A Late Miocene Proboscidean Trackway from Western Abu Dhabi

by Will Higgs, Anthony Kirkham, Graham Evans and Dan Hull

Introduction

The trackway concerned is on one of the level rocky plains outcropping in an arc of about 80km south of the Baynunah forest, in Abu Dhabi's Western Region and east of Ghayathi. It was first examined in response to a report from Mubarak al-Mansouri, who comes from the area, regarding apparent fossil footprints which had been assumed by local people for many years to have been made by dinosaurs. The trackway sites are located north-east of Ghayathi, midway between the town and the coast. This area is characterised by forestry plantations and lacks properly surfaced roads, making it difficult of access. Unforested areas feature both sand dunes and bare rock.

The site can be identified on satellite images using the GPS readings taken on site (*Fig. 1*). The initial visit to Mleisa by one of the authors (D. Hull), in the company of Stephen Rowland and Mubarak al-Mansouri, was made in early 2001 while he was undertaking work at Jebel Dhanna for the Abu Dhabi Islands Archaeological Survey, ADIAS, under the aegis of the Abu Dhabi Company for Onshore Oil Operations, since ADCO. Two further visits have been made to the Mleisa site to obtain more comprehensive data on the footprints in geological and ichnological terms. The second visit was made by A. Kirkham, G. Evans and D. Hull in February 2002 during a further phase of fieldwork at Jebel Dhanna, while the third visit was undertaken by W. Higgs, M. J. Beech and A. Gardner in February 2003 as part of the palaeontological work carried out by ADIAS near Ruwais on behalf of the Abu Dhabi Oil Refining Company, TAKREER. During this visit, mapping of the site was undertaken.

Multiple footprint tracks at the Mleisa outcrop werepexamined. These are probably Proboscidean in origin, while isolated footprints at another outcrop at Niqqa were of two types, smaller than those at Mleisa and with distinct toes.

Geological Setting

The bedding plane displaying most of the footprints at Mleisa forms the floor of a rocky, oval topographical depression approximately 500m long and 300m wide surrounded by mobile, wind-blown sand and low hills of horizontally stratified late Miocene strata. The Miocene period extended from approximately 23 – 5 My BP but these particular strata probably date from 8 - 6 My BP (late Miocene) by analogy with the exposed Miocene stratigraphy in the Jebel Dhanna region (Whybrow & Hill, 1999). The footprints are preserved in an indurated bed of light grey marl (a calcareous mudstone) which is part of this Miocene sequence, as can be demonstrated at the

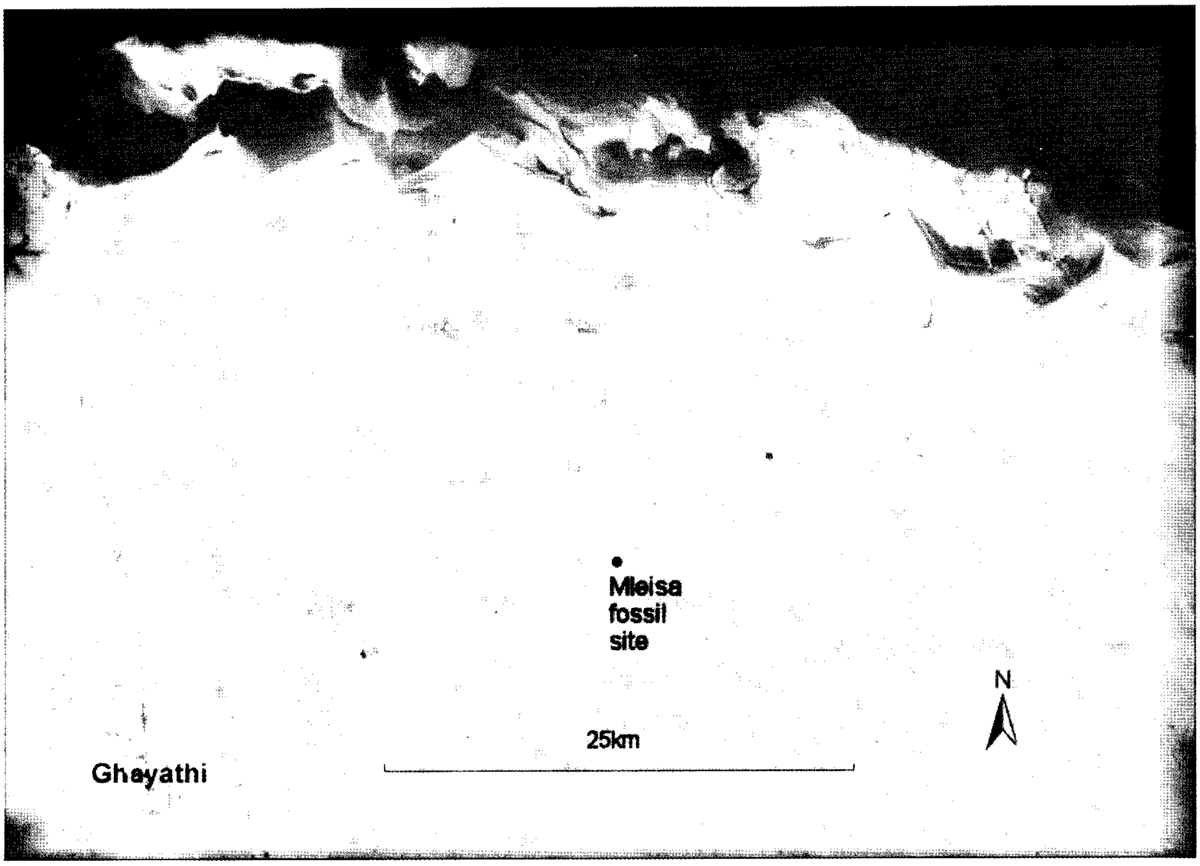

Figure 1: Satellite image showing the location of Mleisa. A band of similar whitish outcrops can be seen, stretching east-west.

southern margin of the depression and at the central outlier.

The main bedding plane displaying the footprints shows intense cracking into polygonal patterns (*Fig. 2*). Other similar surfaces exposed in interbedded strata at the edge of the depression show different intensities of cracking and thicknesses of indurated marl, the footprint-bearing layer being the thickest. This polygonal patterning is usually interpreted as desiccation of the marl due to exposure of the original sediment to the atmosphere after deposition. In other words, the polygons are mud cracks.

The footprint-bearing marls are overlain by a caliche or palaeosol (fossil soil) which passes upwards into a 0.5m-thick red sandstone that is, in turn, overlain by additional grey or greenish marls. This stratigraphic sequence was largely evident from an outlier (pedestal) of rock that has survived erosion near the centre of the depression (*Fig. 3*). The lateral extension of this stratigraphic sequence can be observed around the periphery of the depression. Numerous small (up to 13mm) dark grey fossil gastropods were found (by A. Gardner) in one of the upper layers of the outlier. These have been identified as a species belonging to the genus *Melanoides*, family Thiaridae, which has a wide (natural) distribution today throughout Africa, Asia and Oceania. (*pers. comm.* J. Todd, The Natural History Museum, London)

Palaeo-environments

The late Miocene strata of Western Abu Dhabi have been subdivided into two horizontally bedded formations. The type localities of these formations, the lower Shuweihat Formation and the upper Baynunah Formation (Whybrow *et al.*, 1995), are on Shuweihat Island, west of Jebel Dhanna.

The Shuweihat Formation is dominated by red aeolian sandstones with intercalated gypsiferous, interdune sabkha facies and sheet flood or fluviatile sandstones (Bristow, 1995). The Baynunah Formation is dominated by friable mudstones, siltstones and sandstones with a general grey colouration. It represents a fluvio-lacustrine environment with common floodplain deposits in which rich, delicate root systems were fossilised as rhizoliths. The boundary between the Shuweihat and Baynunah Formations is placed at the top of the uppermost selenite bed on Shuweihat Island and the main Mleisa trackway occurs in sediments similar to those of the Baynunah Formation.

Sedimentological work by Whybrow *et al* (1999) shows evidence of aridity and large river systems within the Baynunah Formation. Faunal evidence for a river system is provided by abundant crocodile, turtle and fish remains, as well as the *Unio* valves discovered in April 2003 during an ADIAS excavation (Beech & Higgs forthcoming). It has been suggested that the regime may have resembled present-day northern Egypt, where the River Nile crosses an arid region. The large vertebrates may have frequented a relatively narrow, fertile floodplain beside a major river system, or the ecosystem may have resembled the present-day East African savannah, as indicated by the range of fauna. The gastropod genus *Melanoides* is today found in a wide range of inland, mainly freshwater habitats, although some species are able to tolerate a range of salinities (*pers. comm.* J. Todd).

Figures 2.1,2.2 The exposed late Miocene bedding plane of the topographic depression. Polygonal fossil mud cracks are ubiquitous and they are imprinted by the Proboscidean footprints.

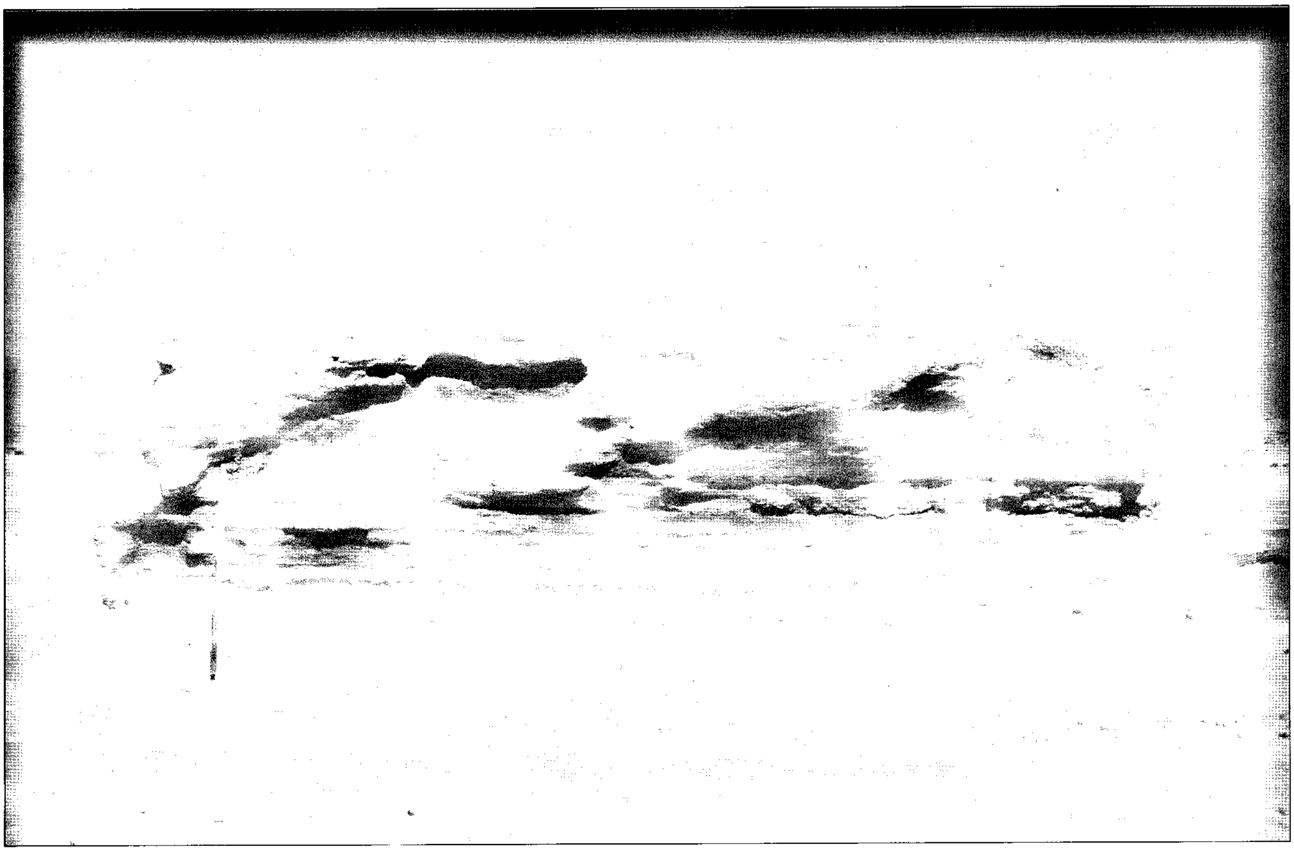

Figure 3: The outlier in the centre of the topographic depression. The Late Miocene sediments of the outlier overlie the mud-cracked bedding plane displaying the Proboscidean footprints. The white layers of the outlier represent calcareous palaeosols. Shells of the gastropod *Melanoides* were collected near the top of the outlier.

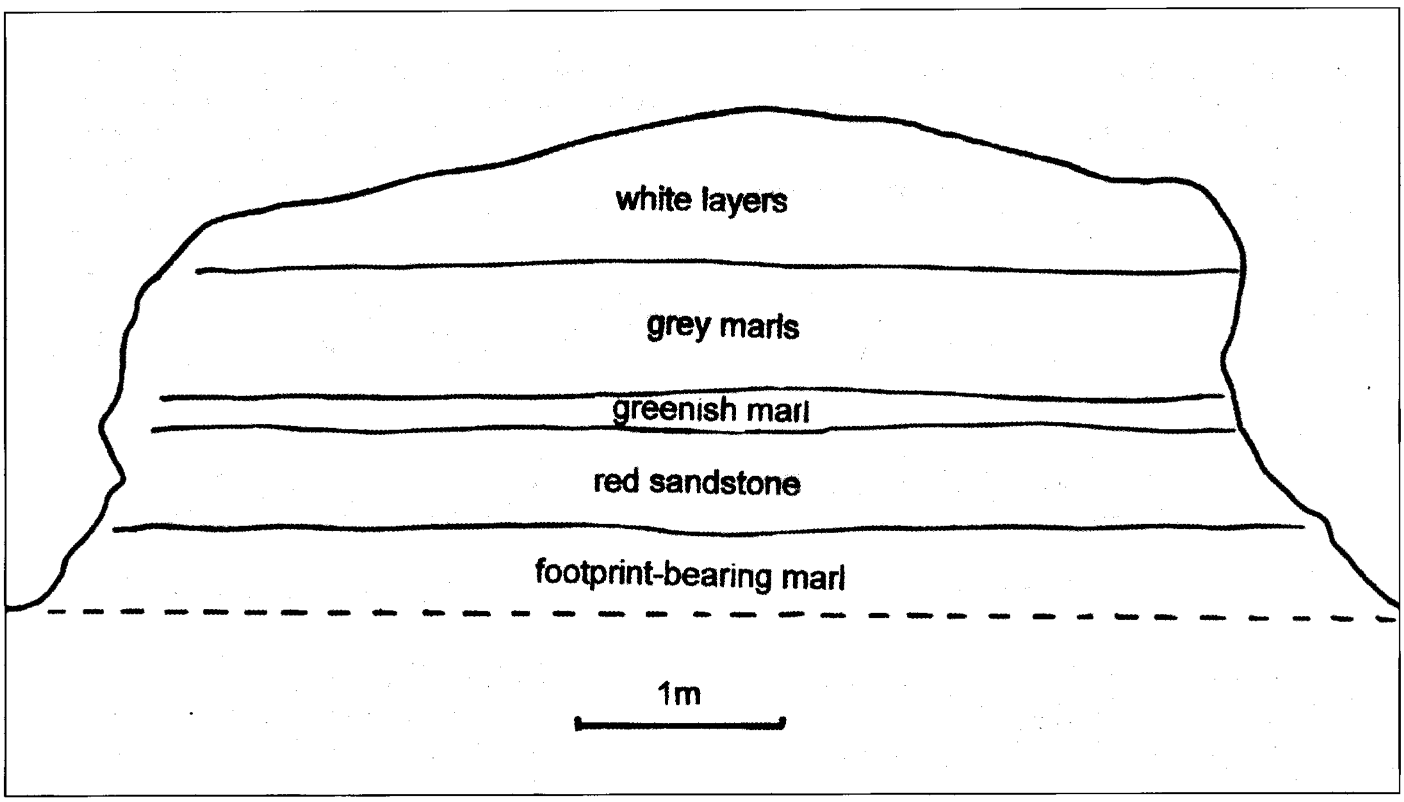

Figure 4: Diagram of the stratigraphy of the outlier.

The contemporary coastline is unknown. There is a probable infilled tidal channel exposed on Zabbut islet, immediately north of Shuweihat, but, due to the shallowness of this part of the Gulf during the Miocene, the local coastline was highly responsive to fluctuations in sea level and inferences from widely separated exposures of this poorly known strata should be made with caution.

It is not yet clear exactly what type of ground surface the animals were crossing. First impressions suggest a soft (moist), muddy surface drying into polygons as it became exposed to the atmosphere, perhaps a fluvial floodplain. Alternatively, the extensively cracked marl in which the footprints are located could have been an ephemeral lake or playa that was intermittently flooded and then dessicated. The occurrence of a caliche at a slightly higher stratigraphical position within the outlier testifies to a seasonal alternation of wet and very dry periods. It was possibly part of an inland basin that ponded rainwater in much the same way as the depression is probably periodically doing today and may have done through much of the later Quaternary period. The Mleisa 'basin' may be an isolated deposit, but satellite photographs suggested that it is an exposed part of a much larger, continuous area.

Additional Proboscidean Fossils in the Region

Fossil proboscidean remains have been recently excavated at various sites in western Abu Dhabi Emirate. A team from the Natural History Museum, London, and Yale University discovered scattered remains attributed to *Stegotetrabelodon syrticus* within a fluviatile deposit in the Baynunah Formation on Shuweihat Island (Whybrow & Hill, 1999). Late Miocene fossils of hippopotami, crocodiles, turtles and other large vertebrates have also been found in the same region. Other Proboscidean fossil fragments been discovered within the Miocene strata at Mugharraq, just west of Jebel Dhanna, and at Jebel Barakah and near Ruwais. A complete 2.45m *Stegotetrabelodon* tusk was found near Ruwais in November 2002 and ADIAS excavations there in February 2003 uncovered a relatively complete *Stegotetrabelodon* mandible, as well as a cluster of water-lain proboscidean bones remarkably similar to the Shuweihat assemblage (Beech & Higgs, forthcoming). It is therefore of some interest that proboscidean (and other) footprints have been discovered in the Baynunah Formation elsewhere in the region, enabling comparison of rich sources of complementary fossil evidence about this important fauna. Tooth fragments assigned to *Deinotherium* were also found by the NHM/Yale team.

Trackway Description

The Mleisa trackway consists of a group of up to 14 roughly parallel tracks, with one larger track crossing them. Based on the size and subcircular shape of the footprints, the tracks are very likely to be those of Proboscideans. A rough map has been created by plotting GPS points taken around the perimeter and at the ends of the trackways on a graph (*Fig 5*).

It can be seen from the map that the main trackway is approximately 170m long and 20-38m wide, crossing the area on a NE – SW axis. It is crossed by track 1, which is 290m long, containing 177 footprints, on a NW – SE axis. The footprints are generally well marked but due to their featureless shape it is difficult to identify the direction of travel in each example. As long series are available for most of the tracks, a clue can usually be found from the direction of displacement of surrounding and underlying material in some footprints, more material tending to be projected forward by the initial footfall. Tracks apparently travelling in opposite directions were found within the main trackway, indicating that it is the product of more than one episode.

The picture is further complicated by the occurrence of eroding footprints standing proud of the surface, suggesting that more than one imprinted layer could exist within the deposit (*Fig. 6*). Alternatively, it is not unusual for apparent fossil footprints in fact to be 'underprints' originally impressed into an overlying layer which has since eroded away (Thulborn 1990). Footprints of heavy animals impressed through multiple layers in this way provide opportunities for sophisticated analysis of the

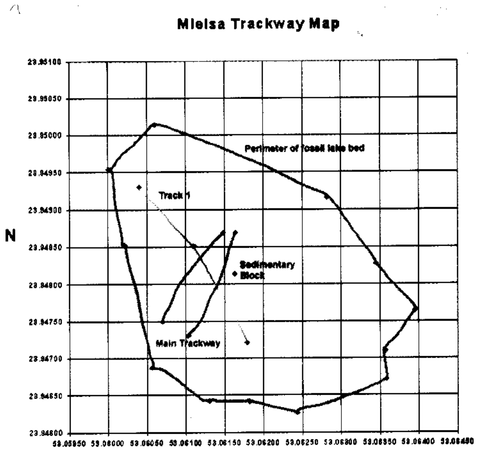

Fig. 5 – Map of the Mleisa trackway.

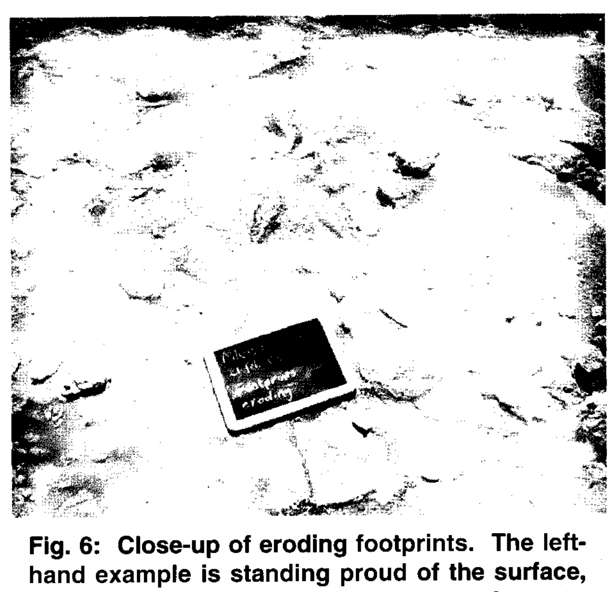

Fig. 6: Close-up of eroding footprints. The left-hand example is standing proud of the surface, probably resistant to erosion due to compression of the sediment. Displacement of polygons can be seen around the upper edge of the right-hand print.

deposit. The lower layer of the outlier is of light grey marl, contiguous with the footprint-bearing surface, providing 40cm of additional depth for such overlying layers in the same sediment.

Around the edge of the basin, interbedded outcrops of similar marls can be found up to one metre above the level of the main trackway. Footprints were found in one of these higher outcrops, indicating that Proboscideans were using the site over a period commensurate with the time taken for the accumulation of the deposits.

Measurements

Tracks made by a quadruped often appear, as at Mleisa, to consist of alternating imprints which could have been made by a biped. This is due to registration of the quadruped's front and hind feet on the same side, meaning that the hind foot is placed precisely on top of the imprint of the front.

Tracks 2 and 3 from Mleisa were selected from the main trackway group; track 1 is the larger track crossing the main trackway. Asian elephant (*Elephas maximus*) tracks were recorded at Blackpool Zoo in March 2003, using adult females over 30 years old which were guided along a raked sand avenue in their enclosure at a slow walking pace (*Fig. 7 & Table 1*)

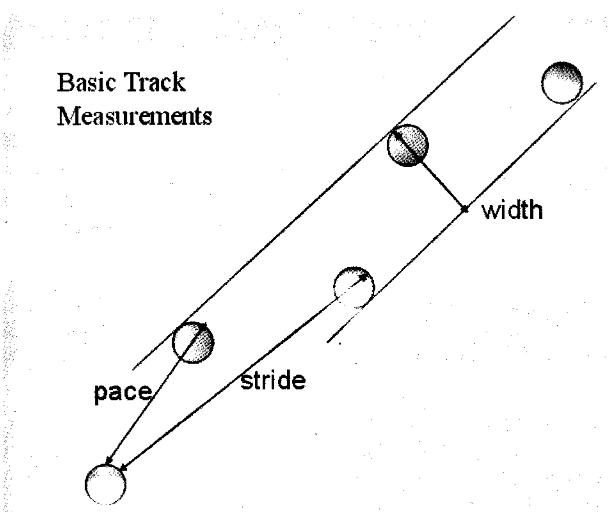

Fig. 7: Trackway measurements, following Thulborn, 1990.

Table 1: Figures are simple averages of at least four measurements in each case.

Track	Stride (cm)	Pace (cm)	Width (cm)
Mleisa track 1	306	173	128
Mleisa track 2	267	136	86
Mleisa track 3	264	137	94
Elephas maximus (mean of 3 animals)	241	127	77

It would appear from this data that the Mleisa track makers were considerably larger than modern Asian elephants, but precise correlations of track measurements with body size are complicated by various factors such as:

* Morphology – The Mleisa track makers may have had different body proportions and different gaits from modern elephants. If, as may be conjectured, the author of the exceptionally large 'track 1' at Mleisa was a mature adult male *Stegotetrabelodon*, it may have been carrying four tusks, two of which could have been over two metres in length, creating a very different weight distribution to that of the 'tuskless' female Asian Elephant.

* Relative speed – Stride length increases and track width tends to narrow with increasing speed, but it is reasonable to assume that the Mleisa track makers were also walking slowly.

* Type of substrate – The Blackpool elephants were walking on a solid substrate with which they were familiar. The Mleisa track makers may have been walking in soft mud. If this was the case, they may have been cautiously 'feeling their way' which might explain the relatively greater width of track 1, in particular.

* 'Naturalness' – The Blackpool elephants have spent their lives in confinement, so their gaits may not be identical to those of wild animals, and they were guided along the sand avenue to make their tracks, so may not have been travelling at their preferred walking pace.

Further experimental work and data from wild elephants may clarify some of these issues.

Conclusion

Our understanding of the Miocene vertebrate fauna of the Arabian peninsula, derived from isolated outcrops in Kuwait, Saudi Arabia and southern Oman, has been considerably enhanced by recent discoveries in Abu Dhabi Emirate (Whybrow and Hill, 1999; Beech and Higgs, *forthcoming*).

The extensive and well-preserved late Miocene fossil surfaces of the Mleisa area provide many opportunities for further research. It is of particular interest that the trackways lie within 50km of Ruwais and other late Miocene fossil sites, from which extensive collections have been made, including numerous proboscidean bones. Fossil footprints often complement data from fossil bones in a general way, where the links between the trackways and the fossil bones are tenuous due to wide separation in time and space. The Mlpisa footprints seem, however, to have been made by Proboscidean populations close in time and space to those whose remains have been recently excavated.

The Mleisa site, and neighbouring outcrops, provide an opportunity for development of palaeontology in Abu Dhabi Emirate by building on the data and fossil collections now held by ADIAS. Opportunities exist here for palaeontological, sedimentological and palaeoecological research that is possibly unparalleled in the Arabian peninsula. In the meantime, more thorough survey and recording of the footprint sites is a priority.

Acknowledgements

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This trackway would not have been documented without the initiative of Mubarak al Mansouri (ADCO) in drawing attention its existence.

The research co-ordinator at Blackpool Zoo provided access to the zoo's well-trained Asian elephants.

Finally, the Minister of Higher Education and Scientific Research, H.E. Sheikh Nahyan bin Mubarak Al Nahyan, is thanked for his continuous support and encouragement for this and many other similar projects.

The authors and ADIAS would be interested to hear from anyone able to supply basic measurements of the tracks of wild African or Asian elephants.

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Will Higgs (*),
4, Stanley Crescent, Gilsland,
Cumbria CA8 7BH, UK
e-mail: W.J. Higgs@Bradford.ac.uk

Anthony Kirkham
5, Greys Hollow, Rickling Green,
Saffron Walden, Essex CB11 3 YB, UK,
e-mail: kirkhama@compuserve.com

Graham Evans,
Crandon, La Route de La Haule,
Jersey, Channel Islands, via UK

Dan Hull,
Department of Archaeology,
University of York,
Exhibition Square,
York YO1 7 EP, UK
e-mail: danielhull@yahoo.com

(- to whom all correspondence should be addressed)*

Abu Dhabi's Dew Forest

by Simon Aspinall and Peter Hellyer

Abstract

Saxaul *Haloxylon persicum* woodland is present over an area of under two per cent of the total land area of the UAE and is restricted to the Emirate of Abu Dhabi. While this area is deserving of protection in its own right, the associated faunal community thus far identified clearly adds further merit to the area being considered for, and afforded, protection. The local saxaul woodland is described here as a 'dew forest' because of the way in which the foliage of the saxaul trees trips the condensation of fog moisture. (The term 'fog desert' has been used elsewhere to describe similar areas such as the coastal Naimb and coastal parts of the Jiddat al-Harasis in Oman, [A.S. Gardner, *pers. comm.*]). A call is made for the formal designation and management of this important but little-known community as an area of national conservation importance.

Introduction

Native woodland in the UAE includes extensive *Acacia* savannah on alluvial plains in the eastern regions, in particular adjacent to the Hajar Mountains, a *ghaf* dominated landscape on sandsheets and dunes from the Gulf littoral to south of Al Ain, and mangrove or mangal *Avicennia marina* swamps. It should be noted that none of these woodlands, with the exception, to some extent, of mangroves, is effectively managed in the United Arab Emirates.

The saxaul *Haloxylon persicum* 'dew forest' of Abu Dhabi, however, has probably thus far received the least attention of all of the UAE's native wood- and shrublands in terms of scientific study, despite the fact that it covers the smallest areas of all the native woodlands, with the exception of the well-known and visually prominent mangrove forests and the relict species high in the mountains.

Although saxaul (*ghadar* Ar.) ranges from the deserts of western Arabia to the steppes of eastern central Asia, it is rather localised in the UAE, as indeed it is around the Rub' al-Khali of Saudi Arabia (Mandaville 1990). In the UAE, saxaul extends in a narrow east-west oriented belt from some kilometres east of Medinat Zayed up to the district of Al Wathba alongside the Abu Dhabi to Al Ain truck road, a distance of approximately 100 kilometres. The width of the belt is variable and in places interrupted by sabkha, but is 25km wide at its greatest extent where *H. persicum* is dominant. It is significant, climatically, that it occurs just inland of the coastal sabkha, in a zone of seasonally high humidity (although not all similarly humid areas possess saxaul).

Within the belt are the Rumaitha and Shanayel oilfields operated by the Abu Dhabi Company for Onshore Oil Operations, ADCO, part of the Abu Dhabi National Oil Company, ADNOC, Group, a factor that may contribute favourably to conservation, as seen below. The width of the belt is variable and is reduced in places by sabkha, (including both 'fingers' of coastal sabkha and inland sabkha plains), and by aeolianite plains.