



## Bear-claw deep tracks in the Pleistocene at north of Praia do Cavalo, Odemira (Portugal)

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### Abstract

The Pleistocene coastal eolianite formations in Portugal have provided an unexpected ichnological record of moderate diversity and circumscribed abundance related with mammals and birds, particularly in SW Alentejo. Several large tracks attributed to bear were recently been found in a small inlet at north of Praia do Cavalo, not far from Longueira (Odemira), at Medo Tojeiro/Almograve Eolianite which is tentatively dated from MIS3-2? (about 30,000 years BP). They are organized in two trackways composed of possibly 10 tracks; tracks are not well preserved since they show different undertrack preservational variants, in coarse-grained sandstones. The strong variation of track length, the wide range of footprint length/width ratio, the sole impression of the claws and the non-recognized impression of the heel are possibly related with an animal walking up a steep dune slope; the speed estimation of 2,4 km/h contributes for this interpretation. Most of these large tracks show five-digit dragging prints and the inward rotation of the foot typical from bears. The digit prints are generally packed together which is a characteristic of brown bears. These are the first tracks tentatively attributed to bears in the Portuguese paleontological record and the first ever recorded in eolianite facies.

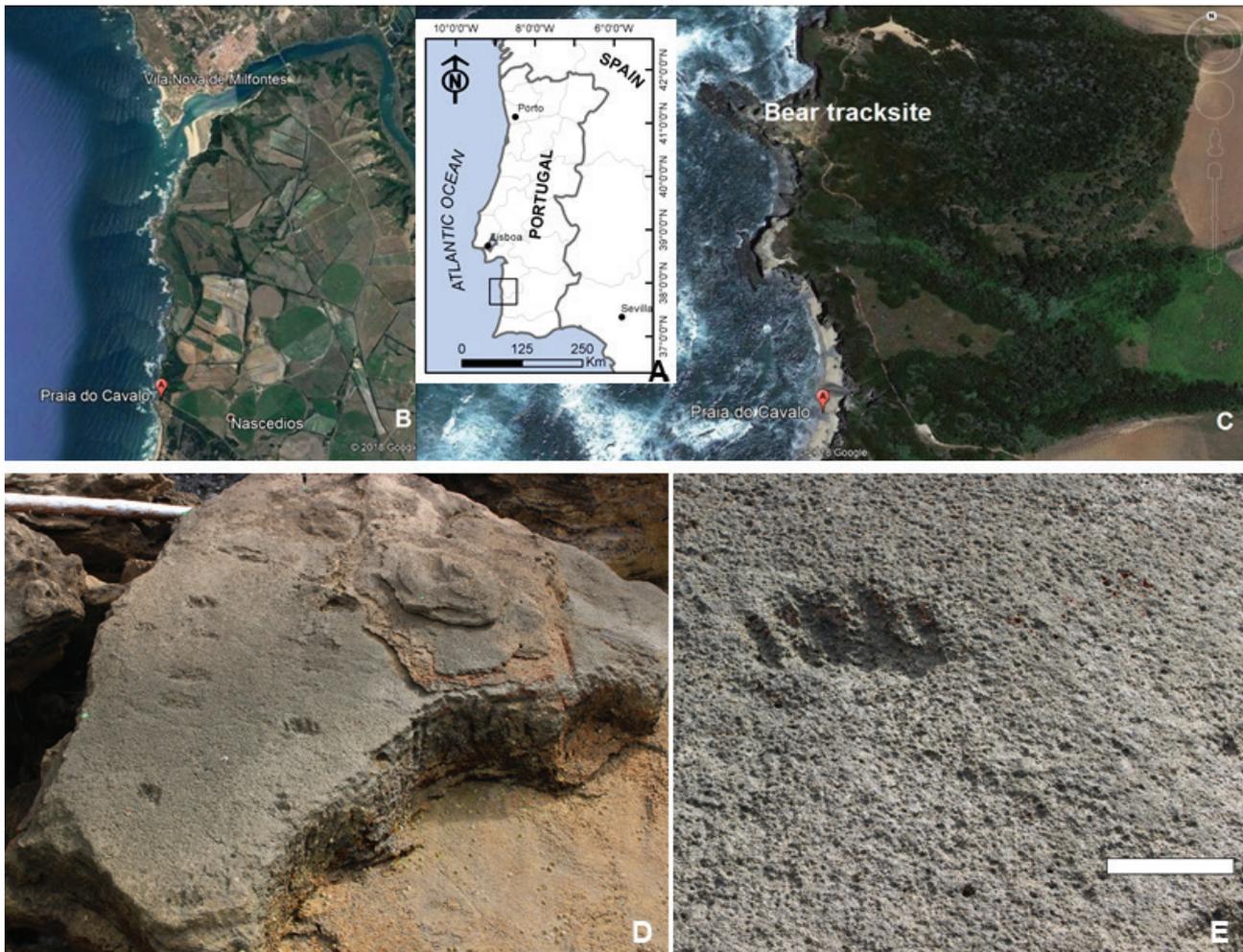
**Keywords:** eolianite, bear tracks, claw imprints, SW Alentejo, Portugal.

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## 1. Introduction

The eolianites from SW Portugal show five events of eolian deposition by N-NW prevailing winds. These events were related with sea-level low-stand periods and tentatively dated between MIS 6 to Holocene (Pereira & Angelucci, 2004). Since cervid trackways were described in these lithofacies for the first time by Neto de Carvalho *et al.* (2003), at least 17 stratigraphic levels were recorded in 7 different tracksites (Ilha do Pessegueiro, Forte da Ilha de Dentro, Aivados, Malhão, Angra da Vaca, Praia do Cavalo, and Murração), including a vertebrate ichnofauna that is moderately diverse and attributed to straight-tusked elephant, red deer, fox, wolf(?), iberian lynx and hare, as well as charadriiform shorebirds (Neto de Carvalho, 2009; Neto de Carvalho *et al.*, 2016). Part of the species that were represented in the upper Pleistocene tracksites are still found nowadays in the active dune field, or were part of this habitat until became extinct by Man after the Last Glacial (Brugal & Valente, 2007).

In the area of Praia do Cavalo the eolianite crops out over the coastal platform as an erosional remnant of a wider dune field that existed between S. Torpes and North of Cape Sardão, only interrupted by the estuary of Mira River. The Medo Tojeiro/Almograve Eolianite sequence at north of Praia do Cavalo (Figs. 1A-C) shows up to 2 m-thick, low-angle oblique backsets of coarse-grained sandstones. This sequence lies in disconformity over a sequence of white and orange sandstones deposited over a conglomerate unit of the Eemian (MIS5). Here a block fallen from the cliff lies on the small beach showing two parallel trackways and possibly few other tracks in the same horizon. In the area there are evidences of quarrying for the extraction and production of millstones (*sensu* Medici *et al.*, 2007). The loose block where the tracks are found shows two unfinished small millstones that would be used for manual milling, the “moinhola”, as well as the delimitation by chisel of another one, larger for water or wind mill, in the track surface (Fig. 1D).



**Fig. 1.** -Location of the bear tracksite in the SW coast of Alentejo, Portugal (A), in northern Praia do Cavalo beach (B, C) and Longueira (Odemira). D) Trackways with indication of the footprints (l, r). Detail of r3 showing the inward rotation of the five-digit imprints and expulsion rims between them.

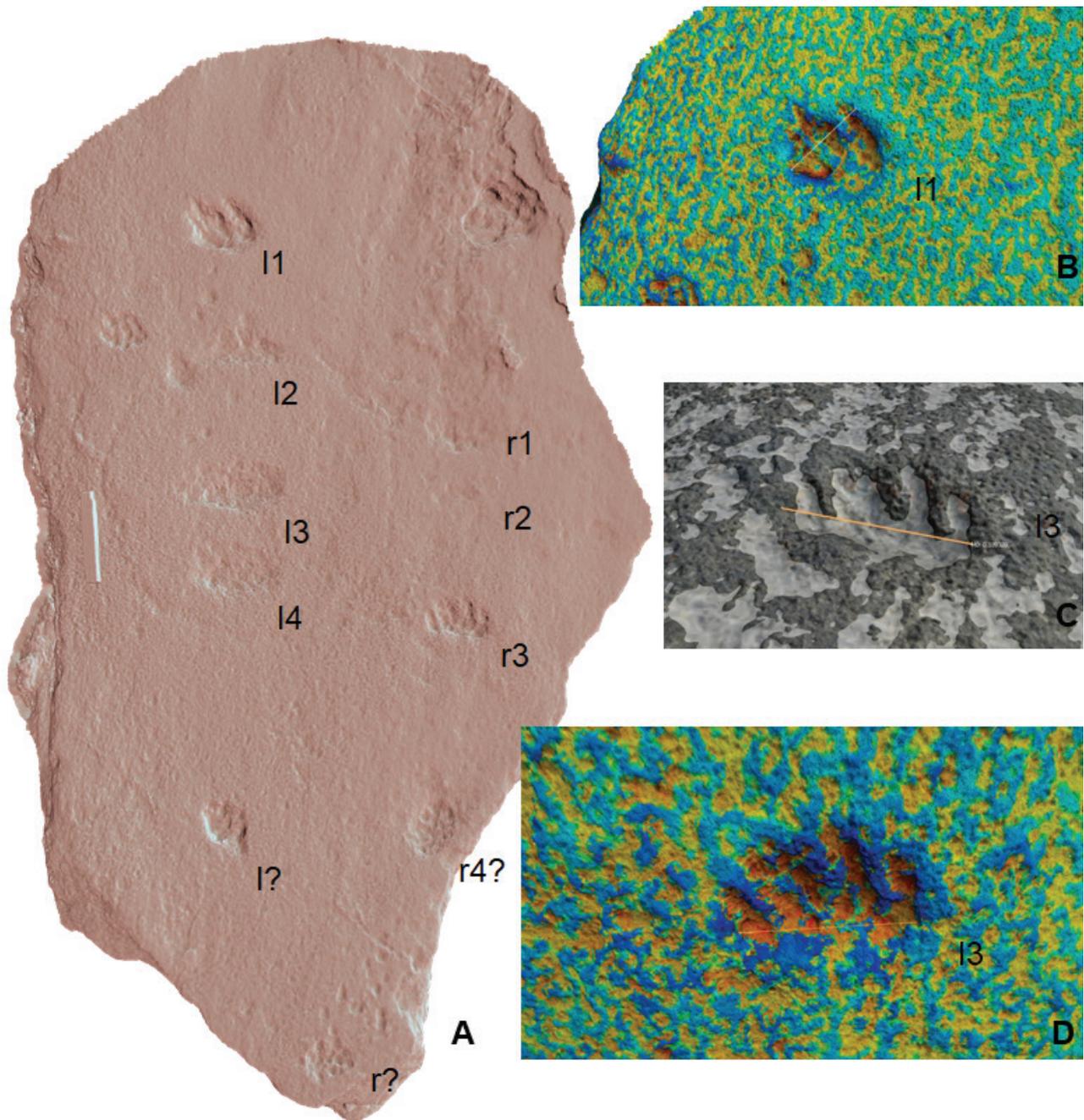
## 2. Description of the tracks

The two trackways found at north of Praia do Cavalo are composed of at least 4 and 3 tracks (trackway l and trackway r, respectively), with the presence of three more tracks that could be related with the trackways (Figs. 1, 2); tracks are not well preserved since they show different undertrack preservational variants, from faint pad prints to deep claw impressions, in coarse-grained sandstones (Fig. 1D; photogrammetric model in Fig. 2A). The trackways may be up to 3,6 m long and show a very narrow gauge, with the prints placed one in front of other. Tracks were separated by left (l) and right (r) trackways for purpose of description; average track length is 15,3 cm (range 7-27 cm; n=9) and average track breadth is 18,3 cm (range 12-27 cm; n=9); heel area seems never preserved; the strong variation of track length, mean footprint length/width ratio of 0,89 (range 0,5-1,58; n=9), and the seldom impression of the heel is possibly related with an animal walking up a slope. The

tracks r1, l1 and l2 show five claw prints (Fig. 1E; figs. 2B-D) (four in l?) and the inward rotation of the claw prints in respect to the midline are typical from bear walking, also indicating the direction of movement. The toe prints are generally packed together with expulsion of sediment by pressure between claws (expulsion rims; Fig. 2C,D). Some of the footprints (r1, r2) are faintly impressed but l1 is up to 4 cm deep (Fig. 2B). Pace length was calculated between l2 and l3 and is of 45 cm; stride length may be of 55 cm measured between l1 and l4 tracks; no measurements were made for trackway r.

## 3. Discussion

Diedrich (2011) defined the ichnogenus *Ursichnus* in the upper Pleistocene of the Urşilor Cave, Romania, by erecting a single new ichnospecies *Ursichnus europaeus*. The diagnosis of this ichnogenus was revised by Aramayo *et al.* (2015) for the bear tracks of Pehen-Co, as a quadrupedal trackway composed



**Fig. 2.** -3D photogrammetric digital model of the block with the trackways. Several digital techniques were used to highlight the track details. A – Orthogonal view of the 3D model with the application of the algorithm Lit Sphere Radiance Scaling; the shadow effect evidence greatly the track shapes (white scale is 20 cm). B and D – 3D detailed models of l1 and r3 tracks emphasizing the microtopographic curvature; the warm colours correspond to concave areas and the cold ones to convex areas; this false colour technique also emphasizes the morphology of the imprints and the expulsion rims of sediment. C – 3D model of r3 track evidenced by microtopographic highlighting technique adapted from Cerrillo-Cuenca *et al.* (2019).

of plantigrade, pentadactyl manus and pes imprints of different morphologies; manus nearly circular and pes ovoid, and manus/pes length ratio of about 1:1.25; in a normal gait, the manus imprint is in front and close to the pes imprint, or can be absent if the animal walked only on its hind limbs; the heel of the manus is absent and the palm is ovoid to kidney-shaped and small, while the large sole of the pes is

roughly triangular and shows a well-developed heel. Manus and pes with short, oval to rounded digit imprints, with clear claw marks; digit imprints are not connected with heel impression.

The wide footprint length/width ratio, together with the inward rotation of the 5-toe footprints, enables to compare the badly preserved and deeply imprinted trackways of Praia do Cavalo to *Ursichnus*

Diedrich, 2011, with Ursidae as producers. For adult brown bears hindfoot is 30 cm long and 17 cm wide; the track of forefoot is slightly shorter and broader, about 28 cm long and 21 cm wide (Bang & Dahlström, 2006). The tracks turn in; heel pad only seldom registers. Brown bear toes are very close together and form like a straight line which seems not to be the case in I?, but also where only four toes are recorded (Fig. 2A). Claws are usually longer than toes but here it is difficult to make the comparison since only claw prints are preserved. The speed estimate may be of 2,4km/h (Alexander's method: Alexander, 1989) which confers with a heavy animal moving slowly up a dune face.

The presence of a single species of bear, the *Ursus arctos* (brown bear) was well determined for the Pleistocene of Portugal by Cardoso (1993). Brown-bear remains are commonly found in cave sites, from Lorga de Dine, in the northeast, to Gruta do Escoural, in the southwestern of Portugal (Cardoso, 1995). Their bones are common in the upper Pleistocene record of caves in the Centre of Portugal (Cardoso, 1993; Valente, 2004), and the coastal caves of Furninha, Algar de Cascais and Figueira Brava (Cardoso, 1993; Brugal *et al.*, 2012) show how recurrently brown bears roamed for food and shelter in the coastal areas. Some behaviors are known for bears in Portugal taken from the ichnological record, especially coprolites (Brugal, 2010). Foraging for berries, grasses, herbs, roots, insects or, most likely, carrion, including whales stranded on the beach, these typically solitary animals would find also in the coastal dunes of SW Alentejo small mammals with which they could fulfill their protein demand and thrive during the Pleniglacial.

Recently, McDonald *et al.* (2007) analyzed 584 bibliographic references describing Cenozoic vertebrate tracks and trackways in a world-wide distribution. Only 10 references of them report mostly cave bear tracksites, dated from Miocene to Pleistocene, in Italy, France and USA. The ichnogenus *Ursichnus* was defined for cave bear tracks in Romania (Diedrich, 2011) and identified also in Argentina (Aramayo *et al.*, 2015). Bear tracks are common, although least studied, in the stratigraphic record of caves, where they occur often well preserved. However, for the Pleistocene eolianites the Praia do Cavalo tracksite could be the first record of bear tracks and an important contribution for the reconstitution of the communities that roamed by the coastal dunes of Alentejo during the Last Glacial.

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