYES 1983). The method is most widely used for dinosaurs but may be applied to other tetrapods as well. We use it here for Pleistocene mammals in order to further the reconstruction of the activities at the tracksite. As the detailed calculations have already been presented in KOENIGSWALD et al. (1995), only the final results are discussed here. First, none of the animals represented by the 30 trackways were running or trotting. Instead, the trackmakers progressed steadily but were not in a hurry.

Some aspects of the lion trackway are of interest, adding further details to our reconstruction of events at the tracksite. The lion approached from the southeast. Then, in the center of the area, its right hind foot slipped into the deep footprint of a large herbivore. This slip did not affect the stride, but the animal changed direction slightly and disappeared from the exposed area.

Because predators as well as their potential prey moved at a modest pace, the tracksite obviously does not document a hunting situation. Most probably enough time was involved in the formation of the tracksite that the herbivores did not appear on the scene simultaneously with the lion and the wolf.

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