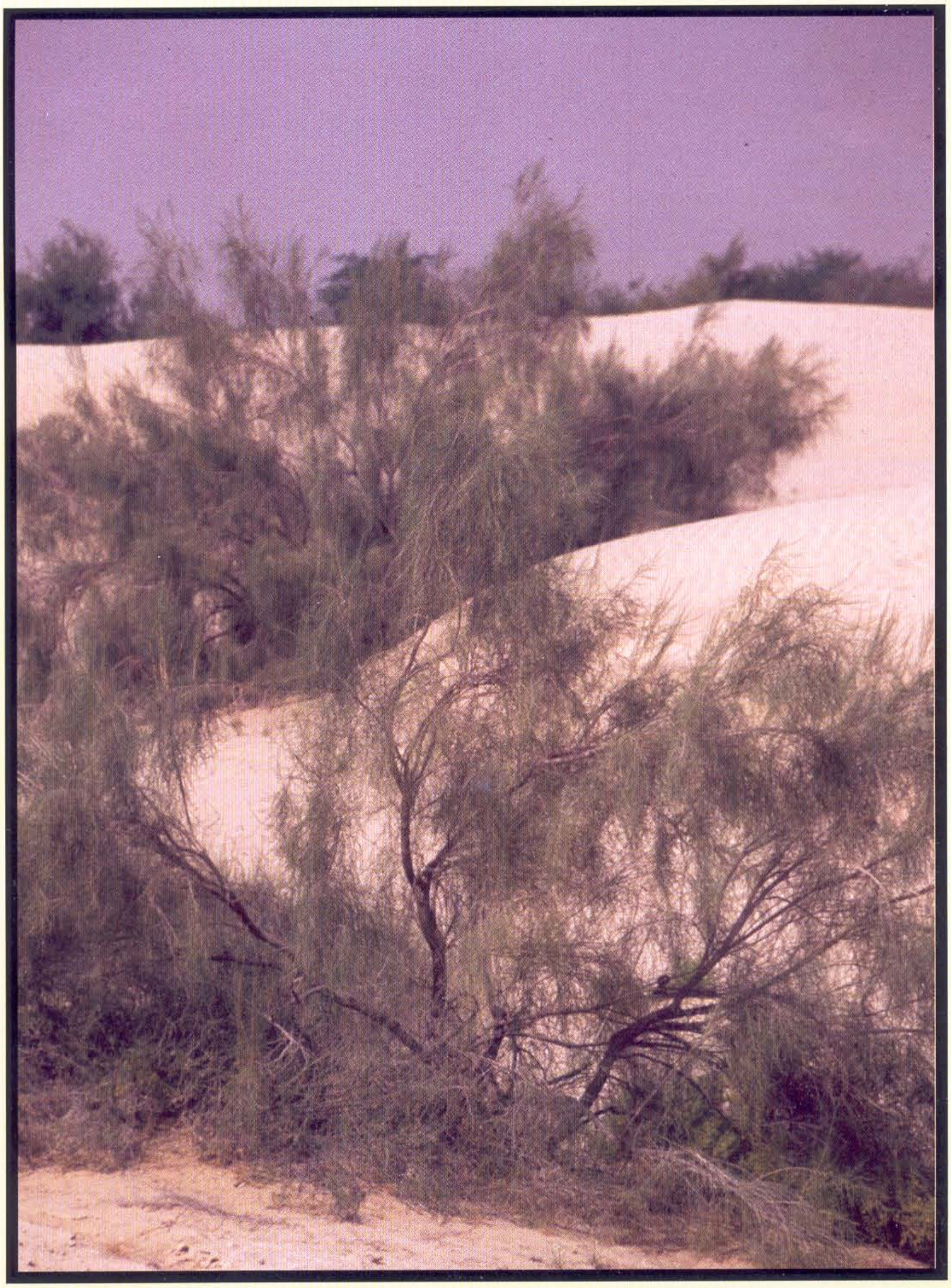
TRIBULUS

Journal of the Emirates Natural History Group

Vol. 13.2 Autumn/Winter 2003



TRIBULUS

NOTES FOR CONTRIBUTORS

TRIBULUS is the Journal of the Emirates Natural History Group and was launched in 1991. The Group was founded in 1976, and over the next fourteen years, 42 issues of a duplicated Bulletin were published.

TRIBULUS is published twice a year. The aim of the publication is to create and maintain in standard form a collection of recordings, articles and analysis on topics of regional natural history, heritage, geology, palaeontology and archaeology, with the emphasis on the United Arab Emirates and adjacent areas. Papers, short notes and other contributions are welcomed from anyone but should not have been published elsewhere. Guidelines are set out below. The information carried is as accurate as can be determined, in consultation with the Journal's Advisory Panel and referees, but opinions expressed are those of the authors alone.

All manuscripts received are reviewed by the Editorial Board and appropriate Advisory Panel members and, where appropriate, are also submitted to blind peer review.

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The plant motif above is of the genus Tribulus, of which there are six species in the UAE. They all have pinnate leaves, yellow flowers with free petals and distinctive five-segmented fruits. They are found throughout the country, except in coastal sabkha.

The animal motif above is of a tiny golden bull, excavated from the early Second Millennium grave at Qattarah, Al Ain. The original is on display in Al Ain Museum, and measures above 5 cm by **4** cm.

Manuscripts should be submitted in electronic form, with a printed copy, typed on one side only, and double-spaced. A short abstract should precede the article, with the address(es) of the author(s) at the end. Photographs may be submitted and should be clearly captioned. Line drawings and maps, if not submitted in electronic form, should be in black ink on strong white or translucent paper. References should give the author's name, with the year of publication in brackets, and with the list of articles, showing title and publisher, in date order. Scientific names should follow customary nomenclature in Latin, while the English and, if appropriate, available local Arabic names should also be supplied.

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TRIBULUS

Vol. 13.2 Autumn/Winter 2003

Contents

Cover illustrations:

Front: Saxaul *Haloxylon persicum* at Al Wathba, Abu Dhabi *(see p. 8)*
..........................*Picture by Simon Aspinall*
Back: An iguana on the tidal flats at Al Dabb'iya *(see p. 23)*
..........................*Picture by Cajus Diedrich*

The Editorial Board of TRIBULUS and the Committee of the Emirates Natural History Group acknowledge, with thanks, the support of the Group's Corporate members, a full list of whom can be found on Page 2, without whom publication in this format would be impossible. We also acknowledge the support and encouragment of our patron, H.E. Sheikh Nahayan bin Mubarak Al Nahayan, UAE Minister of Higher Education and Scientific Research.

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EDITORIAL

it is now a little over a quarter of a century since a small band of amateur expatriate enthusiasts with an abiding interest in the natural history of the UAE first came together to establish the Emirates Natural History Group - the first environmentally-related non-governmental organisation to be established in the country.

They had a mixed bag of interests - an examination of papers published in the early issues of the ENHG *Bulletin,* which preceded *Tribulus,* shows contributions on, for example, birds and marine mammals, fish and archaeology, flowering plants and ants. All of those early members, though, whatever their own particular interests, shared a general interest in the UAE as a country, in its origins, its traditions and its people.

Many of them, who included diplomats, oil company personnel, teachers and even an airforce pilot, made important discoveries about the natural history and archaeology of the country, not so much because they were themselves all trained scientists - far from it - but because the UAE in the 1970s was almost virgin terrtory as far as scientific research was concerned. So little had been done, and so little of that was, in any case, easily accessible locally, being buried in obscure academic publications overseas, that new discoveries were remarkably easy to make, whether finding a bird species not previously recorded in the country, or locating a previously-undescribed ant, or finding an archaeological site.

Some were polymaths in their interests, like one of the Group's founders, the late J.N.B. 'Bish' Brown, for whom all and any thing was sufficient to provoke his curiosity. Others, like Ian Hamer, were more focussed, on a particular part of the animal kingdom, for example - in his case ants, bees and wasps.

Yet one thing characterised almost all of them - an interest in the country as it had been, and in what had gone before. For them, as for succeeding generations of expatriate enthusiasts, there was one source, above all, which gave them an idea of what the UAE had been like in the pre-federation, pre-oil days - the book *Arabian Sands,* written in the late 1950s by author, photographer and explorer Wilfred Thesiger, but describing the country even earlier, in the late 1940s.

As our readers will know, Thesiger died in August, indisputably the last of the great explorers. An obituary appears elsewhere in this issue, but it is appropriate to note here that the Group was honoured that he agreed to be our first Honorary Life Member during his last visit. For many of the Group's members - those a quarter of a century ago and those of today - he was not merely a source of information, but of inspiration too.

As far as the rest of the content of this issue is concerned, it is, as usual, a bit of a mixed bag. Perhaps the paper that will attract most attention is that by Will Higgs and others on the Late Miocene fossil elephant footprints in the Western Region. These are of international importance, and, once again, are testimony to the significance of Abu Dhabi's palaeontology.

Equally important in scientific terms is the detailed study by John Burt on the macroinvertebrates present in the Wadi Qahfi in Oman, not far from Hatta. These are a poorly studied group anywhere in Arabia and Burt's work, supported by Zayed University, offers important additions to existing knowledge.

Two shorter papers, on the first record of tadpole shrimp for the UAE and on the saxaul 'dew forest' west of Abu Dhabi offer new information of direct relevance not only to the UAE's wildlife and habitats, but also to issues of pest control and conservation.

The remaining paper is, we should concede, a bit of an oddity - using an iguana from Central and South America on Abu Dhabi sabkhas to simulate in a modern environment Triassic fossil footprints from the days of the dinosaurs found in Europe. There is a rationale behind it all, as the paper shows, while the Editors felt it worthwhile to place on record this unusual example of the UAE's involvement in broader international research.

Two lengthy reviews, by Geoffrey King and Gary Feulner, complete the main body of material in this issue.

We are pleased to note not only that results of new research are reported but also that several new contributors appear for the first time. We would, of course, welcome more.

Finally, your Editors would like to note that we rarely receive comments from our readers suggesting topics they would like to receive more - or less - attention. Within the constraints placed on us by the fact that we can only publish material that is submitted to us, we would be pleased to try to oblige.

Corporate Members of the ENHG

Production of *Tribulus,* and many of the other activities of the Emirates Natural History Group, including the grant programme of the Group's Conservation Fund, would not be possible without the generous support of the Group's Corporate members, many of whom have provided consistent assistance over many years. The Editorial Board and the Group Committee acknowledge, with thanks, the invaluable support of the following companies and bodies, currently Corporate members of the Group, and all past corporate sponsors:

Abu Dhabi Company for Onshore Oil Operations, ADCO; Abu Dhabi Gas Industries Ltd., GASCO; Al Fahim Group;-Al Nasser Holdings; Al Sayegh Richards Butler; Beach Rotana Hotel; British Petroleum (BP); Denton, Wilde, Sapte; Emirates Holdings; Environmental Research and Wildlife Development Agency, ERWDA; Kanoo Group; Le Royal Meridien Abu Dhabi; METCO; Mohammed bin Masood; Motivate Publishing; Nama Development; National Bank of Abu Dhabi; Omeir Travel Agency; Serco-IAL Ltd; Trowers & Hamlin; Union National Bank; URS (Dames & Moore); WESCO.

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

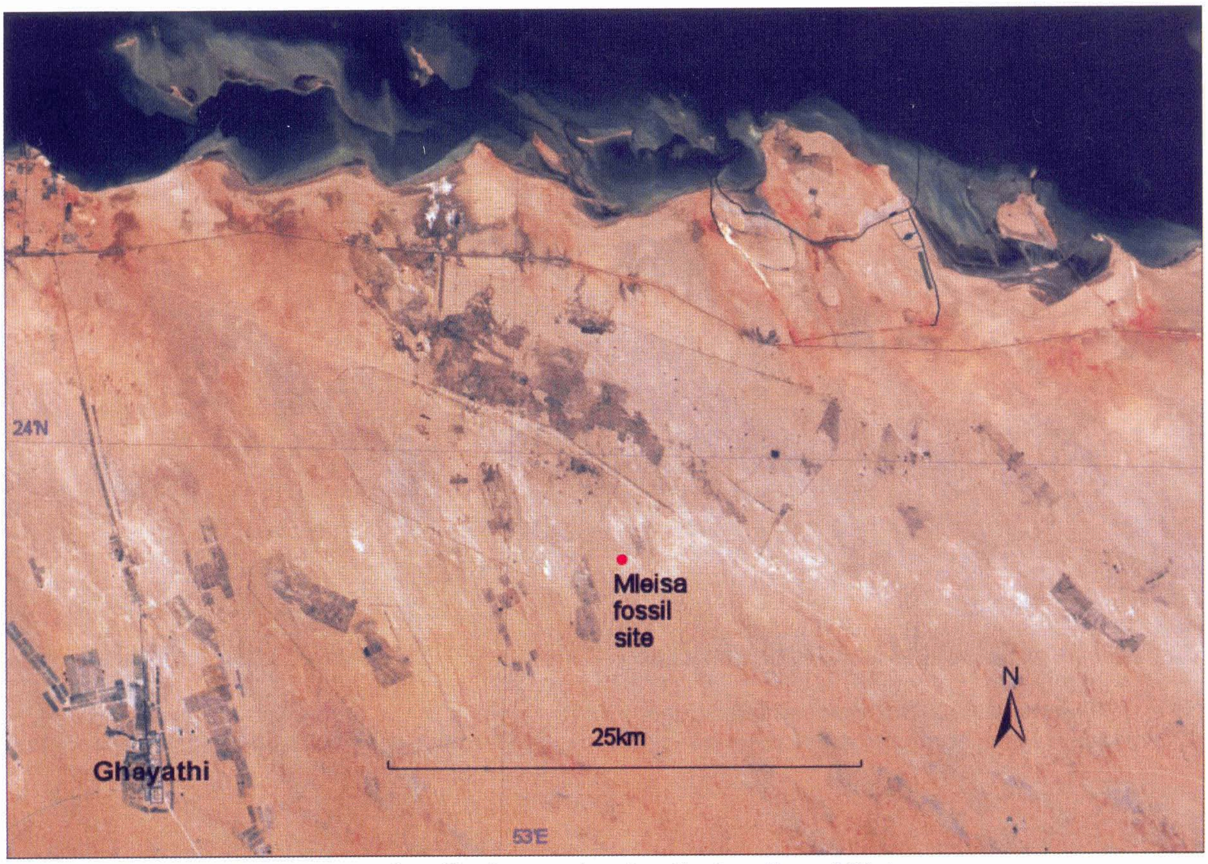


Figure 1: Satellite image showing the location of Mleisa. A band of similar whitish outcrops can be seen, stretching east-west.

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.

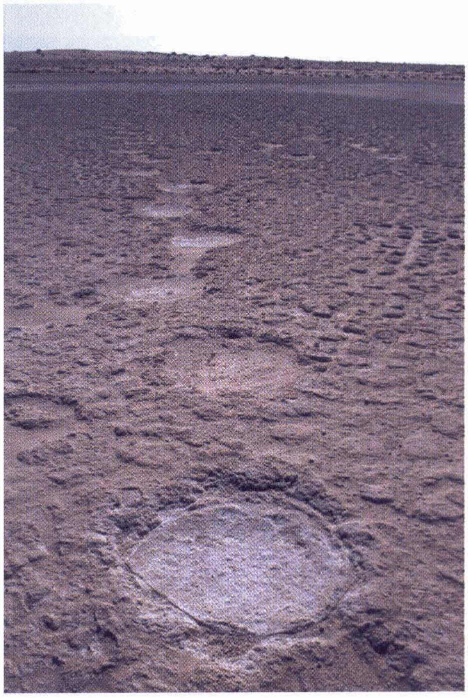
The footprint-bearing marls are overlain by a caliche or palaeosol (fossil soil) which passes upwards into a 0.5m-thick red sandstone that is, in turn, overlain by additional grey or greenish marls. This stratigraphic sequence was largely evident from an outlier (pedestal) of rock that has survived erosion 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.

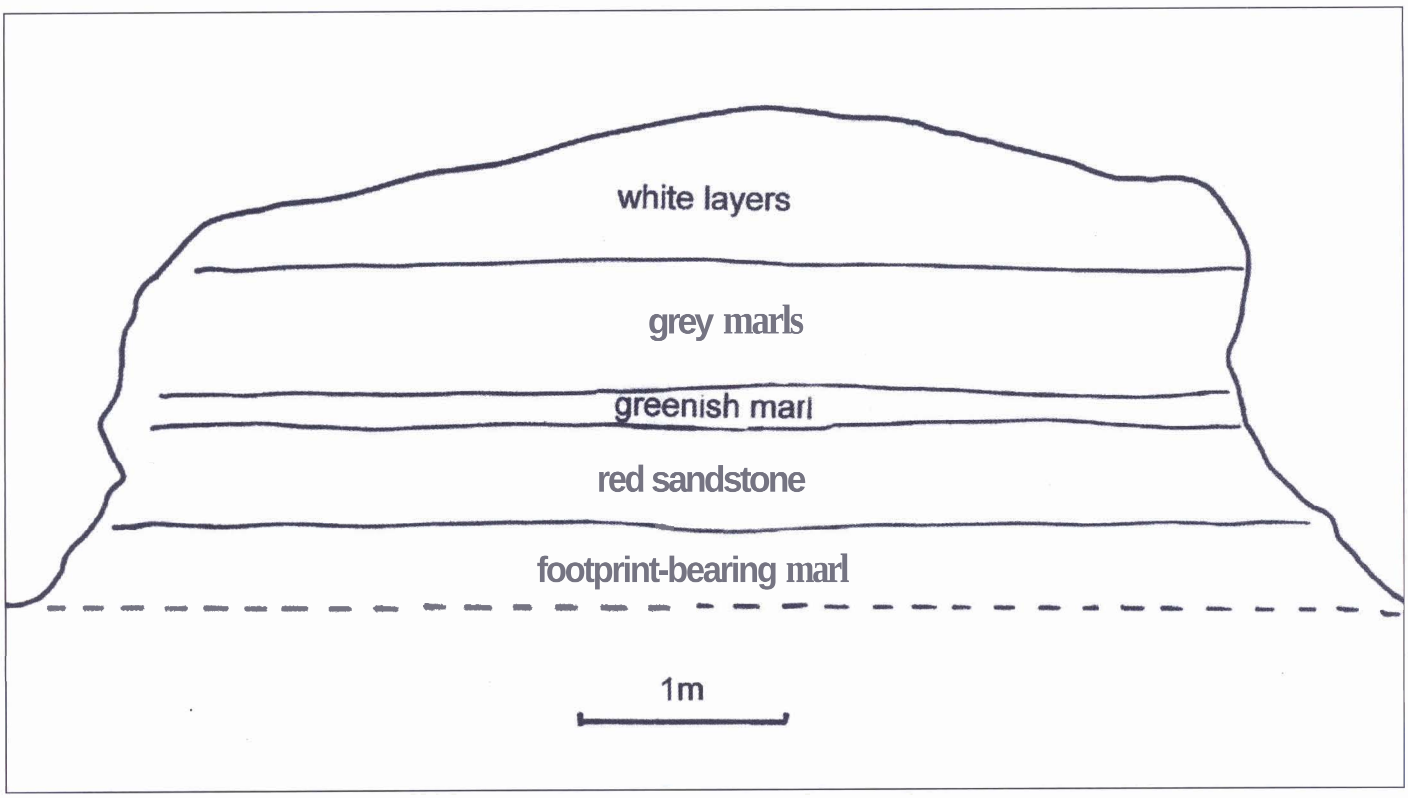


Figure 4: Diagram of the stratigraphy of the outlier.

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

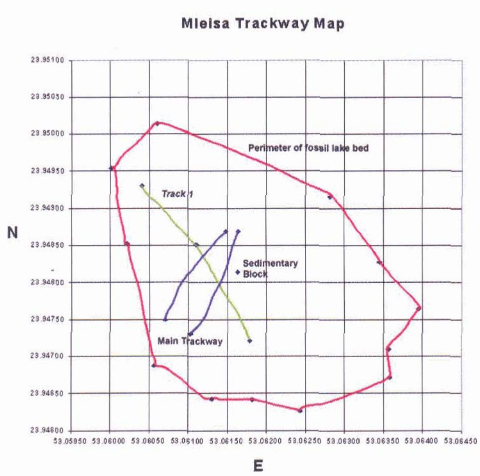


Fig. 5 – Map of the Mleisa trackway.

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*)

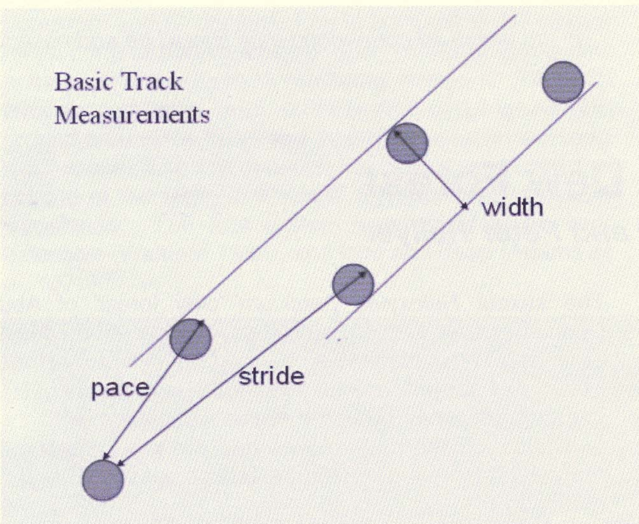


Fig. 7: Trackway measurements, following Thulborn, 1990.

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

The authors wish to thank the Abu Dhabi Islands Archaeological Survey, ADIAS, and the Abu Dhabi Company for Onshore Oil Operations, ADCO, for their sponsorship and logistical support. Dr. Mark Beech, Senior Resident Archaeologist, ADIAS, provided much help in the field during the mapping phase, and also prepared the maps of the site. A.S. (Drew) Gardner, Associate Professor of Biology at Zayed University, Abu Dhabi, also provided invaluable support in the field
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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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.

The total areal cover of this belt has yet to be determined precisely, but appears to be under 2,000 sq. km, less than 2% of the total land area of the Emirates. The area over which saxaul is actually either dominant or co-dominant appears to be less than 25% of the estimated range given above and such woodland, therefore, covers less than 0.5% of the UAE, an indication of how scarce it is among habitats nationally. There is a possibility that the UAE range of saxaul was once more extensive, with anecdotal information certainly suggestive of a greater cover even in recent historical time.

Human activity in the main area, as shown by archaeological survey, appears hitherto to have been relatively light, at least during the recent past and the preceding Late Islamic period. This is somewhat surprising, since the wood is highly regarded as tinder and as firewood (long-lasting and burning very hot), while the trees' foliage is itself suitable as browse for camels. There is, however, evidence of a more extensive human presence in the area during the Late Stone Age (5,500-3,50OBC), with a number of sites from this period having been identified in the Rumaitha area (Hellyer 2002). At this period, however, there was more rainfall than there is today and the vegetation may well have been significantly different from that present today.

Saxaul grows to a height of 3-4m and is similar in appearance, and can be confused with, *Calligonum comosum* and *C. crinitum.* Fog is common in the saxaul forest zone at certain times of year, primarily spring and autumn, and the feathery 'weeping' foliage of the trees trips condensation, water droplets then dripping onto the ground around the bush and serving as an auto-watering mechanism. It is this process which has prompted the coining of the term 'dew forest' for Abu Dhabi's saxaul woodlands. The root system is reported to be very extensive (Western 1989), and long and deep (Adams *et al.* 1978).

In some areas in the east of the saxaul belt, steep dune faces descend to narrow winding inter-dunal flats, where tamarisk *Tamarix* sp., tolerant of even relatively high salinity water, flourishes at the immediate foot of the dunes. Cover of the salt-tolerant *Zygophyllum qatarense* is also often distinctly higher here than in almost any other desert habitat in Abu Dhabi (Hellyer and Aspinall 1999). The permeation of fresh water from condensed dew through the sand after dripping from the saxaul branches may be an important factor. This particular floral community, with these three species simultaneously co-dominant, is not known anywhere else in the desert regions of Abu Dhabi, although this does not necessarily confer any particular status of ecological "superiority". Two other more widely recorded and typical co-dominants are *Cyperus conglomeratus* and *Haloxylon salicornicum.*

A preliminary wildlife survey was completed of the westernmost part of the saxaul belt by staff of the National Avian Research Centre, now part of Abu Dhabi's Environmental Research and Wildlife Development Agency, ERWDA, early in 1997, but thereafter little has been done by way of survey or research in this highly restricted community.

During late 1998 and early 1999, during an archaeological baseline study undertaken by the Abu Dhabi Islands Archaeological Survey, ADIAS, for ADCO, (Hellyer and Aspinall 1998; King, Hellyer & Aspinall 1999), extensive and healthy saxaul woodland was found to be widespread in the dune-fields prevalent in parts of the Rumaitha and Shanayel oilfields, and recommendations were made for its protection. A limited amount of data on fauna was also collected.

Although only limited faunal assessment has thus far been undertaken in the saxaul belt, a number of nationally scarce species of bird have been found, including nesting desert eagle owl *Bubo b. ascalaphus,*

Rob Western describing the ecology of saxaul to oil company personnel at Shanayel, December 1998.

and overwintering golden eagle Aquila chtysaetos and long-legged buzzard Buteo rufinus, all doubtless sustained by the dense populations of Cape hares Lepus capensis, small rodents, snakes, lizards and geckoes. The relatively stable mounds that form around the base of individual saxaul trees house rodent burrows and colonies (of jirds (Meriones sp.). Flourishing 'dhub' Uromastyx aegyptia microlepis colonies occur locally in aeolianite outcrops. Stone curlew Burhinus oedicnemus, a popular local quarry for hunters, is also common here, as are flocks of lesser short-toed larks Calandrella rufescens in winter. Houbara Chlamydotis macqueenii also occurs. Most of these species are, in fact, commoner here than in any other part of the Abu Dhabi desert habitat, and no other single site is known to support all of them at the same time.

Preliminary investigation of other components of the floral community has suggested that the saxaul belt may also be an important habitat for the little-studied lichens of the UAE, with two epiphytic species certainly occurring (Gary Brown, pers. comm.) No study has yet been undertaken of flowering annuals in the area.

Further development of the Rumaitha and Shanayel fields is currently (late 2003) under way, with ADCO having adopted a cluster-drilling approach that will limit impact upon the woodland. The Health, Safety and Environment, HSE, policy of the Company requires that it should minimise adverse environmental impact during its operations.

These two oilfields, which encompass both the saxaul woodland and other areas such as outcrops of aeolianite and the sabkha belt, as well as the Dabb'iya field, are included in a proposal currently being developed for the conservation of the geology, archaeology, marine habitats, fauna and flora of ADCO's North East Bab oilfields.

In the area of the saxaul belt as a whole, the responsibilities and authority of a number of other Government-related bodies, including ADCO and the Abu Dhabi Municipality, overlap with those of ERWDA, and no single body has complete planning and management jurisdiction over the area.

However, ERWDA is the one Government body with a specific mandate to safeguard the emirate's biodiversity and may, if required, seek to bring together all relevant parties. Part of the current work programme of ERWDA's Terrestrial Ecology Research Centre, TERC, is aimed at the selection of potential protected areas.

It is to be hoped that that the saxaul community will be in the short-list of sites considered of high biodiversity value on both a national and a regional scale and thus worthy of formal designation. Coupled with plans by ADCO to conserve the saxaul community in the Rumaitha and Shanayel areas, this may help to provide this unique 'dew forest' with the degree of protection it requires.

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Authors' note:

The 'incinerator road' that heads south to Hameem, at the eastern end of the Liwa, from the Abu Dhabi-Tarif/Sila'a road, bisects the saxaul belt at Shanayel, around 10 km. from the turning off the main highway.

A particularly lush area of saxaul is visible immediately east of the road within the fenced-off compound, including a car museum, that belongs to Sheikh Hamed bin Hamdan Al Nahyan. We are grateful to him for permitting us access and for his hospitality.

Dr. Gary Brown of ERWDA commented on the original draft and provided much additional useful information, while Professor A.S. (Drew) Gardner kindly drew our attention to the parallels with the 'fog deserts' of Oman and Namibia.

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First Record of the Tadpole Shrimp *Triops cancriformis* (Bosc. *1801)* (Crustacea: Branchiopoda: Notostraca: Triopsidae) from the UAE

by Yasar Al-Khalili and Kevin Thompson

Abstract

In order to investigate the possible presence of tadpole shrimp (Family Triopsidae) in the United Arab Emirates, UAE, seven dry soil samples were collected from desert sites in the emirate of Sharjah. These were hydrated in the laboratory and the tadpole shrimp *Triops cancriformis* (Bosc. 1801) was found in two samples, constituting a first record for the UAE.

Key Words: Notostraca, *Triops cancriformis,* biological control, United Arab Emirates.

Introduction

Tadpole shrimp (Notostraca: Triopsidae) are freshwater crustaceans that inhabit temporary fresh water accumulations worldwide (Longhurst, 1955). *Triops cancriformis* (Bosc. 1801) is one of four species of the genus *Triops,* and is the oldest known extant species, dating back 220 million years. Its geographical distribution ranges from southern Europe to North Africa, and Asia as far as India (Boxhall, *pers. comm.).*

Prior studies have examined the fauna of freshwater crustaceans inhabiting temporary inland water bodies of Arabia generally (Thiery, 1996), but there has been little data published for the UAE and there have been no previous reports of tadpole shrimp. However, the possibility that isolated populations of tadpole shrimp might be present in different parts of the UAE is not inconsistent with what has been found elsewhere in the Arabian Peninsula. Tadpole shrimps are known to occur, for example, in the Wahiba Sands and Jiddat al-Harasis of central Oman, where they are relatively abundant, although the species found there is *Triops numidicus* (Thiery, 1996). The presence in Sharjah of *T. cancriformis,* which in Arabia has been considered a Palaearctic relic limited to higher elevations (Thiery, 1996), was somewhat unexpected. To date, the only other Arabian records of this species are from the Yemen Highlands, and all other records refer to *T. numidicus.*

Several authors have noted the importance of the tadpole shrimp as a biological control agent for mosquito larvae (Tietze and Mulla 1989; Tietze and Mulla 1990; Tietze and Mulla 1991; Fry *et al.* 1994). Tadpole shrimp are known to have a high reproductive potential, producing dry-resistant eggs that may remain viable and dormant in a desiccated state in soil for several years (Fry and Mulla, 1992). This high reproductive capacity and the fact that the desiccated eggs (cysts) are easy to distribute make the tadpole shrimp a potentially useful biological control a'gent for controlling the mosquito larvae inhabiting temporary rainwater accumulations in the deserts of the UAE.

Mosquitoes are known for their ability to transmit causal agents of malaria and several viral diseases to humans and animals. Several species having the ability to transmit these diseases are recorded in Dubai (Pest Control Section, Dubai Municipality – unpublished data). Of these, *Anopheles stephensi* and *A. culicifacies* are

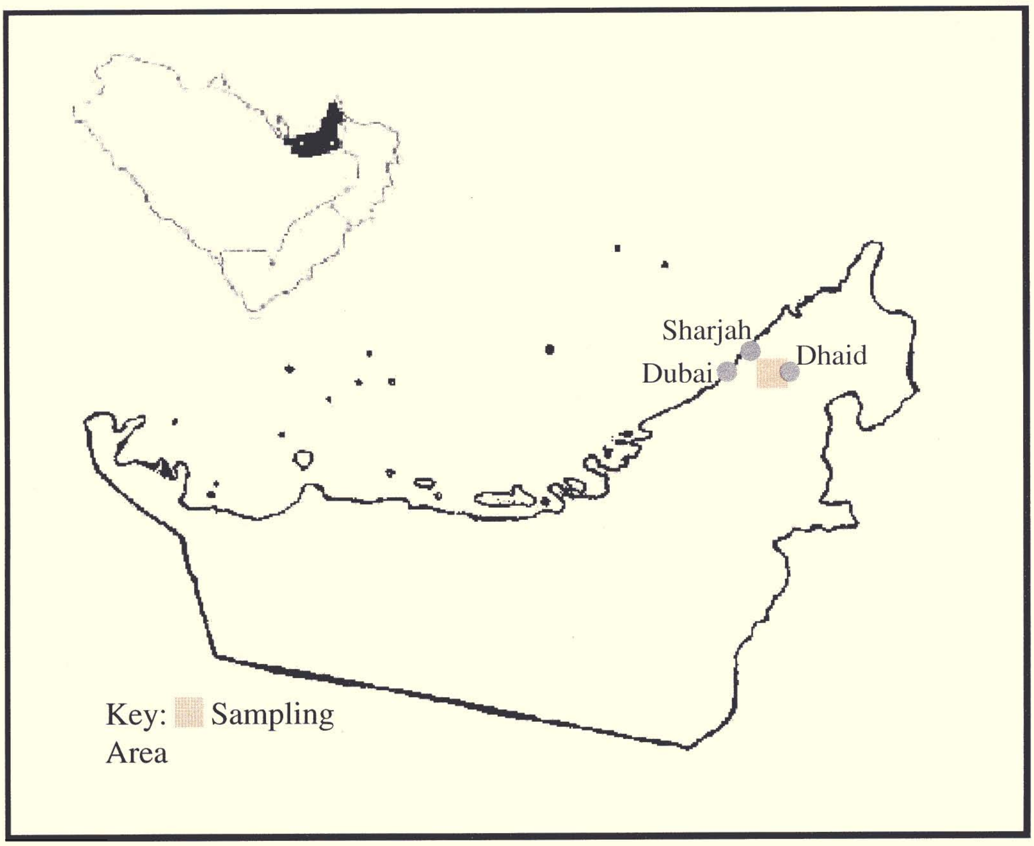

Figure 1: Map of the United Arab Emirates showing the nearest cities to the sampling sites

important vectors of the malaria parasite.

The locating of small water collections where mosquitoes breed and treating them with pesticides is labour-intensive, costly, and has an adverse effect on the environment. Thus alternative biological methods for control of mosquitoes are required.

As a preliminary step in investigating the possibility of using the tadpole shrimp as a biological control agent of mosquito larvae in Dubai, it was necessary to determine whether or not tadpole shrimp occur naturally in the UAE. For this purpose, a survey was carried out in late February and early March of 2001 in desert areas of the Emirates of Dubai and Sharjah. This was near the end of the statistical "rainy" season in the UAE (December-February), but, owing to below average rainfall in the area, which has continued since 1998 (Dubai International Airport, unpublished data), no temporary freshwater pools were found at the time of this study. Sampling was, therefore, limited to locations where surface water was known or believed to collect from historical or field evidence. After several years of drought, it was not always easy to determine where temporary inland pools might be located.

Materials and Methods

Seven soil samples, weighing 10 kg on average, were collected from sites considered reasonably likely to contain cysts of the tadpole shrimp (Map 1, Table I). All sample sites were within the Sayh Musannad area of the Emirate of Sharjah, a silty plain extending among scattered low, vegetated dunes. From older maps, it can be inferred that this plain formed originally as the terminus of a natural overflow channel from Wadi Faiyah, a wadi that traverses the sand desert and whose main channel runs several kilometres to the east. Individual sample sites included places where dry mud flats and dunes converged on gravel plains; places where small depressions formed between dunes; and places where sands met isolated rocky outcrops (Gary Feulner, pers. comm.)

Samples were collected in plastic zip-lock bags, numbered and sealed in the field, and the locations were recorded using a GPS. In the laboratory, all samples were divided into 2 kg portions on average and placed in trays, 38cm x 25cm x 5cm, which were hydrated with tap water and kept in a room with a constant temperature of 26°C +/-2 "C and an average of 12 hr light/dark intervals. Any cysts present in the samples were allowed to hatch naturally and each tray was checked daily for any changes.

Results

Triops cysts started to hatch from two samples within 2-3 days from hydration with tap water. Both positive samples were from man-made environments (Table 1). This was probably because they are more effective collectors of natural water, or because man has also disrupted the original natural hydrology and made it less efficient than it was. Alternatively, the man-made connection may be significant and T. cancriformis is not native but recently introduced with agricultural materials (G.R.Feulner, pers. comm.).

However, there was no evidence of agricultural materials in the areas of collection, the only vegetation being natural. The man-made environments involved were holes of approximately one metre in depth, which had been dug for an undetermined purpose. Later collections of samples from natural dried-up mud-flats (not dealt with in this paper) also showed the presence of tadpole shrimp when hydrated. This confirms their natural origin. Nymphs were reared at room temperature (26°C +I-2 "C) and fed with ground TetraMin® tropical fish food until the natural death of the shrimps (2-3 weeks). Adults were reared for the purpose of identification only. A

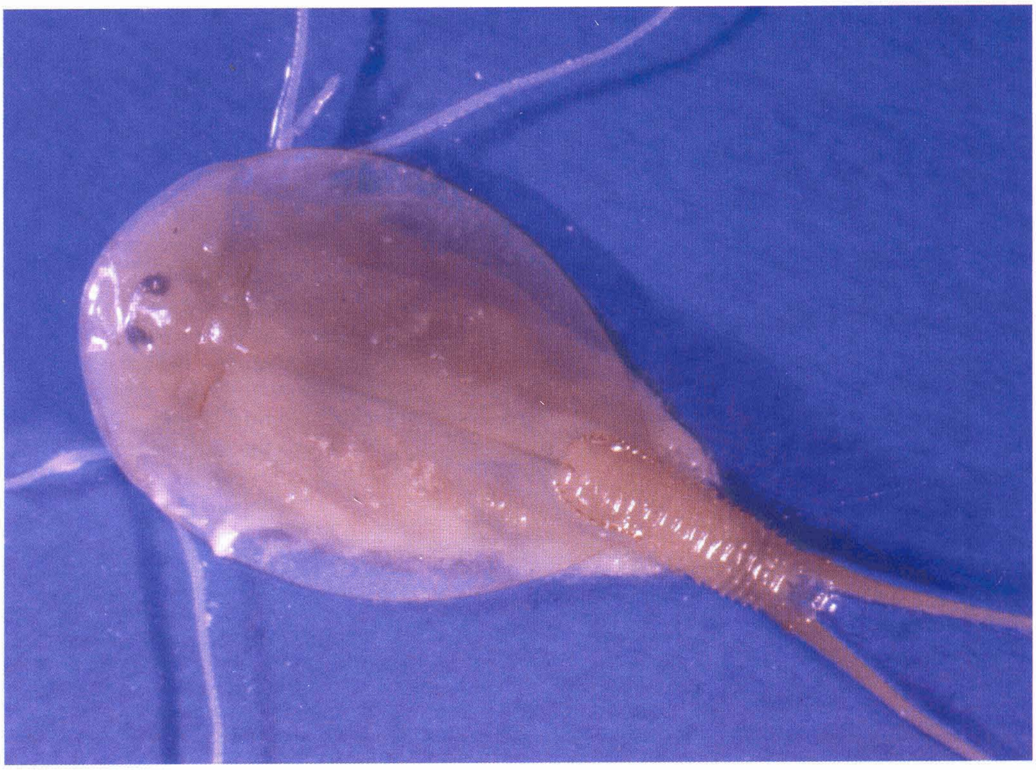

Plate 1. ***Triops cancriformis***

Table 1: Sampled Sites and Results

Sample	Date	Type of Habitat	GPS Reading Deg Min MM	*Notostraca* Present/Absent
1	28/02/01	Open pan	25°15'15N 55°39'25E	Absent
2	28/02/01	Open pan, near to tree line	25°15'10N 55°39'29E	Absent
. 3	28/02/01	Edge of pan next to *Calotropis procera* plant	25°15'25N 55°39'33E	Absent
4	08/03/01	Man made hole at base of *Prosopis cineraria* tree	25°15'66N 55°39'80E	Present
5	08/03/01	Small dried pool surrounded by *Acacia* trees	25°15'56N 55°39'86E	Absent
6	08/03/01	Edge of pan surrounded near ***Prosopis cineraria*** trees	25°15'71N 55°39'61E	Absent
7	08/03/01	Man-made pool surrounded by ***Acacia*** trees	25°15'34N 55°39'67E	Present

representative specimen was sent to The Natural History Museum, London and was identified by Dr. G.A. Boxhall as *Triops cancriformis* (Bosc. 1801) (G.A. Boxhall, *pers. comm.).*

Discussion

The confirmation of the presence of a tadpole shrimp in the UAE, of native origin unless introduction can be proven, justifies further investigation of the potential use of these crustaceans as a biological control agent for mosquitoes in the UAE. If future trials show *Triops cancriformis* to be an efficient predator of mosquito larvae inhabiting temporary freshwater collections, it could be used as part of integrated control measures. Its presence in man-made water bodies in the desert environment suggest that it may already be playing this role. Preliminary studies on salinity tolerance of *Triops cancriformis* showed low tolerance to saline water (Yasar Al-Khalili, unpublished data). This in turn, might limit its use as a biological control agent in saline groundwater collections in the UAE. Further studies of *Triops cancriformis* are recommended, focusing on its life cycle and its possible use in integrated pest control in the UAE.

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Aquatic macroinvertebrates of an intermittent stream in the arid Hajar Mountains, Oman

by John Burt

Abstract

Aquatic macroinvertebrates were collected from six habitats in two permanently flowing sites in Wadi Qahfi, northern Oman. A total of 38 taxa were identified, many to taxonomic levels previously unrecorded for aquatic fauna in Arabia. Overall richness was comparable between all habitats sampled. While very little regional information is available for identification of aquatic macroinvertebrates, the combination of regional descriptive information with foreign keys for aquatic stages has proven to be a valuable approach. Recommendations are made for appropriate levels of classification for the major taxonomic groups, and references are provided to assist in identification.

Keywords: Oman, Arabia, fauna, freshwater, intermittent stream, wadi

Introduction

The Hajar mountain range straddling northern Oman and the eastern United Arab Emirates forms part of the Arabian Highlands. The World Wildlife Fund for Nature has identified this area as part of the Global 200 Ecoregions, making it a priority area for biodiversity research and conservation (Launay and Jungius, 2001). Although the rainfall of the Hajar mountain range is low and relatively infrequent (UNESCO 1979, Boer 1997), there are numerous spring-fed streams throughout the region. A survey of the eastern United Arab Emirates alone found twenty-seven permanent sources of water (Feulner 1998), and more than eighty sites are known in Oman, Yemen, Saudi Arabia and Kuwait (Segars and Dumont 1993). The majority of these streams are spatially and temporally intermittent, with flow alternating between the surface and the hyporheic (alluvial) zone.
These intermittent desert streams, known as wadis (from the Arabic wadian), represent ecosystems chemically and biologically distinct from streams in more temperate climes (Busch and Fisher 1981, Grimm *et* al. 1981, Boulton et al. 1992, Boulton and Stanley 1995, Clinton *et* al. 1996), with spatially infrequent surface flows acting as 'islands' for organisms with aquatic life stages (Brooks 2000).
Unfortunately, knowledge of freshwater fauna in the

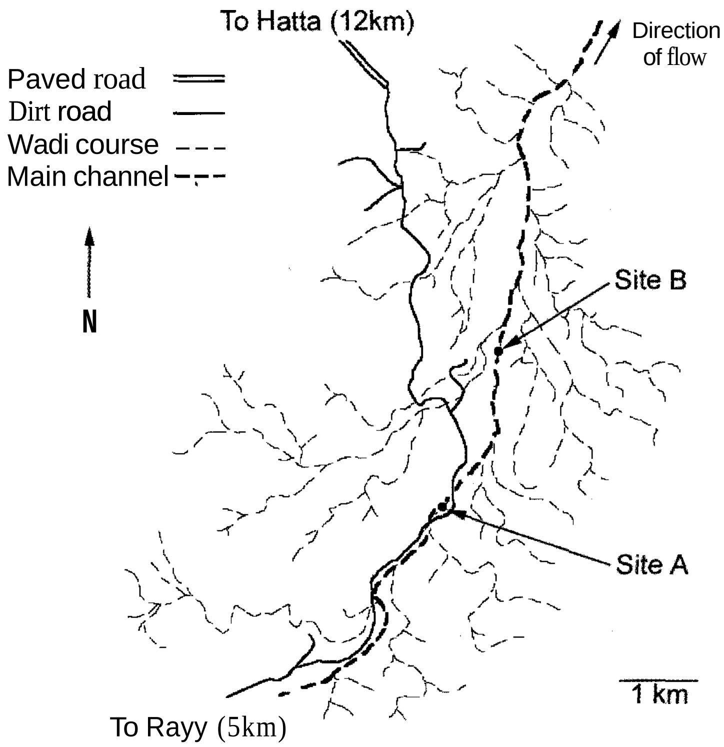

Figure 1: Map of Wadi Qahfi study area.

Arabian Peninsula is extremely limited (Victor and Al-Mahrouqi 1996). The purpose of this study was to examine the macroinvertebrate fauna of isolated areas of permanent flow.

Methods

Study Area

Study sites were located in Wadi Qahfi, Oman, 12 km south-east of the village of Hatta, United Arab Emirates, in an area known to expatriate UAE residents as 'the Hatta pools' (Figure *1).* Wadi Qahfi originates on the eastern edge of the Hajar mountain range and travels north-east before merging with Wadi Hatta and travelling east to the Gulf of Oman. Upper tributaries of Wadi Qahfi are permanently dry with the exception of seasonal flooding. Spring-fed hyporheic water flows down the main channel, with periodic zones of permanent surface flow where the hyporheic zone is constricted by bedrock.

The upper tributaries drain sparsely vegetated mountain sides, mainly Upper Cretaceous to Pre-Permian allochthonous gabbro and ultrabasic sediments. The main channel areas contain Pleistocene and Holocene autochthonous fluvial deposits with periodic exposures of cherts and volcanics (UAEU 1993).

The major human activities in the study area are agriculture and recreation. A few small date farms irrigated by traditional channels (aflaj) are located within a few kilometres of the sampling sites. The impact of this diversion is minimal given the small volume of water being extracted (pers. obs.). Swimming in perennial pools is a common weekend pastime, and sport utility vehicles are used for recreation in the wadis.

Two sites containing perennial surface water were selected for sampling. These sites are 2.5 km apart and were designated as Site A (24°42'47" N; 56°11'10" E) and Site B (24°41'56" N; 56°10'24" E). The sampling sites are along a third order stream which represents the main channel, and these sites represent the only accessible areas in the main channel with permanent surface flow (Figure 1).

Site A contains two pools (Figure 2) flowing into a riffle zone followed by a run which eventually disappears into the sediments. The pools are constrained by bedrock walls with sand and gravel bottom, while the riffle and run traverse an unconstrained section of stream bed with gravel and cobble (Figure 3). Site B contains two pools constrained by sheer bedrock walls with a sand and gravel bottom. These pools each end at a gravel bar, where water infiltrates back into alluvial deposits. No riparian vegetation or aquatic macrophytes were present in either sampling site, although algal mats (primarily Spirogyra) were present in the riffle and run of Site A.

Sampling Methods

Care was taken to sample only in areas with minimal disturbance from vehicular activity. Samples and physiochemical data were collected monthly from April to June 2002 during the last week of each month, between 09:00 and 14:OO. Pools and the run were qualitatively sampled by disturbing the bottom for a period of approximately three minutes while sweeping a D-frame net (mesh size 250µm) rapidly through the disturbed area (Boulton 1989). Riffles were sampled in a similar fashion, except that the net was held over the substrate immediately downstream (<50 cm) from the disturbance and flow carried benthos into the net.

Samples were live sorted in the laboratory within 48

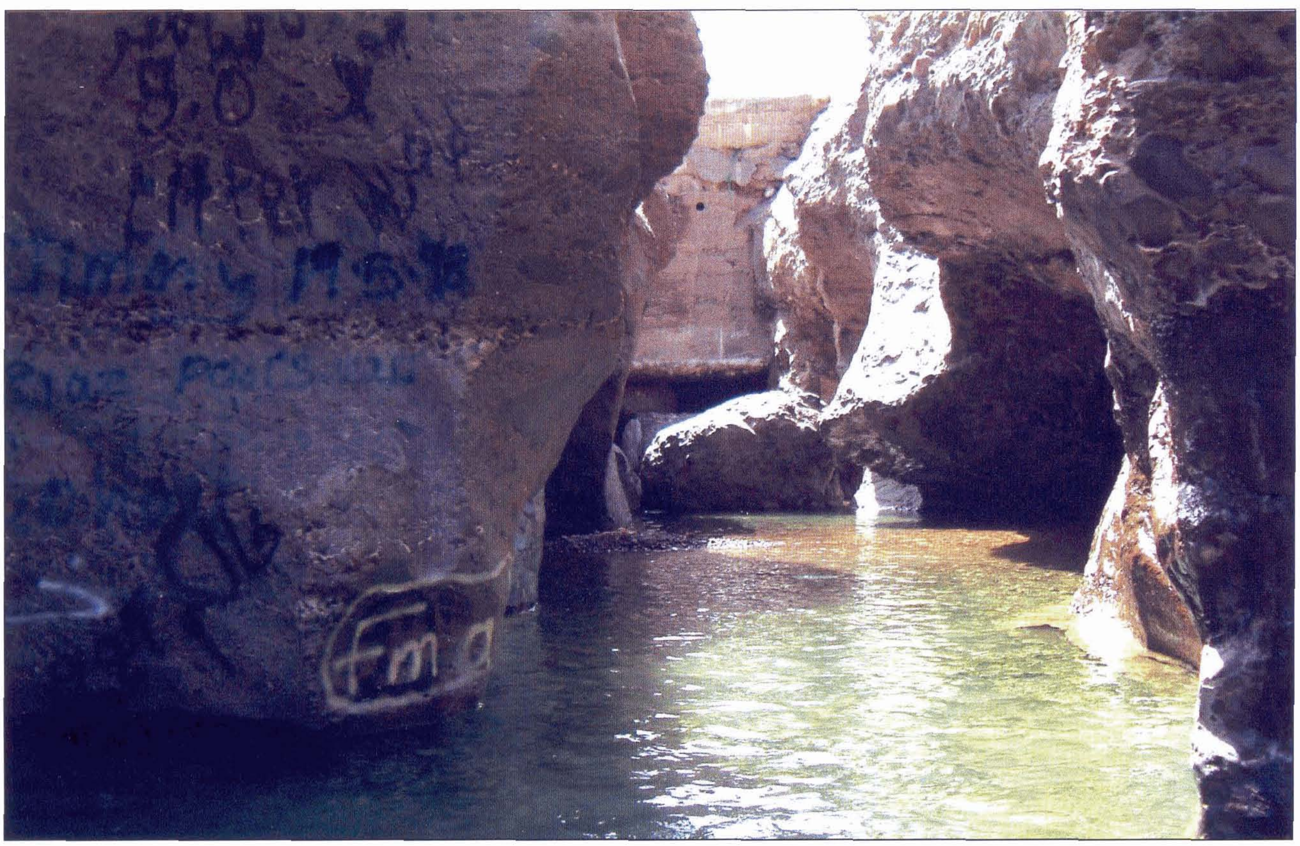

Figure 2: Upper pool of Site A in Wadi Qahfi.

hours of collection using a Leica GZ4 stereomicroscope following the qualitative methods prescribed by the USGS (Moulton *et al.* 2000). Live sorting was required due to the poor visibility of some organisms following preservation (Boulton and Stanley 1995). Organisms were preserved in 70% ethanol, with the exception of Chironomidae, which were slide mounted in DePeX mounting media.

Identification was attempted to the lowest taxonomic level appropriate for a standard taxonomic assessment as recommended by the USGS (Moulton *et al.* 2000). Taxa were identified to family or higher level using keys from North America (Pennak 1989, Merrit and Cummins 1996). Regional resources specific to taxa of the Arabian Peninsula such as the *Fauna of Saudi Arabia* series, *Tribulus,* the *Insects of Eastern Arabia* field guide (Walker and Pittaway 1987), and *Entomofauna of Saudi Arabia* checklist (Al-Ahmadi and Salem 1999) were used to identify beyond the Family level, in conjunction with other keys. Where morphology deviated from descriptions in keys, individuals remained at the previously established level.

Mean abundance of each taxon was categorized qualitatively as present (1-2 individuals), common (3-10 individuals) or abundant (>10 individuals) for each of the habitats over all sampling dates. More detailed quantification would have been inappropriate given the qualitative nature of the sampling methods (Boulton 1989).

Table 1

Table 1. Temperature and conductivity (mean ± SD) and pH (range) of water at sampling sites (n=3).

Habitat	Temperature (° C)	PH Range	Conductivity (S/cm)
Site A Pools	28.8±1.0	8.1 8.9	671+33
Site A Run	29.2±0.6	8.3 - 9.1	670±34
Site B Pools	26.7±1.8	9.1 - 9.5	722±55

Figure 3: Riffle and run (right, background) for Site **A** in Wadi Qahfi.

Results

Mean and standard deviation of water temperature and conductivity and range of pH from Sites A and B are recorded in Table 1. Due to a malfunction with the probe, dissolved oxygen readings were unreliable and are omitted. No measurable differences in these parameters were observed between sites.

Currently there is no regional information regarding freshwater Turbellaria, Oligochaeta, or Hydracarina. These organisms could not be classified beyond these levels. The freshwater amphipods, the insect orders Odonata and Coleoptera, and the dipteran family Tipulidae can be reduced to the family level using North American keys, but cannot be reduced further due to inadequate regional information. Trichoptera larvae can be identified at least to family, with some families reducible to genus. The insect families Ephemeroptera, Hemiptera, Ceratopogonidae, Culicidae, Chironomidae, and Tabanidae can all be reduced to the generic level. Molluscs, at least in the case of Wadi Qahfi, can be identified to the species level using combined regional and international resources (Table 2).

Macroinvertebrates collected from different habitats for the two sampling sites are listed in Table 3. Out of 38 taxa identified, 3 were identified to species, 23 to genera, 9 to family, and 3 to higher levels.

All habitats sampled contained a fairly consistent level of taxa richness. The exception was the upstream pool in Site A, where richness was approximately half of that of the remaining habitats among both sites. Water mites (Hydracarina) (Figure 4), the dragonfly family Libellulidae, small saucer bug adults, Heleocoris, (Figure 5) the chironomid Ablabesmyia, and tipulid craneflies were the only taxa ubiquitous to all sites and habitats sampled. Turbellarian flatworms, oligochaetes, long-toed water beetles (Dryopidae), chironomids Crictopus and Rheotanytarsus, the Tabanus /Atylotus horse flies (Figure 6), and the micro-caddisfly family Hydroptilidae were present in multiple habitats but restricted to Site A. Site B was not as rich in site specific taxa. Only the planorbid snail Gyraulus piscinarum, the mosquito Anopheles and the chironomids Procladius, Paratendipes and Polypedilum were present only at Site B. In all cases, abundance was ranked in the lowest category of 'present' and each was found in only a single pool. Various other taxa were recorded from different habitats within and among sites (Table 3).

Discussion

Prior to the present study, the only comprehensive examination of benthic macroinvertebrate fauna for the Arabian Peninsula was the study of Wadi Bani Habib of Jebel Akhdar, northern Oman (Victor and Al-Mahrouqi 1996). A comparison between these studies is interesting. Wadi Qahfi water chemistry is similar to that observed in Wadi Bani Habib. Water in Wadi Qahfi was slightly alkaline, perhaps due to the influence of algal mats and limestone deposits in the area. Alkalinity was also observed in Wadi Bani Habib. As the majority of water flow in Wadi Qahfi is subterranean, water temperatures remained relatively consistent over the sampling period due to buffering from sediments. These results are similar to Wadi Bani Habib where periods of high summer air temperatures (>40 °C), did not significantly alter water temperatures.

There are many similarities in faunal composition between Wadi Bani Habib with the results recorded here for Wadi Qahfi.

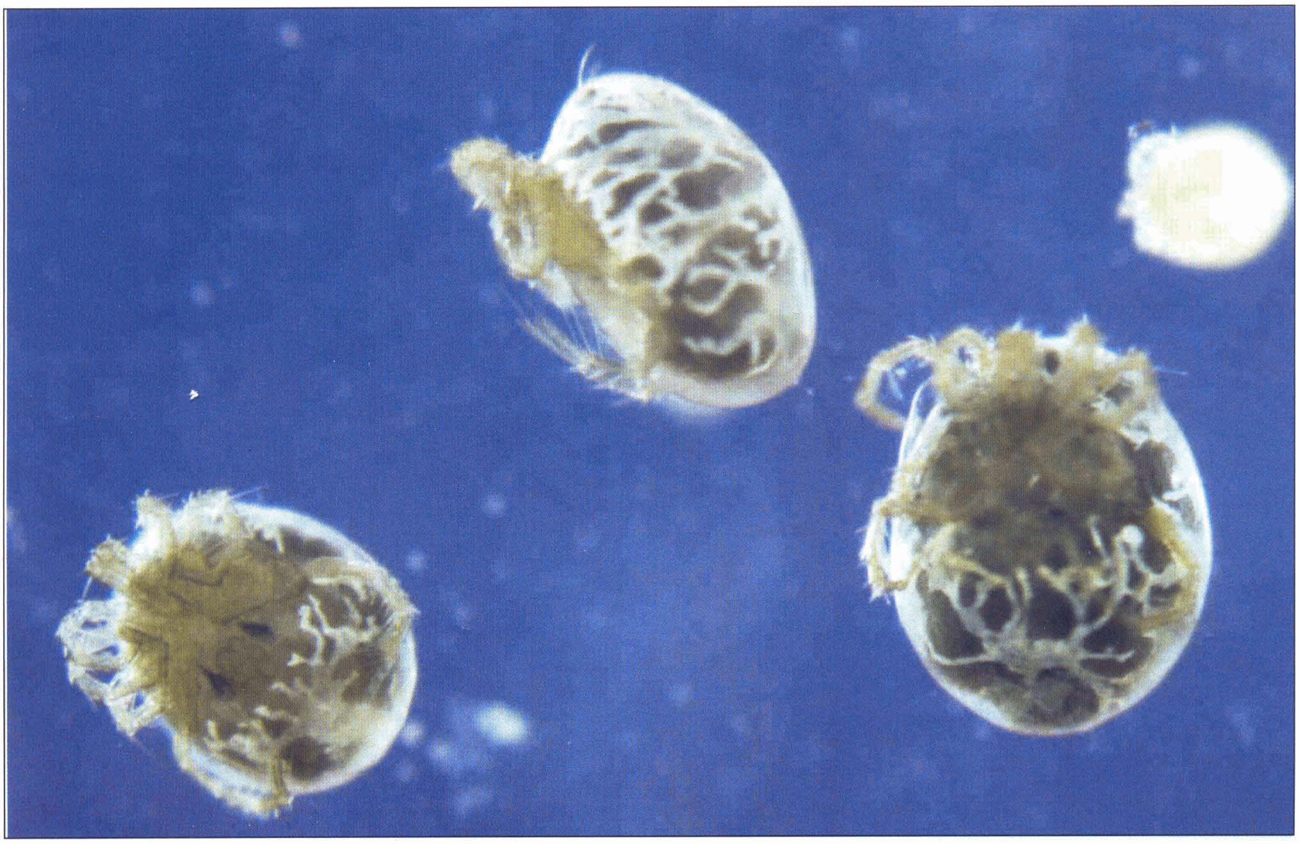

Figure 4: Water mites, Hydracarina, were found to be common to abundant in all habitats examined in Wadi Qahfi.

Table 2. Resources describing adult and larval stages of taxonomic groups of Arabia with aquatic life stages. Reference is made to lowest practical identification level for each group, with resources that can be used to assist in classification.

Taxonomic Group	Regional Information (Adults)	Regional Information (Larvae)	Lowest Confident Larval Identification Level (Resource)	Comments
TURBELLARIA	None	Not applicable	Class (Pennak 1989)	Identification beyond Class should be done carefully as no regional information is available
OLIGOCHAETA	None	Not applicable	Class (Pennak 1989)	Identification beyond Class should be done carefully as no regional information is available
AMPHIPODA	None	Not applicable	Order/Family (Pennak 1989)	Identification beyond Order should be done carefullv as no regional information is available
HYDRACARINA	None	Not applicable	Order (Pennak 1989)	Identification beyond Order should be done carefully as no regional information is available
GASTROPODA	Neubert 1998, Feulner and Green 1999	Not applicable	Genus/ Species (Neubert 1998)	Regional material are descriptive but comprehensive
EPHEMEROPTERA	Al-Ahmadi and Salem 1999, Sartori 1991, Sartori and Gillies 1990	Chorterpes and Cloeon (Sartori and Gillies 1990)	Genus (Merritt and Cummins 1996)	All genera listed for Arabia can be identified
ODONATA	Schneider and Dumont 1997, Schneider and Krupp 1993, Waterson 1980,1984	Unavailable	Family (Merritt and Cummins 1996)	No keys are available to identify larval Platycnemididae
HEMIPTERA	Al-Ahmadi and Salem 1999, Linnavouri and Alamy 1982	Not applicable	Family (Merritt and Cummins 1996); Some Genera (Walker and Pittaway 1987)	Notonectidae incorrectly described as Water Boatmen (Corixidae) instead of Backswimmers by Walker and Pittaway (1987)
COLEOPTERA	Gentili 1989, Hebauer 1997, Heinertz 1979, Olmi 1980	Unavailable	Family (Merritt and Cummins 1996); Some Genera (Nilsson 1996)	Many genera are indigenous to the region making use of foreign keys difficult
DIPTERA	Diverse resources; See below	Unavailable for all families	See individual families below	See individual families below
Ceratopogonidae	Boorman and van Harten 2002	Unavailable	Genus (Merritt and Cummins	Larval keys unavailable for Homohelia

			1996)	and Phaenobezzia
Culicidae	Roberts and Irving-Bell **1997**, Al-Ahmadi and Salem **1999**	Unavailable	Genus (Merritt and Cummins **1996**)	Only three genera are known for Arabia. Pesticide use is widespread to combat malarial mosquitoes.
Chironomidae	Cranston and Judd **1989**	Unavailable	Genus (Merritt and Cummins **1996**)	Of **23** genera Paratrichocladius and Virqatanvtarsus can not be identified as larvae using this resource. Conchapelopia can only be identified as a member of the Thienmannimyia group
Tipulidae	Hancock **1997**	Unavailable	Family/Subfamily (Merritt and Cummins **1996**)	Identify only to subfamily, as only **7** of **12** genera can be identified using Merritt and Cummins (**1996**)
Tabanidae	Leclercq **1982**, Al-Ahmadi and Salem **1999**	Unavailable	Genus (Merritt and Cummins **1996**)	Atvlotus and Tabanus are indistinguishable as larvae and should be grouped together
TRICHOPTERA	Malicky **1986**, Al-Ahmadi and Salem **1999**	Unavailable	Family; Genera of Philopotamidae, Hydropsychidae, and Leptoceridae (Merritt and Cummins **1996**)	Keys for genera of Hydroptilidae unavailable. Ecnomidae, Psychomyiidae, and Limnephilidae have only one genus recorded for each.

	(Site A)				(Site B)	
	Upper pool	Lower Pool	Riffle	Run	Upper Pool	Lower Pool
TURBELLARIA		+	+	+		
OLIGOCHAETA			++	+++		
AMPHIPODA						
Gammaridae		++				
HYDRACARINA	++	+++	++	++	+++	+++
GASTROPODA						
Thiaridae						
Melanoides tuberculata				+		
Lymnaeidae						
Lymnaea natalensis			+++	+++	+	
Planorbidae						
Gyraulus piscinarum					+	
EPHEMEROPTERA						
Caenidae						
Caenis	++	++		++	++	++
Leptophlebiidae						
Chorterpes	+++	++		++	++	+++
ODONATA						
Gomphidae (indet).		+		+	+	+
Paragomphus [t]				+		+
Libellulidae (indet.)	++	+	+	++	+	++
Coenagrionidae (indet.)	+				+	
HEMIPTERA						
Veliidae (indet.)		+				
Naucoridae						
Heleocorus (A)	+	+	+++	+++	+	+
COLEOPTERA						
Carabidae (indet. A)			+			+
Hydrochidae						
Hydrophilidae (indet.L)		+		+	+	
Arabhydrus (A)			+			
Dryopidae (indet. A)				+		
Dryops (L)		+				
DIPTERA						
Ceratopogonidae						
Sphaeromias			+			
Bezzia		+	+	+	+	+
Culicidae						
Anopheles					+	
Chironomidae						
Procladius						+
Ablabesmyia	+++	+++	+	++	+	++
Paramerina	+	+		+	+	+
Thienemannimyia group (Conchapelopia [t])	+	+			+	
Cricotopus		+	+			
Dicrotendipes				+		+
Stictochironomus		+				+
Paratendipes					+	
Polypedilum						+
Neozavrelia		+				
Rheotanytarsus		+		+		
Tipulidae	+	+	++	++	+	+
Tabanidae						
Tabanus / Atylotus		+	+	+		
TRICHOPTERA						
Philopotamidae						
Chimarra			+			
Psychomyiidae (indet.)		+				
Abaria [t]	+		+	++	+	+
Hydropsychidae (indet.)			+			
Hydroptilidae (indet.)		+		+		

Table 3. Taxa recorded at sites in Wadi Qahfi, Oman. Qualitative abundance categories represent mean number collected at each habitat over three sampling dates (+ = present (1-2 individuals), ++ = common (3-10 individuals), +++ = abundant (>10 individuals)). Life stage is denoted as L (larval) or A (adult) where relevant, and tentative classification is indicated by (t).

However, due to the difficulty in locating appropriate taxonomic resources, all groups were identified only to family level or higher in that study (Victor and Al-Mahrouqi 1996). Information regarding freshwater invertebrate fauna from the Arabian region is scarce. Aside from molluscs, few studies have examined the composition of aquatic communities in the region (Victor and Al-Mahrouqi 1996, Roberts and Irving-Bell 1997, Victor and Victor 1997), and aquatic taxonomy remains an area in need of substantial development. There is very little information on the larval stages of aquatic insects in the Fauna of Saudi Arabia series, the primary taxonomic resource for the region, and a common naturalist guide, Insects of Eastern Arabia (Walker and Pittaway 1987), only has an incorrectly identified larval dragonfly (Schneider and Dumont 1997).

Widespread sampling of aquatic habitats in Arabia has been conducted in separate surveys in the 1990's, but these have focused on distinct taxonomic groups (Rotifera: Segars and Dumont 1993) or on subterranean habitats (Stygofauna of Oman series: ex. Magniez and Stock 1999, Martinez-Ansemil et *al.* 2002), which are known to differ significantly from benthic habitats (Boulton et *al.* 1992).

Despite challenges in several taxa, the results of this study show that the integration of comprehensive keys from other locales with regional taxonomic information allows for a relatively detailed survey of the aquatic invertebrate fauna. The inclusion of larval information when creating taxonomic checklists should be considered a priority for taxonomists working in the Arabian Peninsula. While larval identification keys could be developed from existing literature for a number of taxa in the region, others will require significant research. The development of a rearing programme for positive identification from mature adults would be an essential step forward in the understanding of freshwater fauna in the region.

Figure 5: Saucer bugs, *Heleocoris* (Naucoridae), were collected in all habitats in Wadi Qahfi, and were abundant in the riffle and run of Site A.

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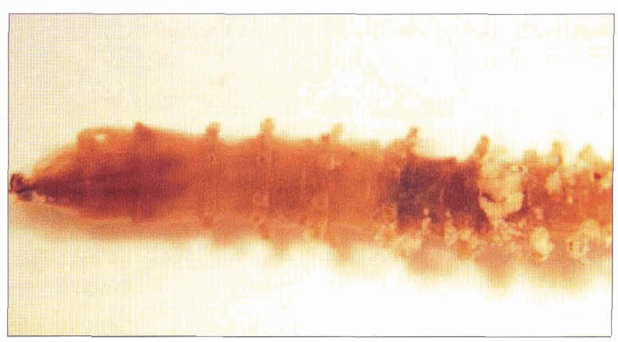

Figure 6: Horse flies, *Tabanus/Atylotus* (Tabanidae), were observed in pool, riffle, and run habitats of Site A.

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Lacertilian trackway experiments in the carbonate tidal flats of Al Dabb'iya, western Abu Dhabi, U.A.E.

by Cajus G. Diedrich and Andrew S. Gardner

Introduction

Numerous fossil vertebrate track sites have recently been discovered in the Middle Triassic and Late Jurassic marine carbonate tidal flat deposits of Europe (Diedrich 1998 - 2003). These include over 35 localities in Germany, discovered by the MTMP (Middle Triassic Megatracksite Project) (Diedrich 2002c).
This project aims to elucidate the fossil carbonate tidal flat ecosystem and its reptiles. The situation in Europe appears to be unique, with the discovery of partial skeletons of the putative track makers in the Netherlands associated with the track beds (biolaminates) (Diedrich 2002c).
Comparisons between fossil and recent marine biolaminates and their trackways are important for the understanding of the facies, the palaeogeography and the track makers. Sedimentological comparisons between the Germanic Basin (Middle Triassic, 240 MBP) and the recent Arabian Gulf were first made by Knaust (1998).
Both basins were/are flat marginal basins with high salinity in dry subtropical latitudes. In both basins, biolaminates were/are present on the flat carbonate ramp coastlines. The recent carbonate tidal flats of the Abu Dhabi region (Evans and Kirkham 2001) are an ideal comparative locality and were used in this study.
Firstly biolaminates were studied in Khor Qirqishan (Plate 1). Then a large individual of the iguanid lizard, Iguana iguana, was used for a series of trackway experiments in the carbonate tidal flats of Al Dabb'iya peninsula, west of Abu Dhabi. This animal has a similar footprint size, as well as the overprinting of the forelimb, that has been observed in the fossil record of the Middle Triassic trackways of Rhynchosauroides tirolicus. In the experiments, tracks on microbial mats of varying texture and wetness were produced to compare track imprinting and preservation. Tracks produced by slow walking to fast running, and also swimming activities were documented and compared with the fossil material.

2. Sedimentological observations

The track sites of the Middle Triassic period in Europe represent fossil carbonate tidal flat regions. These tracks were found in mud-cracked microbial biolaminates. The microbial mud-cracked mats were therefore studied to the west of Abu Dhabi, to compare these sediments to the ones of the European Middle Triassic (241-238 MBP) track sites (locations of sites see Plate 1).
The Holocene non-active microbial mats at the Western Abu Dhabi coast in the Khor Al Qirqishan bay (Plate 2A-B) consist of millimetre thinly bedded and mud-cracked fine to medium-grained carbonate sands (up to 60 cm in height). The consistency of these biolaminates is still soft, but when cementation is finished, these biolaminates build hard beach rocks (cf. Evans et al. 2002) that can be found along the recent coastline of the Khor Al Qirqishan bay.
In the daily inundated carbonate tidal flats of the Al Dabb'iya experiment site (Plate *2C-F),* the living microbial mats have not yet accumulated many centimetres of laminated beds. Here the process of building biolaminates is still in progress. The fossil Middle Triassic biolaminates only differ macroscopically from the recent ones of the Abu Dhabi region in their grain size, being built in most cases of silty carbonate particles and not of sand.

3. Track Experiments

The experiments at Al Dabb'iya were conducted at low tide from 9 a.m. until the tide turned at noon, rapidly flooding the low-relief flats (Plate 3A, B). The lizard used in the trackway experiments was a large, male green iguana (Iguana iguana Linnaeus 1758), a Central and South American species.
The green iguana is primarily an arboreal herbivore, but is known to be an accomplished swimmer (Müller 1972). This individual was approximately 41 cm in snout to vent length and 4 kg in weight. Although the tail tip had

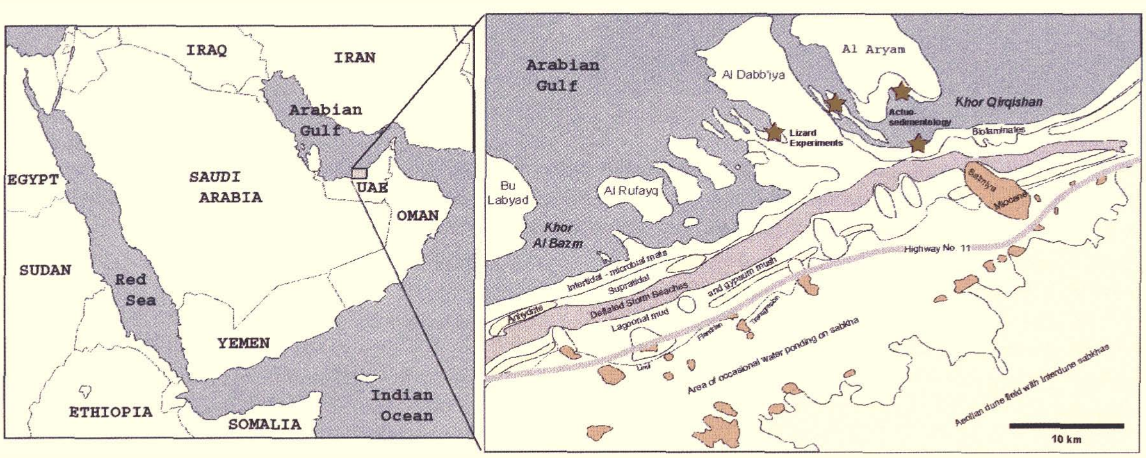

Plate 1. Sites examined in the carbonate tidal flat regions in the Khor Qirqishan and the experiment area on Al Dabb'iya, U.A.E. (Map redrawn from Kirkham 1997)

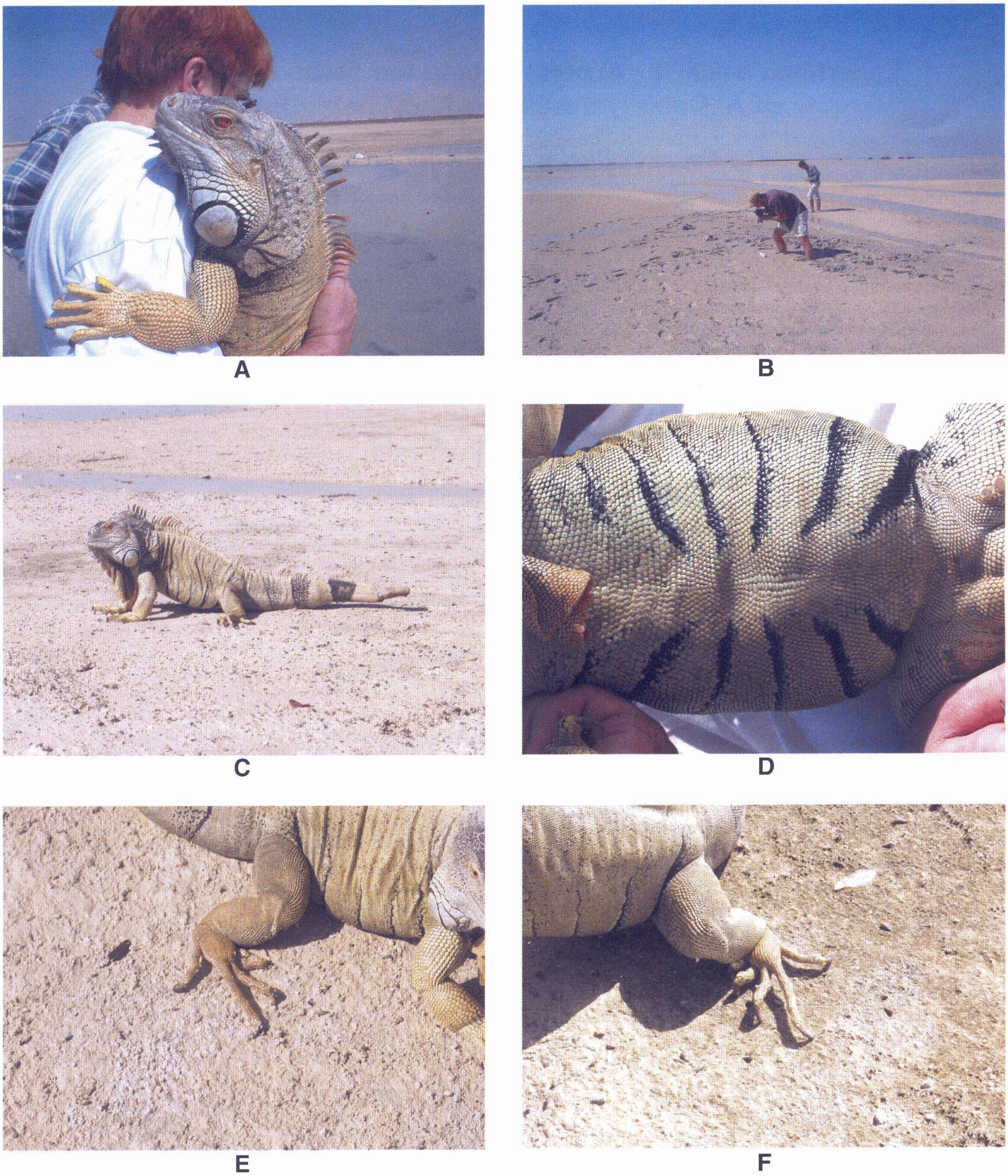

Plate **2.** The experimental animal and low relief tidal flats at Dabb'iya. **A.** Molly McQuarrie and the ***Iguana.*** B. The authors left deep trackways in the mud. **C.** Left lateral side. D. Ventral side. E. Right pes with strong claws. F. Right manus with strong claws.

previously been lost, this was not considered of importance for the track experiments (Plate *2C)*. The body is completely covered by small, spiny-tipped scutes (Plate 3D). The sharp and well developed claws of the manus and pes (Plate *3E,* F) did not cut deeply into the mud (Plate ***3D,*** E).

3.1. Observations on Iguana locomotion and behaviour

1. Basking: The iguana basked to raise its body temperature, with its pelvis on the mud substrate and the forelimbs uplifted (Plate *2C)*

2. Slow walk: While walking slowly the pes reaches the side of the manus print but does not overstep it. The hindlimbs are not strongly raised off the substrate and the tail touches the ground (Plate 4C).

3. Fast running: During fast movement, the pes

overprints the manus. The hindlimbs are well raised from the substrate (Plate 5C). The tail generally does not touch the ground.

4. Swimming: The lacertilian swims paraxially (Plate 4A) in water deeper than 30 cm. In shallower water (<20 cm) the manus and especially °°the pes were sometimes used for locating and touching the bottom.

3.2. Track imprinting

An attempt was made to duplicate the different track imprint types found in the fossil record by utilising a range of different surfaces. Nearly dry and slightly mud-cracked surfaces, soft carbonate mud, very soft channel mud, and under water surfaces were used for the experiments.

1. Mud-cracked surfaces of dry microbial mats: (Plate 2F). The microbial mats towards the landward edge of the tidal flats are only periodically flooded and had built 2-3 mm thick, cracked surfaces with a dry, leather-like consistency. Here no footprints could be imprinted by the lizard.

2. Mud-cracked surfaces of slightly wet microbial mats: Here the microbial mats built 2-3 mm thick, soft, leathery cracked dry surfaces (Plate 2O). On these surfaces only claw marks of the footprints were left (Plate 3C).

3. Soft carbonate mud of wet microbial mats: Under these conditions the best and most detailed preservation of the tracks was produced. Here the fine parallel scratches of the ventral scutes of the tail (Plate 3A), ventral body scales, the digital pads and the scales of the footprints (Plate 30) were left as shallowly impressed tracks and traces.

4. Very soft subaeric channel and pond mud: These soft substrates allow an imprint, usually without scales or digital pads (Plate 3E, 5A). Often not all digits are impressed well (digits 1 and 5 imprints usually are not preserved). On the channel margins scratch marks and deep tail marks (Plate 3B) were left by the iguana as it left the water after swimming through a tidal channel.

5. Extremely soft subaquatic channel and pond mud: These wet mud conditions do not preserve detailed track impressions. In many cases only scratch marks were left on the channel or pond bottom (Plate 3F, 55).

The most impressive track is illustrated on the back cover and in Plate 4C. Over a short distance of 6 metres the animal used several types of locomotion and crossed varied surfaces of carbonate mud, leaving a range of track impressions on subaquatic to slightly dry microbial mat surfaces.

3.3. Track form with different locomotion types

Different movement speeds and swimming activities have a strong effect on the tracks produced, leaving impressions that differ enormously. This is especially important to document as such differences have been used in track ichnotaxonomy to create erroneous ichnospecies.

1. Slow movement: The slow moving Iguana produces a trackway with non overprinting of the hindlimb and a sinous tail mark in the middle of the trackway (Plate *5A).* The trackway width is broad and the pace angulation low.

2. Fast movement: During fast movement the hind limbs are raised and overstep the manus, and no tail marks were left in the trackways (Plate 5C). The pace angulation is high.

3. Swimming: Paraxial swimming does not generally leave any tracks (Plate 4A). When the animal can touch the ground with its extremities it begins to produce scratches (Plate 4B).

4. Discussion

Numerous tracks of bird species were observed in the recent tidal flats of the Abu Dhabi region, and included those of the Western Reef Heron Egretta gularis and several smaller waders. However no tracks of indigenous lizards were found on the tidal flats. Only one small lizard was seen during the present study; the very small agamid Phrynocephalus arabicus Anderson 1894 (cf. Leviton et al. 1992, Jongbloed 2000) which was seen on microbial mud-cracked biolaminates on the shore of Khor Al Qirqishan. This species was too small and light for the experiments on the carbonate tidal flat surfaces, and would leave tracks only on the softest surfaces. It is quite possible that the largest lizard presently living in the UAE, Varanus griseus (Daudin, 1802) occasionally ventures onto tidal flats. The other large lacertilian species, Uromastyx aegyptia microlepis Blanford 1874 is not known to venture onto soft tidal flats. Hence there is no functionally equivalent reptilian species presently living on the Abu Dhabi coast to compare with the European track makers.
The experiments with the Iguana successfully illustrated a range of track impressions under different substrate moisture conditions and different locomotory activities, allowing comparison with the fossil tracks. These recent tracks are so close in morphology to the ones preserved in the fossil record of the European Middle Triassic, that the hypothesis that the observed fossil tracks of the ichnogenus Rhynchosauroides were produced by the prolacertilian Macrocnemus, as previously suggested (Diedrich 1998-2002), is substantially supported. Fortuitously, the proportions of the Iguana are very close to those of the Rhynchosauroides track maker. Other similarities include the overprinting and the partially lacking tail mark during fast movement. Undoubtedly the Middle Triassic trackmaker was not a modern lacertilian, but it had very close proportions and walked in the same modus.

Acknowledgements

We are most grateful to Molly McQuarrie for allowing us to use her pet iguana for the experiments, for accompanying us in the field, and for persuading the animal to make the right tracks in the right mud! Thanks too to Claudia Turtenwald for able field assistance and to Peter Hellyer and Dr Mark Beech for vital information and assistance.

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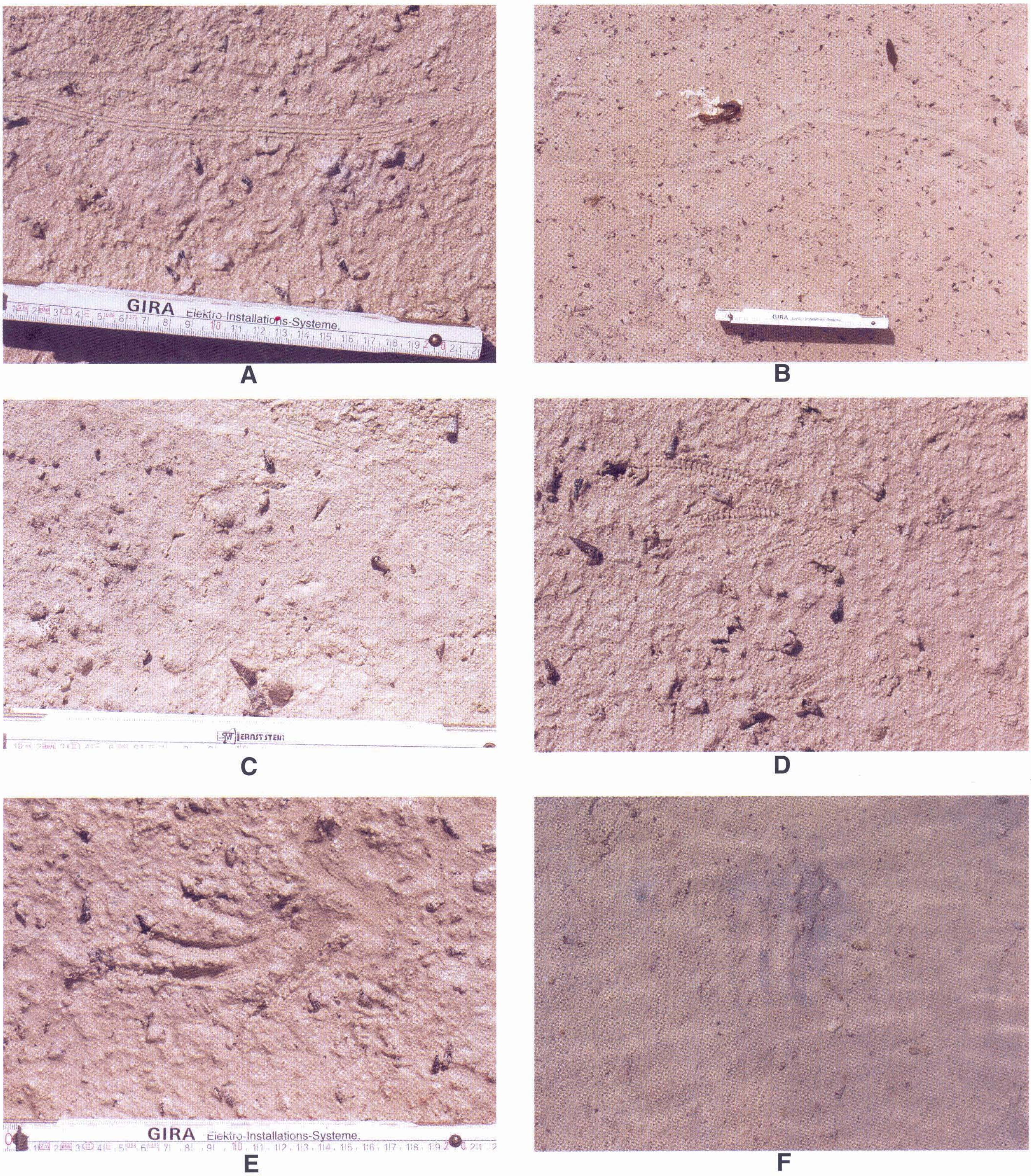

Plate 3. Imprints of the Iguana tracks. A. Tail mark with some parallel scute scratches on wet microbial mat covered mud. B. Tail mark as simple U-shaped depression in 1 cm deep water in a pond. C. Claw marks left on drying microbial mat surface. D. Detailed dermal scute imprint preservation on slightly wet microbial mat covered muds. E. Less detailed dermal scute imprint preservation on wet muds. F. Underwater scratch mark track in a 25 cm deep channel.

Kluwer Academic Publishers, Dordrecht, Holland.

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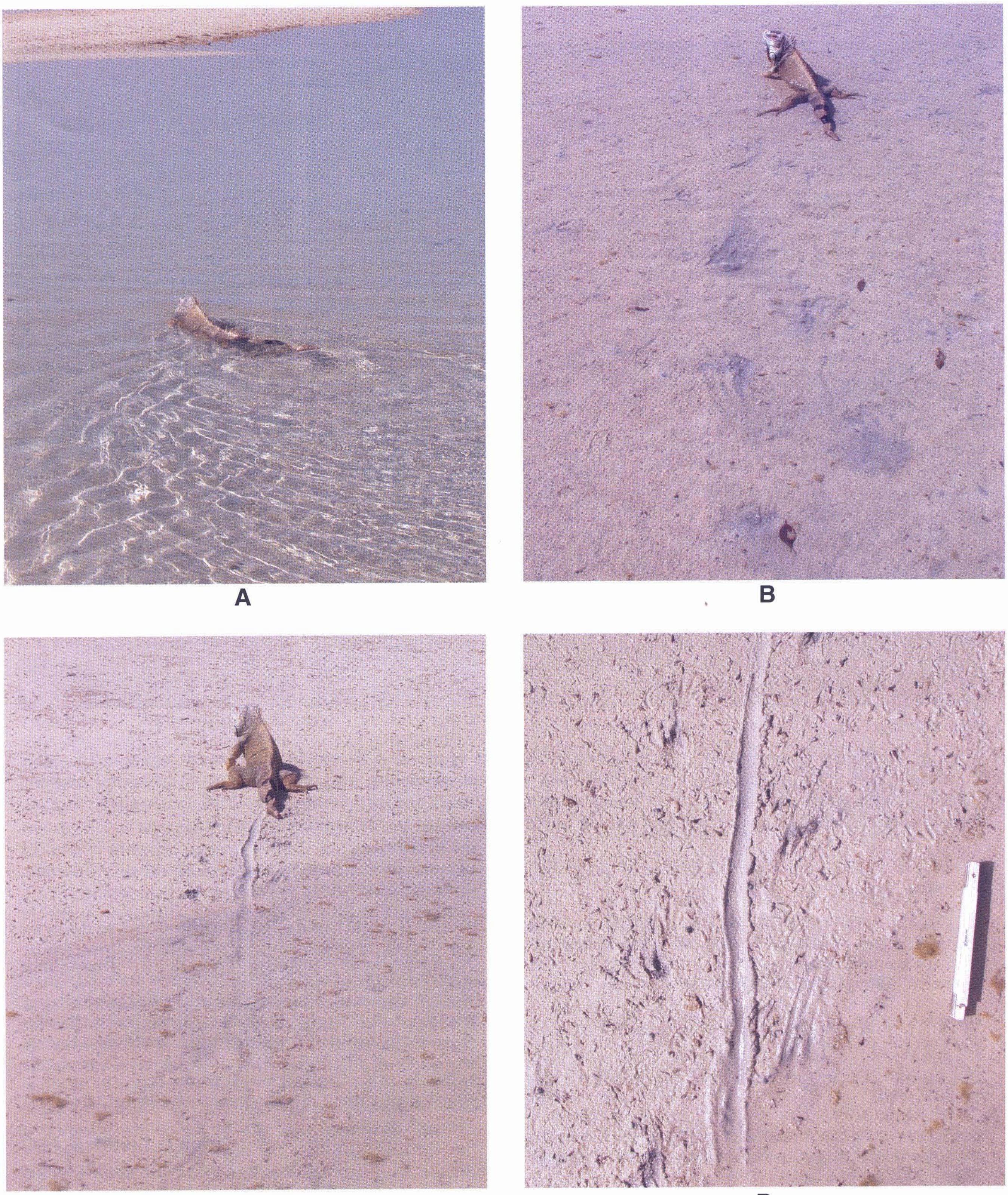

Plate 4. ***Iguana iguana. A.*** Swimming through a 30 cm deep channel. B. Walking scratch marks left in 10 cm deep water. C. Change of the trackway preservation from unclear under water to clear track and tail marks as the ***iguana*** emerged from the tidal channel. D. Differences in the footprint and tail mark impressions over a very short distance of 60 cm.

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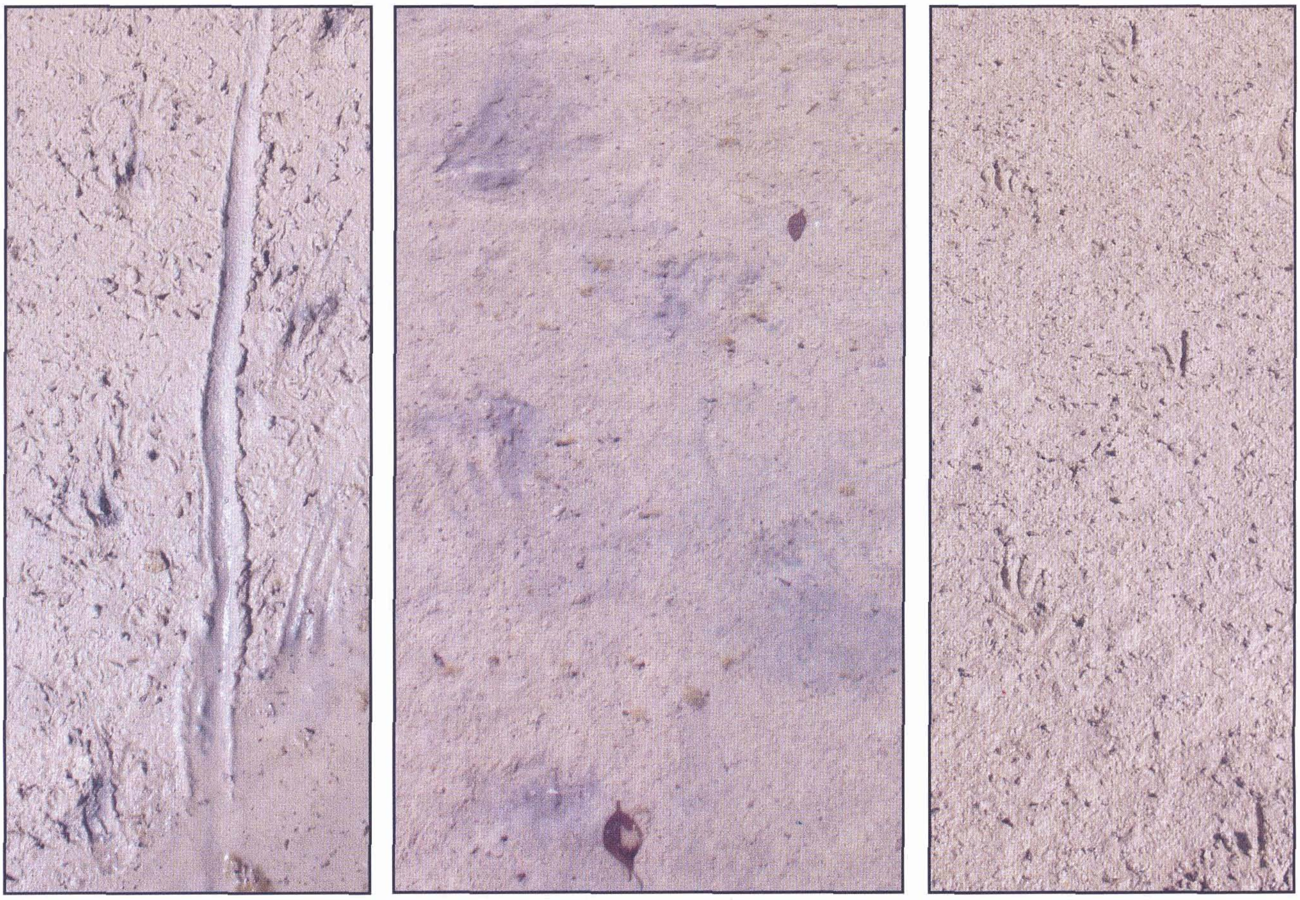

A B C

Plate 5. Trackway preservation with different movernent types and in varying substrate wetness. A. Slow movement with non-overprinting on wet surfaces with the presence of a tail mark. B. Underwater walking trackway, with some scratch mark and some deeply impressed but less detailed imprints, lacking tail mark. C. Fast movement with overprinting of the pes on slightly wet surfaces, without tail mark.

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Notes and Conferences

Correction

On page 14 of **Tribulus Vol. 12.1** (Spring/Summer 2002), in the paper by Tim Fogg, Pam Fogg and Tony Waltham on *'Magharet Qasir Hafit, a significant cave in the United Arab Emirates',* Plate *7* was captioned:

'A free-tailed bat in nearby Kahf Hamam.'

Dr lyad Nader, Director of the King Khaled Wildlife Research Centre in Saudi Arabia, *(in litt.)* notes: "The bat ... is a Mouse-tailed bat, and most likely is the Muscat mouse-tailed bat *(Rhinopoma muscatellum),* and not a free-tailed bat.

We are grateful to Dr Nader for pointing this out, The error is regretted.

Seminar for Arabian Studies - London

News of recent archaeological work in the UAE was to the fore at the July 2003 annual Seminar for Arabian Studies, held at the British Museum in London.

A total of eight papers on UAE-related topics were presented.as follows:

Vincent Charpentier (CNRS, Paris): *Neolithic trihedral arrowheads and the Arabian bifacial tradition.*

Mark Beech and Peter Hellyer (ADIAS): *New archaeological investigations at Abu Dhabi Airport, United Arab Emirates*

Heiko Kallweit (ADIAS and University of Freiburg): *Lithics from the Emirates: new finds from the Abu Dhabi Airport site*

Robert A. Carter (ADIAS and University of London): *Archaeological evidence for pearling in the Arabian Gulf.*

Christian Velde (National Museum of Ra's al-Khaimah): *Wadi Sur – a large fortification in Ras-al-Khaimah*

William Lancaster and Martin Bridge: *Tree-core sampling in Ras Al-Khaimah*

Anne Benoist (CRNS): *The Iron Age in Bithnah: two campaigns of excavation*

Peter Magee (Bryn Mawr): *The 2002-03 research at Muweilah, Emirate of Sharjah, United Arab Emirates*

Obituary

Sir Wilfred Thesiger

The famous explorer of Arabia, Sir Wilfred Thesiger, died in August 2003 at the age of 93. He was the only Honorary Life Member of the Emirates Natural History Group, a recognition bestowed on him during his last visit to the UAE, in early 2000.

Known to the Bedu of the UAE and the rest of south-eastern Arabia as Mubarak bin London, Thesiger was the first European to cross the deep sands of Arabia's Empty Quarter from Oman through to Liwa. His journeys, in the late 1940s, were recorded in several papers in *The Geographical Journal and, later, in his book Arabian Sands,* a classic of travel-writing and of exploration, which was subsequently translated into Arabic.

Thesiger was a fine writer, and recorded faithfully the story of his travels, and of the people he travelled with, and met along the way. His papers and book, together with his photographs, recorded a way of life that has since almost completely disappeared. Through *Arabian Sands,* however, knowledge of the way of life of people like the Manasir, the Manahil and the Rawashid, has been preserved, so that the younger generation can understand something of how their forefathers lived in this land.

During his travels in south-eastern Arabia, Thesiger met, and became a close friend of, President His Highness Sheikh Zayed bin Sultan Al Nahyan, when the latter was Ruler's Representative in the Eastern Region. Indeed, many of his journeys in the area were made possible only by the help and protection offered to him by Sheikh Zayed. In 2000, to coincide with his 90th birthday, Thesiger was presented with a top medal by the President, to mark the contributionshe made made to the country.

Thesiger completed his travelling in Arabia in 1950, and lived for much of the rest of his life in Kenya. He made several subsequent visits to the UAE, however. During two of them, in 1991 and in 2000, he travelled once again to the edge of the Empty Quarter. Those visits permitted him to meet with sbme of the people he had first encountered half a century earlier, and also gave him a chance to see some of the changes that had been brought about as a result of recent development in the deep desert.

Thesiger was, as one might have expected, not altogether enamoured of the changes that had come over the desert that he loved so much. On a brief visit to the UAE in the late 1970s, he described the development as 'an Arabian nightmare,' while, on a later visit, while flying over the flares and smoke of the desert oilfields, he was heard to mutter, repeatedly, 'desecration, desecration!'

With advancing years, however, he mellowed a bit, and certainly came to enjoy the admiration with which he was treated on his later visits. In particular, I recall from his last visit in 2000, he much enjoyed the way in which young nationals flocked to see him, and to ask him what it was like here over fifty years ago.

Despite frequent invitations from Sheikh Zayed, Thesiger declined, however, to accept the offer to come and live out his days in the Emirates. It is a pity, perhaps, that he didn't – a nursing home in Purley, in the southern suburbs of London, never seemed quite appropriate.

Wilfred Thesiger was perhaps the last of the great explorers. Arabian Sands introduced many of us to the nature of the region and its people, while the fine series of subsequent books, many produced by Motivate Publishing, introduced his travels – and his writing and stunning photography – to many more.

These books on the UAE are his final gift to the Emirates. He will remain in the memories of those, both UAE nationals and others, who had the opportunity to meet him in recent years.

And, personally, I shall never forget that the first time I ventured into the deep sands south of Liwa, I did so in the company of Thesiger - the stuff of which memories are made!

Peter Hellyer

Reviews and Publications

Al-aflâj fî dawlat al-imârât al-'arabiyat al-mutahida. Dirasât âthârîya fi anzamat al-rayy al-qadîma,
Ministry of Information and Culture, Abu Dhabi (2002), ISBN 9948-03-028-1, pp. 161 [= Aflâj in the United Arab Emirates. Archaeological studies on ancient irrigation systems]. By Dr Walid Yasin al-Tikriti.

The falaj (Pl. aflâj) irrigation system is encountered all over the Oman peninsula but no comprehensive and detailed monograph of the systems within the UAE has been published hitherto. Dr Walid al-Tikriti's contribution to our knowledge of these irrigation systems is therefore extremely welcome and has brought together the results of his research over nearly three decades on the falaj systems of the Emirates.

He provides an account of the environment in which the use of aflâj developed for the exploitation of the limited water resources available in this arid country. These channels, both on the surface and tunnelled underground, allowed the oases of the Emirates and Oman to develop an irrigation system that has permitted sustained agriculture from the Bronze Age through the Iron Age down to the Islamic period.

The central body of the work records Dr al-Tikriti's survey and excavations of a number of significant falaj systems around Hilî, Bida' Bint Sa'ûd, in Al Ain itself and on the Madam plain in Sharjah. The book also includes a discussion of the broader tradition of the falaj system in the more familiar context of Iran.

Dr al-Tikriti traces the earliest instance of the use of the word falaj (in its cognate form, palgu) to Akkadian texts of the 3rd millennium BC from Mesopotamia with the meaning qanaffchannel. Subsequently, the term is encountered in New Babylonian sources.

This is relevant to an important distinction that must be made in the design of falaj, between the water channel-type, excavated relatively shallowly into the surface of the earth, standing either above ground with stone side walls and covering slabs, or set just below ground-surface, again below slabs that' prevent evaporation: these are termed by Dr al-Tikriti as al-qanat al-mahfûra. The alternative system, whose use depends on the lie of the land, is subterranean, termed al-qanat a-jawîlya, deeply cut into the bedrock through deep tunnelling. A given falaj system may involve both systems, depending on the topography of the landscape that the channel crosses. While both types of falaj require very subtle engineering to ensure a gradient, the skills for the tunnelling of subterranean falaj channels underground are of a different and a higher order. These subterranean aflâj are reached through access shafts termed thaqba.

An interesting effect of the long-term use of a falaj arises from the build-up of surface soil: this creates complex stratigraphic problems illustrated well in plate 40 (p. 83), where a fhaqbalaccess of Iron Age date, once excavated, was exposed to stand high above an earlier falaj. The thaqba had been dug down when siltation had raised the level of the land: its purpose was to access a more ancient irrigation infrastructure which presumably had once been on the surface.

The aflâj of the Emirates were a crucial and basic element of the agricultural system of the oases of the region. They once constituted the essential infrastructure for maintaining an agricultural regime that appears to have operated in one form or another from the Bronze Age down to the pre-oil period. In a map, Dr al-Tikriti shows the principal groupings of falaj in the UAE, principally in the area of al-Hilî, Al Ain in Abu Dhabi, on the western slopes of the Jabal Hajar in Sharjah and on the east side of the same mountain range in Fujairah. As a mild criticism, one hopes that a future edition might provide a more refined location map of these aflâj. and this point can, perhaps, be addressed in future editions of this important book. The sheer number of UAE aflâj that have been discovered is impressive and it would be an interesting exercise to expand Dr al-Tikriti's mapping to encompass the aflâj of Oman as well, for the cumulative list would probably be quite formidable.

Dr al-Tikriti has also provided a map of the sites which were in use in the Iron Age when falaj construction seems to have been especially extensive in the main areas with agricultural potential. It would be interesting also to see the distribution of aflâj in the area in the Islamic period, although distinguishing early and later Islamic examples inevitably presents problems of dating. Many of these Islamic irrigation systems continued in use up until the pre-modern period and were regularly cleaned out, thereby interfering with the stratigraphic accumulation that might have allowed dating. By contrast, the Iron Age aflâj have long-since fallen out of use and, sealed with later soil deposits, give a better chance of establishing dates.

The aflâj at Hili 2 and Hili 15 are especially interesting with the results of Dr al-Tikriti's excavation showing the structure of falaj channel system junction points as they intersect with other channels. These two sites are both dated to the Iron Age. Related to these falaj systems at Hilî and the agricultural regime that they supported is a very large structure, a large hisn excavated by Dr R. Boucharlat and whose presence puts the aflaj of Hilî into a broader Iron Age settlement context.

Apart from the sites at Hilî, Dr Tikriti also records his excavations at the Bida' Bint Sa'Qd falaj system, 14 kms from Hilî. The archaeological importance of this area had initially been recognised by Dr Karen Frifelt and the investigation of the site was continued subsequently by Dr al-Tikriti who has conducted extensive excavations there. In the neighbourhood of Bronze Age and Iron Age tombs, he found a remarkable falajwith a well-preserved system of steps for descending to the falaj channel. There was also a well-defined building of considerable size that he termed Bait al-falaj from which Iron Age pottery was recovered.

Aflâj at Al Ain/al-Buraimi of the early Islamic period which Dr al-Tikriti records correspond well with the early Islamic sources which show that this oasis, under the name al-Tuwwâm, appears to have been one of the region's most important centres. A remarkably well-preserved stone-vaulted falaj found in the city of Al Ain itself is of early Islamic date. Its deep channel (al-qanat al-jawfîya) had over 3 m. of deposit which produced the typical blue glazed sherds of a type encountered at many other early Islamic sites in the UAE and the Gulf region more generally. Also pointing to an early Islamic date are the results of C14 analysis of samples recovered during excavation from this falaj. These produced dates of ca 670 AD and ca 820 AD (+/-25 years in each case), fitting well with the presence of blue-glazed early Islamic pottery.

Near to the Al Ain falaj was another very important discovery, a mosque built of mud brick, whose origins also appears to be early Islamic. This is a discovery of note for we have virtually no record of early Islamic architecture in the Emirates. The presence of a mihrâb niche suggests a post-early 8th C. date, corresponding well with the presence of early Islamic pottery.

Broader questions that are raised by these UAE aflâj include their relationship with the far better known Iranian tradition, a matter discussed at some length by the author. He also notes the important work of Dr Abdullah al-Nasif of King Saud University, Riyadh who has addressed the issue of irrigation systems in al-'Ulâin the Hijâz. Dr al-Nasîf has raised the interesting social and economic issue of access to water in western Arabian irrigation systems and individual farmers' time-access to the water-flow from the al-'Ulâ' channels. The matter of time/water-flow access allowed to the owners of land is a question of relevance to the UAE and Omani falaj systems as well.

In the light of Dr al-Tikriti's work, it would be of interest to expand studies of aflâj to Oman, where those around Sohar have been recorded in detail but not so far to lesser known sites. In addition, it would be interesting in the light of Dr al-Tikriti's work to reconsider the irrigation channels in southern central Saudi Arabia at Laylâ' (in the district appropriately known as Aflâj) to estimate to what degree they relate to those of the UAE.

This is an elegantly designed book and it is desirable that a study of a subject so important for the history of settlement in the UAE should be published in Arabic: with few exceptions, there is little written in Arabic and thereby readily accessible to nationals and especially to students of history and archaeology in the UAE. It is important that such up-to-date studies should be made available to the national readership. Having said that, it is to be hoped that Al-Aflâj will, one day, be translated into a European language to make this important research accessible to the non-Arabic speaking public.

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Emirates Bird Report No. 20. Edited and Compiled by Colin Richardson, Published by Emirates Bird Records Committee, PO Box 50394, Dubai, UAE. Price: Dh 70, inc. post and packing, inside the UAE. Available in good bookshops and through the three UAE Natural History Groups. Overseas rates on application to Colinr@emirates.net.ae. A5, 324 pp., 31 colour plates.

Emirates Bird Report No. 20 is a catch-up volume that summarises UAE bird records on a species-by-species basis for 1995-2000 and brings this formerly annual series more nearly up to date. For rare bird reports, the volume is current through summer 2003. This is especially important because the past several years have brought us a wealth of new species with each migration.

Also included are written reports of the first sightings of a number of species, a graphic index of monthly sightings (a picture is worth a thousand words), occasional graphs of comparative figures from year to year, and the UAE results of the Asian Waterfowl Census of conducted annually in the UAE's wetlands from 1996 through 2000. At the back of the main list are introduced species and escapees, many of which continue to survive, if not thrive, in local parks and landscaped grounds, some to a greater extent than indicated by the records.

Publication was sponsored by the Ports, Customs & Free Zone Corporation of Dubai, and by the Emirates Natural History Group, Abu Dhabi, who deserve great thanks for their support of this addition to our collective knowledge about the natural history of the UAE.

For those whose principal interest is in ticking off new species on their life lists, this volume will alert you to what has been seen and where. But there is greater virtue in a comprehensive publication of data for several years, in that it has the potential to elucidate trends and patterns that may be of interest to students of ecology, behavior, migration patterns and timing, and biogeography. In many instances the authors have commented on apparent trends, especially population or range expansion or decline.

It is useful, nevertheless, to be aware of various factors that may influence the generalisations that come out of records such as these, but that are not expressly acknowledged in the volume itself. These include, among others, (i) the increase over time in the number of observers reporting to the Emirates Bird Records Committee, fuelled in part by regular visits by foreign birdwatchers and foreign commercial birdwatching tours; (ii) the influence of several years of relative drought on species numbers and diversity in wild areas (affecting 1998-2000); (iii) a continuing dearth of reports from mountain areas, and perhaps even a decline in the number of such reports (with the result that Jebel Hafit and Qarn Nazwa(!) are among the most frequently mentioned mountain sites); and finally (iv) the fall-off in the number of observers each summer (which, as much as anything, may account for the absence of summer sightings of two admittedly "elusive" or scarce resident birds that are restricted to "wild" areas, the Long-Billed Pipit and Desert Eagle Owl).

The individual records often make surprisingly interesting reading for both birdwatchers and general naturalists. Thus, one can learn that three barn owls were seen chasing a cat at a UAQ roundabout, an hour after sunset one September. Or that House Crows are limited to coastal towns and have yet to gain a foothold in Abu Dhabi, being seen there only in single digits through 2000. Among the many items that were news to this reviewer was the regular occurrence of the Hoopoe Lark at coastal sites, e.g., Khor Dubai, Khor Al-Beidah, Dreamland beach and Khor Kalba. There is even fuel for the emotions, from frustration to pride: I have yet to pick out the current, long-staying Red-Knobbed Coot at the Wimpey Pits, but, given the excitement that attends each Purple Gallinule, I was pleased to learn that the one I saw at Ramtha Wetlands in 1995 was only the UAE's fourth.

Only occasionally do the editors seem to forget the nature of the underlying data, as when they remark of the Desert Eagle Owl that "most records [are] from Qarn Nazwa", without acknowledging that many of these sightings are likely to be of the very same individuals resident at this small site. Other comments may be excessively diplomatic: the Brown-Necked Raven is said to be "declining due to disturbance and development of desert areas" whereas the "[r]eason for decline at its Jebel Hafit stronghold is unknown."

The volume does not include an index, so it is helpful for readers to know the 'birdwatcher's alphabet" – the standard taxonomic order for listing bird species – but for those who do not, the table of monthly sightings serves as a relatively convenient list. A gazetteer is included and most place names are unexceptional. The majority will be recognisable to those who have traveled around the UAE (but note that Al-Ghar lake has been erased from the record books in favour of Al-Wathba Lake). *(The new name being that officially chosen by HH the UAE President - Editors' note).* It is a minor irritant that the editors have adopted the spelling of "Ra's" for "Ras" – the equivalent of a distracting tic for most English language readers. "Ra's" is in fact technically correct, but the apostrophe represents a glottal stop that is mostly honoured in the breach by native speakers, and the editors have not been so fastidious in their other transliteration choices (for example, Seih and Shaib are vowelled identically in Arabic spelling and pronunciation, and Beida, Shawkah and Medinat all end in the same Arabic letter).

The effort of compiling the data in this volume is enormous. More than 400 species can be found in the UAE and birdwatchers are now out and about on a daily basis for most of the year. Thus it is easy to sympathise with the delays that earlier overtook the Emirates Bird Report and we should be thankful for the efforts of Colin Richardson and those who assisted him in the compilation and editing of the systematic list – David Diskin, Simon Aspinall, Clive Saunders and Paul Bourdin – all of whom have "day jobs" as well. Their compilation greatly amplifies the value of the information provided by individual birdwatchers.

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Publications received:

Books: (Mention here does not preclude future review)

Archaeology of the United Arab Emirates, Potts, D.T. Naboodah, H. and Hellyer, P. *[eds.]*(2003): Published by Trident Press for the Zayed Centre for Heritage and History. 336 pp. ISBN: 1-900724-88-X. Proceedings of the 2001 1st International Conference on the Archaeology of the UAE.

From Under Desert Sands: ADCO's 40 **years of oil exports,** 1963-2003. By Peter Hellyer. Produced by Motivate Publishing, published by the Abu Dhabi Company for Onshore Oil Operations, ADCO (2003). 248 pp (half English, half Arabic), ISBN: 1 86063 159 2. An illustrated history of ADCO, the UAE's major oil producing company, from the early days of exploration to first production in 1963, and then up to date.

Sulphur, Camels and Gunpowder: The sulphur mines at Jebel Dhanna, Abu Dhabi, UAE. Edited by G.R.D. King, with contributions by D. Hull, S. Rowland, P. Hellyer, S.J. Aspinall, M.J. Beech, R.A. Carter and G.R.D. King. Published by Abu Dhabi Islands Archaeological Survey, ADIAS, and Abu Dhabi Company for Onshore Oil Operations, ADCO (2003). 112 pp. ISBN: 1-904566-43-X; LCCN: 2003 113985. Distributed by Zodiac Publishing, POB 502127, Dubai, UAE. E-mail: generalQzodiacpublishing.org

A study of the Late Islamic sulphur mines at Jebel Dhanna, with a review of historical sources. These are the only known sulphur mines in south-eastern Arabia.

Journals and Magazines

Arabian Archaeology and Epigraphy (Vol. 14) **Print ISSN:** 0905-7196; **On-Line ISSN:** 1600-0471. **ISSN:**

Papers of local interest include:

Barker, D. (2003). 'Perforated shell and stone objects from Sharm.' **AAE** 14(2): 196-202.
Davidde, B. (2003). 'Three unpublished collections of South Arabian coins.' **AAE** 14(1): 63-70.
Kallweit, H. and P. Hellyer (2003). 'A flint 'dagger' from Rumaitha, Emirate of Abu Dhabi, UAE.' **AAE** 14(1): 1-7.
Kennet, D. (2003). 'Julfar and the urbanisation of Southeast Arabia.' **AAE** 14(1): 103-125.
Zutterman, C. (2003). 'The softstone vessels from ed-Dur, Umm al-Qaiwain, United Arab Emirates.' **AAE** 14(1): 81-87.

Falco, Newsletter of the Middle East Falcon Research Group (e-mail: falco@falcons.co.uk). Issue No. 22, July 2003. ISSN: 1608-1544.

Articles of local interest include:

Barton, N.W.H., 'The Microchipping Scheme.' (pp. 8-10). This reports on results of the microchip scheme originally set up in 1989 by the National Avian Research Centre, (now part of ERWDA) and used for sakers and peregrines. The paper reports on recoveries from falcon hospitals in Abu Dhabi, Dubai and Saudi Arabia.
Bailey, T., Di Somma, A. and Al-Muhairi, H., 'Twenty years of Falcon medicine at Dubai Falcon Hospital, 1983-2003.' (pp. 15-17). The title speaks for itself – though the bibliography of this short paper is longer than the text!
Launay, F. and Muller, M.G., 'Falcon Release and Migration.' (pp. 22-23). Another short paper, giving some results from the ERWDA-administered Sheikh Zayed Falcon Release Programme.

Other recently published research articles in which readers of ***Tribulus*** might be interested include:

Alsharhan, A. S. and C. G. S. C. Kendall (2003). "Holocene coastal carbonates and evaporites of the southern Arabian Gulf and their ancient analogues." **Earth-Science Reviews** 61(3-4): 191-243.
Bray, H. E. and S. Stokes (2003). "Chronologies for Late Quaternary barchan dune reactivation in the southeastern Arabian Peninsula." **Quaternary Science Reviews** 22(10-13): 1027-1033.
Ishida, S., A. G. Parker, *et al.* (2003). "Phytolith analysis from the archaeological site of Kush, Ras al-Khaimah, United Arab Emirates." **Quaternary Research** 59(3): 310-321.
Jorgensen, D. G. and W. Yasin al-Tikiriti (2003). "A hydrologic and archeologic study of climate change in Al Ain, United Arab Emirates." **Global and Planetary Change** 35(1-2): 37-49.
Smith, M., K. J. Budd, *et al.* (2003). "The Distribution of Blanford's fox *(Vulpes cana* Blanford, 1877) in the United Arab Emirates." **Journal of Arid Environments** 54(1): 55-60.

تريبيلوس

مجلة جمعية الامارات للتاريخ الطبيعي

المجلد ١٣،٢ خريف / شتاء ٢٠٠٣ م