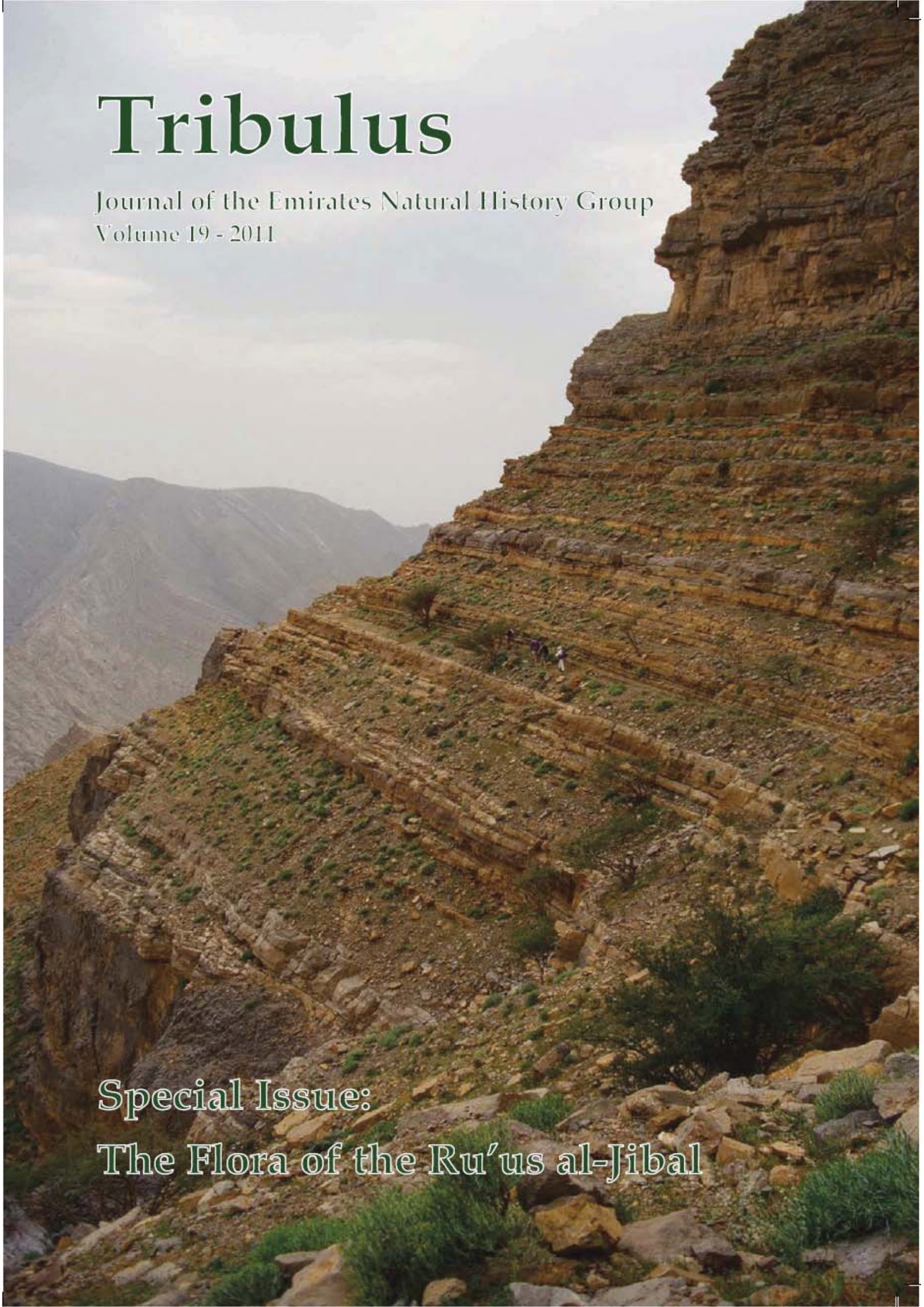
Tribulus

Journal of the Emirates Natural History Group
Volume 19 - 2011



Special Issue:
The Flora of the Ru'us al-Jibal

TRIBULUS

Notes for Contributors

TRIBULUS is the Journal of the Emirates Natural History Group and was launched in 1991. The Group, based in Abu Dhabi, was founded in 1976, and is the oldest environmental non-governmental organisation in the United Arab Emirates.

It has two sister groups, the Al Ain ENHG and the Dubai Natural History Group. Between 1976 and 1990, the Group published 42 issues of a thrice-yearly duplicated **Bulletin**.

Copies of **TRIBULUS** and of the **Bulletin** are available on the website of the Al Ain ENHG, at www.enhg.org

Between 1991 and 2006, **TRIBULUS** was published twice-yearly, in A4 format, but from Volume 17 (2007), the number of pages has been increased and frequency has become (near)-annual, rather than bi-annual.

The aim of the publication is to create and maintain in standard form a collection of recordings, articles and papers on topics related to the natural history, heritage, geology, palaeontology, archaeology and history of South-Eastern Arabia, with the focus on the United Arab Emirates and adjacent areas.

Papers, short notes and other contributions are welcomed from both residents of the United Arab Emirates and others, but should not have previously been published elsewhere. Guidelines are set out below.

Information contained in papers is as accurate as can be determined by the Editorial Board, in consultation with the members of the Advisory Panel and other referees, but opinion expressed are those of the authors alone.

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

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Manuscripts should be submitted in electronic form. A short abstract may precede the paper, with the address(es) of the authors, including e-mail address, at the end.

Photographs, line drawings and maps should be submitted, in electronic format, and should be of sufficiently high resolution to permit reproduction.

References should give the author's name, with the date of publication in brackets, showing title, publisher and country of publication, in date order. For journal articles, conventional abbreviations of journal titles may be used.

Scientific names should follow customary nomenclature in Latin while the common English names (if any) and local Arabic names (if available) should also be supplied.

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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 without whom publication would be impossible:

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URS, Wave Craft, Ltd., WSP Group

We also acknowledge the support and encouragement of our Patron, H.E. Sheikh Nahyan bin Mubarak Al Nahyan, UAE Minister of Higher Education & Scientific Research.

Tribulus is published for circulation to members of the three Natural History Groups in the United Arab Emirates, in Abu Dhabi, Dubai, and Al Ain, and is also available on subscription inside and outside the UAE. Subscription in the UAE & the Arabian Gulf states is Dh50 per year, including postage. Overseas details on request.

Cover Illustrations:

Front: Hikers on a trail above Wadi Naqab in the Ru'us al-Jibal range – the mountains of the Musandam peninsula. *Picture by Gary Feulner*.

Back: Date palms, *sidr* and fig trees cultivated on a fertile silt plain in the Ru'us al-Jibal. *Picture by Gary Feulner*

Published by the Emirates Natural History Group
P.O. Box 45553, Abu Dhabi, United Arab Emirates

Designed by Ginny dela Fuente

International Standard Serial Number (ISSN): 1019 - 6919

Printed by Dar Al Fajr Press, Printing, Publishing and Advertising,
P.O. Box 505, Abu Dhabi, UAE

Editorial

One of the key objectives of **Tribulus**, and of the thrice-yearly **Bulletin** of the Emirates Natural History Group that preceded it, has been that the journals should seek to publish the results of original scientific research into the natural history, history, geology, archaeology and palaeontology of the United Arab Emirates and of adjacent areas of the Sultanate of Oman. An important corollary to this is that the research will be published locally, rather then in academic journals overseas which, albeit worthy, can often be difficult to access by UAE residents. While, thanks to the Internet and the growing practice of journals publishing on-line versions, this is less of a problem than it used to be, it remains a constraint on the dissemination of information within the UAE.

Moreover, **Tribulus** has never drawn any distinction between papers submitted by academically-qualified professionals and enthusiastic and well-informed amateurs, the primary requirement being only that they should be accurate as far as this is possible. Thanks to the introduction many years ago both of an advisory board and of a peer-review process, we believe that papers in the journal are, indeed, generally prepared in accordance with the appropriate academic standards.

Having said that, however, it is fair to note that the broad range of topics covered in the journal, unlike in specialist journals on particular topics, may, on occasion, appear to have relatively little linking them, apart from the simple fact that they are all related to the UAE and neighbouring Oman.

There are, however, reasons for this. The first is that many of the journal's readers may have a specific interest in a particular topic, but also have much wider-ranging interests covering a variety of other subjects. Very few, we suspect, will be interested purely in a single paper on a single aspect of the country.

A second reason is that the Editors have always sought to encourage such a breadth of interest. While a narrowly-focussed paper on, for example, the finds from an archaeological site may be of great value, it is our belief that a placing of that site, and its finds, in the broader context of local geology or vegetation can often provide broader insights into why and how the site flourished or was eventually abandoned. Likewise, an interest in birds will gain from an understanding of why they are found in particular types of habitat or of what plants or other animals they may eat. Certainly members of the Editorial Board have frequently argued in the field, with some success, with dedicated specialists that they could learn much more from such an approach.

It is in this broad context that we are pleased to devote virtually all of this much-expanded issue of **Tribulus** to the lengthy paper by Gary Feulner on the flora of the Ru'us al-Jibal, defined here as encompassing most of Oman's Musandam exclave but also extending into the northern UAE.

The paper 'ticks' so many of the right boxes. Gary is not an academically-qualified botanist, but, in over twenty years of local field study, he has amassed and digested the enormous amount of information presented in his paper. Engaging with the best specialists in the field in what has been very much a two-way exchange of information, he has made good use of their expertise to ensure that his paper is of the highest academic standard. His knowledge of geology, in which he does have an academic qualification, enable him to draw conclusions about which plants are found where that might well escape an author with a focus purely on botany, as well as to draw valuable comparisons with mountain flora elsewhere in the Emirates and in Oman.

Likewise, his devotion to recording everything and anything related to history and natural history, such as the often abandoned high terraced fields, allows him to suggest which plants may have originally arrived through human agency. Other records, not relevant to this paper, include reptiles, butterflies and birds seen or the identity of marine mollusc shells found in remote mountain settlements or particular components of the geology that may have been exploited by Man in the past. It is as a result of that breadth of interest, and of the painstaking recording associated with it, that his paper is so detailed and of such value. Not surprisingly, the Checklist includes many species of flora that are new to the UAE and Oman, with a number of species still to be definitively identified.

The paper, along with its illustrations, both of individual plants and of the types of landscape in which they are to be found, will, we believe, become a much-used handbook to the Ru'us al-Jibal and its flora for many years to come.

The Editors of **Tribulus** and the Emirates Natural History Group as a whole are delighted to have been offered the opportunity to publish Gary Feulner's research. We are confident that many publishers of academic botanical manuscripts will regret that they were not themselves given that opportunity.

Peter Hellyer

The Flora of the Ru'us al-Jibal — the Mountains of the Musandam Peninsula: An Annotated Checklist and Selected Observations

by Gary R. Feulner

Abstract

The Ru'us al-Jibal range – the mountains of the Musandam peninsula in Eastern Arabia – constitutes a distinct geological, geographical and ecological unit having a correspondingly more distinctive flora than has generally been recognised. This paper presents an annotated checklist of some 338 higher plant species found in the Ru'us al-Jibal, identifies species that are restricted (in Eastern Arabia) to the Ru'us al-Jibal, and makes some general botanical and biogeographical observations, highlighting a number of characteristics that distinguish the flora and vegetation of the Ru'us al-Jibal from that of the remainder of the Hajar Mountains of the UAE and Northern Oman, including the Jebel Akhdar.

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3.3.6.	Some rare and diminutive annuals among bedrock at c.900 m (from left to right): *Sedum hispanicum*, *Filago desertorum*, *Campanula erinus* and *Galium decaisnei* (lower right).
3.3.7.	Association of annuals in a fallow field at c.800 m: *Asphodelus tenuifolius*, *Roemeria* sp., *Adonis dentata*, *Astragalus* sp. *et al.* Photo courtesy of Barbara Couldrey.
3.3.8.	An atypical assemblage of annuals on the stony pavement of the south-western Ru'us al-Jibal, c.500 m: *Aizoon canariense*, *Polycarpaea robbeirea* and *Reichardia tingitana*.
3.3.9.	An unusually rich association of Ru'us al-Jibal shrub species, observed in the mixed rocks of the Dibba Zone at the southern edge of the Ru'us al-Jibal, c.500 m, during the wet years of the late 1980s: Among the species visible are *Astragalus fasciculifolius*, *Convolvulus acanthocladus*, *Euphorbia larica*, *Gymnocarpos decandrum*, *Helianthemum* sp., *Launaea bornmuelleri*, *Lavandula subnuda*, *Leucas inflata*, *Ochradenus arabicus* and *Tephrosia apollinea*.
3.4.	**'Ayn as-Sih**
3.4.1.	At 'Ayn as-Sih, water seeping from the cliff wall creates a unique site that features a number of species not found elsewhere within the Ru'us al-Jibal. These include *Arundo donax*, *Epipactis veratrifolia*, *Nerium oleander*, *Pteris vittata*, *Schoenus nigricans* and others. A self-seeded date palm can be seen on the cliff at the upper right. For further discussion see Section 12.
3.4.2.	The spring at 'Ayn as-Sih (dark areas) is dwarfed by the scale of the wadi and cliffs that surround it.
3.4.3.	A close-up view of a wet wall at 'Ayn as-Sih.
3.4.4.	Looking up the cliff wall at 'Ayn as-Sih.

4.	**Comparison: Some illustrations of the geography, flora and vegetation of the high Jebel Akhdar.**
4.1.1.	A panorama of the Jebel Akhdar at c.2900 m, looking south-west from Jebel Shams to Jebel Kawr. The large shrubs in the foreground are *Dodonaea viscosa*, the smaller ones are mostly *Euryops arabicus*.
4.1.2.	Juniper trees (*Juniperus excelsa* subsp. *polycarpos*) on the summit ridge of Jebel Shams, at c.2900 m. Also common as ground cover are *Euryops arabicus*, *Cymbopogon jwarancusa* (dry) and *Teucrium mascatense*.
4.1.3.	A rocky summit at 2900 m above Dar As-Sawdah, featuring juniper and *Euryops arabicus*.
4.1.4.	Summit plateau of juniper and *Sideroxylon mascatense* (Arabic "*boot*"), c.2400 m, Saiq Plateau.
4.1.5.	Juniper, *boot* and wild olive *Olea europaea*, c.2400 m, overlooking the Grand Canyon of Wadi Ghul.
4.1.6.	Open woodland of juniper, *boot* and wild olive, c.2300 m, Saiq Plateau.
4.1.7.	A forested wadi at c.2200 m, Saiq Plateau.
4.1.8.	A shallow wadi with wild olive and *Dodonaea viscosa*, c.1900 m, near the Grand Canyon of Wadi Ghul.
4.1.9.	Parkland of wild olive and *Dodonaea viscosa*, c.1850 m, near the Grand Canyon of Wadi Ghul.
4.1.10.	Rain in the Jebel Akhdar, near the Grand Canyon of Wadi Ghul, c.1800 m.
4.1.11.	Well-developed tufts of *Cymbopogon jwarancusa* and woodland of wild olive and *Dodonaea viscosa*, c.1850 m, Sharafat al-Alamayn.
4.1.12.	The wooded trail above Wakan (c.1600 m), the route followed by French collector and explorer Piere Remi Martin Aucher-Éloy to cross the Jebel Akhdar in 1838. The flora of these north-facing slopes is exceptionally rich.
4.1.13.	*Dionysia mira*, a high elevation species also native to Iran and the Makran.
4.1.14.	*Euryops arabicus* (syn. *Euryops pinifolius*), a common and characteristic species of the high Jebel Akhdar, endemic to Oman.
4.1.15.	*Teucrium mascatense*, another common and characteristic species of the high Jebel Akhdar. Ghazanfar considers that this species is equivalent to *T. stocksianum* of the Ru'us al-Jibal. For a brief discussion, see the Checklist entry for *T. stocksianum*.
5.	**Selected flora of the Ru'us al-Jibal**
5.1.	**Ru'us al-Jibal species newly recognised in the UAE and Oman by this study.**
5.1.1.	*Adonis dentata.* Record and photo by Barbara Couldrey. See also *Fig. 3.3.7*.
5.1.2.	*Aegilops kotschyi*
5.1.3.	*Asperugo procumbens*. See also *Fig. 3.2.2*.
5.1.4.	*Bellevalia* sp. aff. *longipes*
5.1.5.	*Chaenorrhinum rubrifolium*
5.1.6.	*Crepis kotschyana*
5.1.7.	*Garhadiolus hedypnois*
5.1.8.	*Lactuca orientalis*
5.1.9.	*Leontice leontopetalum*. See also *Figs. 1.3.2* and *3.2.1.*
5.1.10.	*Minuartia picta.* This photo of the specimen sent for expert determination shows the author's erroneous preliminary identification as "*Spergularia diandra*(?)". It compares very well with the illustration of *M. picta* in *Flora of Egypt*.
5.1.11.	*Notobasis syriaca*. This specimen, the only known collection from Eastern Arabia, is in the herbarium at the Sharjah Natural History Museum.
5.1.12.	*Poa bulbosa*
5.1.13.	*Poa* sp.aff. *asirensis*
5.1.14.	*Rosularia adenotricha*
5.1.15.	*Stipa parviflora*
5.1.16.	*Teucrium oliverianum*
5.1.17.	*Valerianella szovitsiana*

5.2.	**Some still unidentified species from the Ru'us al-Jibal.**
5.2.1.	Unidentified Poaceae sp. 1, seen at c.1100 m on open slopes.
5.2.2.	Unidentified Poaceae sp. 2, possibly a grain species, from a small fallow field in the Sahasa area, c.1450 m.
5.2.3.	Unidentified *Astragalus* sp., seen at a peri-agricultural site, c.800 m.
5.2.4.	Unidentified Boraginaceae (*Paracaryum*?) sp. 1, seen at two peri-agricultural sites, c.800-1000 m.
5.2.5.	Unidentified Boraginaceae sp. 2, seen at open sites and sheltered sites with other annuals, c.1300 m (see *Figs. 3.3.2* and *3.3.3*).
5.2.6.	Unidentified Brassicaceae sp. 1, adjacent to cultivation at 1500 m (see *Fig. 3.2.2*).
5.2.7.	Unidentified Brassicaceae sp. 2, near seasonal habitation in the eastern Ru'us al-Jibal, c.1200 m.
5.2.8.	A medley of diminutive unidentified species, some growing in polygonal traces, in the damp soil of an abandoned field beside a gravel wadi, shaded by trees and steep, north-facing cliffs, c.450 m.
5.3.	**Some Ru'us al-Jibal species not illustrated in other regional references.**
5.3.1.	*Arenaria serpyllifolia*
5.3.2.	*Arenaria* sp. (possibly *A. leptocladus*)
5.3.3.	*Arnebia decumbens*
5.3.4.	*Astragalus* sp. aff. *schimperi*. See also *Fig. 1.3.3.*
5.3.5.	*Avena barbata*
5.3.6.	*Bromus danthoniae*
5.3.7.	*Bromus fasciculatus*
5.3.8.	*Chesneya parviflora*
5.3.9.	*Clypeola jonthlaspi*
5.3.10.	*Cymbopogon jwarancusa*. The several *Cymbopogon* species found in the UAE and Northern Oman are difficult to distinguish when not in seed. See also *Fig. 5.4.7.*
5.3.11.	*Enneapogon desvauxii*
5.3.12.	*Eragrostis cilianensis*
5.3.13.	*Eragrostis ciliaris*
5.3.14.	*Euphorbia inaequilatera*
5.3.15.	*Fagonia schimperi*
5.3.16.	*Filago pyramidata*
5.3.17.	*Gastridium phleoides*
5.3.18.	*Geranium trilophum*
5.3.19.	*Helianthemum kahiricum* (photo from Saiq Plateau, Jebel Akhdar, Oman)
5.3.20.	*Heliotropium* sp. aff. *strigosum*
5.3.21.	*Herniaria hirsuta*
5.3.22.	*Jurinea carduiformis* This species is normally prostrate but stalked plant*s* may be locally common after rain.
5.3.23.	*Lallemantia royleana*
5.3.24.	*Lamarckia aurea*
5.3.25.	*Linaria simplex*
5.3.26.	*Malcolmia africana*. See also *Fig. 1.3.3.*
5.3.27.	*Orobanche cernua* among *Artemisia sieberi*.
5.3.28.	*Pennisetum orientale*
5.3.29.	*Plantago notata*

5.3.30.	*Poa sinaica* (?)
5.3.31.	*Pterocephalus brevis*. This specimen, collected by A.R. Western, is in the herbarium at the Sharjah Natural History Museum
5.3.32.	*Pupalia lappacea*
5.3.33.	*Salvia mirzayanii*. See also *Fig. 1.3.3.*
5.3.34.	*Stipagrostis raddiana*, the common *Stipagrostis* species of the high Ru'us al-Jibal. The morphology of the spikelets is very close to what has been depicted as *S. paradisea* in *Flora of Egypt* and Cope (2007) and synonymised by Ghasemkhani *et al.* (2008).
5.3.35.	*Thymelaea mesopotamica*
5.3.36.	*Tripteris vaillantii* (syn. *Osteospermum vaillantii*) (Photo from Saiq Plateau). The sole record of this species in the Ru'us al Jibal has been determined to be erroneous. It is rare in the Jebel Akhdar but locally common in the Eastern Hajar Mountains.
5.3.37.	*Ziziphora tenuior*
5.4.	**Common and characteristic species of the Ru'us al-Jibal.**
5.4.1.	*Artemisia sieberi*. See also *Figs. 3.1.6, 3.1.12, 3.1.13, 3.1.19, 3.1.22, 3.2.1* and *3.3.1.*
5.4.2.	*Asterolinon linum-stellatum*
5.4.3.	*Astragalus fasciculifolius*. See also *Figs. 3.1.22* and *5.5.3.*
5.4.4.	*Brachypodium distachyum*
5.4.5.	*Centaurea wendelboi*. See also *Fig. 3.3.1.*
5.4.6.	*Convolvulus acanthocladus*. See also *Figs. 3.1.1, 3.1.4, 3.1.5, 3.1.8, 3.1.9, 3.1.11, 3.1.13, 3.1.15, 3.1.16, 3.1.17, 3.1.21, 3.1.23* and *3.3.1* and compare *Fig. 5.5.4.*
5.4.7.	*Cymbopogon jwarancusa*. This hillside near As-Sayh, at c.1300 m, is dominated by tufts of *C. jwarancusa*. See also *Figs. 3.1.1, 3.1.8, 3.1.9, 3.1.11, 3.1.17, 3.1.18, 4.1.11* and *5.3.10.*
5.4.8.	*Diplotaxis harra*. This rock or cliff-dwelling form is typical of the Ru'us al-Jibal. Compare with *Fig. 5.5.6*, which shows the morphology common in the foothills and gravel outwash plains of the Hajar Mountains to the south (see Section 14).
5.4.9.	*Dodonaea viscosa* dominates the higher ground adjacent to cultivation at Ra's al-Maq (c.750 m). See also *Figs. 3.1.1, 3.1.3, 3.1.5, 3.1.8, 3.1.9, 3.1.21* and *3.1.23.*
5.4.10.	*Ephedra pachyclada* in flower. See also *Figs. 3.1.7, 3.1.13* and *3.1.22*.
5.4.11.	*Euphorbia larica*. See also *Fig. 3.1.21.*
5.4.12.	*Farsetia aegyptia*. See also *Figs. 3.1.5* and *3.1.23.*
5.4.13.	*Ficus cordata salicifolia*. Normally confined to wadi beds, on the east coast of the Musandam this species is also common on hillsides at lower elevations.
5.4.14.	*Ficus johannis*. The white bark is distinctive. This species is one of the only deciduous trees found in the UAE and Northern Oman. Within mountain settlements it is cultivated for its fruit and often colonises traditional cisterns.
5.4.15.	*Helichrysum glumaceum*. This species has recently been synonymized with *H. makranicum* by N. Kilian, based in part on specimens and information provided by this study.
5.4.16.	*Gymnocarpos decandrus* (dry). See also *Figs. 3.1.16* and *3.3.1.*
5.4.17.	*Helianthemum lippii* is highly variable in its morphology. The plant on the left has relatively large, broad leaves and is yellow-green in colour; the plant on the right has small, narrow leaves and is grey-green.
5.4.18.	*Ixiolirion tataricum*
5.4.19.	*Jurinea berardioides*
5.4.20.	*Launaea bornmuelleri*. See also *Figs. 3.1.18* and *3.1.21.*
5.4.21.	*Moraea sisyrinchium*. See also *Fig. 3.2.1.*
5.4.22.	*Phagnalon schweinfurthii*
5.4.23.	*Pulicaria edmondsonii*
5.4.24.	*Teucrium stocksianum*
5.4.25.	*Vernonia arabica*

5.5.	**Some additional Ru'us al-Jibal species and botanical phenomena.**
5.5.1.	*Acacia ehrenbergiana*. These few trees found in the Ru'us al-Jibal are atypical in branching from a single basal trunk, in the manner of *A. tortilis*. The author had passed them in Wadi Khabb a number of times without distinguishing them, until they were seen bearing yellow flowers.
5.5.2.	*Acacia tortilis*. Above about 800 m, *A. tortilis* generally thrives only on or adjacent to agricultural terraces. At 1250 m, this large specimen in upper Wadi Shah is one of the highest, but from this point another small tree could be seen somewhat higher still, at about 1350 m, adjacent to a steep wadi. See also *Figs. 3.1.23*, *3.1.25* and *3.2.6*.
5.5.3.	"De-barked" *Astragalus fasciculifolius.* During the extreme drought of 1999-2003, *A. fasciculifolius* plants were regularly observed with their tops removed and the stump stripped to expose the core. The animals responsible (goats or possibly donkeys) were presumably seeking out nutritional or medicinal components.
5.5.4.	*Convolvulus acanthocladus* is a dominant species in the high Ru'us al-Jibal but it is essentially absent in the Hajar Mountains for c.135 km to the south. It reappears along the mountain front in the Mahdhah area of Northern Oman, where it exhibits the rectilinear morphology shown here, which is distinct from the tomentose morphology of Ru'us al-Jibal plants. See Section 14 and compare *Fig. 5.4.6.*
5.5.5.	*Cordia* sp. aff. *quercifolia. T*he identity of this straggling shrub remains provisional. Only a handful of plants are known from a single locality, where they are found on south-facing cliffs and ledges inaccessible to browsing animals. They were feared to have perished in the exceptional drought of 1999-2003, but the largest specimen (shown here) was reportedly substantially restored as of spring 2010.
5.5.6.	*Diplotaxis harra* is common as a small annual on gravel terraces along and within the Hajar Mountain front, as shown here. This morphology is distinct from that of the cliff-dwelling form common in the Ru'us al-Jibal. Compare *Fig. 5.4.8* and see Section 14.
5.5.7.	*Galium* sp. See note in the Checklist under *Galium aparine.*
5.5.8.	*Grewia tenax* is found as a cliff-dwelling species in the area of the Wadi Khabb Shamsi narrows.
5.5.9.	*Heliotropium bacciferum* (left foreground) and *H. brevilimbe* (syn. *H. calcareum*) (right foreground) are shown together at c.1200 m in the eastern Ru'us al-Jibal. The species discussed here as *H. bacciferum* occurs in the Ru'us al-Jibal and along the west coast of the Arabian Gulf in Saudi Arabia, Qatar and Kuwait. It has been erroneously equated by several authors with the species identified in Western (1989) and Jongbloed (2003) *as H. kotschyi.*
5.5.10.	The wild olive *Olea europaea* in good condition at 1000 m on Jebel Qitab, c.65 km south of the Ru'us al-Jibal, in March 1998. Compare *Fig. 5.5.11.*
5.5.11.	Barren wild olive trees at the same locality as *Fig. 5.5.10*, in December 2006.
5.5.12.	The enigmatic seedling of the milkweed *Periploca aphylla.*
5.5.13.	Traditionally, the sidr tree, *Ziziphus spina-christi,* was regularly coppiced for lumber in the Ru'us al-Jibal. See also *Figs. 3.1.23* and *3.1.24*.
6.	**Some common Hajar Mountain species that are absent or very rare in the Ru'us al-Jibal.**
6.1.1.	*Boerhavia elegans*
6.1.2.	*Cleome noeana*
6.1.3.	*Cometes surattensis*
6.1.4.	*Crotalaria aegyptiaca*
6.1.5.	*Haplophyllum tuberculatum*
6.1.6.	*Iphiona scabra*
6.1.7.	*Lindenbergia arabica*
6.1.8.	*Physorrhynchus chamaerapistrum*
6.1.9.	*Pulicaria glutinosa.* See also *Fig. 1.5.1.*
6.1.10.	*Rhazya stricta*
6.1.11.	*Saccharum griffithii*
6.1.12.	*Taverniera cuneifolia*

Introduction

The Ru'us al-Jibal range, comprising the arid, 1500-2000 metre carbonate peaks and plateaux of the Musandam peninsula, is a geologically and geographically distinct unit within the mountains of the United Arab Emirates and Northern Oman. The Ru'us al-Jibal also represents a distinct ecological unit having its own characteristic flora and vegetation, which has too often been ignored and/or inadequately characterised in botanical generalisations about the Hajar Mountains, mostly for want of detailed knowledge. The first and still the most comprehensive prior investigation of the flora of the Musandam region was undertaken in 1979 (Mandaville 1985). No subsequent study has focused specifically on the flora of the Musandam or attempted to distinguish it in a regional context.

The Ru'us al-Jibal

Nomenclature

The Musandam (pronounced *mu-SAN-dam*) peninsula points north-northeastward across the Strait of Hormuz towards the south-eastern end of the Zagros Mountains of Iran, some 125 km away (Map 1). It has sometimes been called the "Horn of Arabia" and takes its modern name from Musandam Island at its north-eastern extremity. Most of the peninsula lies within the Musandam Province (*Wilayat Musandam*) of the Sultanate of Oman, but the western and southern margins, including parts of the Ru'us al-Jibal range, belong to the UAE (the emirates of Ra's al-Khaimah and Fujairah, respectively).

Some authors have used the expression "Musandam region" to refer to the whole of the area in question, in deference to the point of view that the term "Musandam peninsula" should be confined to the isthmus and fjordlike headlands of its northerly terminus, although even as a whole the "region" satisfactorily conforms to the definition of a peninsula. Many researchers acquainted with the area now avoid these conceptual minefields and refer simply to "the Musandam". In this paper, Musandam peninsula, Musandam region and Musandam are used essentially interchangeably.

The Musandam peninsula is the northernmost extension of the mountains of Northern Oman and the eastern UAE, which parallel the coast of the Gulf of Oman for a distance of more than 600 km and are best known collectively as *Al-Hajar* or the Hajar Mountains **(**Map 2**)**. *Al-Hajar* means, literally, "the rock", and a loose translation might be "the Rockies" (Mandaville 1977). The Hajar Mountains are divided broadly into *Al-Hajar ash-Sharqi* and *Al-Hajar al-Gharbi* (the Eastern and Western Hajar, situated respectively to the east and west of the Jebel Akhdar range) and comprise various smaller ranges and massifs which have independent local names, e.g., Jebel Akhdar, Jebel Bani Jabr, Jebel Kawr, Jebel Aswad, Jebel Asfar, Jebel Abyadh, Saih Hatat, etc.

The term *Ru'us al-Jibal* (pronounced *roo-OOS al-ji-BAL*) is the traditional local name for the mountains of the Musandam peninsula, which are geologically and geographically distinct from the mountains to the south, even to the casual observer. They are also characterised by a distinctive traditional human culture. Ru'us al-Jibal means, literally, "the Heads of the Mountains", although a better colloquial translation might be "the Mountain Tops" or "the High Peaks". The name reflects the fact that the peaks in the area are higher than any for some 275 km to the south (Jebel Akhdar). In addition, human settlement and cultivation within the area is generally at relatively high elevations in comparison to the mountains to the south. Maps 3 and 4 give a good impression of the overall terrain of the Ru'us al-Jibal.

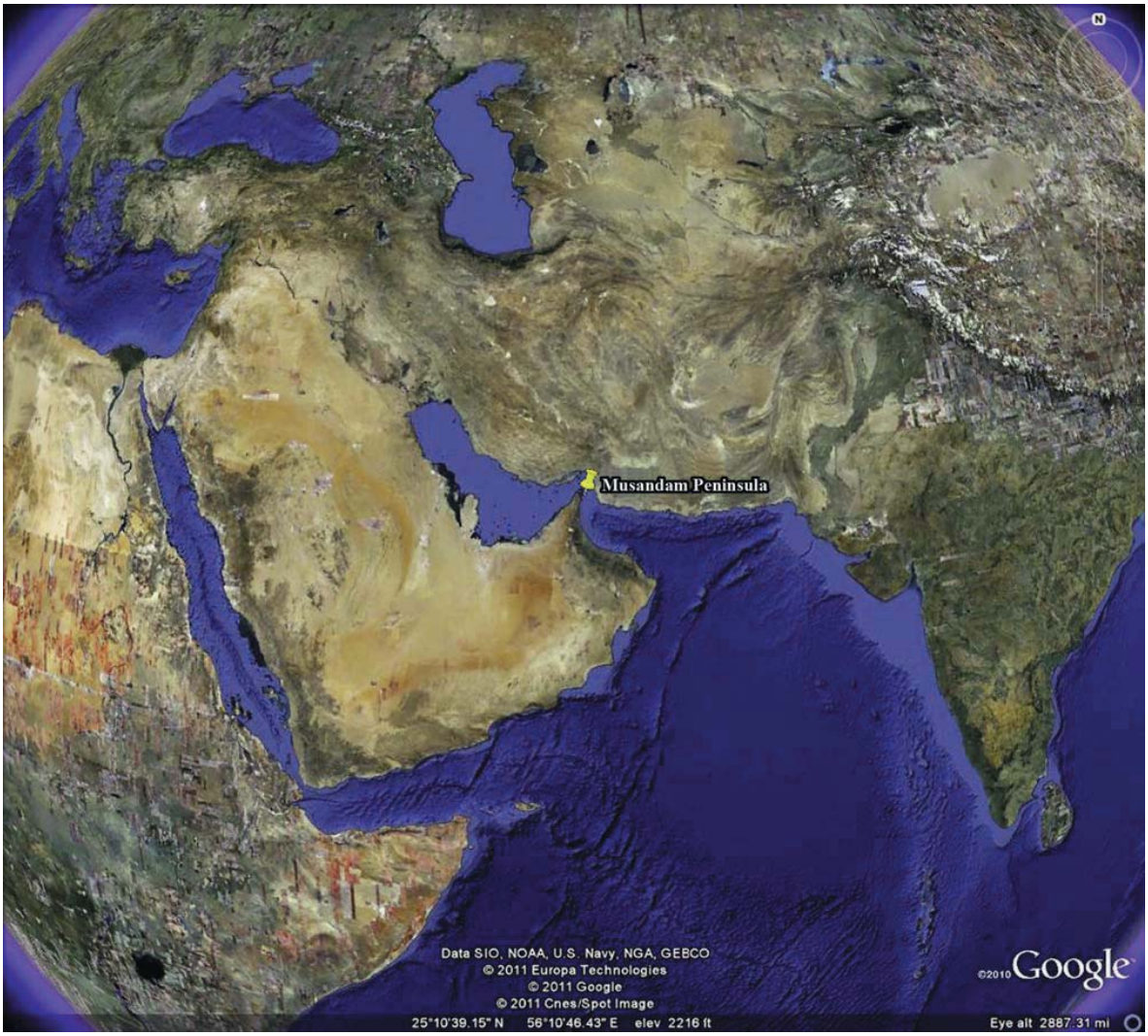
The expression "Eastern Arabia", as used in this paper, is synonymous with the UAE and Northern Oman. "Northern Oman" in turn refers to what might more accurately be called north-eastern Oman – that part of Oman that stretches south and east from the Musandam peninsula, parallel to the Gulf of Oman, extending to Ra's al-Hadd (the easternmost point of Arabia) and Masirah Island on the Arabian Sea coast. Northern Oman as so defined constitutes a more or less discrete geographical unit comprising principally the Hajar Mountains and their extensive outwash plains, and numerous other authors have used the term with more or less the same meaning assigned here. Excluded are the Wusta and Dhofar regions of central and southwestern Oman.

Geology

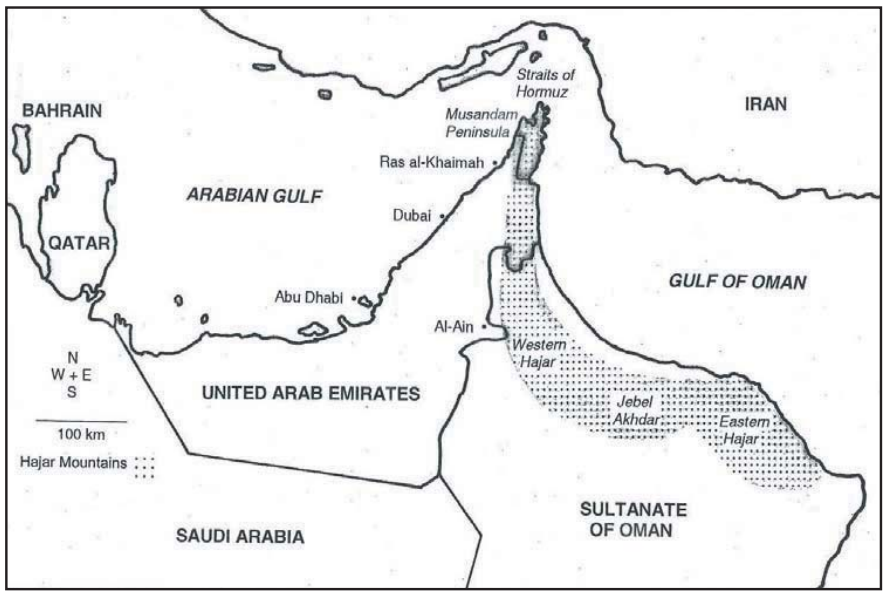
Geologically, the Hajar Mountains are composed largely of a suite of igneous rocks of ultrabasic composition (peridotite and dunite) with associated basic rocks (gabbro and basalt), collectively called "ophiolite", representing extensive slabs of the earth's upper mantle and oceanic crust that have been detached and uplifted by plate tectonics (see generally Feulner 1996, 2005). Ultrabasic rocks are rare at the earths's surface and the ophiolite of the Hajar Mountains constitutes the most extensive exposure known.

Ultrabasic bedrock is associated with distinctive soil chemistry (e.g., low calcium, nitrogen and phosphorus, high magnesium and heavy metals, and hyperalkaline groundwater) which is often reflected in distinctive flora, including the evolution of races or species that are confined to ophiolite substrates and that selectively accumulate heavy metals as a deterrent to predators (Harrison & Kruckeberg 2008; see also discussion below at Section 6.2). No study has yet specifically addressed the influence of the ophiolite substrate on the distribution of plant species in the Hajar Mountains, although it has sometimes been asserted that species diversity is lower within the ophiolite than on carbonate bedrock (e.g., Insall 1999).

In addition to the ophiolite, the Hajar Mountains include a number of ranges and massifs of carbonate sedimentary rock, located either centrally (e.g., Jebel Akhdar) or peripherally (e.g. Jebel Bani Jabr in the Eastern Hajar and Jebel Abyadh, north of Ibri).



Map 1. The Middle East and surrounding regions, showing the geographical position of the Musandam peninsula.



Map 2. UAE and Northern Oman, showing the location of the Hajar Mountains.

Map 3. Computerised rendering showing the Ru'us al-Jibal in its regional context. This exceptional computer-generated image dramatically portrays the distinctive character of the Ru'us al-Jibal. The simulated view is from the north.

Map 4. Oblique view of the Musandam region, annotated to show certain locations mentioned in the text.

The Ru'us al-Jibal is one such carbonate range and consists of a thick sequence of limestone and dolomite of predominantly shallow water origin. The age and stratigraphy of the Ru'us al-Jibal carbonates correlate well with those of the Jebel Akhdar and both sequences are interpreted as sediments deposited on the Arabian continental shelf over an extended period of time from late Permian to mid-Cretaceous.

The carbonate sediments of the Jebel Akhdar were subsequently overriden by the ophiolite but the same does not appear to be true for the Ru'us al-Jibal (John M. Hurst, *pers. comm.*; Ellison *et al.* 2006; Phillips *et al.* 2009; contra LeMetour *et al.* 1992). Instead the Ru'us al-Jibal area seems to have been decoupled from the obduction tectonics to the south by a major transverse fault that occupied the area of the Dibba Zone, a structually complex boundary that separates the Ru'us al-Jibal from the remainder of the Hajar Mountains to the south.

The south-east margin of the Ru'us al-Jibal, just north of the Dibba Zone, includes colourful deep water sediments (carbonates, shales, cherts and conglomerates) that have been thrust against the shelf carbonates that otherwise characterise the Ru'us al-Jibal (*Fig. 1.5.2*).

In terms of current regional geodynamics, the Ru'us al-Jibal, the Hajar Mountains generally, the Arabian Gulf and even the Zagros Mountains of Iran are all part of the Arabian tectonic plate, which is converging with the Asian plate to the north-east. In the north-west of the convergence zone, the Arabian plate is overriding the Asian plate, creating the parallel folded mountain belts of the Zagros. In the south-east of the convergence zone, from the Strait of Hormuz south-eastwards, the Arabian plate is being subducted under the Asian plate along the south-eastern coast of Iran (the Makran region). The Ru'us al-Jibal constitutes a salient of the emergent Arabian landmass approaching the subduction zone.

Geography

The Musandam peninsula is approximately 100 km long by 35 km wide and is centred at approximately 26º N latitude, a few degrees north of the Tropic of Cancer. The mountainous Ru'us al-Jibal divides the Indian Ocean (Gulf of Oman) from the Arabian Gulf, a very shallow water body characterised by high salinity, very high summer water temperature and extreme variations beween summer and winter water temperature.

Physiographically, the Ru'us al-Jibal is characterised by steep-sided, rocky wadis and steep lower slopes, including many sheer cliffs, but culminating in summit areas of rolling, stony plateaux, rounded hills and intermittent basins at elevations of 500-1500 m. Some half dozen ridges and summits exceed 1600 m, of which the highest is Jebel Harim at c.2008 m.

The impression given in the summit areas is of a relatively mature landscape that has been rapidly uplifted as a block, a phenomenon that might be expected to have a significant impact on the make-up of the resident plant species. Overall uplift in the Ru'us al-Jibal has been estimated at more than 3,000 m within the past 30 million years or less (Feulner 2005). Such a rate, if it has been uniform, is not exceptional geologically, but there is evidence that recent movement has been more rapid (an estimated c.60 m in the past 10,000 years) and also asymmetrical, with the northern tip of the peninsula being depressed and the southern part uplifted (Vita-Finzi 1979, 1986; Glennie 2009). Tectonic movement in this area is presumably related to the subduction of the Arabian plate in the Makran region.

To the north-west, north and east, the mountains of the Ru'us al-Jibal drop steeply into the sea (*Figs. 1.2.1* to *1.2.3*), but this contemporary phenomenon is a transient one, attributable primarily to the latest post-glacial rise in sea level. As recently as 16,000 years ago, the Arabian Gulf was "dry". Global sea level was then some 120 m lower than today, with the water locked up as ice in continental glaciers. The marine shoreline was outside the Strait of Hormuz (i.e., beside the eastern Ru'us al-Jibal) and the Arabian Gulf served as a broad downstream extension, perhaps marshy and/or intermittent, of the Tigris-Euphrates watershed of Mesopotamia (Lambeck 1996; Glennie 1996; Uchupi *et al.* 1999; Parker *et al.* 2004). The rise and fall of sea level has been repeated a number of times during the Pleistocene (the past 1.8 million years) in response to glacial cycles, a fact which is significant for the possibility of dispersal of plant and animal species across the Arabian Gulf.

To the south-west, the Ru'us al-Jibal is bordered by an alluvial plain of coarse gravel to fine silt. To the south, across the Dibba Zone, the Hajar Mountains continue parallel to the coast of the Gulf of Oman, comprising primarily ophiolite with scattered associated metamorphic rocks, deep water sediments and occasional limestone exotics. The area of the Hajar Mountains from the Dibba Zone southwards to Wadi Hatta, a distance of c.100 km, is the lowest area of the entire Hajar Mountains, with only three scattered peaks and two high ridges reaching as much as 1000 m. To the south of Hatta, summits in the Western Hajar range from 1400 to 1600 m, excluding the much higher massifs of the Jebel Akhdar and Jebel Kawr.

Climate

The northern Hajar Mountains and their outwash plains effectively constitute the north-eastern boundary of the hyper-arid sand desert of the Empty Quarter, the *Rub' al-Khali*. Even in the mountains, temperatures are high and rainfall is low. There are two basic seasons: a prolonged hot, dry summer from May through October, and a mild to warm winter, with occasional rain, from November through April. Insolation levels are high because of the general lack of cloud cover, although cloud formation is much more common in mountain areas than for the UAE as a whole.

Temperature: Mean annual temperature at UAE coastal sites on both flanks of the mountains is 26-28°C, with average monthly means in summer of 33-36°C and average monthly winter means of 18-20°C (UAE University 1993). Monthly mean maximum temperatures in summer are in the range of 41-45°C,

with the Arabian Gulf coast more likely to be in the higher end of the range than the Gulf of Oman coast. Monthly mean minimum temperatures in winter are c.12-15°C on both coasts. The climate of the Gulf of Oman coast is moderated by the Indian Ocean and experiences somewhat less extreme temperatures than the Arabian Gulf coast as a whole, but isotherm data indicate that the Arabian Gulf coast north of Ra's al-Khaimah, adjacent to the Ru'us al-Jibal, is insulated from the lowest winter temperatures (UAE University 1993), perhaps because the nearby mountain escarpment traps and focuses the moderating influence of the sea.

Temperatures at mountain elevations are somewhat lower than the figures given above. Frost is unknown in coastal areas but frost or light snowfall can occur as an exceptional event at the highest elevations in the Ru'us al-Jibal, above c.1700 m. This seems to occur on a time scale of approximately once every decade or so.

Rainfall**:** The climate and weather patterns of the Ru'us al-Jibal, as of the UAE generally, are greatly influenced by regional geography. This has been summarised as follows by UAE meteorological authorities: "The Arabian Gulf is almost totally enclosed by the arid landmasses of the northern desert belt. Prevailing winds over the area are north-westerly because of the very frequent pressure pattern of a ridge of high pressure extending southwards into central Saudi Arabia and low pressure over the eastern Gulf. The mountain barrier along the Iranian coast further enhances the prevailing flow by naturally channeling any eastward moving low level airflow towards the south-east.

"All areas [of the UAE] experience sporadic winter rainfall derived from Mediterranean-type depressions and local convergence phenomena. Cold fronts associated with the Mediterranean [cyclonic] depressions travel east across Saudi Arabia and Iraq, sometimes penetrating as far as the Arabian Sea, but generally producing only small amounts of rain. Most of the rainfall seems to be derived from the warm waters of the Gulf itself, which provides a reservoir of moist air at low levels. Local boundary fronts develop between this warm, moist air and the cooler, drier continental air to produce convergence situations which can give very heavy rainfall, thunderstorms, and line squalls and occasionally hailstorms" (Climatological Report 2003).

Mean annual rainfall in the Ru'us al-Jibal is estimated to be in the range of 190 mm per year and falls mainly in the winter (see Section 8.4 below). Summer rain is exceptional. Annual rainfall is nevertheless highly variable and may be concentrated in a small number of events. Limited available data suggest that in the Ru'us al-Jibal the annual rainfall total can range from less than 80 mm to more than 450 mm (UAE University 1993). Rainfall variation for the UAE as a whole has recently been recognised to be periodic (Jongbloed 2003; Feulner 2006) and appears to be related to the El Niño phenomenon (Emirates Wildlife Society-WWF 2006; see also Böer 1997, *Fig. 4*).

The height of the Ru'us al-Jibal focuses and enhances the potency of the orographic* phenomena associated with the prevailing north-westerly winds, themselves associated with westerly cyclonic depressions at higher latitudes, which are generally considered to be the principal source of rainfall in the Ru'us al-Jibal today (Climatological Report 2003; Parker et al. 2004, 2006). [*Note: The "orographic effect" is the scientific expression for the process whereby mountains induce rainfall by forcing passing air masses to rise, thereby cooling and precipitating their moisture.]

A smaller component of Ru'us al-Jibal rainfall may be associated with phenomena involving the Gulf of Oman. An important subsidiary wind direction in the UAE as a whole is from the south-east (UAE University 1993; Climatological Report 2003) and it is not unusual to observe cloud formation along the Gulf of Oman flank of the Ru'us al-Jibal. However, that coast remains inaccessible by road and only sparsely settled, with the result that its rainfall regime is poorly recorded and unstudied.

The Ru'us al-Jibal is currently beyond the influence of the Indian Ocean south-west monsoon, a summertime phenomenon, although it has received monsoon related summer rain at intervals in the past, including the early Holocene (8500-6000 BP) (Parker *et al.* 2004, 2006).

Rainfall in the Ru'us al-Jibal is not generally considered to be very different from rainfall in the Hajar Mountains of the UAE immediately to the south. Further to the south and south-east, however, annual rainfall in the mountains is evidently somewhat higher and summer rainfall may make a significant contribution, presumptively due to a combination of higher elevations and the influence of the Indian Ocean monsoon. In the Jebel Akhdar, some 275 km to the south-east, where the orographic effect is maximised by plateaux and summits ranging from 1800-3000 m in elevation, mean annual rainfall is c.300-350 mm/yr and summer rainfall may sometimes exceed winter and spring totals (Ghazanfar 1991, 1992b). The influence of rainfall patterns on the flora and vegetation of the Ru'us al-Jibal is discussed in more detail in Section 8.4 below.

Mean annual rainfall in the UAE diminishes rapidly to the south-west, away from the mountains. For example, mean annual rainfall at Abu Dhabi, situated on the Arabian Gulf coast some 225 km from the Ru'us al-Jibal, is only c.60 mm (Feulner 2006).

Fig. 1.1. Geography of the Ru'us al-Jibal: Overviews

Fig. 1.1.1. An exhilarating panorama, looking north from Jebel Naqab in the south-central Ru'us al-Jibal.

Fig. 1.1.2. A sun-dappled view of the Fine Peak plateau (c.1000 m), north-western Ru'us al-Jibal, seen from the south.

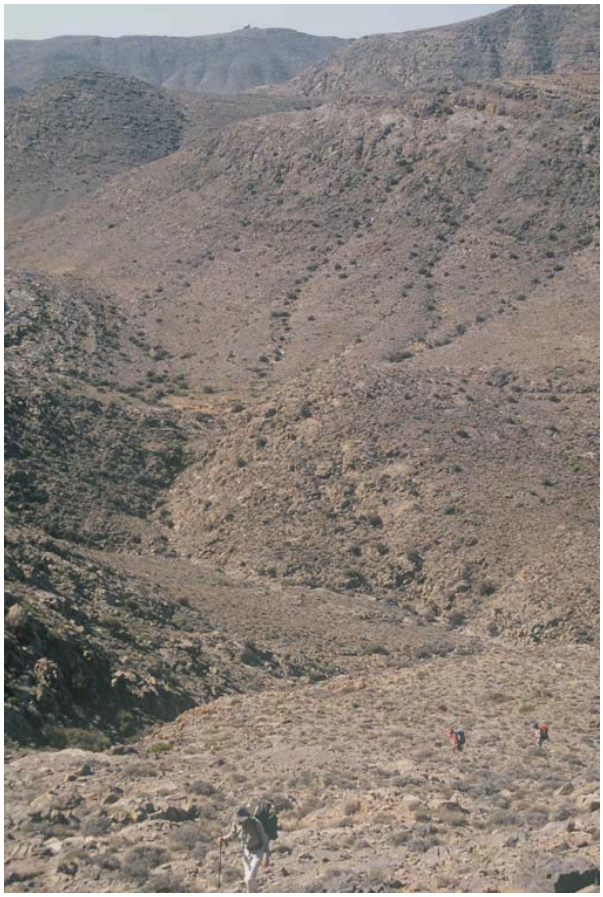


Fig. 1.1.3. Hikers on typical slopes in the central Ru'us al-Jibal, c.1200-1500 m.

Fig. 1.1.4. A cliffside trail from Wadi Sha'am to the Fine Peak plateau, c.900 m.

Fig. 1.1.5. The bowl below Jebel Qi'wi. The Ru'us al-Jibal is dotted with seasonal agricultural settlements, some of which may be up to 700 years old.

Fig. 1.1.6. A seasonal settlement in the still remote eastern Ru'us al-Jibal, c.850 m.

Fig. 1.1.7. Looking south along the cliffs north-east of Jebel Yabana. The top of these cliffs, c.1250 m, is not a plateau but a narrow ridge between two watersheds, with precipitous drops on both sides.

Fig. 1.1.8. The Hidden Valley escarpment, site of a vertiginous Bedu trail today known popularly as the "Stairway to Heaven". The plateau is at c.1300 m.

Fig. 1.2. Geography of the Ru'us al-Jibal: Land and sea

Fig. 1.2.1. The wadis at the northern tip of the Musandam region have been flooded by a combination of plate-tectonic subsidence and rising sea level. This rare perspective, looking south from the mountains above Shisa, shows Khor Ash-Shamm, the isthmus, Khor Habalayn and the mainland beyond.

Fig. 1.2.2. The east coast of the Ru'us al-Jibal at Shisa, beyond the isthmus.

Fig. 1.2.3. The east flank of the Ru'us al-Jibal, seen from the sea, rising to Ar-Ra'alah at 1250 m.

Fig. 1.3. Geography of the Ru’us al-Jibal: Highest areas

Fig. 1.3.1. Looking from north to south across the Ru'us al-Jibal, from Jebel Jais (at c.1800 m) to Jebel Yibir (c.1525 m). The prominent peak at the left is Jebel Qi'wi (c.1750 m). In mid-distance at right of centre are Jebel Yabana (c.1500 m) and Jebel Hagab (c.1350 m). With the exception of J. Qi'wi, the tallest peaks and ridges shown are all c.1500-1550 m.

Fig. 1.3.2. Looking east from Ra's Mintera (c.1880 m), north of Jebel Harim. The terrain in the mid-ground ranges from c.1500 to c.1600 m, representing the highest plateau area in the Ru'us al-Jibal. Fields in this area are the only known sites for *Leontice leontopetalum*. The peaks in the distance, in the remote north-east of the Ru'us al-Jibal, approach 1500 m. The flats at the centre of the photo are also shown and discussed in *Figs. 3.1.6 and 3.1.7.*

Fig. 1.3.3. View towards "Birthday Cake" peak (c.1500 m), east of Jebel Harim, the only locality where the author has found *Salvia mirzayanii*, *Malcolmia africana* and *Astragalus* sp. aff. *schimperi*.

Fig. 1.3.4. Overview of the Sahasa area, a plateau at c.1450 m nestled between the two highest peaks in the Ru'us al-Jibal, Jebel Harim (shown) and Jebel Jais. See also *Fig. 3.1.9*.

Fig. 1.3.5. Overview of the south-central Ru'us al-Jibal, looking northeast from "Hidden Ridge". The plateau in the centre of the photo is at c.1050 m.

Fig. 1.3.6. View from Jebel Dhahr (c.1625 m) to the south-east, showing well-developed "cushion" vegetation on the slopes and the terraced settlement of Sasahan. See also *Fig. 3.1.4.*

Fig. 1.3.7. Looking north across the Ru'us al-Jibal from Jebel Yibir to the highest areas of the UAE — Jebel Rahabah (centre) and Jebel Jais (right). See also *Figs. 1.3.8* and *1.3.9*.

Fig. 1.3.8. The highest area of the UAE, ranging from 1400-1800 m+. The view is from Jebel Rahabah (c.1565 m) towards Jebel Jais, whose summit (c.1935 m) is in Oman. This photo was taken in the mid-1990s. A road is currently under construction across this area (see *Fig. 1.3.9*).

Fig. 1.3.9. Road construction on the slopes of Jebel Rahabah (May 2010).

Fig. 1.4. Geography of the Ru'us al-Jibal: Wadi environments

Fig. 1.4.1. Upper Wadi Bih, overlooking the settlement of Salhad.

Fig. 1.4.2. Overlooking mid-Wadi Bih. The characteristic profile of the Ru'us al-Jibal is of very steep, rocky lower slopes, with gentler terrain predominating only above c.500-600 metres or more.

Fig. 1.4.3. Terraces beside the wadi at the end of the vehicle track in Wadi Naqab.

Fig. 1.4.4. Hiking in mid-Wadi Naqab.

Hydrology

Hydrologically, the Ru'us al-Jibal is a karstic environment, although no significant caves are known and many internal solution channels may be clogged with sediment and debris under the current arid conditions (Borreguero & Jeannin 1990). Permanent surface water is very scarce, and most of it is found either in rare small springs or seeps draining bedrock or gravel, or in deep, shaded pothole pools. Some of the latter are effectively inaccessible to most terrestrial wildlife.

In contrast, wadis in the ophiolite of the Hajar Mountains to the south often feature permanent water in the form of intermittent pools in the wadi bed (Munton 1985; Feulner 1998). This may be attributable in part to the pervasive fracturing that characterises the ophiolite, allowing water to flow relatively freely through cracks in the rock until it encounters an impermeable layer (see also Section 6.1 below). It may also reflect the extensive development of thick (10-30 m) gravel terraces along wadis within the ophiolite, which can serve as reservoirs for groundwater (*Figs. 2.1.1* and *2.1.3*), whereas there is little development of gravel terraces within most of the Ru'us al-Jibal.

Prior Investigation of the Flora of the Ru'us al-Jibal

The Musandam region was effectively closed to outsiders until the early 1970s. The only prior account dedicated to the Musandam flora is that of the early 1979 reconnaissance led by James P. Mandaville Jr., reported in Mandaville (1985) and described in a lighter vein by Larsen (2002). Mandaville, assisted by several other individuals now well known for their contributions to the natural history of the UAE and Oman, collected for 2½ weeks at 18 sites covering much of the northern half of the peninsula, relying on helicopter support to sample at higher elevations. Taxonomic determinations were made principally by Dorothy Hillcoat of the British Museum (Natural History).

Other collectors have made additional contributions from the mid-1970s to the present, including (in rough chronological order) A. Radcliffe-Smith, Michael Gallagher, J.R. Edmondson, Leane, A.R. Western, A.G. Miller, R.E. Ash, R.A. Braund, Marijcke Jongbloed, Carolyn Lehmann, John Martin, Ian McLeish, Benno Böer and Shaukat Chaudhary, and Gary M. Brown. For logistical reasons, since the early 1980s the Musandam region has been more readily accessible to naturalists based in the UAE than to Omani researchers based in Muscat.

Much of the earliest collection in the Musandam is catalogued in Ghazanfar (1992a), although individual catalogue entries do not necessarily distinguish Ru'us al-Jibal locations from Musandam data generally, including coastal, urban and mountain front plantation sites. Observation and collection by UAE-based investigators, as well as most of the Mandaville (1985) data, is compiled in Jongbloed (2003), *The Comprehensive Guide to the Wild Flowers of the United Arab Emirates*, which covers both the UAE and neighbouring areas of Oman, and represents the most comprehensive account to date of plant species present in the Ru'us al-Jibal, including most of those contained in the checklist that accompanies this paper. *Flora of Oman*, vols. 1 & 2 (Ghazanfar 2003, 2007) generally does not incorporate Jongbloed's information, in part because preparation of the two works was contemporaneous. The subsequent *Flora of the United Arab Emirates* (Karim & Fawzi 2007) ignores Jongbloed (2003) and does not attempt a comprehensive treatment of mountain areas.

Notwithstanding the foregoing efforts, it cannot be said that the flora of the Ru'us al-Jibal has yet been systematically collected, studied or reported on. The result is that the distinctive botanical character of the Ru'us al-Jibal has generally passed unremarked (e.g., Brown & Böer 2005a, 2005b; Karim & Fawzi 2007) and, on the relatively few occasions when the Musandam region has received express mention botanically, generalisations have been made on the basis of experience in the Jebel Akhdar or elsewhere in the Hajar Mountains which do not accurately represent the situation in the Ru'us al-Jibal (e.g., Deil & al Gifri 1998; Ghazanfar 1999, 2003). Deil & al Gifri write, for example, that "*Acacia tortilis* and *A. gerrardii*, associated with *Maerua crassifolia*, *Acridocarpus orientalis* and *Moringa peregrina* occur on the slopes of the Hajar and Musandam mountains of northern Oman", but effectively only *A. tortilis* and *M. peregrina* are present in the Ru'us al-Jibal, and only at lower elevations. Similarly, they write that "Other E[*uphorbia*] *larica* associations are with *Barleria*, *Commiphora*, *Convolvulus* and *Iphiona* in the foothills of the Hajar and Musandam mountains", but *Barleria*, *Commiphora* and *Iphiona* are absent in the Ru'us al-Jibal and *Convolvulus* is extremely scarce there at lower elevations where *E. larica* is most common.

Annotated Checklist of the Flora of the Ru'us al-Jibal

In order to facilitate more discriminating attention to the flora of the Ru'us al-Jibal, the Appendix to this paper, an annotated checklist ("the Checklist"), undertakes to list the species of higher plants that have been recorded to date from the mountains of the Musandam region, excluding the surrounding gravel plains, coastal plains and coastal and mountain front settlements and plantations.

The Checklist is based primarily on fieldwork by the author (GRF), supplemented by additional records documented in Mandaville (1985), Western (1989), Ghazanfar (1992a, 2003 and 2007), Miller & Cope (1996), Jongloed *et al*. (2000), Jongbloed (2003), Karim & Fawzi (2007) and Cope (2007). Details of the methodology and conventions used in defining the Ru'us al-Jibal and preparing the Checklist are described in the Introduction to the Appendix. A few particulars are worth highlighting as a preliminary to the discussion which follows.

The author is not formally trained in botany but has an academic background in natural science and two decades of field experience as a serious amateur

naturalist in the UAE and neighbouring Oman, including regular day-long and overnight excursions on foot in mountain regions. The observations and notes on which the Checklist and this paper rely represent more than 120 such excursions throughout the Ru'us al-Jibal from January 1995 through December 2010, plus selected earlier observations, in all seasons (mostly late autumn, winter and early to mid-spring, but including several summer outings at all elevations).

The decade of the 1990s benefitted from relatively heavy rainfall throughout the UAE, making it an excellent period for botanical observations. From 1990 through 1998, only two years were significantly below the long-term average annual rainfall, and the years 1995 through 1998 were four of the ten wettest years in the 70-year history of UAE weather recording (Feulner 2006). In contrast, the subsequent period from mid-1999 through mid-2004 was a period of exceptional drought: rainfall in each year was less than half the long-term average, and the period as a whole had less than half the rainfall of the next driest five-year period recorded (Feulner 2006).

Routine field identifications by the author are generally supported by photographs and were made in the first instance by reference to Western (1989), Jongbloed (1989), Jongbloed (2003) and the herbarium established by Jongbloed at the Sharjah Natural History Museum in the UAE, supplemented by personal communications from Jongbloed and Western, and by reference to Collenette (1985), Shuaib (1995), Boulos' four-volume *Flora of Egypt* (Boulos 1999, 2000, 2002 and 2005, cited collectively herein as "Boulos (FoE)") , Ghazanfar (2003, 2007) and Cope (2007).

Expert identification of specimens has been provided in most cases by Loutfy Boulos, now professor emeritus, Alexandria University, Egypt, initially through the courtesy of Dr. Jongbloed. Prof. Boulos arranged for the determination of a number of grass species by Thomas A. Cope. Selected identifications have also been provided by Gary M. Brown, Ian R. Curtis, Norbert Kilian (for Asteraceae) and Hildemar Scholz (for Poaceae).

In the course of preparation of the Checklist, the taxonomic nomenclature employed in Jongbloed (2003) was modified to take account of Ghazanfar (2003, 2007), advice by Boulos in connection with subsequent determinations generally, advice by Kilian in relation to Asteraceae, and Cope (2007) in relation to grasses. Taxonomic nomenclature was further updated in August 2010 on the basis of a draft preliminary Red Data List for the UAE, prepared and provided by Shahina Ghazanfar. The preliminary Red Data List is based primarily on Jongbloed (2003) but also incorporates most data from the Checklist, a draft of which was provided by the author prior to publication. For ferns, the nomenclature advocated by Rothfels *et al*. (*in press*) has been adopted here. Synonyms are mentioned in the Checklist if the superseded name is one that has heretofore been in common use among naturalists in the UAE and Oman.

The Checklist is considered to be extremely comprehensive for perennials other than grasses. It is somewhat less complete for grasses and, inevitably, for annuals. These limitations reflect, in the case of grasses, the limitations of the author's own abilities, and in the case of annuals, the logistical difficulties, when observing on a part-time basis only, of being in the right place at the right time to encounter seasonal plants, some of them not at all conspicious.

Selected Observations on the Flora and Vegetation of the Ru'us al-Jibal

The flora of the Ru'us al-Jibal is abundant and diverse by regional standards. At low and medium elevations it resembles the flora of the Hajar Mountains to the south, although with a number of consistent differences which merit attention. At higher elevations (above c.1100 m) the flora is dominated by elements having affinities with central Iran and is distinct from the higher elevation flora of the mountains to the south, including the Jebel Akhdar of Northern Oman, to which the Ru'us al-Jibal has often been compared.

1. Abundance and diversity

As detailed in the accompanying Checklist, the Ru'us al-Jibal is home to at least 68 families, 239 genera and 338 species of higher terrestrial plants. This amounts to 47% of the total of c.718 species of higher terrestrial plants recorded to date for the UAE and adjacent areas of Oman (see Section 1.1).

For convenience, Table 1 lists the species recognised by this study from the Ru'us al-Jibal that were not mentioned in Jongbloed (2003), either for the UAE or neighbouring Oman. That list includes a total of 39 entries: 16 are Ru'us al-Jibal records that appear in prior or contemporaneous literature and 23 are records resulting exclusively from the present study. Of the latter, at least 17 appear to be new records for the UAE and Northern Oman, including 16 identified species and one unidentified Boraginaceae. The six additional records are still pending determination and some of them may also prove to represent new records for the region. One unidentified plant (Brassicaceae sp. 2) is treated conservatively as possibly belonging to a recorded taxon.

The species newly recognised by this study are illustrated in *Fig. 5.1.* (*Adonis dentata* is included because the sole record has not previously been reported in a botanical context.) Species pending identification are illustrated in *Fig. 5.2.*

1.1. A note about overall numbers. The aggregate figures presented here are inevitably approximations due to uncertainties in the available records and the underlying taxonomy, as well as ongoing collection and publication. One of the most difficult figures to determine with precision is the total number of species recognised to date from the UAE and northernmost Oman. Some 678 species of vascular terrestrial plants were mentioned in Jongbloed (2003) for the UAE and adjacent areas of Oman, including the Ru'us al-Jibal; the calculation is not entirely straightforward because of a small number of omissions and erroneous typefaces

in the index to Jongbloed (2003). To that total must be added at least the following: (i) the 39 additional records listed in Table 1 (described above); and (ii) a minimum of 7 additional species subsequently recorded in the UAE, outside the Ru'us al-Jibal (*Anthemis deserti*, *Cutandia dichotoma*, *Paspalus vaginatus*, *Saccharum kajkaiense* [but replacing *S. spontaneum*], *Schoenoplectus littoralis*, *Seddera latifolia* and *Zeuxine strateumatica*).

Five deletions from the Jongbloed (2003) total are also required, because: (i) The synonymy of *Helichrysum makranicum* with *H. glumaceum* and of *Phagnalon viridifolium* with *P. schweinfurthii* is newly recognised (N. Kilian, *pers. comm.*); and (ii) The sole records of *Lasiopogon muscoides*, *Teucrium polium* and *Tripteris vaillantii* are considered to be erroneous. The sole records of *Helianthemum stipulatum* and *Umbilicus botryoides*, and the few records of *Crepis foetida*, are also now considered to be erroneous but were not included in Jongbloed (2003).

The exceptional Jazirat al-Ghanem records excluded from the Checklist (discussed in Section 13 below) were not included in Jongbloed (2003), so no adjustment was required on that account.

Karim & Fawzi (2007) introduces additional complications to an overall count, which are not addressed here. That two-volume work describes a total of c.600 plant species from the UAE, but ignores Jongbloed (2003) and omits numerous species mentioned and illustrated in the latter. On the other hand, it includes c.70 species not previously recorded from the UAE. Most of the additional taxa (54) are congeners of known UAE species and many are ruderal or segetal species found so far only in the Al-Ain area, or in some cases on the East Coast. Several appear to be exclusively cultivated or ornamental species. If these additional species are added to those in Jongbloed (2003) and otherwise recorded as described above, then the UAE total would exceed 780. (Although Jongbloed (2003) includes records from areas of Oman adjacent to the UAE, only a very small number of the species listed therein, and in the Checklist, have not been recorded within the UAE proper.)

Table 1: New and overlooked records from the Ru'us al-Jibal: additions to Jongbloed (2003) — A list of taxa not included in Jongbloed (2003) that have been recorded or recognised by this study from the Ru'us al-Jibal. [Citations are given for species recognised from literature records only and (as "also") for species recorded by this study but previously published elsewhere.]

Liliaceae	
Bellevalia sp. aff. *longipes*	
Poaceae	
Aegilops kotschyi	
Bromus danthoniae	also Cope (2007)
Bromus fasciculatus	also Cope (2007)
Poa bulbosa	
Poa sp. aff. *asirensis*	
Stipa mandavillei	Cope (2007)
Stipa parviflora	
Stipagrostis raddiana	
Poaceae sp. 1	
Poaceae sp. 2	
Asteraceae	
Crepis kotschyana	
Cymbolaena griffithii	Ghazanfar (1992a)
Echinops atrox	N. Kilian, *pers. comm.*
Garhadiolus hedypnois	
Notobasis syriaca	
Lactuca orientalis	
Berberidaceae	
Leontice leontopetalum	
Boraginaceae	
Asperugo procumbens	
Boraginaceae sp. 1	
Boraginaceae sp. 2	
Brassicaceae	
Arabidopsis pumila	Miller & Cope (1996), Ghazanfar (2003)
Erophila verna	Miller & Cope (1996), Ghazanfar (2003)
Hetercaryum szovitsianum	Jongbloed *et al.* (2000)
Brassicaceae sp. 1	

Caryophyllaceae	
Arenaria leptoclados	Jongbloed *et al.* (2000)
Minuartia meyeri	Ghazanfar (2003)
Minuartia picta	
Pteranthus dichotomus	Jongbloed *et al.* (2000)
Crassulaceae	
Rosularia adenotricha subsp. adenotricha	
Dipsacaceae	
Pterocephalus brevis	Jongbloed *et al.* (2000)
Fabaceae	
Astragalus sp. 1	
Chesneya parviflora	also *Focus* (Nov. 2009) (newsl. of Emirates Nat. Hist. Group — Abu Dhabi)
Lamiaceae	
Teucrium oliverianum	
Ziziphora tenuior	also Mandaville (1985)
Ranunculaceae	
Adonis dentata	*Gazelle* (May 2007) (newsl. of Dubai Nat. Hist. Group)
Scrophulariaceae	
Chaenorrhinum rubrifolium	
Thymeleaceae	
Thymelaea mesopotamica	also Ghazanfar (1992a)
Valerianaceae	
Valerianella szovitsiana	

Karim & Fawzi (2007) does not attempt a comprehensive treatment of mountain areas, especially for higher elevations, nor can it be considered authoritative with respect to geographic distribution, so it is peripheral to the present study. It does, however, report Hajar Mountain records for a few species (all considered "rare" or "very rare") that are otherwise known only from the Ru'us al-Jibal.

1.2. A note about Ru'us al-Jibal numbers. Existing Ru'us al Jibal records include all eight of the species mentioned in Section 1.1 as synonymised or erroneous: *Helichrysum glumaceum* and *H. makranicum*, *Phagnalon schweinfurthii* and *P. viridifolium*, *Lasiopogon muscoides*, *Teucrium polium*, *Tripteris vaillantii*, *Helianthemum stipulatum*, *Umbilicus botryoides* and *Crepis foetida*. Those earlier records have been mentioned in the Checklist, on the basis that it is instructive to do so, but they have been disregarded in compiling the statistical information presented here. Likewise mentioned but disregarded are the sole record of *Artemisia* cf. *olivieri* from the Ru'us al-Jibal, which is considered extremely doubtful, and the Ru'us al-Jibal records of *Zilla spinosa*, which are believed to be mislocated. In each case, the treatment accorded to the records is indicated and explained by a note in the text of the relevant Checklist entries.

In addition, for purposes of this study, Ru'us al-Jibal records of a number of closely similar congeners have been treated conservatively, and have been regarded as a single species in compiling the statistical information presented here. That approach has not been applied to reduce the Jongbloed (2003) totals, which include most of the species concerned, but only to ensure that the account given here of the abundance and diversity of the Ru'us al-Jibal flora is not overstated. Affected are records of three *Galium* spp., two *Papaver* spp., two *Roemeria* spp., two *Salvia* spp., two *Stipagrostis* spp. and two *Torilis* spp. Again, in each case the treatment accorded to these records is indicated and explained by a note in the text of the relevant Checklist entries.

Apart from records included in the several relevant florae published by botanical professionals (Miller & Cope 1996; Ghazanfar 2003, 2007; Cope 2007), fifteen Checklist entries represent singular records, in the sense that they are records by a single observer, at a single location, of a single plant (or at most a few plants in close proximity) of a species not otherwise known from the region. Almost all of these records are of annual species, which may account for the somewhat serendipitous nature of the observations. They are attributable to individual collectors as follows: Feulner (5), Böer & Chaudhary (5), Jongbloed (3), Braund (1) and Western (1). In all cases the records are based on professional determinations and in several cases the species in question is distinctive, so they are generally listed with confidence. Evidently a small number of the records included in the professionally authored florae are also singular in this sense, e.g., *Arabidopsis pumila*.

A note about grass species numbers

The figure of 45+ given in the main text for grass species (Poaceae) found in the Ru'us al-Jibal is undoubtedly somewhat understated due to lack of comprehensive and authoritative attention. It is reasonable to expect that the actual number of grasses could exceed fifty (50). Nine (9) grass species that have been recorded from Musandam sites at low elevation (Mandaville 1985; Ghazanfar 1992a), outside the Ru'us al-Jibal as defined here, are mentioned in the Checklist but are disregarded for statistical purposes. However, some of those could possibly be present within the mountain environment as well, particularly in the lower reaches of Wadi Bih or in cultivated fields. The effort was made in winter and spring 2008-09, and again in spring and summer 2010, to devote particular attention to grasses in order to enhance the completeness of the Checklist. Hildemar Scholz kindly provided timely expert determinations. That effort seconded a number of Ru'us al-Jibal records by others, re-confirmed several single records by the author, and confirmed the presence of several UAE/Oman grass species that had not yet been reported from the Ru'us al-Jibal but were expected to occur there (e.g., *Hyparrhenia hirta* and *Tricholaena teneriffae*). It also added five identified grass species not previously expected, including three new to the region. Several grasses known only from photographic records could not be positively identified, but are evidently not among the species mentioned in Jongbloed (2003). From this experience it is certain that a number of additional grasses must remain to be recognised.

1.3. Some quantitative comparisons. The families best represented in the Ru'us al-Jibal, in terms of number of species, are Poaceae (45+) (see box), Asteraceae (43), Fabaceae (25), Brassicaceae (22), Caryophyllaceae (21), Boraginaceae (17), Lamiaceae (11), Euphorbiacieae (10) and Scrophulariaceae (10). 28 families (41%) are represented by only a single species.

The top three families (Poaceae, Asteraceae and Fabaceae) also hold the top three positions within the florae of the UAE (Jongbloed *et al*. 2000), Oman (Ghazanfar 1992b) and eastern Saudi Arabia (Mandaville 1990) as a whole. Each of the other leading Ru'us al-Jibal families also ranks in the top ten in the UAE and Oman (Table 2). For the UAE, these parallel statistical relationships probably reflect in part the high proportion of mountain species represented in the UAE flora as a whole, although the UAE statistics also compare well with eastern Saudi Arabia. The Oman statistics, on the other hand, are significantly influenced by the diverse and distinctive flora of Dhofar.

The few disparities in relative diversity at the family level are worth brief mention. In the UAE, fourth place (and fifth place in eastern Saudi Arabia) goes to Chenopodaceae, which is absent from the other two lists in Table 2. Chenopods typically inhabit saline environments not common in the mountains; only three Chenopod species are found in the Ru'us al-Jibal. Euphorbiaceae is better represented in both the UAE and Oman as a whole than it is in the Ru'us al-Jibal, which may reflect the fact that, regionally, a number of

its members are plantation species. The relative importance of Zygophyllaceae in the UAE and eastern Saudi Arabia is partly attributable to the diversity of *Tribulus* and *Tetraena* (formerly *Zygophyllum*) species in the sand deserts of the region, but may have been somewhat overstated due to taxonomic confusion (see Ghazanfar 2007).

The Ru'us al-Jibal list in Table 2 also includes Capparaceae, which appears in none of the other lists. Although two species of *Capparis* are common or occasional in the Ru'us al-Jibal, the ranking for Capparaceae is also based on records of four species of *Cleome* and one of *Maerua*, all of which are rare. In fact, if all Musandam records for Capparaceae shown in the distribution maps in Ghazanfar (2003) were accepted as Ru'us al-Jibal records, six additional species would be added and Capparaceae would be catapulted to 7th place, ahead of Lamiaceae, Euphorbiaceae and Scrophulariaceae. However, all of those additional records are exceptional and could represent recording or transcription errors; four are mentioned in the Checklist for the sake of completeness but have been disregarded in compiling the statistics presented here. Two others, if correct, are considered most likely to represent introduced or cultivated specimens and have been excluded from the Checklist.

As for relative diversity at the genus level, 59 of the 239 genera present in the Ru'us al-Jibal, or about 25%, are represented by multiple species. The best represented genera are: *Astragalus* (6-7 spp.), *Euphorbia* (6 spp.), *Plantago* (5 spp.), *Launaea* (4 spp.), *Heliotropium* (4 spp.) and *Cleome* (4 spp., but all are rare). Other genera that may have as many as 4 species are: *Fagonia* (4 spp., but one is represented by a single record) and *Galium* (4 spp. recorded, but the records of 3 very similar, primarily segetal species are treated as only two taxa for purposes of this study). At least 14 Ru'us al-Jibal genera are represented by 3 recorded species: *Bromus*, *Convolvulus*, *Cymbopogon*, *Eragrostis*, *Geranium*, *Grewia*, *Helianthemum*, *Nanorrhinum*, *Poa*, *Plocama*, *Pulicaria*, *Salvia, Silene* and *Stipa*.

1.4. The influence of geological and

Table 2: Comparison of plant families best represented (by number of species) in the Ru'us al-Jibal, UAE, Oman and eastern Saudi Arabia.

Ru'us al-Jibal (this study)		**UAE (Jongbloed *et al.* 2000)**	
Poaceae	45+	Poaceae	114
Asteraceae	43	Asteraceae	84
Fabaceae	25	Fabaceae	73
Brassicaceae	22	Chenopodiaceae	39
Caryophyllaceae	21	Brassicaceae	37
Boraginaceae	17	Boraginaceae	30
Lamiaceae	11	Caryophyllaceae	27
Euphorbiaceae	10	Euphorbiaceae	27
Scrophulariaceae	10	Zygophyllaceae	19
Rubiaceae	8	Convolvulaceae	17
Capparaceae	7	Lamiaceae	17
Apiaceae	~6	Scrophulariaceae	17
		Apiaceae	16
Oman (Ghazanfar 1992b)		**Eastern Saudi Arabia (Mandaville 1990)**	
Poaceae	201	Poaceae	91
Asteraceae	98	Asteraceae	66
Fabaceae	81	Fabaceae	50
Euphorbiaceae	39	Brassicaceae	46
Scrophulariaceae	38	Chenopodiaceae	42
Caryophylaceae	37	Caryophyllaceae	22
Boraginaceae	37	Zygophyllaceae	15
Lamiaceae	35	Boraginaceae	14
Acanthaceae	31		
Brassicaceae	31		
Malvaceae	31		

Fig. 1.4.5. Dip slope and terraces in upper Wadi Shah.

Fig. 1.4.6. Bedrock gorge in lower Wadi Zibat, one of the most challenging trails in the Ru'us al-Jibal.

Fig. 1.4.7. A campsite in upper Wadi Zibat, c.1050 m.

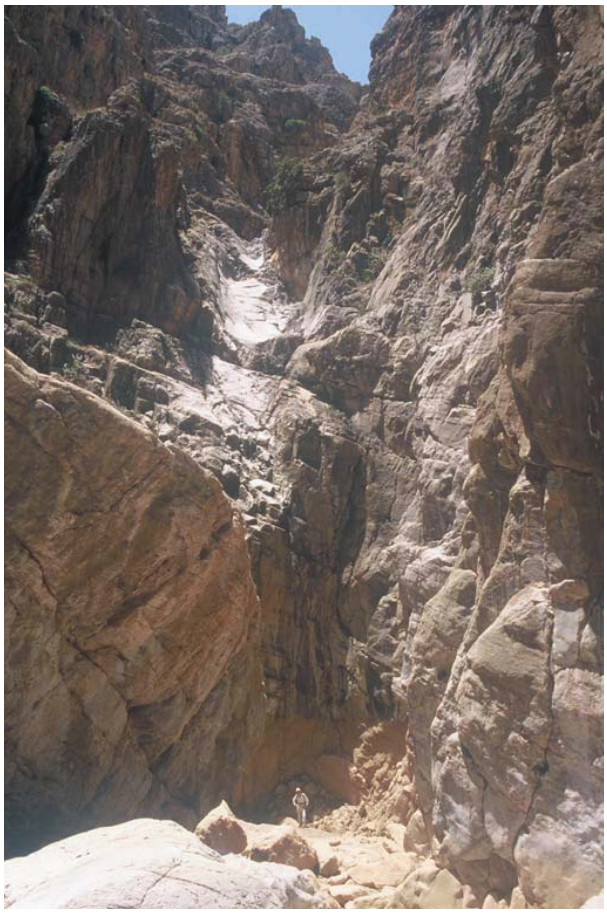


Fig. 1.4.8. A waterfall impasse in Wadi Madnan, a tributary of Wadi Naqab. See figure at bottom for scale.

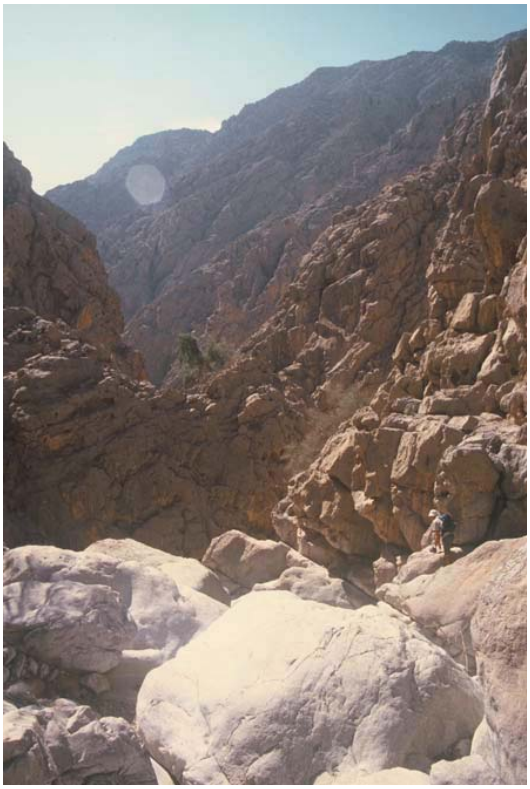


Fig. 1.4.9. A waterfall impasse in Wadi Kharras, a tributary of Wadi Khabb, from above. See figure at right centre for scale.

Fig. 1.4.10. A trail parallels this wadi that ascends from the Wadi Khabb Shamsi narrows.

Fig. 1.4.11. The formidable gorge of the southern tributary of Wadi al-Wa'eeb.

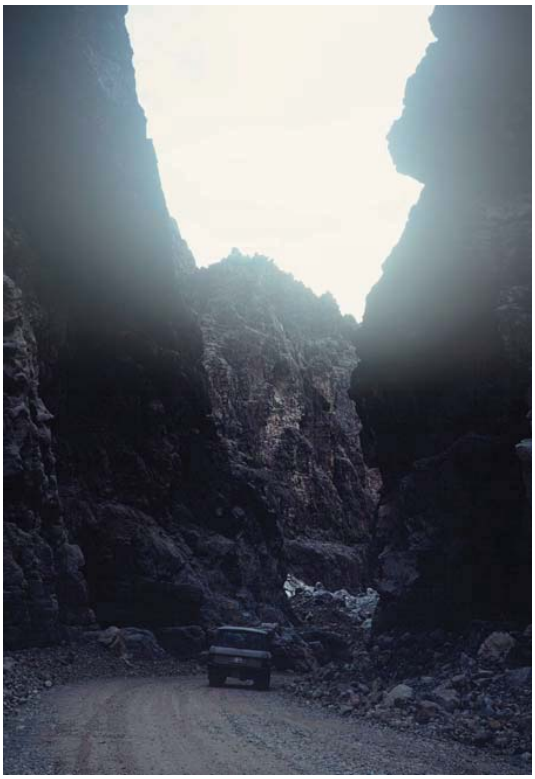


Fig. 1.4.12. The Wadi Khabb Shamsi narrows. The cliffs in this area are home to species not found elsewhere in the Ru'us al-Jibal and uncommon in Eastern Arabia generally, including *Abutilon fruticosum*, *Commelina albescens*, *Dalechampia scandens*, *Ehretia obtusifolia*, *Grewia tenax*, *G. villosa* and *Pistacia khinjuk*. See Section 11.

Fig. 1.5. Geography of the Ru'us al-Jibal: The southern margins

Fig. 1.5.1. The south-western corner of the Ru'us al-Jibal is relatively low, with plateau summits at less than 500 m (extreme right). It slopes down to the Dibba Zone (the wadi and beyond). Several species can be found in this area that are common in the Hajar Mountains but are not present elsewhere in the Ru'us al-Jibal, e.g., *Pulicaria glutinosa* (*Fig. 6.1.9*). See also Table 6a.

Fig. 1.5.2. A view across Wadi Khabb at Baqeel, looking south-east. The geology of the mountains that comprise the south-eastern margin of the Ru'us al-Jibal (background) is distinct from that of the main Ru'us al-Jibal (foreground) and consists of relatively colourful deepwater sediments, many of them turbidites or conglomerates deposited in a tectonically active environment. The contact between the two units follows, more or less, the course of Wadi Khabb.

Fig. 1.5.3. View of the south-eastern Ru'us al-Jibal from the Dibba plain. The darker, reddish-brown deep water sediments of the Hawasina Group are clearly visible in front of the main carbonate massif.

Fig. 1.6. Geography of the Ru'us al-Jibal: Terraced settlements

Fig. 1.6.1. Overlooking Hoob (c.850 m), above Wadi Bih near Wadi Zibat, January 2008.

Fig. 1.6.2. Silhi (c.1100 m) in the central Ru'us al-Jibal, once a very remote settlement, April 1995.

Fig. 1.6.3. Palm cultivation at Difan (c.850 m) in the southern Ru'us al-Jibal, January 1993.

Fig. 1.6.4. Samarat (c.1000 m), verdant in late February 1998, but no date palms are cultivated here.

Fig. 1.6.5. Upper Sha'iri (c.1000 m), a relatively remote settlement, very dry in November 2008.

Fig. 1.6.6 As-Sayh (c.1150 m) is by far the largest cultivated area in the Ru'us al-Jibal. It is permanently occupied and has been served by a road since 1980. The extensive flats were formed by siltation behind an ancient landslide (at upper left) that blocked the main wadi.

Fig. 2. Comparison: Geography of the Hajar Mountains

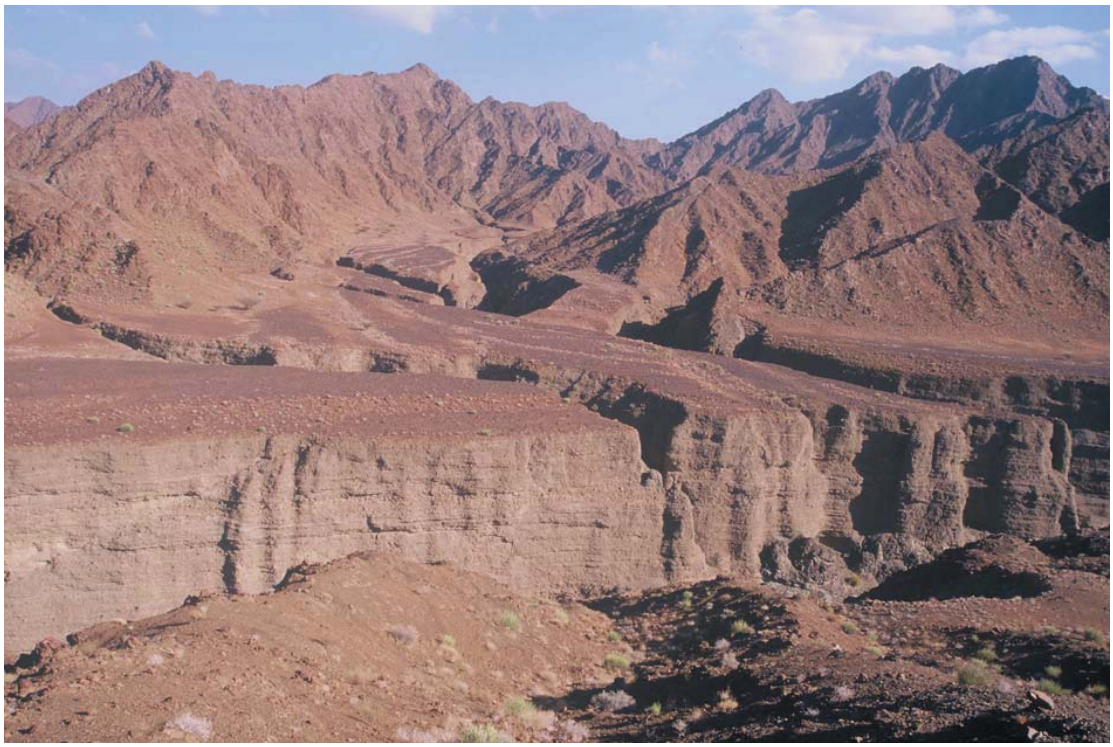


Fig. 2.1.1. The Hajar Mountains in the UAE and northernmost Oman are composed primarily of ultrabasic and basic igneous rocks collectively called ophiolite. Physiographically, they are characterised by triangular peaks and thick gravel terraces cut by steep-sided wadis, representing multiple phases of erosion and deposition.

Fig. 2.1.2. A bird's eye view of typical Hajar Mountain topography. The ophiolite bedrock is often highly fractured and very difficult to climb. Areas such as this remain home to the Arabian tahr.

Fig. 2.1.3. Surface water is much more common in the Hajar Mountains than in the karstic environment of the Ru'us al-Jibal.

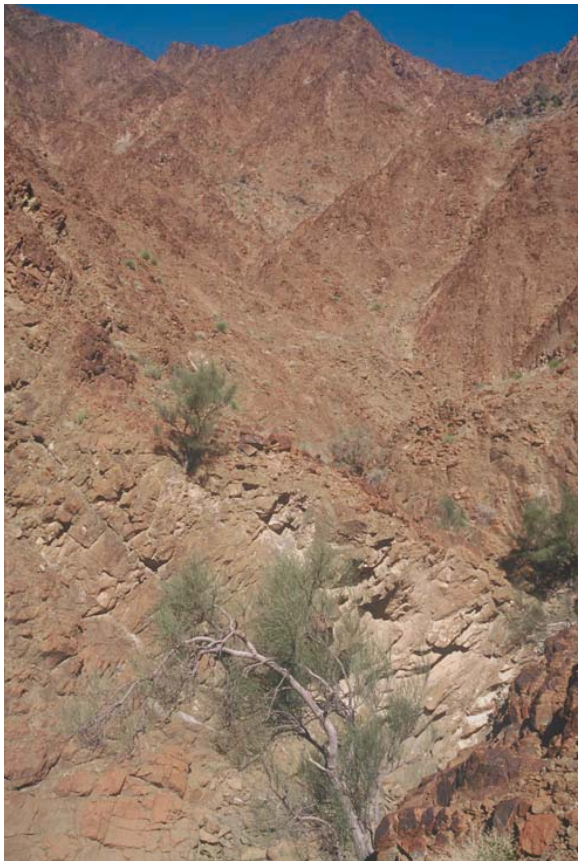


Fig. 2.1.4. *Moringa peregrina*, shown here in upper Wadi Zikt, is the most common tree on Hajar Mountain slopes in the UAE. To the south, in Northern Oman, the wild olive *Olea europaea* is common in rocky wadis similar to this, but at higher elevations.

Fig. 3. A sampling of botanical habitats within the Ru'us al-Jibal
Fig. 3.1. Plateaux and open slopes

Fig. 3.1.1. The barren summit of Ra's Mintera, c.1880 m (late October 2006): *Convolvulus acanthocladus* and *Cymbopogon jwarancusa* are dominant, but very dry, along with *Dodonaea viscosa* and a few stunted almonds, *Prunus arabica*.

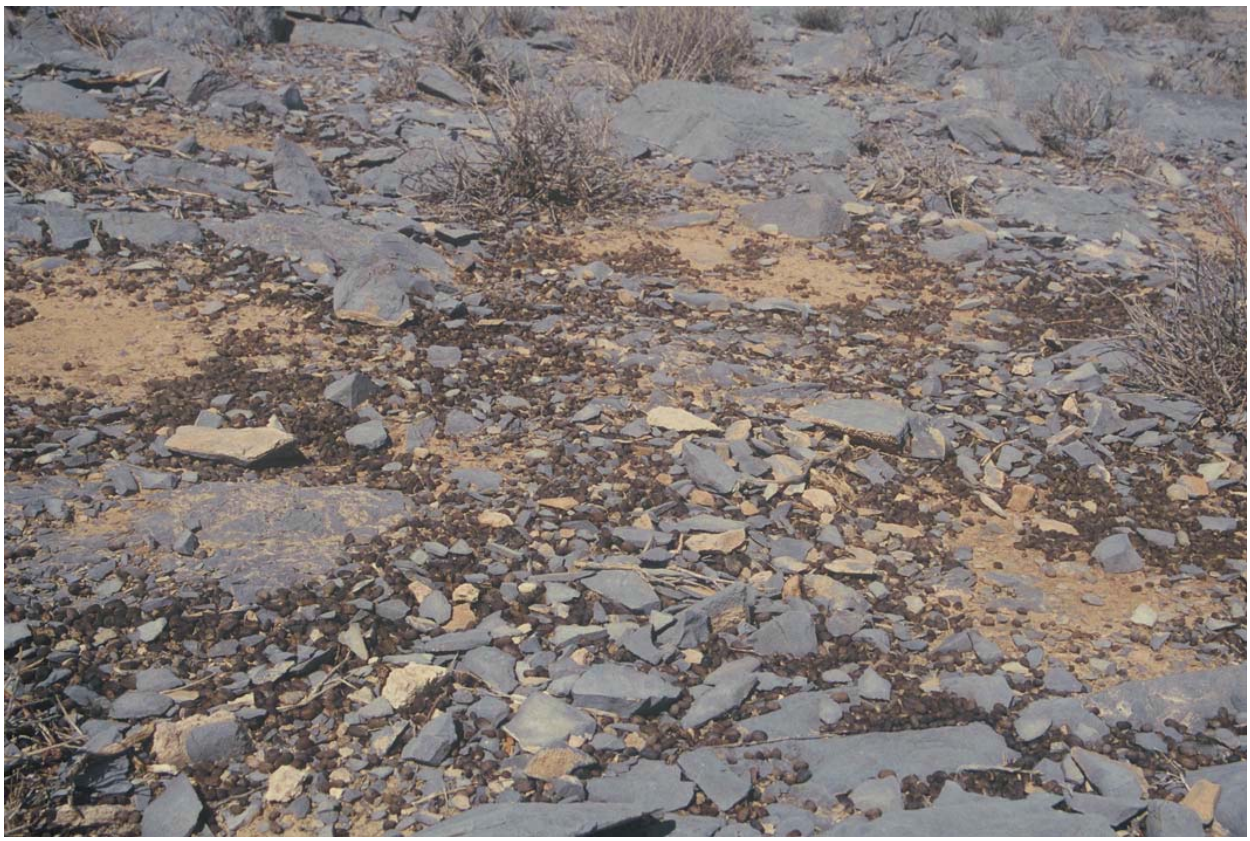


Fig. 3.1.2. Evidence of overgrazing: Abundant goat droppings at the barren summit of Ra's Mintera (see *Fig. 3.1.1*).

Fig. 3.1.3 Slopes near Ra's Mintera, c.1700 m (March 1995): *Dodonaea viscosa* appears refreshed and dominates the landscape.

Fig. 3.1.4. Near the summit of Jebel Dhahr, c.1625 m: *Convolvulus acanthocladus* is dominant, with occasional stunted *Prunus arabica*.

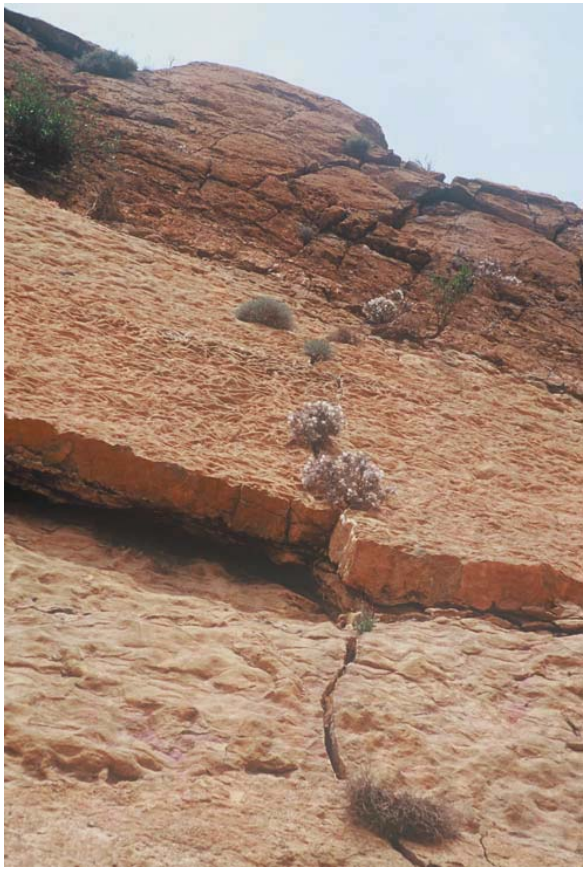


Fig. 3.1.5. Looking up a vertical cliff below Jebel Harim, c.1600 m: *Convolvulus acanthocladus* (in flower), *Dodonaea viscosa*, *Farsetia aegyptia*, *Plocama hymenostephana et al*.

palaeoclimatological history. A significant factor in the botanical diversity of the Ru'us al-Jibal, particularly at high elevations, is the geological history of Eastern Arabia, including its palaeoclimatological history. Ghazanfar (1999, 2003) has characterised the flora of the Hajar Mountains and Northern Oman as deriving from tropical vegetation of African origin that occupied the western parts of Arabia c.50-25 million years ago. This dates from a time when the Red Sea had not yet opened to separate Arabia from Africa, and before the Tethys Sea had finally closed in the region of Asia Minor to divide the Mediterranean from the Indian Ocean.

Many subsequent events have had an influence on the climate, habitat and conditions of access that have determined the present species composition of the flora of the Hajar Mountains and the Ru'us al-Jibal. These include the first emergence of the Zagros Mountains at about 5-6 million years ago and the associated depression of the Arabian Gulf (slight, but sufficient to permit an incursion of the sea); the continued elevation of the Hajar Mountains and the Ru'us al-Jibal; the climatic viscissitudes of the Pleistocene glacial and inter-glacial periods (generally corresponding inversely to pluvial and inter-pluvial periods in Arabia and North Africa); and the smaller scale climatic viscissitudes of the latest inter-glacial period, including the Holocene or Recent Epoch, i.e., the past 10,000 years.

Although most palaeoclimate studies in Eastern Arabia proper have focused primarily on the past few tens of thousands of years, more general studies indicate that there have been many alternations of wet and dry periods during the 1.8 million years or so of the Pleistocene (Glennie 1991, 1996; Sanlaville 1992, 1998; Goodall 1994) and earlier, since the late Miocene, 6-8 million years ago, when large rivers flowed through savannah in western Abu Dhabi (Goodall 1994; Glennie 1997; Whybrow et al. 1996; Whybrow & Hill 1999). At various times during the Pleistocene and earlier, the Arabian Gulf was partly or wholly emergent due to fluctuations in global sea levels, and formed a broad extension (perhaps a relatively fertile one) of the Tigris-Euphrates watershed of Mesopotamia, thereby facilitating the movement of terrestrial plants and animals between Iran and Arabia (Glennie 1996; Lambeck 1996).

The peak of the most recent glaciation occurred at c.17,000-18,000 BP. At that time, sea level was some 120 m lower than at present and the Arabian Gulf was completely dry, with the shoreline outside the Strait of Hormuz (Lambeck 1996; Glennie 1996; Uchupi *et al.* 1999; Parker *et al.* 2004). Sea level rose thereafter, reaching its current level, or a metre or two higher, about 6,000 BP. Climatically, the initial retreat from the glacial maximum was accompanied in Eastern Arabia by a period of extreme aridity from c.17,000-11,000 BP (Goodall 1994; Parker *et al.* 2004; Zander & Brückner 2005). One implication is that much of the current flora of the Hajar Mountains generally, including the Ru'us al-Jibal, may have become established within the past 11,000 years. The highest elevation species may have been particularly sensitive to such viscissitudes because they do not have the option to go further "up" to find refuge from warming or aridity.

In contrast, the period which followed in Eastern Arabia and elsewhere, from 10,000 to 6,000 BP, was a mesic interval known as the "Climatic Optimum", during which climatic conditions were less arid than today (Sanlaville 1992; Glennie 1997; Parker *et al.* 2004). This is generally considered to have been the result, directly or indirectly, of a northerly incursion of the influence of the Indian Ocean monsoon during that time period (Parker *et al.* 2004, 2006). The Climatic Optimum would have facilitated both the geographic expansion of existing plant species and the recruitment of new species from more mesic and fertile areas. Parker *et al.* (2004, 2006) studied a thick sequence of Early Holocene lake sediments at Awafi in Ra's al-Khaimah, only 10km to the west of the Ru'us al-Jibal, which clearly record a change after 6,000 BP from C3 dominated savannah grasslands to C4 grasslands adapted to drier conditions, as well as other evidence of desertification (see box, this page).

After 6,000 BP, the local climate again became more arid, reaching more or less its present state by about 4,000 BP (Parker *et al.* 2004, 2006). The current flora is therefore generally considered to be the diminished residuum of an earlier, more abundant and diverse flora that flourished in a more botanically favourable environment. In particular, the higher elevation species of the Hajar Mountains as a whole have generally been considered to represent relict populations, i.e., the remnants of populations that were more widespread at an earlier time when the local climate was wetter and perhaps somewhat cooler (e.g., Mandaville 1977; Sanlaville 1992; Ghazanfar 1998a, 1999). Support for this hypothesis includes (i) the presence of various species throughout Oman that are reckoned to be relicts of African origin, and, in Northern Oman, others that are considered Asian relicts (Ghazanfar 2003); (ii) the disjunctive distribution of certain species or species complexes in Oman, Africa and/or Asia (Zohary 1963, 1973; Ghazanfar 1991, 1999, 2003), particularly mountain species such as *Juniperus* spp., *Sideroxylon*

A note about photosynthesis, palaeobotany and palaeoclimatology

The terms C3 and C4 refer to two different metabolic pathways by which plants photosynthesise. C3 plants are the most common and include most trees, shrubs and herbs, and some grasses. C4 plants are mostly grasses and are associated with warm, dry, tropical and subtropical environments with higher light levels. C4 plants have mechanisms for water conservation and use carbon dioxide more effectively. In sedimentary deposits, the remains of C3 and C4 vegetation can be distinguished by their different and non-overlapping carbon isotope ratios. Phytoliths (microscopic biogenic siliceous structures found in the tissues of many plants, including most grasses) can also be recovered from sediment and can be used to distinguish the types of grasses formerly present. Different groups can be recognised that are indicative of different climatic conditions, e.g., C3 Pooidae (cool wet), C3-C4 Panicoideae (warm humid) and C4 Chloridoideae (warm dry). See Parker *et al.* (2004).

mascatensis and *Olea europaea*; and (iii) the fact that many species today found only at medium and high elevations in the Ru'us al-Jibal are also found as plains species in Qatar, northern Saudi Arabia and Kuwait (see Section 2 below).

The Awafi lake sediments nevertheless continued to accumulate through the period of deteriorating climate and date to as recently as 4200 BP, nearly 2000 years younger than most lacustrine and speleothem records from elsewhere in Eastern Arabia. Parker *et al*. (2004, 2006) reason from this that the Ru'us al-Jibal may have maintained a wetter climate for somewhat longer than elsewhere in Eastern Arabia, independent of the Indian Ocean monsoon, due to its northerly position in relation to the westerly cyclonic belt, coupled with its orographic influence.

1.5. The "island effect" on high elevation species diversity. Apart from environmental and historical constraints such as high temperature, low rainfall, limited soil development and overgrazing (see Section 4 below), the high elevation flora of the Ru'us al-Jibal is subject to an inherent limitation on species diversity because the total physical surface area at higher elevations is relatively small. The total area above 1200 m amounts to about 240 sq. km, concentrated in two main massifs, located respectively to the north and south of Wadi Bih. The total area above 1500 m is only c.47 sq. km, of which 90% lies within the north-central part of the peninsula, in the area surrounding the highest peaks; the remainder is scattered among a half dozen individual summits to the south. By way of comparison, the Jebel Akhdar region in Oman not only rises a thousand metres higher but is also several times as large. Comparable figures for the Jebel Akhdar (including the massif of Jebel Kawr) are: c.1135 sq. km for the total area above 1500 m; c.410 sq. km for the area above 2000 m; and c.30 sq. km for the area above 2500 m.

It is a generally accepted principle of biogeography (a statistical generalisation, really) that, other things being more or less equal, a smaller geographical area will have fewer species than a larger area of the same habitat. In relation to isolated or fragmented habitats, this phenomenon is sometimes referred to as the "island effect" due to its initial mathematical elaboration in *The Theory of Island Biogeography* (MacArthur & Wilson, 1967). The causal mechanisms continue to be debated, but the generalisation itself has not been seriously challenged. (For an extended and award-winning popular discussion, see Quammen (1996).)

The phenomenon does not predict, however, that the dominant species should differ between a large area of a particular habitat and a smaller area of similar habitat. On the contrary, it is generally the case that the less common species are the ones that are more likely to be absent within a smaller area. Thus, while the "island effect" may help to explain, for example, the smaller number of tree species in the Ru'us al-Jibal as compared to the Jebel Akhdar, it does not explain why most of the dominant Ru'us al-Jibal species (e.g., *Artemisia sieberi*, *Convolvulus acanthocladus*, *Prunus arabica*,) are not represented in the Hajar Mountains to the south (see Section 6 below and **Table 5**) or in the Jebel Akhdar (see Section 8 below).

2. Local endemism

Ghazanfar (1999) identified "the northern mountains of Oman (including the Musandam mountains) [as] one of the three local centres of endemism in the country" and her Figure 3.3 depicts the high Musandam as an "LCE" separate from the Hajar Mountains generally. On current evidence, however, the "Musandam mountains" (the Ru'us al-Jibal) should probably be excluded from the most rigorous interpretation of that statement. Only four UAE/Oman endemics are found in the Ru'us al-Jibal and no species has yet been identified that is strictly endemic to the Ru'us al-Jibal.

For the northern Oman mountains as a whole, Ghazanfar (1998b, 1999, 2003) has estimated that approximately 25 plant species are nationally or regionally endemic. That figure would include the mountain regions of the UAE, which has no nationally endemic species. Most of those endemics, according to Ghazanfar, are uncommon and restricted to one or two locations in the mountains, although she includes only five northern mountain endemics in her Red List of the Flora of Oman (Ghazanfar 1999, Table 3.3). She also lists six "common species" from among those endemics, of which only one is found in the Ru'us al-Jibal – *Pteropyrum scoparium*, which is however acknowledged to be possibly conspecific with *P. aucheri* of Iran, Afghanistan and Pakistan (Miller & Cope 1996; Ghazanfar 2003). Only four other northern Oman endemics are found within the Ru'us al-Jibal: *Desmidorchis arabica*, a cactus-like milkweed that is widespread but not common (and is apparently included in Ghazanfar's Red List as *Caralluma aucheri*); *Echinops erinaceus*, a spiny thistle, locally common on scree and rubble; *Pulicaria edmondsonii*, a slope-dwelling dwarf shrub that is widespread and locally common; and *Stipa mandavillei*, a grass found at high elevations that is evidently rare outside the Jebel Akhdar.

Nevertheless, local endemism is high in the Ru'us al-Jibal in the sense that some 75 species, representing approximately 22% of the above-mentioned total of 338 for the Ru'us al-Jibal, are confined, within Eastern Arabia, either exclusively (62 spp.) or very nearly so (13 spp.) to the Ru'us al-Jibal, being absent (or very nearly so) in the Hajar Mountains to the south. A complete list of these locally endemic species is given in Table 3 (see Checklist for additional details).

Among the most common local endemics are a diverse array of distinctive perennials including *Artemisia sieberi*, *Astragalus fasciculifolius*, *Centaurea wendelboi*, *Dianthus crinitus*, *Gladiolus italicus*, *Ixiolirion tataricum*, *Jurenia berardioides*, *Lactuca orientalis*, *Leopoldia longipes*, *Moraea sisyrinchium* and *Prunus arabica*, along with a few annuals such as *Helianthemum salicifolium* and *Hippocrepis unisiliquosa*. All of the foregoing are higher elevation species. In addition, *Convolvulus acanthocladus*, one of the three most abundant dwarf shrubs at high

elevations in the Ru'us al-Jibal, is a "near" local endemic, having only a very limited distribution in the mountains to the south.

Approximately 80% of the Table 3 species can be found at medium or high elevations (above 700 m) and approximately 75% are found only at those elevations. These numbers emphasise the contribution of higher elevation species to both the diversity and distinctiveness of the flora of the Ru'us al-Jibal.

Most of the local endemics (like most of the other high elevaton species of the Ru'us al-Jibal) are species that have their principal ranges in more temperate regions, particularly Iran and neighbouring areas of Central Asia (see also Section 5.2 below), and it should be emphasised that, although the plants listed in Table 3 are limited in Eastern Arabia to the mountains of the Ru'us al-Jibal, they are not necessarily restricted to mountain environments elsewhere. A number of the more common Table 3 species (as well as other common species found only in mountain environments in the UAE) are also common or locally common at low elevations on the sand and gravel plains of Qatar, northern Saudi Arabia and Kuwait, where winter temperatures are lower and winter rainfall is more reliable than in the UAE (Mandaville 1990; G.M. Brown, *pers. comm.*). Such species include many annuals, e.g., *Althaea ludwigii*, *Anagallis arvensis*, *Arnebia decumbens*, *Calendula arvensis*, *Campanula erinus*, *Helianthemum salicifolium*, *Plantago amplexicaulis*, *Reichardia tingitana*, *Rumex vesicarius*, *Scabiosa olivieri* and *Trigonella stellata*, as well as a variety of perennials such as *Artemisia sieberi*, *Farsetia aegyptia*, *Helianthemum lippii*, *Ixiolirion tataricum*, *Moraea sisyrhinchium*, *Piptatherum holciforme* and *Prunus arabica* (see, e.g., Shuaib 1995).

A number of the high elevation local endemics found in the Ru'us al-Jibal are ruderal species also discussed separately in Section 7 below. Some of these have probably been introduced initially with agricultural activities.

The presence of some very rare local endemics may be attributable to chance establishment and/or preservation. In the case of the trees *Pistacia khinjuk* and *Cordia* sp. aff. *quercifolia*, for example, both species are represented by fewer than two dozen specimens located along limited stretches of single wadis. Both are also restricted to cliff or ledge sites protected from browsing.

Fig. 3.1.6. A closer view of the high plateau shown in *Fig. 1.3.2*, seen from the north-west. All of the trees in the photo are *Prunus arabica*. The flats at the centre of the photo, at c.1550 m, were created by a man-made dam.
See also *Fig. 3.1.7.*

Table 3: Local endemics of the Ru'us al-Jibal: Species that are are confined, within Eastern Arabia, exclusively (or very nearly so) to the Ru'us al-Jibal.

Adonis dentata
Aegilops kotschyi
Althaea ludwigii
Anthemis odontostephana [1]
Arabidopsis pumila
Arenaria serpyllifolia [2]
Artemisia sieberi
Asperugo procumbens [3]
Asplenium ceterach
Asterolinon linum-stellatum
Astragalus fasciculifolius [4]
Bellevalia sp. aff. longipes
Boraginaceae sp.
Bromus danthoniae
Cakile arabica
Carduus pycnocephalus
Centaurea wendelboi
Clypeola aspera
Clypeola jonthlaspi
Convolvulus ulicinus [5]
Commelina albescens
Cordia quercifolia
Crassula alata
Cymbolaena griffithii
Daucus subsessilis
Echinops atrox
Erophila verna
Fagonia schimperi
Galium ceratopodum
Garhadiolus hedypnois
Gastridium phleoides
Geranium biuncinatum
Gladiolus italicus
Helianthemum salicifolium [6]
Heterocaryum szovitsianum
Hippocrepis unisiliquosa
Jurenia berardioides
Jurenia carduiformis
Justicia heterocarpa
Ixiolirion tataricum
Kickxia floribunda
Lactuca dissecta
Lactuca orientalis
Lallemantia royleana
Lamarckia aurea
Leontice leontopetalum
Leopoldia longipes
Minuartia meyeri
Minuartia picta
Matricaria aurea
Moraea sisyrinchium
Notobasis syriaca
Ononis reclinata
Piptatherum holciforme
Pistacia khinjuk
Plantago notata [7]
Poa bulbosa
Poa sinaica
Poa sp. aff. *asirensis*
Prunus arabica [8]
Pteranthus dichotomus
Roemeria sp(p).
Rosularia adenotricha
Salvia mirzayanii
Scabiosa olivieri [9]
Scandix pecten-veneris [10]
Sedum hispanicum [11]
Stipa parviflora
Teucrium oliverianum
Thymelaea mesopotamica
Torilis nodosa [12]
Umbilicus horizontalis [13]
Valantia hispida
Valerianella szovitsiana
Ziziphora tenuior

Also recorded from:
1 J. Aswad, Eastern Hajar, Oman (JPM)
2 Hatta area, rare (FMK); Khor Fakkan (K&F)
3 Field margins, Wakan, Jebel Akhdar (SAG)
4 J. Aswad, Eastern Hajar, Oman (JPM)
5 Jebel Akhdar, Oman, very rare
6 J.Hafit(?), rare (FMK); J.Hafit & Hatta (K&F)
7 Dhaid, rare (FMK); Al-Ain (K&F)
8 Eastern Hajar (Jebel Bani Jabr), Oman (JPM)
9 N. Oman (SAG)
10 Dhaid, rare (FMK); Masafi, Fujairah, Al-Ain, very rare, (K&F)
11 Northernmost Hajar Mtns (MJ)
12 Ghazanfar (2003) records only *T. stocksiana* in N. Oman.
13 Hatta area, rare (FMK); Masafi, MJ, K&F

FMK = Karim (2002)
JPM = Mandaville (1985)
K&F = Karim & Fawzi (2007)
MJ = Jongbloed (2003)
SAG = Ghazanfar (1992a)
Records appearing in Karim (2002) but not incorporated in Karim & Fawzi (2007) have been excluded.

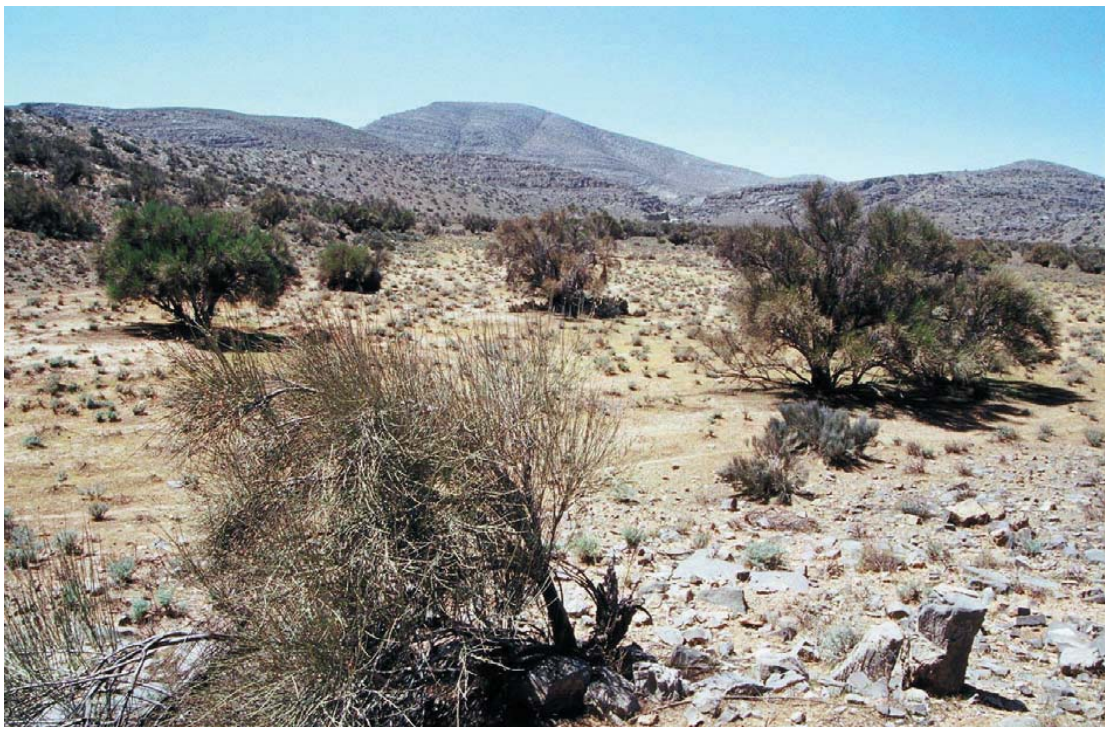


Fig. 3.1.7. The flats shown in *Fig. 3.1.6*, seen from the east at ground level in March 2008. The ground cover among the almonds is dominated by *Artemisia sieberi*. At right in the foreground is *Ephedra pachyclada*.

Fig. 3.1.8. Gentle but rocky slopes near Hidden Peak, c.1550 m (March 2009). Dominant generally are *Convolvulus acanthocladus* and *Cymbopogon jwarancusa*, but *Dodonaea viscosa* is abundant in the foreground, within a rock horizon that weathers to "tombstones".

Fig. 3.1.9. The Sahasa plain, c.1450 m, beneath Jebel Harim: An overview of the same area is shown in *Fig. 1.3.4.* The dominant shrubs here are, once again, *Prunus arabicus*, *Convolvulus acanthocladus*, *Dodonaea viscosa* and *Cymbopogon jwarancusa*. Less common species found in this area include *Althaea ludwigii* and *Thymelaea mesopotamica*.

Fig. 3.1.10. Barren steppe along a trail northeast of Jebel Harim, c.1450 m (March 2008). The largest woody shrubs are *Dodonaea viscosa.*

Fig. 3.1.11. Plateau at Hawshak, c.1350 m (March 2009). *Convolvulus acanthocladus* and *Cymbopogon jwarancusa* are dominant. Almond trees *Prunus arabica* occupy a shallow wadi in the middle distance and abandoned cultivation on the horizon.

Fig. 3.1.12. *Prunus-Artemisia* flats at Labsat, c.1350 m (March 2001). This area was once cultivated.

Fig. 3.1.13. A protected silty hollow at c.1300 m, possibly once cultivated, dominated by *Prunus arabica* and *Artemisia sieberi* (orange-brown dried inflorescences), with *Convolvulus acanthocladus* and *Ephedra pachyclada* (January 1997).

Fig. 3.1.14. The Awshaq basin watershed (c.1200 m+) drains the high ridge between Jebel Harim (c.2008 m, at left) and Ra's Mintera (c.1880 m) and ultimately feeds the fertile plain at As-Sayh. The gravel terraces and lower slopes are the sole natural sites for the newly recorded *Garhadiolus hedypnois*, *Poa* sp.aff. *asirensis* and *Valerianella szovitsiana*. See also *Fig. 3.1.15.*

Fig. 3.1.15. Afoot on a gravel terrace in the Awshaq basin, c.1200 m (April 2005), showing the dominance of *Convolvulus acanthocladus* and *Prunus arabica*. Many annuals can also be found here, including *Ammi majus*, *Asphodelus tenuifolius*, *Clypeola aspera*, *Koelpinia linearis* and *Plantago ovata*.

Fig. 3.1.16. Stunted almond trees *Prunus arabica* crowd the deceptively gentle head of a wadi on a plateau at c.1200 m. *Gymnocarpos decandrus* joins *Convolvulus acanthocladus* as a dominant small shrub on the adjacent ground. Introduced pheasant were found near this site in May 2010.

Fig. 3.1.17. Broken bedrock pavement above Wadi al-Waeeb, c.1200 m: *Convolvulus acanthocladus* is dominant, with occasional *Cymbopogon jwarancusa*. Seen in the distance, to the north-west, are Jebel Harim (right) and Jebel Jais (left), the two highest peaks in the Ru'us al-Jibal.

Fig. 3.1.18. Rain in the Ru'us al-Jibal, at c.1200 m near Jebel Yibir (December 1995). Distinctive in this photo are the orange tussocks of *Launaea bornmuelleri* and the straw yellow tufts of dry *Cymbopogon jwarancusa*.

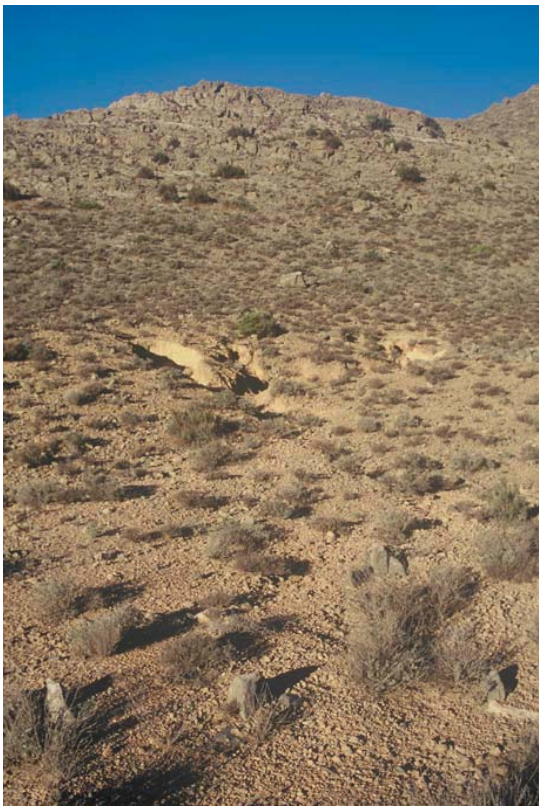


Fig. 3.1.19. Dry *Artemisia sieberi* is dominant here on a gentle colluvial slope at c.1100 m (April 2001). The area in the foreground has been disturbed by small-scale quarrying for building stone and/or silt.

Fig. 3.1.20. Erosion exposes a cross-section of silt flats on the Fine Peak plateau, c.1000 m, which is subject to heavy grazing pressure.

Fig. 3.1.21. Plateau at c.900 m, overlooking Wadi Zibat, near Hoob. Seen among bedrock outcrops in the foreground are *Euphorbia larica*, *Ochradenus arabicus*, *Dodonaea viscosa* and, at left, *Convolvulus acanthocladus* and *Launaea bornmuelleri*. At left in the middle distance is a larger *Prunus arabica*.

Fig. 3.1.22. Above a saddle near Zekiyah at c.900 m in the eastern Ru'us al-Jibal, overlooking Rawdhah Bowl (March 1996). Visible in the foreground are *Ochradenus arabicus*, *Ephedra pachyclada*, stunted *Prunus arabica*, *Artemisia sieberi* and *Astragalus fasciculifolius*.

Fig. 3.1.23. "Tussock" vegetation at Al-Ghalil in the eastern Ru'us al-Jibal, c.850 m (March 1996): *Farsetia aegyptia* and *Convolvulus acanthocladus* are dominant, with *Dodonaea viscosa* and *Ochradenus arabicus*. The silted plain in the centre was almost certainly once cultivated. The trees are *Ziziphus spina-christi*, *Acacia tortilis* and *Phoenix dactylifera*.

Fig. 3.1.24. A rainy day descent in Wadi Khabb, c.500 m (January 1993). The large trees on the slopes and in the wadi are *Ziziphus spina-christi*.

Fig. 3.1.25. A seep below a large, sheltered waterfall in Wadi Kida'ah, c.400 m. Annuals may grow profusely on the shaded banks below.

Fig. 3.1.26. ***Acacia tortilis*** **dominates the gravel outwash plain near the mouth of Wadi Bih, c.50 m.**

Fig. 3.2. Fields and cultivation

Fig. 3.2.1. An abandoned field at Al-Geema, ca.1650 m (March 2008): ***Artemisia sieberi***, ***Leontice leontopetalum*** **and** ***Erodium*** **sp. are dominant at the left and centre;** ***Althaea ludwigii*** **and** ***Heliathemum salicifolium*** **are also present. To the right, in a formerly puddled area,** ***Moraea sisyrhinchium*** **predominates.**

Fig. 3.2.2. Active cultivation at c.1500 m (March 2008): Common wild species present include *Malva parviflora*, *Asperugo procumbens*, *Moraea sisyrhinchium* and *Erodium* sp.

Fig. 3.2.3. The highest date palms (*Phoenix dactylifera*) in the Ru'us al-Jibal: This is the smaller of two unrelated settlements that vie for that distinction, each with only a handful of palms and each coincidentally situated at an elevation of c.1485 m. Palm cultivation at a much higher site (c.1700 m) was attempted in the early 1990s but was abandoned within a few years.

Fig. 3.2.4. Vegetation surrounding a cistern, c.1100 m, after abundant rain (February 1998).

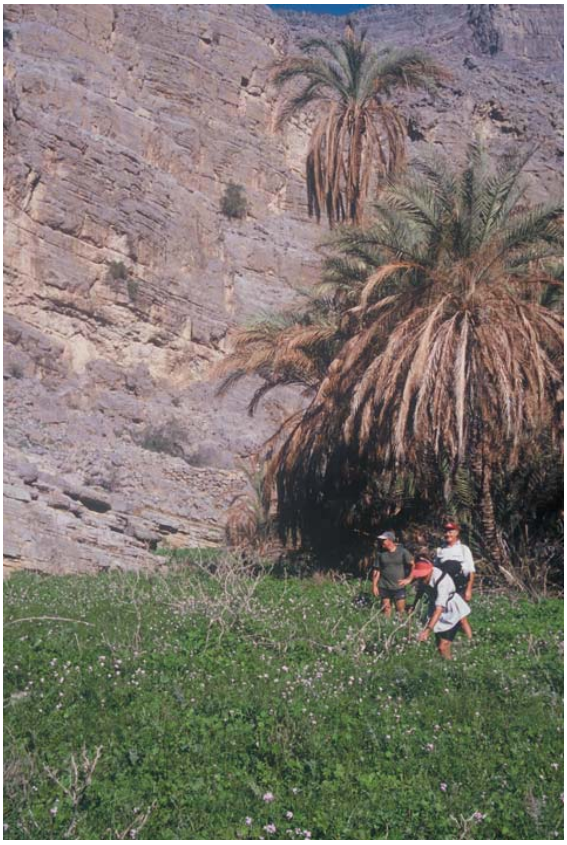


Fig. 3.2.5. Profuse *Malva parviflora* and *Erucaria hispanica* in abandoned cultivation on silt accumulated behind a landslide dam at Palm Paradise, c.800 m (January 2001).

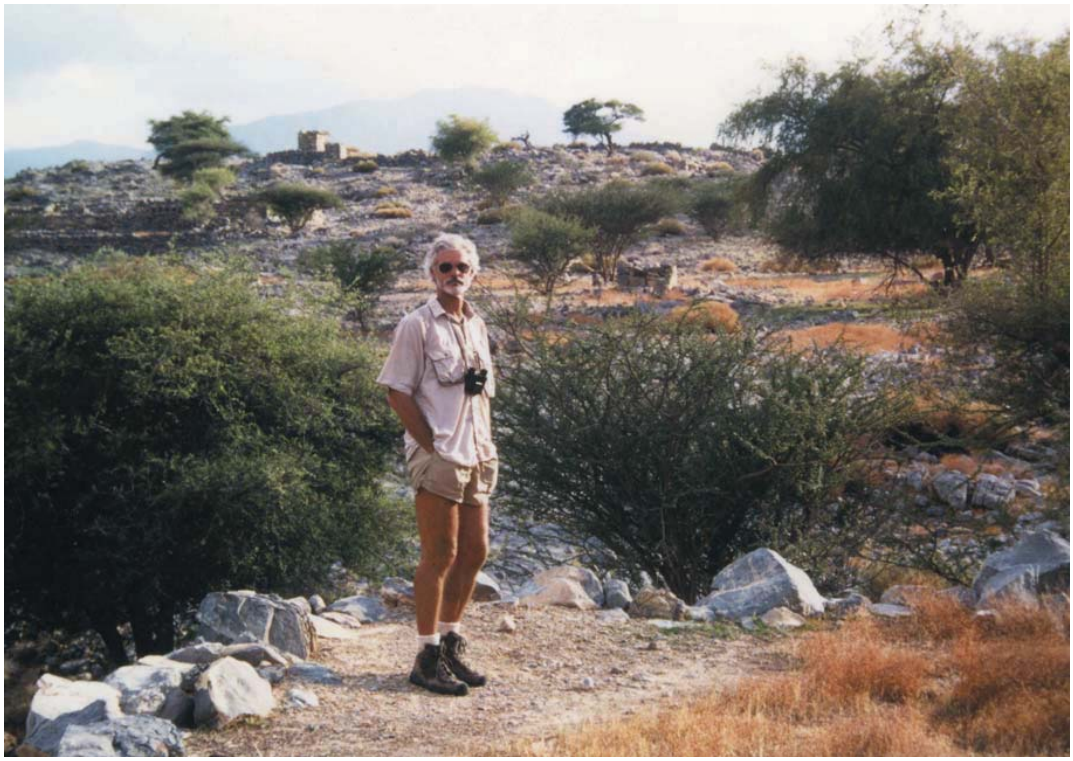


Fig. 3.2.6. The author among abundant *sidr* (*Ziziphus spina-christi*) and *samr* (*Acacia tortilis*) trees that characterise the settlement at Yinas, c.750 m. The *sidr* trees probably originated as plantings.

3. Vegetation zones.

The vegetation of the Ru'us al-Jibal can be represented by three broad zones characterised by habitat and elevation: Zone 1: a mountain wadi zone (c.100-600 m); Zone 2: a low and medium elevation montane zone (c.200-1100 m); and Zone 3: a high elevation montane zone (above c.1100 m). These zones are described in more detail below (see also Table 7).

Zone 1: Mountain wadi zone. This zone includes wadi beds, wadi banks and associated gravel fans and terraces. In the Ru'us al-Jibal, this environment is common at elevations from c.100-600 m. At higher elevations, wadis tend to be narrower and rockier and the distinction between wadi vegetation and slope vegetation (Zone 2) is less evident.

The most conspicuous species are the legume *Tephrosia apollinea* and the trees *Acacia tortilis*, *Ficus cordata salicifolia* and *Ziziphus spina-christi*. Locally common small shrubs include *Gaillonia aucheri*, *Pulicaria nobilis* and *Ochradenus aucheri*. Other commonly occurring species include many annuals, e.g., *Anagallis arvensis*, *Erodium* spp., *Erucaria hispanica*, *Euphorbia granulata*, *Geranium mascatense*, *Parietaria alsinifolia*, *Rumex vesicarius*, *Scabiosa olivieri* and *Sisymbrium erysimoides*.

Zone 2: Low and medium elevation montane zone. This zone encompasses all terrain at elevations from c.100-1100 m, other than the mountain wadi zone (Zone 1), and therefore includes slopes, cliffs, plateaux and basins, upper wadis and gulleys and terraced fields.

The predominant species are *Acacia tortilis*, *Euphorbia larica* and *Cymbopogon* spp. Other characteristic species include the perennials *Astragalus fasciculifolius*, *Gaillonia aucheri*, *Gymnocarpos decandrus*, *Launaea bornmuelleri*, *Lavandula subnuda*, *Leucas inflata*, *Moringa peregrina*, *Periploca aphylla*, *Pulicaria edmondsonii* and *Vernonia arabica* and the annuals *Hippocrepis unisiliquosa*, *Pentanema divaricatum*, *Plantago* spp., *Reichardia tingitana*, *Stipa capensis*, *Trigonella stellata*, *Viola cinerea* and *Zoegea purpurea*.

The upper boundary for this zone is a natural one, chosen on the basis of the disappearance of *E. larica* and associates such as *Gaillonia aucheri*, *Lavandula subnuda*, *Pulicaria edmondsonii* and *Vernonia arabica*, coupled with the first significant appearances of dwarf shrub species more characteristic of the high elevation zone, such as *Artemisia sieberi*, *Centaurea wendelboi* and *Ephedra pachyclada*, as well as *Helianthemum salicifolium* and other high elevation annuals.

The upper half of this zone, from c.600-1100 m, is nevertheless transitional and could be further distinguished on that basis. Within it, some species characteristic of the zone typically disappear at elevations lower than 1100 m, whereas other species more characteristic of the high elevation zone (Zone 3) first appear at somewhat lower elevations. For example:

- The Arabian almond *Prunus arabica* first appears and effectively replaces the morphologically similar (but ecologically distinct) *Moringa peregrina* above c.600 m.
- *Ficus cordata salicifolia* gives way to *F. johannis* very reliably at c.500 m, except in a few sheltered gorges.
- The dwarf shrubs *Astragalus fasciculifolius*, *Fagonia schimperi*, *Farsetia aegyptia*, *Gymnocarpos decandrus*, *Helianthemum lippii*, *Lactuca orientalis*, *Launaea bornmuelleri*, *Periploca aphylla* and *Teucrium stocksianum* first appear at c.400-700 m and can be locally common within the upper part of the low and medium elevation montane zone as well as in the high elevation zone.
- *Convolvulus acanthocladus* and the less common *C. ulicinus*, both characteristic of high elevations, make their first appearances at c.700-800 m (*C. acanthocladus* beginning somewhat lower in the north).
- *Acacia tortilis* is uncommon above c.800 m, except in association with cultivation.

In this context it should be noted that the physiography of the Ru'us al-Jibal is such that the lower half of Zone 2 often consists of very steep and rocky terrain, with gentler slopes predominating only above 500-600 m or more (see *Fig. 1.4.2*). This may have the effect of reducing somewhat both the number and diversity of slope species observed below c.500-600 m.

Zone 3: High elevation zone. This zone encompasses all terrain from c.1100 m to the summit plateaux and peaks at 1500-2000 m. The most common and characteristic species in this zone are *Convolvulus acanthocladus*, *Artemisia sieberi* and *Ephedra pachyclada* (all dwarf shrubs), *Cymbopogon jwarancusa* (a perennial tussock grass), the larger and more conspicuous almond tree *Prunus arabica* (stunted where it grows exposed at higher elevations) and the erect shrub *Dodonaea viscosa*. This association has been called "*Artemisia* steppe" (Mandaville 1985; Ghazanfar 1999, 2003), following the usage of Zohary (1963, 1973), who found associations of the same species and/or genera to be characteristic of many areas of the plateau of central Iran.

Also common or locally common at high elevations are the perennials *Astragalus fasciculifolius*, *Centaurea wendelboi*, *Dianthus crinitus*, *Diplotaxis harra*, *Fagonia schimperi*, *Farsetia aegyptia*, *Gymnocarpos decandrus*, *Helianthemum lippii*, *Jurenia berardioides*, *Launaea bornmuelleri*, *Phagnalon schweinfurthii* and *Teucrium stocksianum*. High elevation species seen most often in agricultural or peri-agricultural contexts include *Gladiolus italicus*, *Ixiolirion tataricum*, *Moraea sisyrhinchium*, *Papaver* sp. and *Roemeria* sp. (see also Section 7 below). Notably absent at high elevations is *Euphorbia larica*, one of the most common and characteristic shrubs of slopes and plateaux at lower elevations, which declines in abundance above 1000 m and is absent by 1200 m.

A number of species, particularly annuals, can be found at all elevations in the Ru'us al-Jibal, as recorded in the Checklist. Common perennials in that category

include the lily *Asphodelus tenuifolius* and the fern *Onychium divaricatum*. The following annuals can regularly be seen at higher elevations: *Anagallis arvensis*, *Anthemis odontostephana, Anticharis arabicus*, *Asteriscus hierochunticus*, *Erucaria hispanica*, *Filago desertorum*, *Galium decaisnei*, *Geranium* spp., *Helianthemum salicifolium*, *Salvia aegyptiaca*, *Senecio glacus*, *Scabiosa olivieri*, *Thymelaea mesopotamica*, *Trigonella stellata*, *Viola cinerea* and *Zoegea purpurea*.

4. Recent environmental stresses: overgrazing and drought

It is important to emphasise that the Ru'us al-Jibal, as wild and remote as it may at first seem, is not a pristine wilderness. Rather, it has been the site of seasonal habitation and localised but widespread terraced agriculture and probably livestock (goats and sheep) herding for at least several hundred years (see box, this page). In recent decades in particular, the vegetation of the Ru'us al-Jibal has been subject to heavy grazing pressure by feral and domestic goats, a phenomenon which has been accelerated by improved access and economic well-being, allowing resident farmers to support larger herds through the use of "imported" food and water when necessary.

This applies not least to the very highest area of the Ru'us al-Jibal, where the main graded road ascends from the extensive cultivation at As-Sayh (a silt plain formed behind a landslide dam at c.1150 m) (*Fig. 1.6.6*) to the stony Sahasa plateau at 1450 m (*Figs. 1.3.4* and *3.1.9*), which lies between the two highest summits, Jebel Harim (c.2008 m) and Jebel Jais (c.1935 m). Herds totalling c.100 goats have been observed near the summit of Jebel Jais and sheep are kept at, and graze from, the highest settlement in the Ru'us al-Jibal, at 1600 m, a 3½ hour walk from the road.

Therefore, in contrast with Mandaville's (1977) assessment for the high Jebel Akhdar, the vegetation in many areas at high elevation in the Ru'us al-Jibal is significantly affected by grazing (see *Figs. 3.1.1* and *3.1.2*). Munton visited the Ru'us al-Jibal in the late 1970s to investigate the presence of Arabian tahr, at or just before the advent of vehicular access to As-Sayh, and commented that "the whole area is used by herds of sheep and goats at all altitudes" (Munton 1985). (Munton also speculated, from the lack of diversity of tree and shrub species in the Ru'us al-Jibal, that cutting of live wood has taken place in the past (see also Section 8.3 below). It is evident, at least, that cultivated *sidr* trees (*Ziziphus spina-christi*) have often been coppiced (*Fig. 5.5.13*).

It is worth reiterating that it is domestic and feral goats that are primarily responsible for overgrazing in the Ru'us al-Jibal, not donkeys (which are nevertheless sometimes unfairly blamed, perhaps because they do not have an economic constituency). The number of domestic or feral donkeys in most of the Ru'us al-Jibal today is negligible, although the number of domestic donkeys in the vicinity of As-Sayh (perhaps two to three dozen) may be increasing slightly.

A note about the terraced settlements of the Ru'us al-Jibal

Some hundred or more modest to small-sized areas of terraced agriculture are scattered throughout the Ru'us al-Jibal, at elevations from c.450-1500 m. The very largest are c.0.25 sq. km. in area and may contain c.80-100 traditional stone dwellings of various ages and in various states of repair. They were established principally for the cultivation of winter wheat but also supported crops such as date palms, watermelon and the fruit of the native *sidr* tree, *Ziziphus spina-christi*, which is also coppiced for lumber. With few exceptions, only date palms have continued to be cultivated into the modern era; the largest settlements may have as many as c.100 palm trees. However, one large settlement was recalled rhapsodically to the author by an elderly resident of another settlement, nearly a day's walk distant: "Ah, Sharmilah . . . two hundred sidr trees!"

Evidence from pottery remains indicates that the earliest terraced settlements were established 600-700 years ago (Derek Kennet, *pers. comm.* 2002) and a 14th century Persian source makes reference to wheat from the Musandam region (William Lancaster, *pers. comm.*, 2000). Historically, this corresponded with the ascendency of the kingdom of Hormuz, whose dominion included the coastal city of Julfar, just north of present-day Ra's al-Khaimah, the first urbanisation along the coast of what is today the UAE. The impetus for the development of the mountain hinterland was evidently the economic and demographic expansion of the local region at that time (Derek Kennet, *pers. comm.* 2002).

However, the construction of the terraces and the conduct of extensive seasonal agriculture also seem to reflect a climatic regime somewhat wetter than the present one, which may have been a necessary condition for successful agricultural development. This emphasises the possible importance of an additional correspondence – a climatic one – with the so-called Little Ice Age (c.1300-1850), which has been recognised on both sides of the North Atlantic and elsewhere and was responsible for, among other things, the abandonment of Viking settlements in Greenland, heavy winter snows in colonial Virginia and early Victorian England, and frozen canals in the Netherlands. Such a correspondence might account as well for the apparent decline of many Ru'us al-Jibal settlements even before the modern era, although other and later factors have also been blamed, including specifically the advent of cheap wheat on the world market during and after WWII, which made traditional wheat cultivation in the Ru'us al-Jibal unprofitable (William Lancaster, *pers. comm.*, 2000).

One effect of overgrazing is that palatable species are reduced in number or eliminated (e.g., many Lamiaceae or mint family species, and many annuals), whereas spiny or unpalatable shrubs are left to dominate, although even the latter may be subject to grazing of tender new growth. This can result over time in the creation of a distinctive landscape of dense, spiny cushions or "tragacanthic steppe" (Zohary 1963, 1973). Among the more common Ru'us al-Jibal shrubs which appear to respond in this manner are *Convolvulus acanthocladus*, *Convolvulus ulicinus*, *Farsetia aegyptia*, *Lactuca orientalis* and *Launaea spinosa*. *Gymnocarpos decandrus*, another typically cushion-shaped dwarf shrub, is more tomentose than spiny, and does not appear to be grazed. Factors other than grazing may also be at work, however, since the cushion shape minimises the ratio of surface area to volume and could therefore be an adaptation to minimise insolation and water loss during prolonged summer drought (see also Section 8.4 below). The mountains of southern Spain feature a comparable plant community known as the "Hedgehog Zone", characterised by distinctive species such as *Erinacea anthyllis*, *Genista umbellata*, *Bupleurum spinosum* and (in the Balearics) *Astragulus balearicus* (R.J. Hornby, *pers. comm.*, 2010).

During the course of this study the Ru'us al-Jibal also suffered (along with the UAE and Northern Oman generally) from an exceptional drought. UAE rainfall records show that the period from mid-1999 through mid-2004 was by far the driest 5-year period in the 70 years for which reliable records are available, with annual rainfall in each of those years below the long-term mean and aggregate rainfall less than half that of any other 5-year period (Feulner 2006).

The combination of extreme drought and accelerated grazing pressure resulted in floral changes in the high Ru'us al-Jibal that were evident even on the time scale of this study (from the early 1990s through 2010), at least in more accessible areas. A number of examples are cited in the following paragraphs.

Throughout the 1990s, the three most common small shrubs at high elevation in the Ru'us al-Jibal were *Artemisia sieberi* (the locally endemic wormwood, a species of sagebrush), *Cymbopogon jwarancusa* (a tussock grass and a source of citronella) and the robust, spiny *Convolvulus acanthocladus*. As the turn-of-the century drought progressed, both *A. sieberi* and *C. jwarancusa* appeared to diminish substantially in abundance, or at least in visual predominance, with the result that the spiny cushions of *Convolvulus acanthocladus* came to appear correspondingly more dominant. A regrettable aesthetic consequence was the absence for many years of the pervasive thyme-scented fragrance of *A. sieberi* that had been such a distinctive and pleasant accompaniment to the author's early excursions on the high plateaux. The dramatic declines of *A. sieberi* and *C. jwarancusa* are best attributed to climatic factors alone, since they appear seldom, if ever, to be the targets of grazing goats. Moreover, from about 2008 onwards, following several winters of rainfall at or above the long-term mean, both species had begun to recover their former predominance in the high elevation plant community.

A number of common but edible perennials such as *Astragalus fasciculifolius*, *Centaurea wendelboi*, *Farsetia aegyptia*, *Launaea bornmuelleri* and *Teucrium stocksianum* also appeared to be substantially reduced in numbers during the drought period. In these instances, overgrazing must be suspected as a contributing factor, although both *F. aegyptia* and *T. stocksianum* have appeared to be somewhat refreshed following successive abundant winter rains.

A few cases seem less equivocal. Overgrazing in the area of the high summits has reduced *Phagnalon schweinfurthii* to stunted specimens growing in cracks between rocks, although its normal habit is that of an erect dwarf shrub. An even more extreme example is the aromatic mint *Salvia mirzayanii*, which Mandaville (1985) reported from the west slopes of Jebel Harim, remarking on its "rather showy blue-violet flowers". For more than a decade and a half, however, it has been recorded only from a single remote ridgetop to the east of Jebel Harim, where no more than two dozen specimens have been observed. That same remote area is also the sole known Ru'us al-Jibal locality for two other species, *Malcolmia africana* and *Astragalus* sp. aff. *schimperi*, both probably edible species.

The spiny but edible leguminous shrub *Astragalus fasciculifolius* suffered from grazing in a somewhat different way during the turn-of-the-century drought. Beginning in 2000, the author began regularly to encounter specimens from which goats had detached the spiny crown of the plant and stripped the bark from the central stem, exposing the pale yellow-orange interior (*Fig. 5.5.3*). Presumably this was done for either dietary or medicinal reasons, to take advantage of some substance concentrated in or under the bark of the plant. One result is that in most areas *A. fasciculifolius* still does not appear to be as common, nor are its shrubs as large, as they were formerly.

5. Biogeographical affinities

The similarity of the flora of the Hajar Mountains to that of southern Iran and the Makran region (encompassing south-eastern Iran and the southern part of the province of Baluchistan in south-western Pakistan) has been recognised by many authors (e.g., Mandaville 1977; Kürschner 1986; Ghazanfar 1999, 2003), but successive efforts to refine the nature and boundaries of plant geographic zones in Arabia, Iran and adjacent areas have produced a daunting array of overlapping terminology.

Section 5.1 below is a brief attempt to introduce the non-specialist reader to the nature of the concepts introduced by plant geographers in the region and the general conclusions that have emerged. Section 5.2 presents a summary comparison of the flora of the mountains of Eastern Arabia (the Ru'us al-Jibal and Hajar Mountains) with that of Iran (to the north and east) and the rest of the Arabian Peninsula (to the west and south). In Section 6, the flora of the Ru'us al-Jibal is contrasted in detail with that of the Hajar Mountains.

To the extent that an accurate characterisation and delineation of plant geographic units permits useful conclusions to be drawn about biological and historical processes and events, the contribution of the present

paper resides primarily in the content of the Checklist, which may permit subsequent researchers to make a better informed assessment of the proper categorisation of the flora of the Ru'us al-Jibal.

5.1. Phytogeographical categorisation and nomenclature in the Middle East. Eig (1931-1932) and Zohary (1973) attempted to generalise about the plant geography of the arid regions of North Africa, the Middle East and Iran and elaborated the concept of more or less latitudinal zones characterised by distinctive floral associations. The different zones are considered to be distinguished primarily by their temperature regime, including summer and winter maxima and minima. As a result, the generally latitudinal character of the zones may be greatly modified by features such as maritime influence and elevation. The concept of latitudinal zonation works relatively well in North Africa; it works much less well in the region of Arabia, where detours must be made for the Red Sea and the Arabian Gulf, as well as the mountain ranges that fringe much of Arabia and Iran.

Zohary (1963, 1973) recognised two major phytogeographical zones in Central and Eastern Arabia – a northerly one (the Saharo-Arabian region) and a southerly one (the Sudanian region) (see Map 5). The Sudanian region also extends eastward across southern Iran and Baluchistan (the Makran). Within the Sudanian region, Zohary found the flora of Eastern Arabia, southern Iran and southern Pakistan sufficiently distinctive to distinguish those areas as the Nubo-Sindian province.

Zohary nevertheless found it difficult to recognise the extension of the Saharo-Arabian region into Iran (Zohary 1963, 1973). Instead, in south-central Iran the Nubo-Sindian flora of the Sudanian Zone grades northwards more or less directly into the next phytogeographical region to the north, the Irano-Turanian region, which occupies most of central and northern Iran. The Irano-Turanian region also encompasses the arid areas of Central Asia to the north and east, and, like the Sudanian and Saharo-Arabian zones (but more northerly), the Irano-Turanian region can be traced westward, into the Anatolian plateau, through northern Iraq and the Syrian desert, and across North Africa to the Atlantic (Zohary 1963, 1973). Within Iran, the Irano-Turanian is characterised by species today best represented, or having their origin, in Iran or Central Asia.

The Sudanian region is considered tropical, and one of the principal differences between the Nubo-Sindian and Irano-Turanian florae in Iran is the tolerance (or requirement) of the former for high summer temperatures and/or an intolerance of low winter temperatures (Zohary 1963, 1973).

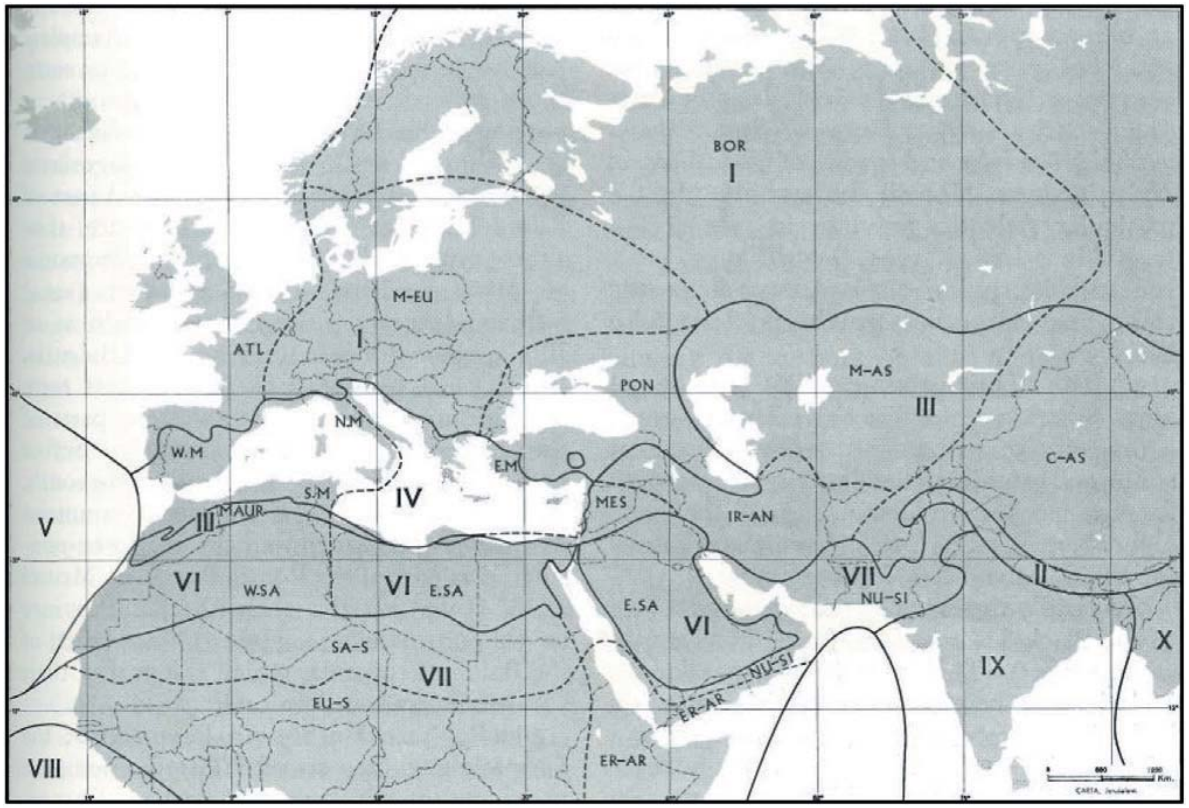
In Eastern Arabia, Zohary placed the boundary between the Sudanian and Saharo-Arabian regions along the southern edge of the Empty Quarter but included the mountains and coastal regions of Northern Oman and the UAE within the Sudanian region (see Map 4). Mandaville (1990), on more extensive floristic evidence, considered that most of Central Arabia should be considered within the Sudanian region *sensu* Zohary, and that the boundary should be drawn much further to the north, passing through central Qatar (which would correspond more closely to the regular influence of the westerly cyclonic belts). Mandaville (1985) nevertheless made an exception for the higher elevation flora of the Jebel Akhdar and the Ru'us al-Jibal, which he considered to constitute Irano-Turanian enclaves.

Kürschner (1986) took more direct account of the floral affinities between Northern Oman, southern Iran and Baluchistan by recognising an "Omano-Makranian subprovince". Léonard (1989), studying the Iranian flora, similarly identified an "Omano-Sindian area".

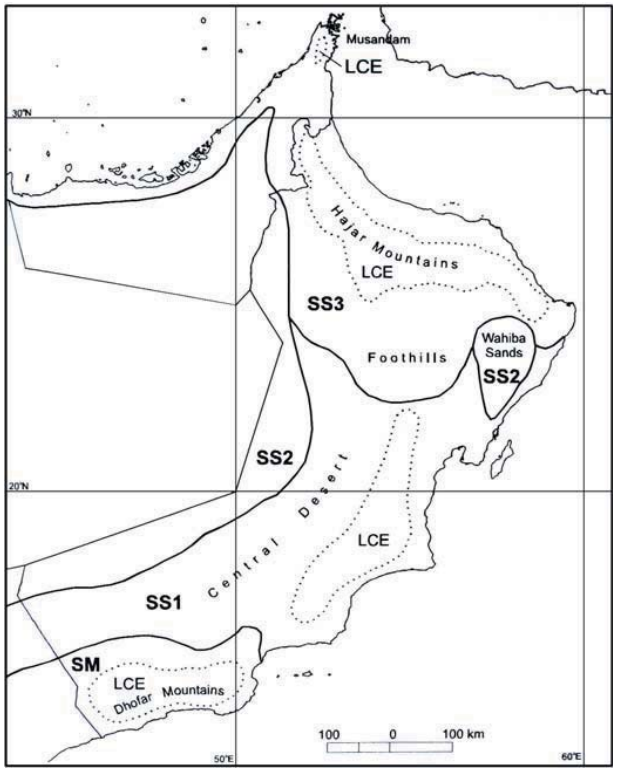
Ghazanfar (1992b, 1999, 2003) and Miller & Cope (1996) have adopted the subsequent nomenclature of Léonard (1989) and White & Léonard (1991) for Arabia, which accepts Zohary's major boundaries, but introduces new terminology: (1) the Somali-Masai regional centre of endemism in the southwest (including only southern Yemen and Dhofar) and (2) the Saharo-Sindian regional zone to the north. The latter is divided into three subzones in Arabia: (i) the Saharan regional sub-zone, encompassing the Red Sea coast of Arabia and a belt along the south coast; (ii) the Arabian regional sub-zone, encompassing most of central Arabia; and (iii) the Nubo-Sindian local centre of endemism, encompassing much of eastern Arabia and extending to the north-east across southern Iran, the Makran and much of Pakistan.

Ghazanfar (1999, 2003) delineates in greater detail the boundaries of the three Saharo-Sindian sub-units in eastern Arabia (see Map 6*)*. The Arabian regional sub-zone extends roughly to the southern and eastern border of the sands of the Empty Quarter (including the inland sand desert regions of Dubai and Abu Dhabi as well as the southern portion of the Eastern Province of Saudi Arabia); the Saharan sub-zone extends in a belt along the south of the Empty Quarter, running north of the Hadramaut and Dhofar and across the central plains of Oman, Huqf and the Jiddat al Harasis to the Wahiba Sands; and the Nubo-Sindian local centre of endemism encompasses the Hajar Mountains and its outliers and alluvial plains, as well as the UAE coastline. Ghazanfar nevertheless acknowledges that it is often difficult to delimit the Nubo-Sindian local centre of endemism from the adjacent Arabian regional sub-zone.

Within the aforementioned zones and sub-zones of eastern Arabia, Ghazanfar also recognises three discrete and subsidiary local centres of endemism ("LCEs"): (a) the Dhofar Mountains; (b) the central limestone plateau area (Haushi-Huqf-Hayma-Harmoul); and (c) the Hajar Mountains (including the Musandam mountains or Ru'us al-Jibal) (Ghazanfar 1999, 2003). The inclusion of the Ru'u's al-Jibal as a separate enclave within the Hajar Mountain LCE should be reassessed in light of the information presented in the Checklist. Specifically, as noted above in Section 2, it now appears that no plant species are endemic to the Ru'us-al-Jibal and only five Eastern Arabian endemic species are found there: *Desmidorchis arabica*, *Echinops erinaceus, Pulicaria edmondsonii*, *Pteropyrum scoparium* (possibly synonymous with the Iranian *P. aucheri*) and *Stipa mandavillei*.



Map 5. Phytogeographical regions of the Middle East, from Zohary (1973), Map 6.



Map 6. Phytogeographical zones of Oman, from Ghazanfar (2003), Fig. 3.3.

Fig. 3.3. Floral associations

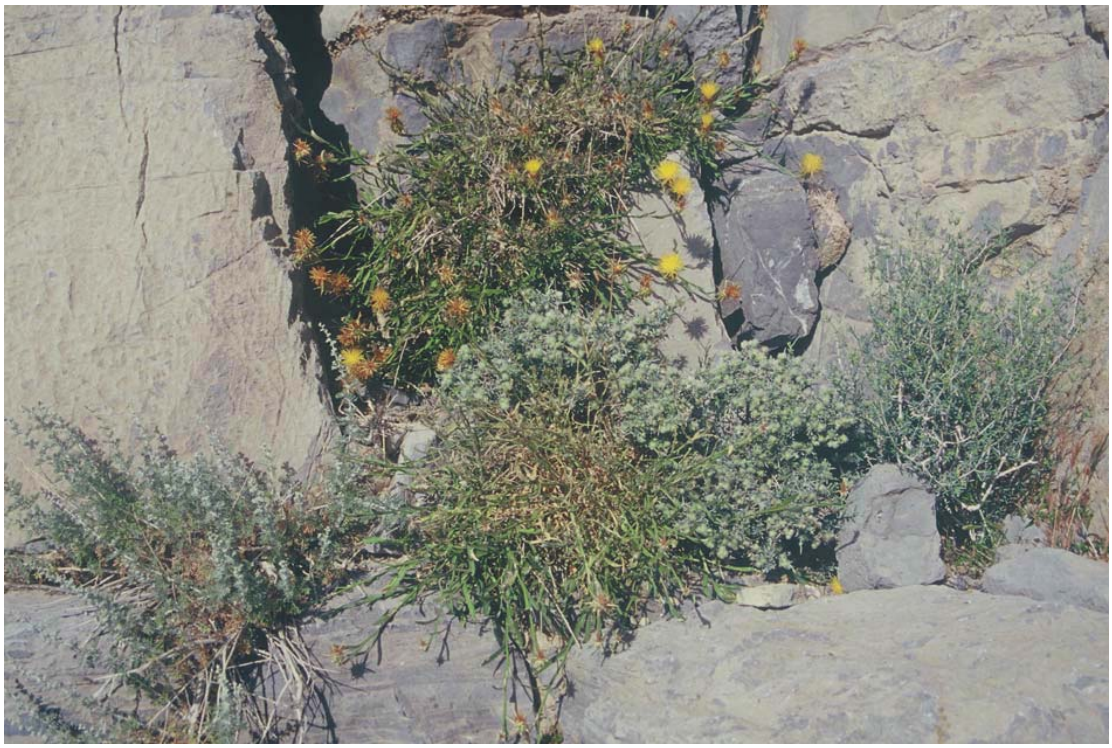


Fig. 3.3.1. Four common high elevation species on a ledge at c.1450 m (from left to right): *Artemisia sieberi*, *Centaurea wendelboi* (top and bottom row), *Convolvulus acanthocladus* and *Gymnocarpos decandrus*.

Fig. 3.3.2. Annuals on damp soil in shade, c.1300 m: *Papaver* sp. (red flowers), *Roemeria* sp. (purple flower), *Fumaria parviflora*, *Geranium* sp., *Boraginaceae* sp. 2 (white flower with large, hairy, elliptical leaves; see *Fig. 5.2.5*) and Caryophyllaceae sp. (lower right).

Fig. 3.3.3. Annuals in a shaded crevice, c.1300 m: *Umbilicus horizontalis* (round leaves), *Asterolinon-linum stellatum* (background centre), *Galium* sp. (right and left, erect with whorled leaves), and Boraginaceae sp. 2. (as in *Fig. 3.3.2*).

Fig. 3.3.4. Vegetated gulley, c.1250 m: Among the species visible are *Artemisia sieberi*, *Cenchrus ciliaris*, *Diplotaxis harra*, *Echinops erinaceus*, *Hyparrhenia hirta*, *Ochradenus arabica*, *Prunus arabica* and *Zoegea purpurea*.

Fig. 3.3.5. Annuals on open, peri-agricultural waste ground, c.1100 m: *Erodium* sp., *Malva parviflora*, *Matricaria aurea* and *Trigonella stellata* are readily identifiable.

Fig. 3.3.6. Some rare and diminutive annuals among bedrock at c.900 m (from left to right): *Sedum hispanicum*, *Filago desertorum*, *Campanula erinus* and *Galium decaisnei* (lower right).

Fig. 3.3.7. Association of annuals in a fallow field at c.800 m: *Asphodelus tenuifolius*, *Roemeria* sp., *Adonis dentata*, *Astragalus* sp. *et al.* Photo courtesy of Barbara Couldrey.

Fig. 3.3.8. An atypical assemblage of annuals on the stony pavement of the south-western Ru'us al-Jibal, c.500 m: *Aizoon canariense*, *Polycarpaea robbeirea* and *Reichardia tingitana*.

Fig. 3.3.9. An unusually rich association of Ru'us al-Jibal shrub species, observed in the mixed rocks of the Dibba Zone at the southern edge of the Ru'us al-Jibal, c.500 m, during the wet years of the late 1980s: Among the species visible are *Astragalus fasciculifolius*, *Convolvulus acanthocladus*, *Euphorbia larica*, *Gymnocarpos decandrum*, *Helianthemum* sp., *Launaea bornmuelleri*, *Lavandula subnuda*, *Leucas inflata*, *Ochradenus arabicus* and *Tephrosia apollinea*.

5.2. Iranian / Eastern affinities of the Ru'us al-Jibal flora. Putting aside the broader phytogeographical classifications, there has been been agreement on the affinity between the flora of the Hajar Mountains generally (including the Ru'us al-Jibal) and that of southern Iran and Baluchistan. Zohary's personal acquaintance with Eastern Arabia seems to have been limited (for example, his 1973 maps do not identify the Ru'us al-Jibal as an area of distinctively high elevation) but he referred generally to "the Bandar Abbas-Jebel Akhdar connection" (Zohary 1973). Subsequent authors have also emphasised this relationship (e.g., Mandaville 1977; Kürschner 1986; Léonard 1989; Ghazanfar 1999, 2003). Kürschner (1986) designated the combined area as the Omano-Makranian subprovince of Zohary's Nubo-Sindian province of the Sudanian region, and Léonard (1989) recognised an Omano-Sindian area. It adds weight to this botanical generalisation that various elements of the fauna of the Hajar Mountains and the Ru'us al-Jibal have a similar biogeographical distribution encompassing Northern Oman, the Musandam and southern Iran and Pakistan. These include, *inter alia*, land snails (e.g., *Granaria persica*, restricted in Eastern Arabia to the high Ru'us al-Jibal), reptiles (e.g., the false horned viper *Pseudocerastes persicus*), and even mammals (e.g., Blanford's fox *Vulpes cana*).

This floristic affinity is also seen in the fact that, although most of the perennial species of the Hajar Mountains probably have a Nubo-Sindian, Sudanian or even pan-Eremic distribution, several of the most common species of the Ru'us al-Jibal (and of the Hajar Mountains generally) are more common in Iran than they are elsewhere in Arabia, to the north-west, west or south. The best example is *Euphorbia larica*, which is among the most common and characteristic mountain species of the UAE and Northern Oman, and which is common in southern Iran (Zohary 1963). In Arabia, *E. larica* is effectively limited to Northern Oman. It extends south-west to the dry parts of north-eastern Dhofar, but away from the Hajar Mountains it is always rare. Other examples include *Physorrhynchus chamaerapistrum* and *Plocama aucheri* (formerly *Gaillonia aucheri* or *Jaubertia aucheri*), both of which have the western limit of their range in the Hajar Mountains.

Zohary (1963) discusses in various contexts the characteristic species of southern and south-western Iran. He classifies the flora from the coasts of the Arabian Gulf and the Gulf of Oman inland to elevations of c.1000 m as primarily Nubo-Sindian, and the overall vegetation as an impoverished savannah or tropical desert. His description of the species encountered there (at pp. 42-43) makes familiar reading for anyone acquainted with the wadis, lower slopes, foothills and alluvial plains of the Hajar Mountains. A majority (59 of 111) of the southern Iranian species mentioned by Zohary at pp.63-64 (and a greater majority of the genera) are common to those Hajar Mountain environments as well. The list of shared species is shown in Table 4. Zohary considered most of these species to be of "African" origin, but cited a few as belonging to Asian tropical stock (e.g., *Euphorbia larica*, *Nannorrhops ritchieana* and *Prosopis cineraria*).

Some obvious reasons for the observed floral similarity include physical proximity and physiographic and environmental similarity (rocky mountains, foothills and alluvial plains, versus the sand and gravel flats of central Arabia), as well as similar rainfall amount and patterns, including the absence of summer rains.

Beyond these generalisations there exist certain subsidiary patterns that have the potential to repay closer attention. For example, of the 43 southern Iranian species listed in Table 4 that are primarily mountain species in Eastern Arabia, 13 (30%) are among the Hajar Mountain species that are absent or rare in the Ru'us al-Jibal and 10 of these are among the common such species listed in Table 5 (see Section 6 below and compare Table 4 and Table 5). In contrast, only 3 of the Table 4 Iranian species are essentially limited to the Ru'us al-Jibal (*Astragalus fasciculifolius*, *Convolvulus acanthocladus* and *Teucrium oliverianum*).

Among the high elevation species of the Ru'us al-Jibal, the affinity with Iran is particularly striking. The majority of the most common species have the centres of their range (and/or have their closest congeners) in Iran or neighbouring areas of Central Asia, e.g.: *Artemisia sieberi*, *Astragalus fasciculifolius*, *Centaurea wendelboi*, *Convolvulus acanthocladus*, *Cymbopogon jwarancusa*, *Ephedra pachyclada*, *Jurenia berardioides*, *Prunus arabica* and *Teucrium stocksianum* (Zohary 1963, Mandaville 1985, Ghazanfar 1998b). The same can be said of other, less common, high elevation species such as *Aegilops kotschyi*, *Dianthus crinitus*, *Leontice leontopetalum* and *Salvia mirzayanii* (Zohary 1963, Mandaville 1985, Ghazanfar 1998b).

Of the foregoing species, *Ephedra pachyclada* is the only one also found in the mountains of western Arabia (Boulos FoE; Collenette 1985), although *Artemisia sieberi* otherwise ranges from the eastern Mediterranean to south-west Pakistan and Central Asia. *Cymbopogon jwarancusa* is characterised by Ghazanfar (1998b) as a mesic Asian relict. *Prunus arabica* and *Artemisia sieberi* both exhibit what Mandaville (1985) called a "two-pronged" entry into the Arabian Peninsula from Iran: a northern route via the Syrian desert and a southern route via the Ru'us al-Jibal.

Of the other most common species of the high Ru'us al-Jibal, *Dodonaea viscosa* is nearly cosmopolitan in tropical and subtropical regions; *Gymnocarpos decandrus* and *Helianthemum lippii* have a pan-Eremic distribution from the Canary Islands to Pakistan (Boulos 1999, 2000).

Within Iran, most of the high elevation Ru'us al-Jibal species have a more northerly or higher elevation distribution than the southerly and lower elevation Nubo-Sindian species. Instead, they belong to Zohary's Irano-Turanian region. Zohary's descriptions of the vegetation of the Central Iranian plateau frequently refer to *Artemisia* steppe, including open forests of *Amygdalus* (*Prunus*) spp. and *Pistacia* spp., and he identifies genera (or sections thereof) such as *Aegilops*, *Amygdalus* (*Prunus*), *Anthemis*, *Artemisia*, *Astragalus*, *Heliotropium*, *Pistacia*, *Salvia* and *Trigonella* as being

Table 4: Iranian affinities: Some characteristic plant species of southern and south-western Iran (from Zohary 1963, 1973, supplemented by Ghazanfar 1999[*]) that are also found in and adjacent to the Hajar Mountains (wadis, lower slopes, foothills and alluvial plains).

Aerva javanica
Anvillea garcinii
Astragalus fasciculifolius
Blepharis ciliaris
Calotropis procera
Capparis spinosa
Cenchrus ciliaris
Cleome quinquenervia [= possibly *C. noeana*]
Cometes surattensis
Convolvulus acanthocladus
Convolvulus virgatus
Cymbopogon schoenanthus
Dactyloctenium scindicum
Dichanthium annulatum
Dichanthium foveolatum
Dipterygium glaucum
Dodonaea viscosa
Echiochilon persicum
Ephedra foliata [= *E. ciliata*]
Euphorbia larica
Fagonia brugueri
*Fagonia indica**
Forsskaolea tenacissima
Gaillonia aucheri [= *Plocama aucheri*]
Geranium trilophum
Glossonema varians
Grewia tenax
Gymnocarpos decandrus
Haloxylon salicornicum
Heliotropium kotschyi
Indigofera intricata
Iphiona aucheri
Lasiurus scindicus
Leptadenia pyrotechnica
Lycium shawii
Monsonia heliotropoides
Nannorrhops ritchieana
*Ochradenus aucheri**
Ochradenus baccatus [possibly = *O. arabicus*]
Parietaria alsinifolia
Pergularia tomentosa
Periploca aphylla
Physorrhynchus chamaerapistrum
Polygala erioptera
Prosopis cineraria
Pseudogaillonia hymenostephana [= *Plocama hymenostephana*]
Reseda arabica
Rhanterium epapposum
Salvadora persica
Salvia aegyptiaca
Senecio flavus [= *S. breviflorus*]
Sphaerocoma aucheri
Tamarix aphylla
Taverniera glabra [= *T. cuneifolia*]
Tecomella undulata
Tephrosia apollinea
Teucrium oliverianum
Tribulus macropterus
Tricholaena teneriffae
Viola cinerea
Ziziphus spina-christi

mainly Irano-Turanian. Some common Irano-Turanian species are not present in the Ru'us al-Jibal, but are common in the high Jebel Akhdar, mostly at elevations greater than those reached in the Ru'us al-Jibal. This group includes, e.g., *Dionysia mira* and *Ebenus stellata*.

Overall, it is possible to generalise as follows: The flora and vegetation of the Hajar Mountains generally resembles that of southern Iran, the Makran and Baluchistan. The flora and vegetation of the high Ru'us al-Jibal, however, more closely resembles that of the central Iranian plateau. And, to anticipate the discussion below (see Section 8.4) the flora and vegetation of the high Jebel Akhdar show greater similarities with mountain areas to the north and north-east in Afghanistan and Pakistan. The main parameters that give rise to these relationships are probably temperature (especially annual minima and maxima) and rainfall amount and pattern. The foregoing generalisations do not, however, readily account for the consistent floral differences between the Ru'us al-Jibal at low and medium elevations and the Hajar Mountains generally (see Section 6 below).

[It is a curious historical parallel that the original usage of the term "Makran" (by Herodotus among others) referred collectively to most of the geographical areas under discussion here for their biogeographical affinity – from the southern parts of Sindh, Baluchistan and Iran across the Strait of Hormuz to the southern Arabian Gulf and Northern Oman – that being the extent of Maka, a satrapy of the 4th to 6th century B.C.

6. Many typical Hajar Mountain species are absent in the Ru'us al-Jibal

Some three dozen species, mostly perennials but including a few annuals, that are reasonably common and characteristic within the Hajar Mountains of the UAE and Northern Oman, are nevertheless absent or very rare in the Ru'us al-Jibal. These are listed in Table 5. The perennials are mostly dwarf shrubs but also include trees, shrubs and herbs.

The reasons for such a clear and consistent floral discontinuity most likely relate to factors deriving from the substantial differences in the bedrock geology of the two areas: the carbonate rocks that comprise most of the Ru'us al-Jibal versus the ultrabasic silicate rocks of the ophiolite nappe that make up the bulk of the Hajar Mountains to the south (along with subsidiary areas of basic silicate rocks and and deep water siliceous sediments of the Hawasina group). Those derivative factors probably include not only soil and groundwater chemistry but also retention and circulation of scarce groundwater. The putative influence of these and other factors is discussed below, although in the absence of specialised study it is impossible to offer direct or definitive evidence in support of any particular hypothesis.

In some cases, however, the observed distribution may reflect broader regional biogeographic gradients.

Table 5: Common Hajar Mountain species that are absent or very rare(+) in the Ru'us al-Jibal.

Acridocarpus orientalis
Aizoon canariense +
Arundo donax +
Boerhavia elegans +
Chrozophora oblongifolia +
Cleome noeana +
Cleome rupicola +
Cometes surattensis +
Convolvulus virgatus +
Crotalaria aegyptiaca +
Doellia bovei
Ephedra ciliata +
Haplophyllum tuberculatum +
Hibiscus micranthus +
Iphiona aucheri
Iphiona scabra +
Juncus socotranus
Lindenbergia arabica
Lindenbergia indica
Maerua crassifolia +
Morettia parviflora +
Nannorhops ritchieana
Nerium oleander +
Olea europaea
Pentatropis nivalis
Pergularia tomentosa+
Physorrhynchus chamaerapistrum +
Prosopis cineraria +
Pulicaria glutinosa +
Reseda aucheri +
Rhazya stricta +
Saccharum ravennae
Schoenus nigricans+
Taverniera cuneifolia +
Tribulus terrestris +
Trichodesma enetotrichum +

6.1. Differential hydrology: karst versus ophiolite. In the case of the few water-loving species whose primary habitat is gravel wadi beds, particularly *Saccharum griffithii*, *Nerium oleander*, *Arundo donax*, *Schoenus nigricans*, *Juncus socotranus* and *Doellia bovei*, their absence in the Ru'us al-Jibal is probably due directly to the extreme scarcity of shallow groundwater in the wadis of the Ru'us al-Jibal, which in turn is attributable to the karst hydrology of the carbonate bedrock, involving internal solution channels. This explanation is supported by the presence of several of the foregoing species at a unique site within the Ru'us al-Jibal, at 'Ayn as-Sih, discussed below at Section 12.

In contrast, the hydrological regime of the Hajar Mountain ophiolite conforms relatively well to the generalised description by Harrison & Kruckeberg (2008): ultrabasic rocks, where they appear at the earth's surface, have usually been pervasively fractured by tectonic forces, and "readily form vast masses of sharp-edged scree that drift down hillsides . . . where only the hardiest plants can survive. The same rock characteristics, however, allow underground water to move through cracks in the masses of shattered rock, instead of through pores in rock, as it does elsewhere. Where such water encounters an impermeable layer, it may emerge at a slow but steady rate," facilitating plant growth.

Thus in some cases drainage characteristics of the substrate unrelated to chemistry may be the principal determinant of distribution. Among the best examples are the two *Lindenbergia* species (*L. arabica* (*Fig. 6.1.7*), which is endemic to the UAE and Oman, and *L. indica*). Both are typically found on, or at the base of, the vertical wadi walls of coarse gravel terraces – an extremely common habitat in the Hajar Mountains but a rare one in the Ru'us al-Jibal. The gravel terraces serve, among other things, as reservoirs for the steady percolation and release of groundwater.

Another example is *Prosopis cineraria*, the *ghaf* tree. The *ghaf* is primarily a species of sand and gravel plains, but it is not unusual to encounter it in or adjacent to broader, flatter gravel wadis within the Hajar Mountains. Yet although it is common on the plains to the west of the southern Ru'us al-Jibal, from Ra's al-Khaimah southwards, it is absent within the wadis of the Ru'us al-Jibal itself. Edaphic (soil/substrate) and hydrologic factors are the most likely explanations for its absence. *P. cineraria* is a notoriously deep rooted species but it may be unable to penetrate the carbonate bedrock, or to find sufficient water under karst conditions.

6.2. Distinctive chemistry of the ophiolite environment. The weathering of ultrabasic rocks such as the ophiolite of the Hajar Mountains creates soils that generally have distinctive chemical characteristics (Harrison & Kruckeberg 2008). They are deficient in calcium and other essential nutrients, such as nitrogen and phosphorus; they are rich in magnesium, which interferes with the uptake of calcium; and they usually have high levels of heavy metals such as chromium, nickel and cobalt. The slow percolation of groundwater through ultrabasic rock in an arid climate also produces exceptionally alkaline groundwater, with pH as high as 11.9 (Clark & Fontes 1990; J. Burt, *pers. comm*. 2004).

Consistent with the hypothesis of control by the substrate, in the case of many of the Table 5 species that have been found in small numbers in the Ru'us al-Jibal, their occurence there is limited to the southern fringes, in particular Jebel Ayuzah and Jebel Wamm in the south-east (Table 6b), where the bedrock is not the shallow water carbonates that dominate most of the Ru'us al-Jibal. However, neither is it the ophiolite that dominates the mountains to the south, but rather terrigenous sediments – the turbidites, shales and localised conglomerates of the Hawasina group (*Figs. 1.5.2* and *1.5.3*) – leaving the nature of the correlation with substrate uncertain. (A plant so far known only from this geologically intermediate area is the recently recognised *Chesneya parviflora*, common in the Makran.)

The most compelling example of a species having a distribution favoring carbonates and avoiding ophiolite is the hanging caper *Capparis cartilagenia*, which is common on cliffs in the Ru'us al-Jibal and on virtually all outliers of carbonate rock to the south (e.g., Jebel Mleihah, Jebel Rawdhah, Jebel Ghaweel and Jebel Hafit) but absent in the intervening ophiolite. Two other species that may avoid the ophiolite are *Koelpinia linearis* (Asteraceae) and *Ducrosia anethifolia* (Apiaceae), but both are sufficiently rare, even in the carbonates where they are found, that the failure so far to observe them within the ophiolite cannot as confidently be taken to demonstrate absence.

In a small number of cases, *Table 5* species found in the Ru'us al-Jibal are limited to the south-west Ru'us al-Jibal, where the bedrock is the same as the carbonates of the Ru'us al-Jibal generally (*Table 6a*). That area is distinguished, however, by the fact that it is much lower overall and offers gentler slopes at lower elevations (*Fig. 1.5.1*). The characteristic profile of the Ru'us al-Jibal is of steep slopes rising from base level to 500 m or more, and only then giving way to flatter terrain. In the south-western Ru'us al-Jibal, however, it is possible to ascend by ramp routes from almost base level on the adjacent plains to plateaux at 300-500 metres. Possibly this physiographic difference is sufficient to accommodate a few species and/or to facilitate their introduction.

What is arguably most remarkable, in light of the distinctive nature of the ophiolite substrate, is that the flora of the Hajar Mountains is not richer in endemic species. On a worldwide scale, ultrabasic habitats are uncommon and typically localised, but they are nevertheless widely distributed, occurring in association with most mountain belts, both ancient and modern. Elsewhere they are notorious for endemism: in California, some 12.5% of the state's 2,000 endemic species are said to be restricted to ultrabasic rock; within the tropics, both Cuba and New Caledonia, each of which has substantial areas of ultrabasic rock, have more than 900 ultrabasic endemics, a number of which are distinctive for having evolved the ability to concentrate heavy metals (Harrison & Kruckeberg 2008).

In Oman, on the other hand, despite its endowment with the world's most extensive exposure of ultrabasic rocks, the most common national or regional endemics (Ghazanfar 1999) are either not found in or not restricted to the ophiolite. In fact, it is not clear that any at all of the c.25 national or regional endemics recognised from the mountains of Northern Oman (Ghazanfar 1998b, 1999, 2003) are so restricted. Moreover, in Oman it seems that the only plant mentioned as a known hyperaccumulator of heavy metals is the fern *Pteris vittata* (Chen *et al*. 2002).

The Oman experience is seconded by a preliminary survey of two ultrabasic areas in central Iran, totalling c. 450 sq. km and located within a melange zone. Only a single species, the herb *Cleome heratensis* (Capparaceae), was identified as endemic to the ultrabasic rocks (Ghaderian & Baker 2007). *C. heratensis* is said to cover extensive areas in summer and autumn when there is no rainfall, and is able to restrict excessive heavy metal uptake.

6.3. Regional biogeographic gradients. Several Hajar Mountain species diminish or disappear in a northerly direction even before reaching the Ru'us al-Jibal. The large shrub *Acridocarpus orientalis*, the aromatic Composite *Pluchea arabica* and the tree *Maerua crassifolia**, for example, are all but absent north of the Al-Ain/Buraimi area and Wadi Jizzi in Oman (approximately 24°15' N latitude) and are not found north of Mahdhah, although all are very common in the mountains to the south. The spiny shrub *Zilla spinosa* and the rectilinear mountain front form of *Convolvulus acanthocladus* extend only slightly north of Mahdhah. The tomentose *Heliotropium rariflorum* (tentatively identified by Tim Harrison, *pers. comm*.) is locally common on the gravel outwash plains south of Mahdhah but has never been recorded further north. [*Note: A small number of Musandam area records exist for *Maerua crassifolia*. The author has been able to obtain reasonable confirmation of one of these, which is within the Ru'us al-Jibal as defined here (see Checklist). The others are believed most likely to occur in anthropogenic environments.]

Table 6: Common Hajar Mountain species found in the Ru'us al-Jibal primarily on the southern margin, in the south-west on the low plateau above Wadi al-Qaliddi and in the south-east on Hawasina sediments at Jebel Ayuzah.

Table 6a. Wadi al-Qaliddi
Cleome brachycarpa
Cometes surattensis
Convolvulus virgatus
Crotalaria aegyptiaca (single, low)
Iphiona scabra
Reseda aucheri
Pulicaria glutinosa
Tribulus terrestris

Table 6b. Jebel Ayuzah
Cleome brachycarpa
Convolvulus virgatus
Ephedra ciliata (on *Ziziphus spina-christi)*
Forsskaolea tenacissima
Iphiona scabra
Pergularia tomentosa
Physorrhynchus chamaerapistrum
Rhyncosia minima
Taverniera cuneifolia

Other species have their northernmost occurrences within the Hajar Mountains between Hatta (Wadi Hatta) and Masafi (Wadi Ham). These include the toxic Composite *Iphiona aucheri*, the dwarf palm *Nannorrhops ritchieana*, the wild olive *Olea europaea* and the elusive *Rumex limoniastrum*, collected from Eastern Arabia by Aucher-Eloy but not recorded again until the mid-1990s (Curtis 1999). Still other species become increasingly rare northwards within the Hajar Mountains, e.g., the erect shrub *Hibiscus micranthus* and the semi-prostrate *Schweinfurthia papilionacea*.

The reason for these intra-regional boundaries is speculative at present. They could be an indicator of the geographical advance or retreat of the species in one direction or the other, but they could also reflect factors such as lower annual rainfall, or lower or less reliable summer rainfall, along a northerly gradient. The latter, in turn, could be a result of regional atmospheric conditions (e.g., the northern limit of the influence of the Indian Ocean monsoon) or the lower elevation of the mountains between Hatta and the Ru'us al-Jibal (with maximum summit elevations of 1100+ m, versus 1400+m to the south) and a correspondingly reduced orographic effect. These factors are discussed at greater length in Section 9 below in connection with the case of the wild olive *O. europaea*.

The distributions do not, in any case, seem to represent a simple gradient in response to factors directly correlated with latitude, such as differences in daylight hours or lower temperatures in a northerly direction. As noted above, a number of the Hajar Mountain species that are absent or rare in the Ru'us al-Jibal are nevertheless common and characteristic in Iran and/or the Makran (see Section 5.2 above and compare Table 4 and Table 5). For example, *Iphiona aucheri* is more common in southern Iran than in the Hajar Mountains and was once thought to be an Iranian endemic (Zohary 1963, as *Grantia aucheri*); *Nannorrhops ritchieana* is present in south-central Iran and the Makran, as well as northern India, and is considered to be an Omano-Makranian species (Deil & al Gifri 1998) of Asian origin (Zohary 1973), although its Arabian range extends to southern Yemen and it is much more common on the plains of central Oman than in the Hajar Mountains; and *O. europaea* can also be found in south-central Iran and the Makran, as well as the mountains of Afghanistan and northern Pakistan (see Section 9 below).

Whatever the reasons for these observed boundaries or gradients, their existence should serve as a caution against casual predictions that species found in Northern Oman can be expected to occur in the UAE.

6.4. The wadi bottom habitat. Isolated records of several typical Hajar Mountain species (*Cometes surattensis*, *Lotononis platycarpa*, *Reseda* sp.) are attributable to a spring visit (in April 2005) to wadi bed and low wadi bank habitats along the middle reaches of Wadi Bih, specifically a wide spot in the already broad gravel bed of Wadi Bih, in an area of metre high terraces formed at the junction of Wadi Bih with a minor tributary wadi descending from the cliffs above, near Sabtan. These observations leave open the possibility that a more dedicated investigation of wadi bottom environments could reveal additional records of Hajar Mountain species not otherwise represented in the Ru'us al-Jibal.

The same locality (which is subject to modest grazing pressure by goats) was visited for comparison in early May 2009, when the only unexpected record was a single small *Haplophyllum tuberculatum*. Abundant on both occasions were *Ammi majus*, *Erucaria hispanica* and *Pentanema divaricatum* and, in 2009, *Aristida abnormis* and *Scabiosa olivieri*. Nearby, also in May 2009, *Ochradenus aucheri* was uncharacteristically dominant on rubble slopes adjacent to the main wadi, where *Plocama aucheri* was also common but grazed.

Rhazya stricta is most common in the UAE and Northern Oman as a species of gravel plains, but it is not unusual to encounter it in Hajar Mountain wadis, especially in or alongside the beds of broader, flatter wadis. In all cases the profusion of *R. stricta* is an indicator of overgrazing. It is absent, however, within the wadis of the Ru'us al-Jibal, with a single exception for which overgrazing also appears to be the presumptive explanation. The middle reaches of Wadi Khabb in the southern Ru'us al-Jibal, in the vicinity of its Wadi Shakh tributary, is the only area within the Ru'us al-Jibal that is extensively cultivated far above the wadi mouth. The cultivation there is associated with deep water sediments of the Hawasina group, having a different chemical compositon from the typical Musandam carbonates and also a different hydrology, with springs that are tapped to supply water. The presence of people and agriculture is in turn associated with large numbers of domestic goats and consequent heavy overgrazing, which seems to give *R. stricta* the same comparative advantage in Wadi Khabb that it confers elsewhere.

7. Many higher elevation ruderals of the Ru'us al-Jibal are absent in the Hajar Mountains, including the Jebel Akhdar

The Ru'us al-Jibal features a number of higher elevation ruderal species that are not found in the Hajar Mountains to the south. These include most prominently the monocotyledons *Moraea sisyrinchium*, *Leopoldia longipes* and *Ixiolirion tataricum* and the eudicotyledon *Heliotropium bacciferum*. In the same category, but somewhat more localised and peri-anthropic in their distribution, are the annuals *Asperugo procumbens*, *Cardaria draba*, *Galium* spp. (*G. aparine*, *G. ceratopodum* and/or *G. tricornutum*), *Matricaria aurea*, *Papaver* sp., *Plantago notata*, *Roemeria* sp. and *Scrophularia arguta* and the perennials *Gladiolus italicus*, *Leontice leontopetalum* and *Teucrium oliverianum*. A number of these peri-anthropic species are subject to grazing pressure and are reliably found only where they are physically protected, whether by fencing or natural obstacles.

One obvious explanation for the restriction of these species to the Ru'us al-Jibal is that similar habitats are not available in the mountains immediately to the south.

Within the Ru'us al-Jibal, scattered terraced cultivation is widespread, essentially all of it at elevations of 450-1500 m. In contrast, between the Ru'us al-Jibal and the Jebel Akhdar, a distance of some 250 km, there are virtually no cultivated fields (active or historical) at elevations above c.700-800 m (which in some areas is the base level at the mountain front). This is primarily due to the different physiography of the intervening Hajar Mountains, which are somewhat lower and which tend to weather to hillsides of steep but fractured bedrock, unsuitable for terracing, without the high plateaux that characterise the Ru'us al-Jibal. However, all of the characteristic ruderals listed above are apparently also absent from the Jebel Akhdar (with the exception of a single peri-anthropic occurrence of *Asperugo procumbens*), where habitats seemingly comparable to those of the Ru'us al-Jibal are common.

Another possibility, or perhaps a complementary one, is that some of these high elevation ruderals have been introduced through agricultural activities, whether in historical times or more recently. One species that is reckoned to have escaped from cultivation and peri-anthropic confines and is now established in the mountain environment more generally, both in the Ru'us al-Jibal and in the Hajar Mountains, is *Linum corymbulosum* (Ghazanfar 2007).

It should also be highlighted that most of these high elevation ruderals have their principal geographic ranges within more temperate latitudes, from Central Asia westward across Mesopotamia, the Levant and Turkey to the circum-Mediterranean (Boulos, 1999-2005) and the Atlantic (in the case of *Asperugo procumbens*, *Cardaria drab*a, *Papaver* sp. and at least two of the *Galium* spp.) (R.J. Hornby, *pers. comm.*).

8. Botanical comparison of the Ru'us al Jibal with the Jebel Akhdar

The Ru'us al-Jibal and the Jebel Akhdar are recognised as similar in their geology, physiography and history of human habitation, and the Jebel Akhdar has been relatively well studied botanically, by the standards of the region, so it is potentially enlightening to compare the two.

8.1. Comparison of the vegetation zones of the Ru'us al-Jibal and the Jebel Akhdar. Mandaville (1977) and Ghazanfar (1991a, 2003) have published broadly similar accounts of the zonation of the Jebel Akhdar vegetation. These are compared in Table 7 with the author's zonation for the Ru'us al-Jibal. Both Mandaville and Ghazanfar recognise four main zones in the Jebel Akhdar:

(1) a mountain wadi zone dominated by *Acacia tortilis et al*.
(2) a lower slopes zone dominated by *Euphorbia larica et al*.
(3) an upper slopes zone dominated by *Sideroxylon mascatense* (syns. *Reptonia mascatensis*, *Monotheca buxifolia*) and *Olea europaea*.
(4) a summit zone dominated by *Juniperus excelsa polycarpos et al*.

Zones 1 and 2 described above for the Ru'us al-Jibal are substantially similar to the two lowest zones recognised by Mandaville and Ghazanfar for the Jebel Akhdar. The most significant difference is that each of the zones is shifted downward in elevation by c.300-500 m in the Ru'us al-Jibal. This may reflect in part the fact that the Ru'us al-Jibal is situated some 250 km or 2.5 degrees latitude further north, so that a similar temperature regime prevails at lower elevation. However, an equally or more significant contributing factor may be that the base elevation at the mountain front is some 400-500 m higher in the Jebel Akhdar than in the Ru'us al-Jibal, so that similar physiographic environments and their associated habitats are correspondingly higher in the Jebel Akhdar. For example, the plains to the south of the Jebel Akhdar at Bahla and Nizwa, and to the north at Rustaq and Awabi, have an elevation of c.550 m, whereas the plains to the south-west of the Ru'us al-Jibal at Khatt, or to the south-east at Dibba, have an elevation of less than 100 m, and to the north and east of the Ru'us al-Jibal the base level is effectively sea level.

There are nevertheless a few noteworthy floristic differences in these lower zones, between the Ru'us al-Jibal and the Jebel Akhdar. As characteristic species of the mountain wadi zone, Mandaville includes the large shrub *Acridocarpus orientalis* and Ghazanfar includes the tree *Maerua crassifolia*. Although *A. orientalis* is very common in the Jebel Akhdar and in the Hajar Mountains immediately to the northwest of the Jebel Akhdar, both of those species are absent to the north of latitude 24°22'00", only some 15 km north of Al-Ain, Buraimi and Wadi Jizzi, and still some 150 km south of the Ru'us al-Jibal. Similarly, as smaller shrubs characteristic of the mountain wadi zone, Ghazanfar designates *Rhazya stricta*, *Fagonia indica* and *Pteropyrum scoparium*, but *R. stricta* is rare and *P. scoparium* is uncommon within the Ru'us al-Jibal. See also Section 6.3 above.

At higher elevations the situation is quite different. Above Zones 1 and 2 (wadis and low to medium elevation slopes) there is only limited botanical similarity between the two regions. Zone 4 of the Jebel Akhdar is absent in the Ru'us al-Jibal, probably for the obvious reason that it occupies elevations above those reached in the Ru'us al-Jibal, even allowing for a 300-500 m adjustment.

Zone 3 differs significantly between the two regions in terms of both species and vegetation structure. In the Jebel Akhdar, Zone 3 consists of an open woodland on moderate slopes and plateaux, with trees and large shrubs, and it can be forested in wadis and on protected slopes (see *Figs. 4.1.5* to *4.1.12*). In the Ru'us al-Jibal, Zone 3 is characterised by what has been called *Artemisia steppe*, consisting of low shrubs (including prominently *Artemisia sieberi*), many of them more or less tragacanthic (growing as spiny cushions), and scattered almond trees, stunted where exposed (see Section 3 above and *Figs. 1.3.6, 3.1.1* to *3.1.19*).

Table 7: Comparison of the vegetation zones of the Ru'us al-Jibal and the Jebel Akhdar

Ru'us al-Jibal (this study)	Jebel Akhdar (Mandaville 1977)	Jebel Akhdar (Ghazanfar 1991a, 2003)
2000m High Elevation Zone *Prunus arabica* *Convolvulus acanthocladus* *Artemisia sieberi* *Cymbopogon jwarancusa* *Dodonaea viscosa* *Farsetia aegyptia* *Gymnocarpos decandrus* *Helianthemum lippii* *Ficus johannis* *Ephedra pachyclada* *Centaurea wendelboi* *Teucrium stocksianum* *Dianthus crinitus* *Ixiolirion tataricum* *Moraea sisyrhinchium* *Helianthemum salicifolium* **1100m** Low and Medium Elevation Montane Zone *Euphorbia larica* *Acacia tortilis* *Ziziphus spina-christi* *Lavandula subnuda* *Pulicaria edmondsonii* *Vernonia arabica* *Moringa peregrina* *Plocama aucheri* *Prunus arabica* *Launaea bornmuelleri* *Astragalus fasciculifolius* *Ficus johannis* *Convolvulus acanthocladus* *Periploca aphylla* **600m** Mountain Wadi Zone *Tephrosia apollinea* *Acacia tortilis* *Ficus cordata salicifolia* *Ziziphus spina-christi* *Moringa peregrina* *Ochradenus aucheri*	**3000m** Juniper Summit Zone *Juniperus excelsa* ssp. *polycarpos* *Cymbopogon jwarancusa* *Dodonaea viscosa* *Euryops arabicus* *Teucrium mascatense* **2300m** Reptonia (Sideroxylon)-Olea Woodland + *Sageretia thea* *Ziziphus hajarensis* *Juniperus excelsa* ssp. *polycarpos* *Clematis orientalis* *Ebenus stellata* *Acacia gerrardii* *Dodonaea viscosa* *Ephedra pachyclada* **1350m** Euphorbia Larica Shrub Slopes *Euphorbia larica* + *Plocama aucheri* *Pulicaria glutinosa* *Moringa peregrina* *Maerua crassifolia* *Lavandula subnuda* *Convolvulus virgatus* **1050m** Mountain Wadi Ass'ns *Acacia tortilis* *Ziziphus spina-christi* *Ficus salicifolia* *Acridocarpus orientalis* *Prosopis cineraria* *Nerium oleander* **400m** Acacia Desert Parkland *Acacia tortilis* / *A. ehrenbergiana* + *Z. spina-christi* *Prosopis cineraria* *Pteropyrum scoparium* *Fagonia indica*	**3000m** Juniperus-Ephedra-Teucrium Zone + *Dionysia mira* *Lonicera aucheri* *Ziziphus hajarensis* **2500m** **2100m** Sideroxylon-Olea-Dodonaea Zone **1500m** Euphorbia larica Zone + *Acacia tortilis* *Acacia gerrardii* *Periploca aphylla* **1100m** **1000m** Acacia-Rhazya-Fagonia Zone + *Maerua crassifolia* *Lycium shawii* *Pteropyrum scoparium (wadi fans)* (Typical of gravel plains and foothills) **650m**

Accordingly, to the extent that the two regions appear visually similar, this may be due more to their similar geology and physiography, and to the constraints imposed on plant growth forms, than to actual similarities in their respective florae. Details of floristic differences, and of the tree flora in particular, are discussed immediately below.

8.2. Floristically, the high Ru'us al-Jibal is not closely similar to the high Jebel Akhdar. At elevations above Zone 2, i.e., above the low and medium elevation montane zone of the Ru'us al-Jibal and the lower slopes zone of the Jebel Akhdar (effectively, the *Euphorbia larica* zone in each), only a few species are common in both ranges: *Cymbopogon jwarancusa*, *Dodonaea viscosa*, *Ephedra pachyclada*, *Launaea bornmuelleri* and *Phagnalon schweinfurthii*. Three of the four most common perennials of the high Ru'us al-Jibal are effectively absent in the high Jebel Akhdar: *Artemisia sieberi*, *Convolvulus acanthocladus* (extremely rare), and *Prunus arabica*. In addition, several of the next most common dwarf shrubs in the high Ru'us al-Jibal are either rare (*Centaurea wendelboi*, *Farsetia aegyptia*) or absent (*Astragalus fasciculifolius*, *Gymnocarpos decandrus*) in the Jebel Akhdar. *Teucrium* is common at higher elevations in both areas, but the species found in the Ru'us al-Jibal is *T. stocksianum* whereas in the Jebel Akhdar it is *T. muscatense* (Ghazanfar, in press, synonymises these two *Teucrium* taxa, but see the Checklist and compare *Figs. 4.1.15* and *5.4.24*).

Conversely, with the exception of *Dodonaea viscosa* and *Ephedra pachyclada*, none of the species cited by Mandaville as dominants or associates in the *Sideroxylon-Olea* zone (Mandaville's "*Reptonia-Olea* Woodland") are found in the Ru'us al-Jibal: *Sideroxylon mascatense*, *Olea europae*a, *Sageretia thea* (syn. *S. spiciflora*), *Ziziphus hajarensis*, *Juniperus excelsa*, *Clematis orientalis*, *Ebenus stellata* and *Acacia gerrardi*.

8.3. The diverse tree flora of the Jebel Akhdar is absent in the Ru'us al-Jibal. The number of species of trees and large shrubs found in the Ru'us al-Jibal is very small: *Acacia tortilis*, *Dodonaea viscosa*, *Ficus cordata salicifolia*, *Ficus johannis*, *Moringa peregrina*, *Prunus arabica* and *Ziziphus spina-christi*.* Of these, *A. tortilis*, *F.c. salicifolia* and *M. peregrina* are found only at low and medium elevations, generally up to a maximum of 600-1000 m. *Ficus johannis* and *Ziziphus spina-cristi* survive in small numbers to c.1500-1600 m, but only *Dodonaea viscosa* and *Prunus arabica* are present above that. [*The foregoing list excludes the extremely rare *Acacia ehrenbergiana*, *Cordia* sp. aff. *quercifolia*, *Ehretia obtusifolia*, *Grewia tenax*, *Grewia villosa* and *Pistacia khinjuk*, each found only at a single locality at low elevations.]

In contrast, the Jebel Akhdar above 1000 m is characterised by many trees and large shrubs, including *Acacia gerrardii*, *Acridocarpus orientalis*, *Berberis baluchistanica*, *Daphne mucronata*, *Dodonaea viscosa*, *Juniperus excelsa polycarpos*, *Lonicera aucheri*, *Olea europaea*, *Sageretia thea* (syn. *S. spiciflora*), *Sideroxylon mascatense* (syns. *Reptonia mascatensis*, *Monotheca buxifolia*) and *Ziziphus hajarensis*. *Prunus arabica* is absent from the Jebel Akhdar, although it is present in the Jebel Bani Jabr to the south-east. Only at about 2400 m and above does the number of Jebel Akhdar tree species start to decline (see *Figs. 4.1.1* to *4.1.5*). At the highest elevations, open plateaux are more or less limited to juniper and *D. viscosa*, although other tree species *(B. baluchistanica, D. mucronata, L. aucheri, O. europaea, S. mascatense)* remain present in ravines, sometimes almost to the 3000 m summits. *Ficus cordata salicifolia*, *Moringa peregrina* and *Ziziphus spina-christi* are common at lower and moderate elevations in the Jebel Akhdar, as they are in the Ru'us al-Jibal.

Munton (1985), studying in detail the habitat of the Arabian tahr, also remarked that the Ru'us al-Jibal was "notable for its comparative lack of diversity of shrub and tree species" and speculated that it was "possible that, unlike in areas further south [the Jebel Akhdar and Eastern Hajar], cutting of live wood has taken place in the past." That possibility may not be exceptional. Deil & al Gifri (1998) have commented more generally that the majority of Arabian grasslands are secondary in nature, having replaced woodlands which were destroyed by felling and burning, and Miller & Cope (1996) have lamented that: "The greatest problem in describing the vegetation of the Arabian Peninsula is the effects man and his livestock have had for thousands of years. The potential vegetation in most areas can only be guessed at from small vestiges of apparently natural vegetation which have managed to survive in inaccessible spots."

8.4. Rainfall amount and patterns: the probable explanation for botanical differences. What accounts for the manifest differences in the high elevation flora and vegetation of the Ru'us al Jibal as compared with the Jebel Akhdar? Differences in the amount and pattern of annual rainfall are almost certainly the principal factors.

Zohary (1973) considered that the arboreal assemblage of the Jebel Akhdar suggested an annual rainfall of about 200 mm, whereas Mandaville's (1977) estimate from vegetation was somewhat higher at 250-375 mm. More recent but still limited data from the Saiq Plateau indicate that average annual rainfall in the Jebel Akhdar may be from 307 mm (Ghazanfar 1992b) to 350 mm (Fisher *et al*. 1999, referencing Fisher & Membery 1998). Miller & Cope (1996) estimate a figure of 300-350 mm.

For the Ru'us al-Jibal, Ghazanfar's (1992b) average annual figure of 188 mm/yr for Khasab is consistent with the limited measured data (for 1975-1977) reported in Mandaville (1985). This is significantly higher than Mandaville's interpolation of 100-150 mm/yr from low elevation coastal locations at Sharjah, UAE and Bandar Abbas, Iran (Mandaville 1985), and suggests a modest to significant orographic effect. Data from the coastal site of Sha'am, at the western edge of the Ru'us al-Jibal, record a 25-year average (1967-1992) of 165 mm/year (Böer 1997, citing UAE Ministry of Agriculture and Fisheries 1993). Fisher *et al*. (1999), referencing Fisher & Membery (1998), show average annual rainfall of 198 mm at Khasab; this somewhat higher figure may be influenced by the unusually wet years of the mid-1990s.

A map of isohyets (contours of equal rainfall) showing mean annual UAE rainfall for the 18-year period 1971/1972 through 1988/1989 indicates a figure for the western Ru'us al-Jibal in excess of 160 mm, but apparently not in excess of 180 mm (UAE University 1993, Plate 50).

Generally consistent with the foregoing are annual rainfall data published by Emirates Wildlife Society-WWF (2006) for multiple stations in the Shimaliyah range of the Hajar Mountains, on the East Coast of the UAE between Khor Fakkan and Masafi, some 10-40 km south of the Ru'us Al-Jibal. These indicate a 30-year (1975-2004) regional average of c.160 mm/year, with the composite annual average ranging from 43 mm to 323 mm. Peaks in Shimaliyah are substantially lower than in the Ru'us al-Jibal, with the few very highest ranging from 900-1100 m. The Shimaliyah data are also consistent with the historical periodicity of other UAE rainfall records (Feulner 2006), including the exceptional rainfall of the mid-1990s (1995-1998) and the exceptional drought of 1999-2003.

The foregoing figures indicate that average annual rainfall is some 50-75% higher in the Jebel Akhdar than in the Ru'us al-Jibal. Of equal significance, however, is the annual rainfall distribution. The data show that the Jebel Akhdar receives a substantial and reliable dose of summer rainfall (July and August) (Ghazanfar 1991a, 1992b), which the Ru'us al-Jibal today does not (Ghazanfar 1992b, UAE University 1993 and personal observation).

An explanation of floral and vegetation differences in terms of rainfall amounts and patterns is supported by the similarity of the flora of the high Ru'us al-Jibal, and particularly the development of *Artemisia steppe*, to that of the central plateau of Iran, where total annual rainfall in areas of comparable vegetation ranges from c.100-135 mm and where summer rain is also lacking (Zohary 1963). Mandaville (1977) contributes a further supportive comparison, noting that the wild olive species present in the mountains of Afghanistan and Pakistan (which he called *Olea ferruginea*) is associated there with *Sideroxylon mascatense* (syns. *Reptonia mascatensis*, *Monotheca buxifolia*), which is common and closely associated with *O. europaea* in the Jebel Akhdar. Mandaville notes that although total rainfall in the mountains of Afghanistan and Pakistan is higher than in the Jebel Akhdar, both regions are characterised by relatively abundant summer rainfall.

The summer rainfall in the Jebel Akhdar is probably the result of a combination of the influence of the Indian Ocean monsoon and the orographic effect of the Jebel Akhdar massif, with extensive plateaux above 1800 m and summit ridges to just over 3,000 m. Limited data from the city of Nizwa, on the plains just south of the Jebel Akhdar, indicate that precipitation is low (<100 mm/yr) and falls mainly in the summer (Ghazanfar 1991a), probably reflecting monsoon related phenomena. The Jebel Akhdar may be a barrier to northward penetration of the monsoon, since both Muscat (Böer 1997) and Seeb (Ghazanfar 1992b) on the Gulf of Oman coast north of the Jebel Akhdar exhibit the pattern of winter rain and scarce summer precipitation that seems to characterise the rest of the Hajar Mountains. However, the easterly city of Sur, on the Gulf of Oman coast near Ra's al-Hadd, also shows the typical winter rainfall pattern (Ghazanfar 1992b), although it is not much protected from the south.

8.5. Further comparison with the Eastern Hajar Mountains. The distinctiveness of the Jebel Akhdar flora and vegetation is emphasised by comparison with high elevation areas in the Eastern Hajar, including Jebel Aswad (to c.1900 m) (described in Mandaville 1977), the Selma Plateau area (c.1400-1800 m) and the Jebel Bani Jabr (to c.2000 m). All of these areas are carbonate massifs like the Ru'us al-Jibal and Jebel Akhdar. Most of the Eastern Hajar remains remote, especially at higher elevations, and botanical information is limited. The Eastern Hajar is evidently somewhat drier and lacks the abundance and diversity of trees and large shrubs seen in the Jebel Akhdar, although in the most accessible locations, e.g., the Selma Plateau, overgrazing contributes greatly to the impoverished flora.

Floristically, the Eastern Hajar seems to be somewhat intermediate between the Ru'us al-Jibal and the Jebel Akhdar. It has the characteristic Jebel Akhdar tree assemblage of *Sideroxylon mascatense* and *Olea europaea* (although Mandaville's photographs suggest this is limited to wadi environments), as well as common Jebel Akhdar plants such as *Ebenus stellata*, *Euryops arabicus*, *Teucrium mascatense* (Mandaville 1977) and *Ziziphus hajarensis*. However, several characteristic Ru'us al-Jibal species are present in the Eastern Hajar, although they are absent in the Jebel Akhdar (Mandaville 1977) and also absent or rare in the intervening Western Hajar. These include the Arabian almond *Prunus arabica*, which is common in the Eastern Hajar at a distance of 430 km from its nearest representatives in the Ru'us al-Jibal, and the distinctive spiny *Astragalus fasciculifolius*, which makes a similar disjunctive appearance in the Eastern Hajar. Also found in the Ru'us al-Jibal and Eastern Hajar, but rare, if not absent, in the Jebel Akhdar are *Anthemis odontostephana*, *Convolvulus acanthocladus* and *Zoegea purpurea* (Mandaville 1977).

What might this imply, if anything, in terms of the biogeographical history of the region? Since it is not intermediate geographically, is the high Eastern Hajar averaging climatic factors? The Eastern Hajar cannot fail to receive the south-west winds of the Indian Ocean monsoon. Why is the result not the same as in the Jebel Akhdar? Is it only the exceptional height of the Jebel Akhdar that accounts for its greater annual rainfall, significant summer precipitation, and as a result, its relatively diverse and abundant flora? Mandaville (1977) has inferred this. If so, might "Almond steppe" (it cannot be called *Artemisia steppe* because in the Eastern Hajar there is no *Artemisia*) be simply the "default" mountain vegetation in circumstances of lower rainfall and/or lack of summer precipitation? Examination of rainfall data for high elevation sites in the Eastern Hajar (not to mention additional botanical fieldwork) would help to test these hypotheses.

Fig. 3.4. 'Ayn as-Sih

Fig. 3.4.1. At 'Ayn as-Sih, water seeping from the cliff wall creates a unique site that features a number of species not found elsewhere within the Ru'us al-Jibal. These include *Arundo donax*, *Epipactis veratrifolia*, *Nerium oleander*, *Pteris vittata*, *Schoenus nigricans* and others. A self-seeded date palm can be seen on the cliff at the upper right. For further discussion see Section 12.

Fig. 3.4.2. The spring at 'Ayn as-Sih (dark areas) is dwarfed by the scale of the wadi and cliffs that surround it.

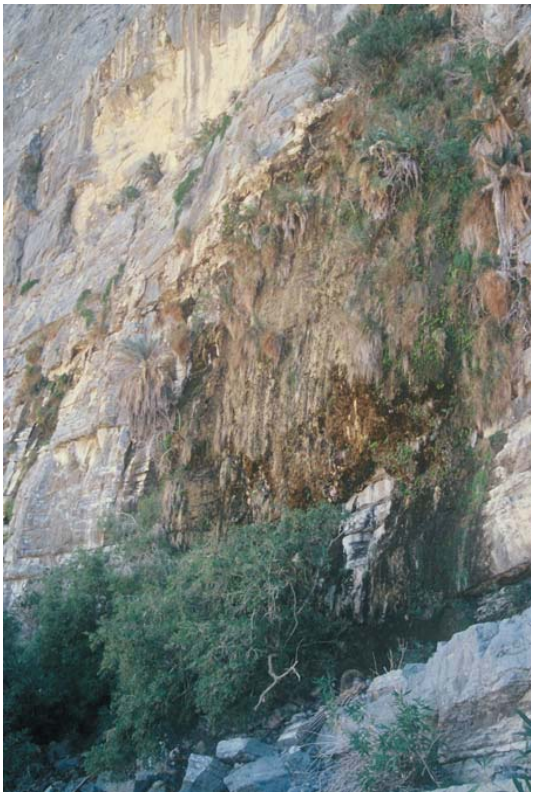


Fig. 3.4.3. A close-up view of a wet wall at 'Ayn as-Sih.

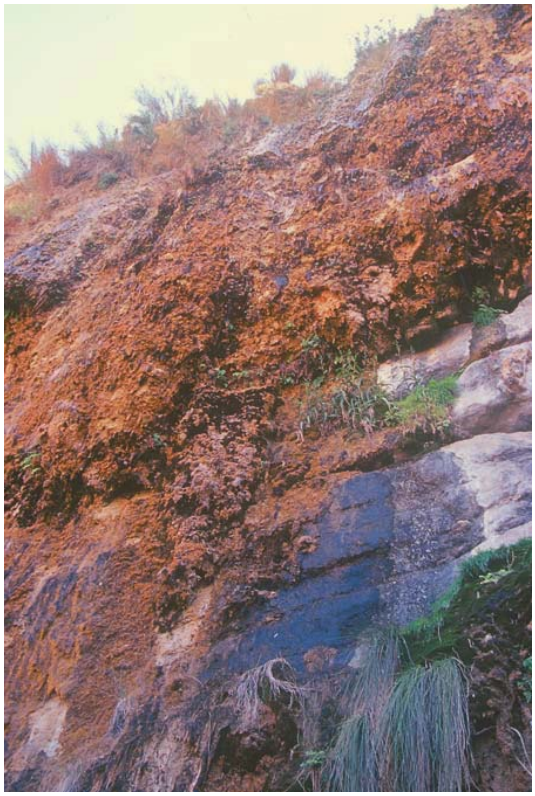


Fig. 3.4.4. Looking up the cliff wall at 'Ayn as-Sih.

Fig. 4. Comparison: Some illustrations of the geography, flora and vegetation of the high Jebel Akhdar

Fig. 4.1.1. A panorama of the Jebel Akhdar at c.2900 m, looking south-west from Jebel Shams to Jebel Kawr. The large shrubs in the foreground are *Dodonaea viscosa*, the smaller ones are mostly *Euryops arabicus*.

Fig. 4.1.2. Juniper trees (*Juniperus excelsa* subsp. *polycarpos*) on the summit ridge of Jebel Shams, at c.2900 m. Also common as ground cover are *Euryops arabicus*, *Cymbopogon jwarancusa* (dry) and *Teucrium mascatense*.

Fig. 4.1.3. A rocky summit at 2900 m above Dar As-Sawdah, featuring juniper and *Euryops arabicus*.

Fig. 4.1.4. Summit plateau of juniper and *Sideroxylon mascatense* (Arabic "*boot*"), c.2400 m, Saiq Plateau.

Fig. 4.1.5. Juniper, *boot* and wild olive *Olea europaea*, c.2400 m, overlooking the Grand Canyon of Wadi Ghul.

Fig. 4.1.6. Open woodland of juniper, *boot* and wild olive, c.2300 m, Saiq Plateau.

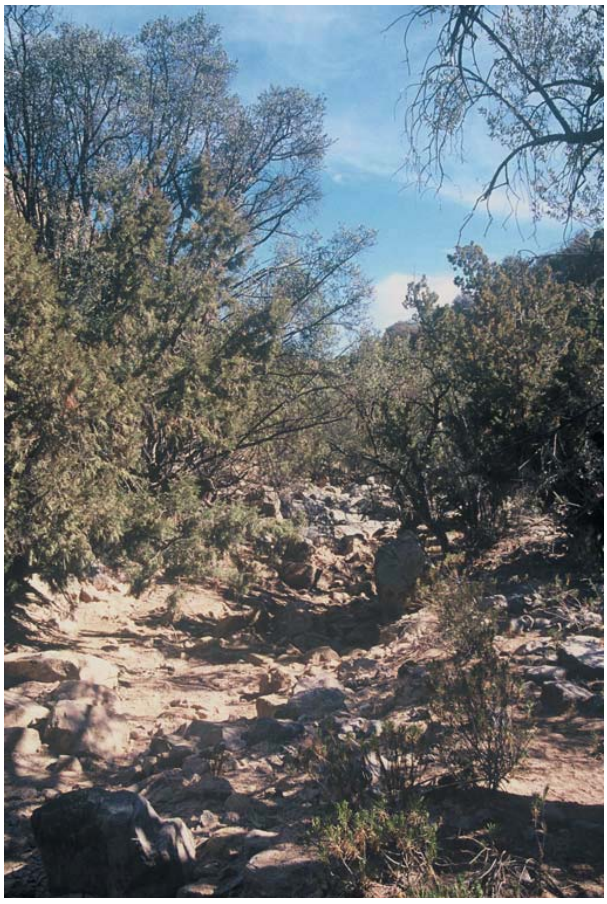


Fig. 4.1.7. A forested wadi at c.2200 m, Saiq Plateau.

Fig. 4.1.8. A shallow wadi with wild olive and *Dodonaea viscosa*, c.1900 m, near the Grand Canyon of Wadi Ghul.

Fig. 4.1.9. Parkland of wild olive and *Dodonaea viscosa*, c.1850 m, near the Grand Canyon of Wadi Ghul.

Fig. 4.1.10. Rain in the Jebel Akhdar, near the Grand Canyon of Wadi Ghul, 1800 m.

Fig. 4.1.11. Well-developed tufts of *Cymbopogon jwarancusa* and woodland of wild olive and *Dodonaea viscosa*, c.1850 m, Sharafat al-Alamayn.

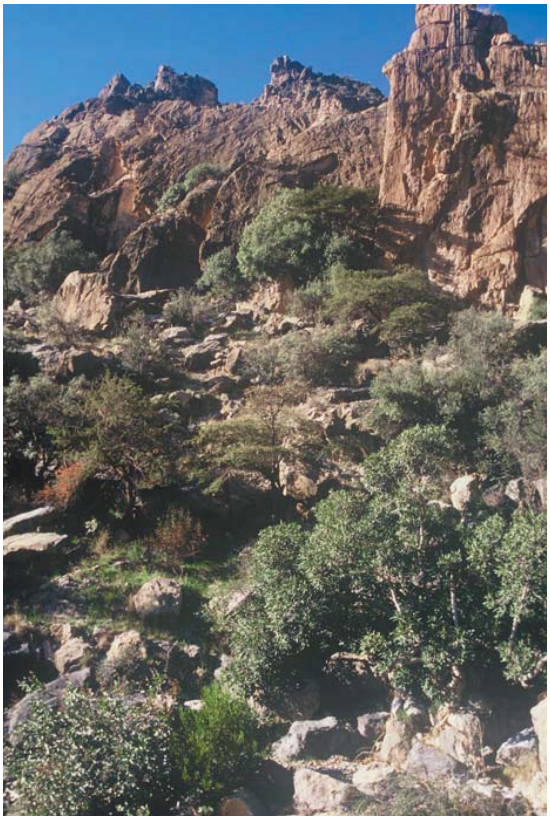


Fig. 4.1.12. The wooded trail above Wakan (c.1600 m), the route followed by French collector and explorer Piere Remi Martin Aucher-Éloy to cross the Jebel Akhdar in 1838. The flora of these north-facing slopes is exceptionally rich.

Fig. 4.1.13. *Dionysia mira*, a high elevation species also native to Iran and the Makran.

Fig. 4.1.14. ***Euryops arabicus*** **(syn.** ***Euryops pinifolius*****), a common and characteristic species of the high Jebel Akhdar, endemic to Oman.**

Fig. 4.1.15. ***Teucrium mascatense*****, another common and characteristic species of the high Jebel Akhdar. Ghazanfar considers that this species is equivalent to** ***T. stocksianum*** **of the Ru'us al-Jibal. For a brief discussion, see the Checklist entry for** ***T. stocksianum*****.**

9. The absence of the wild olive (Olea europaea)

One of the most intriguing absentee species in the Ru'us al-Jibal is the wild olive tree, *Olea europaea*, also discussed in the regional literature as *O. africana*, *O. aucheri*, *O. chrysophylla* and *O. ferruginea*. Boulos (2000) reasons from the conclusions of Green & Wickens (1989) that the correct name for Asian and African populations should be *O. europaea* ssp. *cuspidata* (Wall. ex G. Don) Ciferri. Wild olives are found throughout the mountains of south Arabia, from the 'Asir region of Saudi Arabia through Yemen, the Dhofar region of Oman and northwards into the Jebel Akhdar and the Hajar Mountains of Oman and the UAE. In the Jebel Akhdar, wild olives are a significant element of the vegetation from at least 1100-2500 m and can be found to c.2900 m (see Section 8.3 above and *Figs. 4.1.5* to *4.1.12*). The wild olive also ranges to the north and east, into southern Iran (Zohary 1963) and Baluchistan (Stewart 1959, cited in Ghazanfar 1991), across Afghanistan and into the mountains of northern Pakistan (Zohary 1963, Mandaville 1977, Boulos 2000, *pers. obs.*).

Within the ophiolite terrain of the Western Hajar, to the north-west of the Jebel Akhdar, higher elevations are generally very difficult to access and are therefore poorly known, but ascents to a number of summit areas ranging from 900-1800 m between 'Ibri, Oman and Fujairah, UAE confirm not only that wild olives are present in this region, generally beginning at c.800 m, but also that they are the dominant tree species at elevations above c.1000-1200 m and continuing to the local summits. At their northernmost frontier, hundreds of olive trees can be found along the 900-1000 m gabbro ridges of Jebel Qitab and Jebel Sfai, south-west of Fujairah, some 65 km south of the Ru'us al-Jibal, although in that area they are modest in size and are generally restricted to north-facing slopes and ravines (*Figs. 5.5.10* and *5.5.11*).

The absence of the wild olive in the modern Ru'us al-Jibal is all the more puzzling in light of the elevation shift observed in vegetation zones between the Jebel Akhdar and the Ru'us al-Jibal, discussed above. If the wild olive zone in the Jebel Akhdar (c.1100-2500 m) were likewise shifted downwards by 300-500 m in the Ru'us al-Jibal, then wild olives would be expected there at elevations above c.700 m and they should be common above c.1000 m. If *O. europaea* is present in significant numbers in mountains on both sides of the Strait of Hormuz, why is it not also found in the intervening territory of the Ru'us al-Jibal?

The question is obvious; the answer is less so. Given the substantial populations to both the north and south, it is not reasonable to suppose that the wild olive somehow bypassed the Ru'us al-Jibal in the course of its dispersal between Africa and Asia. Therefore two basic possibilities exist, which are briefly discussed below but cannot be definitively resolved by the present study: (1) that wild olives cannot thrive naturally in the Ru'us al-Jibal, at least under current environmental conditions, and that, if once present, they have become extinct locally due to natural causes; or (2) that wild olives were formerly present in the Ru'us al-Jibal but have disappeared due to exploitation by man and his domestic animals. It is also possible that environmental factors and anthropogenic influences have acted in combination to eliminate the wild olive.

9.1. Environmental factors. In comparison with the wild olive stronghold in the Jebel Akhdar, the failure of the wild olive to thrive in the physically and geologically similar environment of the Ru'us al-Jibal can be plausibly explained in terms of differential rainfall, which in the Ru'us al-Jibal is significantly lower and more seasonal (see Section 8.4 above), and probably also somewhat less reliable.

An explanation in terms of differential rainfall patterns is less easy to accept, however, in view of the presence of wild olives in proximity to the Ru'us al-Jibal in the Hajar Mountains south-west of Fujairah. That area is sufficiently close to the Ru'us al-Jibal (c.65 km) that it seems at first unlikely that the local rainfall regime would differ greatly between the two areas, notwithstanding that any peripheral influence of the Indian Ocean monsoon would attenuate in the northerly direction. It is, nevertheless, the impression of a number of UAE-based naturalists that convective summer rainfall is greater in the mountains from Hatta southwards (having regular maximum summit elevations of 1400-1600+ m) than from Hatta to the north (with rare maximum summit elevations of 1100+ m). There is certainly more permanent surface water in the mountains to the south of Hatta.

Alternatively, or in addition to possible rainfall differences, hydrological or edaphic differences may play a determinative role, although it is apparent from the known distribution that the distinction between carbonate and ophiolite substrates is not, *per se*, a controlling factor for *O. europaea*. This hypothesis proposes that the ophiolite bedrock is sufficiently more advantageous, in terms of retaining groundwater in the near surface, that under conditions of lower and more seasonal rainfall it can support wild olive growth, even at higher elevations and among steep slopes and gulleys, whereas the carbonate bedrock of the Ru'us al-Jibal cannot.

In this context it is intriguing to note that an early division of the UAE into bioclimatic zones by Satchell 1978 (reproduced in Böer 1997 at *Fig. 6*) considered the Hajar Mountains of the UAE to be more "mesic" than the Ru'us al-Jibal to the north, although this classification does not match the reported pattern of isohyets in the mountain regions (Böer 1997, *Fig. 2*). Using FAO data, Satchell grouped the East Coast with the adjacent Hajar Mountains as "sub-humid", whereas the Ru'us al-Jibal was grouped with the gravel plains to the west of the Hajar Mountains and the Arabian Gulf coast of the Northern Emirates as "arid". (The majority of the UAE, consisting of sand desert, was classified as "hyperarid", while the high peaks southwards from Hatta to Wadi Jizzi were "semi-arid".) Such a classification seems to imply the influence of the Indian Ocean and Gulf of Oman on the climate of the Hajar Mountains and the Gulf of Oman coast, exclusive of the Ru'us al-Jibal.

The current distribution does not exclude the possibility that the wild olive was once present in the Ru'us al-Jibal, and perhaps even widespread, under more favourable conditions, and that it waned and ultimately disappeared entirely in response to deteriorating climate. That is arguably implied by the generally accepted hypothesis that the climate of Eastern Arabia has been more mesic from time to time over the past few thousand to few million years (see Section 1.3 above). There is, however, as yet no direct evidence of the former presence of the wild olive in the Ru'us al-Jibal.

9.2. Anthropogenic influences. Circumstantial evidence exists in local culture for the former presence of wild olives in the Ru'us al-Jibal. The wild olive tree is known to present-day Shihuh tribal residents of the Ru'us Al-Jibal by the name *'itm* (or '*utm*), the same name used in the Jebel Akhdar. According to Shihuh tradition, the wood of the *'itm* protects the bearer against the *jinn* (evil spirits). This is recited even by younger individuals who admit they have never seen a wild olive tree, and the wood of the '*itm* is considered, at least in theory, the material most preferred for making the handle of the trademark Shihuh axe, the *jirz* (Y. Al-Shihi, *pers. comm*.). However, despite general statements affirming the presence of olive trees, inquiries to older Shihuh residents of the Ru'us Al-Jibal have not succeeded in identifying specific locations where the wild olive can be found today; instead it is speculated that "only one or two" now exist (Y. Al-Shihi, *pers. comm*.). Written accounts uniformly refer to the wild almond (*Prunus arabica*, locally called *mizi*) as the wood traditionally used for the handle of the *jirz* (see, e.g., Vincent (1991)).

The existence of such an oral tradition permits the speculation that selective cropping by humans, and/or browsing by their domesticated animals, could have put fatal pressure on the wild olive. The Shihuh, who have traditionally maintained only seasonal settlements in the Ru'us al-Jibal, seem generally to have been adept at conserving scarce resources, at least until the modern era. Among other things, they have selectively preserved and cultivated the edible fig, *Ficus johannis*, and the sidr tree, *Ziziphus spina-christi*, valuable both for its edible berries and as a source of lumber through coppicing. Thus it seems at least somewhat unlikely that they would have permitted the elimination of the wild olive, but the talismanic value of the olive wood might conceivably have been allowed to overcome more worldly considerations and the olive, a notoriously slow-growing tree, may have been particularly susceptible to over-exploitation. In this context it should be recalled that Munton, who visited the Ru'us al-Jibal in the late 1970s to investigate the presence of Arabian tahr, speculated from the lack of diversity of tree and shrub species that cutting of live wood has taken place in the past (Munton 1985).

Browsing by feral and domesticated animals does not seem to threaten the present day survival of the wild olive in the Jebel Akhdar, but the problem of feral goats is reckoned to be more pervasive in the Ru'us al-Jibal than in the Jebel Akhdar, due to different customs of husbandry; at least, this is true today (Richard Wood, *pers. comm*.). Within the wild olive populations nearest the Ru'us al-Jibal, in the UAE and Northern Oman, browsing of accessible branches and shoots is evident and the absence of any very young olive trees is conspicuous.

If humans or their livestock are primarily responsible for the demise of the wild olive in the Ru'us al-Jibal, this must have occurred at a very rapid pace or there must have been very few olive trees present to begin with (or both), since seasonal habitation and cultivation of the Ru'us al-Jibal is estimated from archaeological evidence to date from no more than c.700 years ago (Derek Kennet, *pers. comm*., 2002). In any case the process must have been singularly effective.

Alternatively, it is possible that the Shihuh belief about olive wood is an example of a tradition that has travelled farther than its cultural and environmental referents, since the Shihuh and other inhabitants of the Northern Oman mountains are generally considered to be historical migrants from the highlands of Yemen, via Dhofar.

10. No inroads by exotic species. No obviously exotic species, invasive or otherwise, were encountered at wild sites within the Ru'us al-Jibal, notwithstanding the large scale introduction of dry-adapted exotic plants for landscaping in the UAE as a whole over the past 30-40 years. This may be an oblique tribute to the rigors of the local environment. Even as cultivated plants within terraced settlements, exotic species (e.g., the neem tree, *Melia azederach*, and *Cordia* spp.) are very rare. The most commonly cultivated tree, after the date palm, is the native mountain fig, *Ficus johannis*.

The introduced mesquite tree, *Prosopis juliflora*, has spread extensively on the gravel plains south and west of the Ru'us al-Jibal and at Dibba to the south-east. It is also found in the vicinity of some larger coastal settlements along the northwest of the Musandam region and at Khasab in the north. *P. juliflora* is now considered a very serious invasive species in many countries where it has been introduced, including the Dhofar region of Oman, but eradication efforts have generally not proven successful. It is therefore comforting to be able to state that only a single specimen of *P. juliflora* is presently known within the territory of the Ru'us al-Jibal, as defined for the purposes of this study (see Checklist).

There is reason to be concerned for the future, however. Since about 2001, possibly in response to the the final agreement of borders between the UAE and Oman within the Ru'us al-Jibal, a number of high terraced settlements have been the site of modest but significant infrastructural improvements such as new stone dwellings, new concrete cisterns, PVC water tanks, improved foot trails, etc., for use by expatriate labourers and recreational visits by local owners. By early 2007, at least one remote high homestead was surrounded by a cement block wall adorned by electric light globes, to be powered by a portable generator. A falcon training camp is said to have been established

recently at another isolated location. Resumption of traditional agriculture does not seem to be a significant motive for these developments, although resident labourers sometimes maintain small plots. The current phase of activity commenced and proceeded initially during a period of drought when agriculture was not feasible, and the properties in question had been largely disused and uninhabited during most of the preceding, relatively wet, decade of the 1990s. Since 2005, in addition, vehicle tracks of varying quality have been driven into a few high areas.

In perhaps the greatest potential threat to the high elevation environment of the Ru'us al-Jibal, a major project was proposed for the construction of a decentralised resort community (there was persistent talk of skiing!) in the very highest area of the UAE, consisting of several square kilometres of land rising to c.1800+ m on the south-western slopes of Jebel Jais (whose 1900+ m summit is in Oman) and representing the UAE's only significant area of habitat above 1500 m (see Section 1.5, Section 3 (Zone 3) and *Figs. 1.3.7* and *1.3.8*). Apart from the direct damage due to habitat destruction, experience suggests that the introduction of exotic flora as landscaping amenities is more likely than not in connection with such a project. That could pose a serious threat to the distinctive high elevation flora, not only in the UAE but in Oman as well, since the summit of Jebel Jais is contiguous with other Omani peaks and plateaux directly to the north and north-east, which represent the very highest area of the Ru'us al-Jibal.

The project in question has become one of many victims of the global economic crisis that commenced in mid-2008, but significant environmental damage has already been done by construction of a major but unfinished access road carved into the eastern slope of the ridge of Jebel Rahabah (1563 m), the UAE's highest peak (*Fig. 1.3.9*). The road was apparently designed to accommodate the anticipated demand for heavy vehicles for the resort project: it is often impressively wide and is built at an extremely low gradient, so that it snakes back and forth along almost the full length of the ridge in numerous successive shallow switchbacks. Some of these characteristics may also have been recommended from an engineering standpoint, since the east flank of Jebel Rahabah is a dip slope subject to landslides. The overall result, however, is to maximise the environmental impact of the road, which now effectively prevents access by foot over much of the mountainside.

11. The Wadi Khabb Shamsi narrows — a refuge for rare species

Wadi Khabb Shamsi drains the south-eastern Ru'us al-Jibal. It flows for some 25 km from Jebel Qi'wi and Aqabat Oso and debouches at Dibba. About 13 km upstream from the mountain front the wadi narrows and makes a right angle bend in an area where for about half a kilometre the wadi is no more than c.30-40 m wide, and at the bend it constricts to only c.10-12 m (*Fig. 1.4.12*). Flotsam indicates that, when the wadi is in flood, water depth at the bend can reach 15 m or more. In this area the cliffs rise steeply on both sides (to 1200 m on the south-west and 600 m on the north-east), although they are cut by fractures and gulleys.

In the narrows and its immediate vicinity are found specimens of a number of plant species not known from any other locations within the Ru'us al-Jibal. Some are also rare within the Hajar Mountains generally. Included are the herbs and small shrubs *Abutilon fruticosum*, *Boerhavia diffusa*, *Commelina albescens*, *Crotalaria aegyptiaca*, *Dalechampia scandens*, *Forskaolea viridis*, *Pulicaria glutinosa* and perhaps *Torilis leptophylla*, and the large shrubs *Ehretia obtusifolia*, *Grewia tenax* and *Grewia villosa*. Specimens of *A. fruticosum*, *D. scandens*, *E. obtusifolia*, *G. tenax (Fig. 5.5.8)* and *G. villosa* are restricted to more or less inaccessible cliff or ledge sites. *Pistacia khinjuk* is restricted to a single wadi about 2.5 km upstream from the narrows, where it is represented by about two dozen small trees on cliffs along some 2 km of wadi.

It is reasonable to suspect that the presence of these species is related to the relatively sheltered nature of the narrows area, whose physiography provides a certain amount of protection from heat and dessication in addition to grazing pressure. If this is true, then many of the listed species could be relicts of more extensive populations that existed in earlier, more equable times.

12. 'Ayn as-Sih — a unique oasis for hygrophilous species

The spring known as 'Ayn as-Sih is located deep within the gorge of Wadi al-'Ayn, which flows north-east from Jebel Harim to Khasab (*Figs. 3.4.1 and 3.4.2*). Access to the spring is by foot only and is not straightforward. The site is at c.470 m and the cliffs immediately above rise steeply to more than 800 m. Water seeps from the south-east wall at various points over a length of c.200 m and from a height of c.50-75 m above the wadi bottom, nourishing the coarse rubble of the wadi bank below (*Figs. 3.4.3 and 3.4.4*).

This is the only natural site known in the Ru'us al-Jibal for a number of hygrophilous species, including *Arundo donax*, *Epipactis veratrifolia*, *Nerium oleander*, *Pteris vittata* and *Schoenus nigricans*, and the only Ru'us al-Jibal site known for self-seeded (feral) date palms *Phoenix dactylifera* (*Figs. 3.4.1 and 3.4.3*). It is one of only two Ru'us al-Jibal sites for *Portulaca oleracea*. Also collected here, by Michael Gallagher in 1982, was the holotype of *Echinops atrox*, a rare species otherwise known in the region only by a few records from Dhofar (N. Kilian, *pers. comm.*).

A small number of other springs are found in the Ru'us al Jibal, several in association with 'dry' waterfalls and some modestly improved by man, but none are on the scale of 'Ayn as-Sih.

13. Exceptional records from Jazirat al-Ghanem.

The records of the Mandaville expedition from the island of Jazirat al-Ghanem, off the extreme north-west tip of the Musandam (Mandaville 1985), are both sufficiently numerous and sufficiently exceptional that they have been excluded from the Checklist and, consequently, from the statistics and generalisations based upon it.

The island lies less than 1 km offshore and is elongated parallel to the coast, 5 km long by 1.5 km wide. It reaches a maximum elevation of c.160 m near its south end, so the entire island is lower than the vast majority of the area considered within the present study. Nonetheless, the Jazirat al-Ghanem records deserve brief discussion as a footnote to the observations presented here.

Traditionally the island had been used intermittently by local tribesmen for grazing of goats and sheep. Mandaville (1985) wrote that at the time of his study there were few signs of recent grazing pressure on the vegetation, but expedition member Torben Larsen, writing a number of years later, had a somewhat different recollection: "Until recently this island had been teeming with goats, which had devastated the landscape by eating down all but the hardiest bushes and trees. In the few days available we found little difference in species composition in our various specialties, but I am sure that the quantitative mix must have been different from the mainland" (Larsen 2002).

13.1. Jazirat al-Ghanem records not included in the Checklist. Even after discounting obvious coastal species and low elevation ruderals, the inclusion of the Jazirat al-Ghanem records would have added nine species to the Checklist for which Jazirat al-Ghanem was the only site: *Commicarpus squarrosus*, *Digitaria nodosa*, *Echiochilon thesigeri*, *Erodium laciniatum*, *Melhania muricata*, *Ochradenus baccatus*, *Seddera latifolia*, *Sedum affnanum* and *Teucrium polium*.

All but one of those species are also either absent or very rare in the UAE and Northern Oman. The exception is *Erodium laciniatum* (Geraniaceae), which, based on its regional distribution, can reasonably be expected to occur at lower elevations in the Ru'us al-Jibal and has possibly been overlooked. Two of the Jazirat al-Ghanem species, *Digitaria nodosa* (Poaceae) and *Echiochilon thesigeri* (Boraginaceae), are known from a small number of Hajar Mountain records and could possibly occur in the Ru'us al-Jibal as well. *O. baccatus* and *T. polium* are species better known to the north, in Saudi Arabia, Qatar and Iran, but each has a very similar congener in the Ru'us al-Jibal (*O. arabicus* and *T. stocksianum*) and the possibility exists that the determinations in Mandaville (1985) might today be revised. Ghazanfar (2003) does not record *O. baccatus* from Northern Oman.

C. squarrosus and *S. affnanum* are otherwise unknown in the UAE and Northern Oman (the Mandaville record of *C. squarrosus* is apparently distinct from the species now considered as *C. mistus* by Ghazanfar (2003)). *Melhania muricata* is otherwise known only from Jebel Qitab, a high ridge south-west of Fujairah, where it is found at elevations above 800 m, and from a few records in the Jebel Akhdar. *E. thesigeri* is otherwise known only from Jebel Qitab, from Jebel Hafit near Al-Ain, and from further south in Northern Oman. *Seddera latifolia* is rare in Northern Oman and has only recently been recorded in the UAE, from the base of cliffs along the coastal plain north of Fujairah; the site has recently been destroyed by construction work.

The Mandaville team also collected on Jazirat al-Ghanem three species for which only a small number of Ru'us al-Jibal records exist: *Abutilon fruticosum*, *Convolvulus virgatus* and *Hibiscus micranthus*. *A. fruticosum* is known in the Ru'us al-Jibal only from inaccessible specimens in the gorge of Wadi Khabb Shamsi (see Section 11 above) and in the UAE only from a few plants on the hillsides of a single wadi south-west of Fujairah. *Convolvulus virgatus* is rare in the Ru'us al-Jibal and is found only at scattered locations up to c.1200 m, but grazing is probably a factor since occasional large, healthy plants have been found at inaccessible cliff sites. It is common in the Hajar Mountains to the south, where it is often heavily grazed. *H. micranthus* is otherwise absent in the Ru'us al-Jibal, except at low elevation in the area of the isthmus (described immediately below and in Section 13.2), but is widespread (although not common) in the Hajar Mountains.

The presence of at least a few of these anomalous species may be related in one way or another to the fact that Jazirat Al-Ghanem had, until the 1970s, supported a British naval facility. The Mandaville team also found *Abutilon fruticosum* and *Hibiscus micranthus* at the tiny island site of Jazirat al-Maqlab, an abandoned 19th century telegraph relay station in Khor ash-Shamm. Like Jazirat al-Ghanem, the Jazirat al-Maqlab site was said by Mandaville to appear free of recent grazing by goats, although it still reflected the disturbance of construction and occupation a century before.

13.2. Ru'us al-Jibal species at anomalously low elevations. On Jazirat al-Ghanem the Mandaville expedition also recorded a number of characteristic Ru'us al-Jibal species at unusually low elevations. *Convolvulus acanthocladus* was collected there at 100 m and all of the following mountain species were collected at 30 m or less: *Callipeltis cucullaris*, *Convolvulus ulicinus*, *Ephedra pachyclada* (as *E. intermedia*), *Grewia erythraea*, and *Vernonia arabica*. Several of these (*C. acanthocladus*, *C. ulicinus* and *E. pachyclada*) are normally found only at medium to high elevations in the Ru'us al-Jibal. The author encountered the same phenomenon on the east coast of the Musandam, not far beyond the isthmus, at a site called Sufayrat, near Ra's Da'aliq, north of the mouth of Khor Habalayn. There, not far from an established homestead and a herd of c.20 goats, *Echiochilon persicum*, *Grewia erythraea*, *Hibiscus micranthus*, *Lavandula subnuda*, *Leucas inflata*, *Teucrium stocksianum* and *Vernonia arabica* were all found, most of them heavily grazed, at elevations below c.75 m.

Gary M. Brown (*pers. comm*., 2009) mentions that this phenomenon – the presence of "mountain" species at low elevation in maritime contexts – is not limited to the Musandam peninsula but is a conspicuous feature as well on certain of the UAE's offshore islands (most of them to the west, off the coast of Abu Dhabi), which host a number of species from the Hajar Mountains.

One possible explanation in the isthmian region is that the intermittent temporary introduction and grazing of free ranging livestock from mountain areas has facilitated the introduction of the seeds of certain mountain species. On most of Abu Dhabi's offshore islands, however, there is no historical tradition of temporary grazing of livestock from mountain areas, so it may be that the more important factor in permitting mountain species to become established below their customary elevations is simply the moderating influence of the sea on peak summer temperatures and evaporation of moisture, perhaps coupled with lack of competition from low-elevation species that never happened to reach these remote areas. A clearer case of maritime influence alone may be the abundant presence of *Ficus cordata salicifolia*, normally a wadi bank species, on slopes overlooking the east coast of the Ru'us al-Jibal, from Dibba northwards to Limah and beyond (*Fig. 5.4.13*).

14. Field relationships with possible taxonomic implications

In several instances, field observations of distinctive growth forms associated with particular habitats and/or geographically separated populations suggest the possible occurrence of unrecognised species or subspecies. Three of the most persuasive examples are briefly discussed below, in the hope of encouraging definitive expert attention.

Convolvulus acanthocladus. *C. acanthocladus* is one of the most common plants at higher elevations in the Ru'us al-Jibal, where it is a spiny, tomentose dwarf shrub (*Fig. 5.4.6*). The same plant occurs sparsely on the highest ridges (900-1000 m) some 65 km south of the Ru'us al-Jibal, but otherwise is absent for ca.135 km to the south.

According to expert determinations, *C. acanthocladus* reappears on the west flank of the Hajar Mountains in the Mahdhah area, but there it is a shrub of lower slopes and gravel terraces along the mountain front (at c.600 m) and has a decidedly more rectilinear habit (*Fig. 5.5.4*). The latter form can be seen southwards to the Ibri area, and also in the upper Wadi Hawasina watershed, which drains the east flank of the Hajar Mountains, north-east of Ibri.

The tomentose form is also found still further south, but only as a very rare plant, in the vicinity of Jebel Kawr, near Jebel Shams in the Jebel Akhdar, at c.1200 m. Ghazanfar has collected *C. acanthocladus* from Jebel Shams itself (Ghazanfar 1992a), apparently at an elevation above 1800 m but otherwise without description. It is evidently rare in that area as well, as the author has never encountered it there (and has recorded only one, heavily grazed, specimen of the similar *C. ulicinus*).

Plants having an intermediate morphology have not been observed. Possibly it is significant is that, from the above records, the two different growth forms appear to be correlated with differences in both elevation and geology: (i) high elevation and carbonate rocks in the Ru'us al-Jibal, Jebel Kawr and Jebel Shams versus (ii) medium elevation and ophiolite rocks in the intervening Hajar Mountain foothills.

Diplotaxis harra. In the Ru'us al-Jibal, the plant recognised as *D. harra* is a rock and cliff-dwelling perennial dwarf shrub found at medium to high elevations, where it grows to a height of up to 50 cm (*Fig. 5.4.8*). The same form is found in the high Jebel Akhdar, to at least 2300 m. In most of the intervening Hajar Mountains, however, *D. harra* is a much smaller, generally single-stemmed annual plant growing abundantly on gravel outwash plains or on gravel terraces within the mountains (*Fig. 5.5.6*). As in the case of *Convolvulus acanthocladus*, the different growth forms are correlated with differences in both elevation and geology. Miller and Cope (1996) state that plants from the high mountains of Oman (3000 m) (which indicates specimens from the Jebel Akhdar) are glabrous and approach *D. kohlaanensis*. The plants in the Ru'us al-Jibal are, however, hirsute.

Dodonaea viscosa. A number of observers have commented on the apparently bimodal habitat distribution of *D. viscosa* in the UAE and Oman, although casual field observations have not so far recognised any consistent morphological differences. At lower elevations it is found along wadi banks, but at higher elevations it is locally common on bedrock plateaux, often in small silty depressions (see, e.g., *Figs. 3.1.3, 3.1.8 and 5.4.9*). It occurs at elevations up to 3000 m in the Jebel Akhdar, where above c.2400 m it is one of the more common large plants, along with the juniper tree *Juniperus excelsa polycarpos* (see, e.g., *Figs. 4.1.1* and *4.1.4*). The taxonomy of *Dodonaea* is problematic (Leenhouts 1983; Curtis 1999) and these field relationships should be taken into account in any definitive resolution.

Acknowledgements

This paper is the product of investigations undertaken over many years and there are correspondingly many thanks and acknowledgements to be conveyed. A.R. (Rob) Western's 1989 book, *The Flora of the United Arab Emirates*: *An Introduction*, first made it practical for non-professional observers to participate in the study of the UAE's plants and their geographic distribution, a study which the author took up enthusiastically in connection with more general exploration of the UAE and its diverse environments. Rob was also a patient correspondent in the author's early years of botanical observation, when Rob himself was still engaged in field work in the UAE.

Marijcke Jongbloed, a physician by profession, is the author of books on many aspects of UAE natural history, and an early and ground-breaking UAE conservationist as well, but her first love in the natural world was plants, culminating in her 2003 book, *The*

Comprehensive Guide to the Wild Flowers of the United Arab Emirates. Conversation and correspondence with Marijcke over the years enlarged the author's knowledge of UAE plants generally, as did many hours spent with the herbarium that she established at the Sharjah Natural History Museum. Consultation with her in connection with the aforementioned volume, in particular in relation to mountain plants, sharpened the author's awareness of the distinctive character of the flora of the Ru'us al-Jibal.

Prof. Loutfy Boulos was introduced to the author through Dr. Jongbloed and was diligent and enthusiastic over many years in providing, to Dr. Jongbloed and later to the author, expert identification of specimens, a crucial step in transforming field information into knowledge.

Dr. Norbert Kilian reviewed and commented on the taxonomy of the Asteraceae included in the Checklist, and was generous in providing information and encouragement. Prof. Hildemar Scholz graciously assisted at a late stage of this study to improve the coverage of grass species. Dr. Shahina Ghazanfar provided numerous reprints and was patient in responding to inquiries over several years. Her draft Red Data List for the UAE (Ghazanfar, *in prep*.) was the primary basis for updating the scientific nomenclature used in Jongbloed (2003).

One reason for the dearth of attention given to the flora of the Ru'us al-Jibal is its general inaccessibility other than by foot. The author has overcome this obstacle by means of regular hiking visits over more than 19 years in company with a number of indulgent, engaging and insightful field companions who merit recognition and thanks here. They include (in rough chronological order of their participation): Charles S. Laubach, the late Martin Parker, Ian Lapraik, Angela and Stephen Manthorpe, Cheryl Jones, Ian Robson, Yusuf Al-Mazroui Al-Aqabi Al-Shihi, Neil Curtis, John Martin, Barbara Couldrey, Geoff Cosson, Peter L. Cunningham, David Palmer, Richard Morris, Narayan Karki (who came to know the plants of the Ru'us al-Jibal almost as well as the author) and Ramesh Bhandari.

John Martin tracked down and provided copies of the works of Michael Zohary cited in this paper.

Gary M. Brown, Richard J. Hornby and Marijcke Jongbloed paid the author's efforts the compliment of reading with care a late draft of the entire manuscript and providing constructive comments and additional information.

Finally, thanks are due to the publisher, editors and sponsors of *Tribulus*, who have, steadfastly and with great foresight and energy, encouraged serious amateur natural history research in the UAE and neighbouring Oman and provided a forum for its dissemination and discussion.

Appendix

Annotated Checklist of the Flora of the Ru'us al-Jibal

by Gary R. Feulner

Introduction

This Checklist undertakes to list the species of higher plants that have been recorded to date from the mountains of the Musandam peninsula, locally called the *Ru'us al-Jibal* ("the High Peaks" or "the Mountain Tops" or, literally, "the heads of the mountains"). The Checklist is based primarily on observation and collection by the author (GRF) from 1995 through 2010, supplemented by additional records documented in Mandaville (1985), Western (1989), Ghazanfar (1992a, 2003 and 2007), Miller & Cope (1996), Jongloed et al. (2000), Jongbloed (2003), Karim & Fawzi (2007) and Cope (2007).

The Checklist accompanies the paper titled *The Flora of the Ru'us al-Jibal – the Mountains of the Musandam Peninsula: An Annotated Checklist and Selected Observations*. The paper provides additional information about the geology, geography and hydrology of the Ru'us al-Jibal and the history of botanical investigation there, as well as setting out certain quantitative data and outlining in a preliminary way a number of significant generalisations about the distinctive flora and vegetation of the Ru'us al-Jibal.

Observation, Collection and Identification

The observations and notes on which the Checklist relies represent more than 120 day-long or overnight excursions on foot throughout the Ru'us al-Jibal from January 1995 through December 2010, plus selected earlier observations, in all seasons (mostly late autumn, winter and early spring, but including several summer outings at all elevations). The use of a portable dictaphone facilitated comprehensive recording. The decade of the 1990s benefitted from relatively heavy rain throughout the UAE, making it an excellent period for botanical observations. From 1990 through 1998, only two years were significantly below the long-term average annual rainfall and the years 1995 through 1998 were four of the ten wettest years in the 70-year history of UAE weather recording (Feulner 2006). In contrast, the subsequent period from mid-1999 through mid-2004 was a period of exceptional drought: rainfall in each year was less than half the long-term average, and the period as a whole had less than half the rainfall of the next lowest five-year period recorded (Feulner 2006).

Routine field identifications by the author are generally supported by photographs and were made in the first instance by reference to Western (1989), Jongbloed (1989), Jongbloed (2003) and the herbarium established by Jongbloed at the Sharjah Natural History Museum in the UAE, supplemented by personal communications from Jongbloed and Western, and by reference to Collenette (1985), Shuaib (1995), Boulos' four-volume *Flora of Egypt* (Boulos 1999, 2000, 2002 and 2005, cited collectively herein as "Boulos (FoE)"), Ghazanfar (2003, 2007) and Cope (2007).

Expert identification of specimens has been provided in most cases by Loutfy Boulos, now professor emeritus, Alexandria University, Egypt, initially through the courtesy of Dr. Jongbloed. Prof. Boulos arranged for the determination of a number of grass species by Thomas A. Cope. Selected identifications have also been provided by Gary M. Brown, Ian R. Curtis, Norbert Kilian (for Asteraceae) and Hildemar Scholz (for Poaceae).

In the course of preparation of the Checklist, the taxonomic nomenclature employed in Jongbloed (2003) was modified to take account of Ghazanfar (2003, 2007), advice by Boulos in connection with subsequent determinations generally, advice by Kilian in relation to Asteraceae, and Cope (2007) in relation to grasses. Taxonomic nomenclature was further updated in August 2010 on the basis of a draft preliminary Red Data List for the UAE, prepared and provided by Shahina Ghazanfar. The preliminary Red Data List is based primarily on Jongbloed (2003) but also incorporates most data from the Checklist, a draft of which was provided by the author prior to publication. For ferns, the nomenclature advocated by Rothfels *et al*. (*in press*) has been adopted here. Synonyms are mentioned in the Checklist if the superseded name is one that has heretofore been in common use among naturalists in the UAE and Oman.

The Checklist is considered to be extremely comprehensive for perennials other than grasses. It is somewhat less complete for grasses and, inevitably, for annuals. These limitations reflect, in the case of grasses, the limitations of the author's own abilities, and in the case of annuals, the logistical difficulties, when observing on a part-time basis only, of being in the right place at the right time to encounter seasonal plants, some of them not at all conspicious.

In recognition of the foregoing, the effort was made in winter and spring 2008-09, and again in spring and summer 2010, to devote particular attention to grasses, in order to enhance the completeness of the Checklist. Hildemar Scholz kindly provided timely expert determinations. That effort seconded a number of Ru'us al-Jibal records by others, re-confirmed several sole records by the author, and confirmed the presence of several regionally widespread grass species that had not yet been reported from the Ru'us al-Jibal but were expected to occur there (e.g., *Hyparrhenia hirta* and *Tricholaena teneriffae*). It also added at least five other grass species not previously recorded, including at least three new to the region (see Table 1).

In the course of preparing the Checklist, the author created and maintains a further annotated version, which contains references to specific locations and/or excursion notes (by date) that support the Checklist records and annotations. The author's version is available by request, for research purposes.

Definitions and Exclusions

The Ru'us al-Jibal is here defined operationally as areas within the mountain front and north of the northern margin of the Dibba Zone, a geological boundary of structurally confused rock separating the carbonate sediments of the Ru'us al-Jibal from the ophiolites of the Hajar Mountains to the south. Thus the southern boundary of the Ru'us al-Jibal is essentially a line following (from west to east) BatHa Mahani, Sayh Muruq, Wadi Hiyar, Wadi Fa'y and the northern edge of the Dibba plain. The Dibba Zone has a geographical as well as geological expression since the mountains of the Ru'us al-Jibal to the north are much higher than the Hajar Mountains to the south. Summit plateaux in the Ru'us al-Jibal range from 1500 to 2000 metres, whereas the tallest peaks and ridges for more than 100 km southwards to the Hatta area, all in ophiolite, are only 900 to 1000 metres. The southeast margin of the Ru'us al-Jibal is atypical and includes colourful deep water sediments that have been thrust against the shallow water carbonates that otherwise characterise the Ru'us al-Jibal.

Excluded from the Checklist are species found within the Musandam region only in non-montane environments, e.g., ruderals, halophytes and other species found only on the coastal plain or outwash plains to the southwest; along the coast road from Ra's al-Khaimah to Khasab; at low elevation sites along the isthmus (principally the Jazirat al-Maqlab and al-Maksar sites of Mandaville (1985); in coastal and mountain front settlements and plantations such as Khasab, the provincial capital, and nearby Qida, which stretches from the coast up a narrow, steep-sided mountain wadi; and/or in plantations within the mountain front, principally in Wadi Khabb and at the mouth of Wadi Bih. Also excluded is the area called Sal al-'Ala, an extensive silty parkland at the head of a broad, flat wadi that terminates in a sort of box canyon 25 km above Khasab at an elevation of 170 m. Sal al-'Ala includes the "Birkat al-Khalidiyah" site of Mandaville (1985), where the Mandaville team collected a large number of widely distributed annuals (including several grasses), many of which are neither common in nor characteristic of the mountain areas.

Examples of species excluded by the foregoing methodology are *Avicennia marina*, *Cressa cretica*, *Cyperus laevigatus*, *Juncus rigidus* and various halophytes, all found in or adjacent to the salt marshes north of Rams, Ra's al-Khaimah; *Dipterygium glaucum*, found in windblown sands along the narrow, intermittent coastal strip to the west; *Heliotropium kotschyi*, found in firmer coastal sand; *Torilis stocksiana*, found in the silty parkland at Birkat al-Khalidiyah; trees such as *Melia azederach* (the *neem* tree) and *Cordia* spp., found in plantations and gardens at Khasab and other settlements along the west coast and in Wadi Khabb; and *Conocarpus lancifolia*, planted in recent years as an ornamental tree along the coast road from Bukha to Al-Jerri.

The exclusion of records from Birkat al-Khalidiyah and coastal sites has the effect of disregarding a small number of grasses recorded by Mandaville that might reasonably be expected in the mountain environment, but for which no such records yet exist. Those species are listed separately at the end of the Poaceae section. They include, among others, *Dactyloctenium aegyptium*, *Schismus arabicus* and *Tragus berteronianus*.

On the other hand, in the case of two grasses, *Cenchrus pennisetiformis* and *Dicanthium annulatum*, the known distribution (Jongbloed 2003) makes it much more likely than not that they are present within the Ru'us al-Jibal as defined herein. For that reason they have been included in the Checklist despite the apparent absence of confirmed records, on the grounds that it would probably be more misleading to exclude them than to include them.

Also excluded from the Checklist are species that occur within the Ru'us al-Jibal only as cultivated species, whether within mountain plantations or as ornamentals. Examples are food crops such as wheat and certain gourds and (rare) trees such as, again, *Melia azederach* and *Cordia* spp. (*M. azederach* is mentioned in the Checklist because it is sometimes conspicuous, but it has been disregarded in compiling the statistics presented in the accompanying paper.) The date palm *Phoenix dactylifera*, an iconic Arabian species, escapes exclusion on this basis by virtue of several feral plants growing at the unique site of 'Ayn as-Sih, discussed in Section 12 of the accompanying paper.

Finally, the records of the Mandaville expedition from the island of Jazirat al-Ghanem, off the extreme north-west tip of the peninsula (Mandaville 1985), are both sufficiently numerous and sufficiently exceptional that they have been excluded from the Checklist. Among other things, even after excluding obvious ruderal or coastal species, the inclusion of the Jazirat al-Ghanem records would have added nine species to the Ru'us al-Jibal list for which Jazirat al-Ghanem was the only site. The Jazirat al-Ghanem records are nevertheless discussed in greater detail in Section 13 of the accompanying paper.

Annotations

Annotations are used to indicate characteristics such as range, elevation and abundance. All annotations are based on the author's observations, except as otherwise stated.

For relative abundance, the basic terminology of Jongbloed *et al*. (2000) and Jongbloed (2003) is adopted. Thus:

Common = generally found in good numbers within favoured habitats.

Occasional = generally found within favoured habitats, but in low numbers.

Locally common = normally occasional or rare within favoured habitats but sometimes found in specific localities in good numbers.
Rare = found only occasionally and mostly as isolated specimens.

With respect to geographic range, unless otherwise indicated, the listed species have been observed at diverse locations within the Ru'us al-Jibal, and should be considered widespread, whether or not they are common.

With respect to elevation, approximate ranges are given for species which seem to be limited by elevation. However, upper and lower limits cannot always be given with complete confidence, especially for annual species, and exceptions can be found, especially in unusually protected (or exposed) sites. Low elevation means approximately 0 to 500-600 metres; medium or moderate elevation includes from c.500 to 1000-1200 metres; and high elevation means above c.1000-1200 metres.

Reference to a "location" indicates a site having an extent of a metre to a few tens of metres. Reference to a "locality" indicates a site having an extent of as much as a kilometre, or as otherwise indicated. If the only record is known to be a single plant or specimen, this is indicated.

Where the author's record has been based upon or confirmed by expert identification, the source of that determination is given as "ID by _____", the majority being by Prof. Loutfy Boulos ("L. Boulos").

Where the identification has been made by the author and is considered provisional, the reference used by the author to make the determination is given as "ID per _____". Reference to Boulos' four-volume Flora of Egypt is given as "Boulos (FoE)" without reference to the date of the individual volume concerned.

An asterisk (*) indicates species that, in the UAE and Northern Oman, are restricted to the Ru'us al-Jibal, i.e., species that are not found in the contiguous mountains to the south. In a few cases, species so marked are absent generally in the mountains to the south of the Ru'us al-Jibal but can be found (usually in very modest numbers) in the Jebel Akhdar or (in the case of *Astragalus fasciculifolius* and the Arabian almond, *Prunus arabica*) in the Eastern Hajar Mountains of Oman. If so, this is indicated in the text.

Checklist entries for species not personally encountered or not distinguished by the author are annotated by a citation in square brackets [ ] in the first line of the entry, to denote that these represent records that have been reported in one or more other reference works, but in each case only a single such reference is cited. In most cases reference is made to Jongbloed (2003) but where a species not encountered by the author is also not recorded in Jongbloed (2003), reference is made to another work in which the species is recorded, usually the most recent one. Prior researchers have not made a distinction between the Ru'us al-Jibal and the Musandam region generally; therefore literature records from the Musandam are included in the Checklist only to the extent that they can be assigned with reasonable confidence to the Ru'us al-Jibal as defined above.

Jongbloed (2003) should generally be considered to amend and supersede Jongbloed *et al*. (2000), but Jongbloed has been consulted in relation to a number of points of difference between those two works and the Checklist reflects the clarifications provided by her. On that basis, a small number of entries listed in Jongbloed *et al*. (2000) but not repeated in Jongbloed (2003) have been included in the Checklist.

Although the author has attempted to take account of known instances of synonymy, it is possible that certain of the species reported only by Mandaville (1985) might today be assigned to similar species reported by subsequent investigators.

A double asterisk (**) indicates the 17 species for which this study appears to represent first records for the UAE and Northern Oman. Table 1 lists those species as well as a number of other reported species not included in previous compilations – Mandaville (1985), Western (1989), Ghazanfar (1992a, 2003, 2007), Miller & Cope (1996), Jongbloed et al. (2000), Jongbloed (2003), Karim & Fawzi (2007) or Cope (2007) – either for the Ru'us al-Jibal or the UAE and Northern Oman generally. A few as yet undetermined species included in the Checklist may also prove to be new records for the region.

Annotated Checklist of the Flora of the Ru'us al-Jibal

PTERIDOPHYTA

ASPLENIACEAE

Asplenium ceterach L.* [Jongbloed (2003)]
Rare. Recorded by Western and Karim. [Syn. *Ceterach officinarum* Willd.]

PTERIDACEAE

Adiantum capillus-veneris L.
Rare. Damp, well shaded sites only, especially near springs and seeps. Not recorded above c.500 m. Common in Hajar Mtns.

Cheilanthes acrostica (Balbis) Tod
Rare, but easily overlooked. To 1900 m+, in shelter of boulders. Also recorded at high elevation in Jebel Akhdar (Mandaville 1977). [Syns. *C. pteridioides* (Reichard) C. Chr.; *C. fragrans* (L.) Sw.]

Cosentinia vellea (Aiton) Tod
Rare, but easily overlooked. In shelter of boulders. [Syn. *Cheilanthes vellea* (Aiton) F. Muell.]

Onychium divaricatum (Poir.) Alston
Common. All elevations, in shade, often in shelter of boulders.

Pteris vittata L.
Rare. Single location at spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal.

GYMNOSPERMAE

EPHEDRACEAE

Ephedra ciliata Fischer & C.A. Meyer

Rare. Two Ru'us al-Jibal records only, in S (J. Ayuzah) and central (W. Zibat). Common in Hajar Mtns. [Syn. *E. foliata* Boiss. ex C.A. Meyer]

Ephedra pachyclada Boiss. subsp. *pachyclada*

Locally common. Above c.900 m, increasing above c.1200 m. Also found at higher elevations in the Hajar Mtns and above c.1700 m in Jebel Akhdar. Elsewhere from Sinai to Iran and Pakistan. [Syn. *E. intermedia* Schrenk & C.A. Meyer] *Fig. 5.4.10*. See also *Figs. 3.1.7, 3.1.13* and *3.1.22*.

ANGIOSPERMAE: MONOCOTYLEDONAE

AMARYLLIDACEAE

Ixiolirion tataricum (Pall.) Herb.*

Rare. Medium to high elevation, c.700 m to at least 1450 m, especially in silt. Also recorded from Dhofar (Ghazanfar 1992a). In Kuwait, found at low elevation. *Fig. 5.4.18.*

ARECACEAE (PALMAE)

Phoenix dactylifera L.

Locally common. Date palm, cultivated. Generally up to c.1200 m, maximum c.1500 m. Only a few feral examples are known, growing on the cliff wall of the spring at 'Ayn as-Sih (see Section 12). See *Figs. 1.6.2, 3.2.3, 3.4.1* and *3.4.3*.

COMMELINACEAE

Commelina albescens Hassk.*

Rare. Single location at c.500 m in steep, rocky trail in SE Ru'us al-Jibal. Also known from Dhofar.

CYPERACEAE

Schoenus nigricans L.

Rare. Single location at spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal.

IRIDACEAE

Gladiolus italicus Mill.*

Rare. Medium to high elevation, c.1000 m and above, in active or abandoned cultivation. *Fig. 5.4.15*.

Moraea sisyrinchium (L.) Ker Gawl.*

Locally common, plateaux or fields. High elevation, c.800 m to at least 1600 m. [Syns. *Iris sisyrinchium*, *Gynandriris sisyrinchium*] *Fig. 5.4.21*. See also *Fig. 3.2.1*.

LILIACEAE

Aloe vera L.

Rare. In or near active or abandoned cultivation. Up to c.1600 m.

Asphodelus tenuifolius Cav.

Common. All elevations, after rain. [Syn. *Asphodelus fistulosis* L. var *tenuifolius* (Cav.) Baker] *Fig. 3.3.7.*

Bellevalia sp. aff. *longipes* Post* **

Rare. Single location within fenced field at 1000 m. ID by L. Boulos. *Fig. 5.1.4.*

Leopoldia longipes (Boiss.) Losinsk.*

Locally common above c.700 m, to c.1500 m. On silt in abandoned fields. ID by L. Boulos. [Syn. *Muscari longipes* Boiss.]

ORCHIDACEAE

Epipactis veratrifolia Boiss. & Hohen

Rare. Single location at spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal. Occasional in Hajar Mtns near springs and seeps, typically among *Adiantum capillus-veneris*.

POACEAE

Aegilops kotschyi Boiss.* **

Locally common in southern Ru'us al-Jibal. On rocky slopes, 1200-1350 m. ID by T.A. Cope. *Fig. 5.1.2.*

Aristida abnormis Chiov.

Locally common. All elevations to at least c.1350 m. Silt in wadi bed or banks or on open slopes among rocks. Sympatric with the similar *A. adscensionis* but more delicate. ID by H. Scholz and per Cope (2007). Common in Hajar Mtns.

Aristida adscensionis L.

Common. From c.100 m to at least c.1400 m. ID per Boulos (FoE). [Note: This is a drought resistant species found at all elevations on rocky slopes and in grasslands in Yemen (Deil 1998).]

Arundo donax L.

Rare. Single locality at spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal. Common in Hajar Mtns near permanent surface water.

Avena barbata Patt. ex Link

Rare. Up to c.1500 m. Two sites: (1) c.900 m among bedrock on ridge, c.0.2 km above cultivation; (2) c.1500 m along donkey trail, c.5.0 km from extensive cultivation. ID by L. Boulos. Also recorded from N Oman in association with cultivation. *Fig. 5.3.5*.

Brachiaria reptans (L.) C.A. Gardner & C.E. Hubb. [Jongbloed (2003)]

"Uncommon" in Ru'us al-Jibal, per Western (1989).

Brachypodium distachyum (L.) P. Beauv.

Locally common. All elevations to at least c.1450 m. *Fig. 5.4.4*.

Bromus danthoniae Trin.*

Rare but possibly overlooked. Open slopes at high elevation. Several widespread records at 1250-1400 m (ID by L. Boulos), also by Mandaville at 2000 m (summit of J. Harim). *Fig. 5.3.6*.

Bromus fasciculatus C. Presl.

Rare but possibly overlooked. Open slopes at high elevation. Several widespread records at c.1250-1650 m. ID by H. Scholz. Also recorded from N Oman (Ghazanfar 1992a). *Fig. 5.3.7*.

Bromus madritensis L. [Jongbloed (2003)]

Occasional. Scattered locations including abandoned fields.

Cenchrus ciliaris L.

Occasional. Up to at least c.1350 m. ID by L. Boulos. [Note: This is a drought resistant species found at all elevations on rocky slopes and in grasslands in Yemen (Deil 1998).]

Cenchrus pennisetiformis Hochst. & Steud. [per Jongbloed (2003)]

Rare, but possibly overlooked due to similarity with *C. ciliaris*. Ruderal. Coastal and low elevation records by Mandaville. Also collected by Braund (Ghazanfar 1992a). Presence in Ru'us al-Jibal (as defined here) is inferred from distribution shown in Jongbloed (2003), where it is depicted as not common but widespread in northern UAE, including Hajar Mtns.

Cymbopogon commutatus (Steud.) Stapf [Western (1989)]

Common. Up to at least 900 m. [Syn. *C. parkeri*] [Note: *Cymbopogon* spp. are common at all elevations and are often co-dominant at higher elevations. Individual *Cymbopogon* species were not generally distinguished by the author in the field. All high elevation specimens collected by the author from the Ru'us al-Jibal and the Jebel Akhdar and submitted for determination have been identified by L. Boulos as *C. jwarancusa*. The other two species listed here represent records published by others. Jongbloed (2003) describes *C. commutatus* and *C. schoenanthus* as common and widespread in the Hajar Mtns but neither Jongbloed nor Western (1989) indicate that those species have been positively identified from the Ru'us al-Jibal. The bent awn of *C. jwarancusa* could possibly result in confusion with *C. commutatus*. The high elevation reports of *C. schoenanthus* by Mandaville (1985) appear to represent field IDs and could therefore reflect confusion with *C. jwarancusa*, which has subsequently been determined from the same area. However, the author has collected *Cymbopogon* sp. with straight awns from the southern Ru'us al-Jibal at elevations up to at least 1300 m; expert determination is pending.]

Cymbopogon jwarancusa (Jones) Schult. subsp. *olivieri* (Boiss.) Soenarko

Common. Medium and high elevation. Co-dominant at high elevation, above c.1200 m. ID by L. Boulos. Visual predominance greatly reduced during turn-of-the-century drought. [See note under *C. commutatus*.] *Figs. 5.3.10* and *5.4.7*. See also *Figs. 3.1.1, 3.1.8, 3.1.9, 3.1.11, 3.1.17, 3.1.18* and *4.1.11*.

Cymbopogon schoenanthus (L.) Spreng. [Mandaville (1985)]

Recorded by Mandaville on slopes to 1900 m and as a "weed" at Birkat al-Khalidiyah, c.200 m. *Cymbopogon* sp. with straight awns is found in S Ru'us al-Jibal up to at least 1300 m; expert determination is pending. [See note under *C. commutatus*.]

Cynodon dactylon (L.) Pers.

Occasional, typically as weed of cultivation.

Dichanthium annulatum (Forrsk.) Stapf [per Jongbloed (2003)]

Not recorded, but presence in Ru'us al-Jibal is inferred from distribution shown in Jongbloed (2003). Not common but widespread in northern UAE, including Hajar Mtns.

Elionurus royleanus Nees ex A. Rich [Ghazanfar (1992a)]

Rare. Collected by Leane. Habitat described in Boulos (FoE) as "rocky ground".

Enneapogon desvauxii P. Beauv.

Rare, but probably overlooked. Single location in wadi gravel beside vehicle track in Wadi Bih, c.250 m. ID by H. Scholz. Locally common in Hajar Mtns. *Fig. 5.3.11*.

Enneapogon persicus Boiss.

Rare, but possibly overlooked. Two localities on plateaux at 1100-1450 m. ID by L. Boulos. Also occasional in N. Oman.

Eragrostis barrelieri Daveau

Locally common. To at least 400 m. ID and additional records by G.M. Brown. Common in lower Hajar Mtns and adjacent gravel plains.

Eragrostis cilianenis (All.) Vign.

Occasional. To at least 400 m. ID and additional records by G.M. Brown. Occasional in Hajar Mtns. *Fig. 5.3.12*.

Eragrostis ciliaris (L.) R. Br.

Rare, but possibly overlooked. Single location among rocks at edge of abandoned field on wadi bank. Also recorded by Mandaville from Birkat al-Khalidiyah. ID per Boulos (FoE). *Fig. 5.3.13*.

Gastridium phleoides (Nees & Meyen) C.E. Hubb.*

Locally common after winter rains. Slopes with soil and rock to at least 1500 m, sometimes among other annuals. ID by H. Scholz and per Boulos (FoE) and Cope (2007). Also recorded from UAE, Wadi Bih by Böer & Chaudhary, and from "Musandam" by Braund (Ghazanfar 1992a). Single record from Hajar Mtns, but possibly overlooked. *Fig. 5.3.17*.

Hyparrhenia hirta (L.) Stapf

Locally common. Favours wadis and wadi banks. Up to at least 1650 m. Locally common in Hajar Mtns. [Note: This is a drought resistant species found at all elevations on rocky slopes and in grasslands in Yemen (Deil 1998).]

Lamarckia aurea (L.) Moench.*

Rare, but possibly overlooked. Recorded from c.800-1350 m. Wadi beds, disturbed ground. ID by G.M. Brown. *Fig. 5.3.24*.

Pennisetum orientale Rich.

Rare. Single locality at spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal. ID by H. Scholz. Also rare in Hajar Mtns. [Syn. *P. setaceum*] Specimens from same site ID'd by Mandaville (1985) as *P. divisum* (J.F. Gmel.) Henrard, which is very common on sand flats in UAE. *Fig. 5.3.28*.

Phalaris minor Retz. [Jongbloed (2003)]

Occasional. Locally common in terraced fields, per Jongbloed (2003).

Piptatherum holciforme (M. Beib.) Roem. & Schult*

Locally common in southern Ru'us al-Jibal. Typically among boulders in vegetated wadis, rare on slopes or cliffs, 300-1450 m. ID by T.A. Cope. [Syn. *Oryzopsis holciformis* (M. Beib.) Haeckel]

Poa bulbosa L. *s.lat.* * **

Rare, but possibly overlooked. Single location among rocks at field margin, 1250 m. ID by H. Scholz. Very similar to *P. sinaica*. *Fig. 5.1.12*.

Poa sinaica Steud.* [Jongbloed (2003)]
Rare, but possibly overlooked. Recorded from UAE, Wadi Bih, by Böer & Chaudhary. Possible but undeterminable specimens from c.1300 m. Very similar to *P. bulbosa*. *Fig. 5.3.30*.

Poa sp. aff. *asirensis* Cope* **
Occasional. Three photographic records from sites throughout the Ru'us al-Jibal at 800-1500 m. H. Scholz has suggested affinity with *P. asirensis*, itself poorly known (Cope 2007), on the basis of short pedicels and congested spikelets. *Fig. 5.1.13*.

Polypogon monspeliensis (L.) Desf.
Rare, but probably overlooked. Single record from spring near Aqabat Oso. ID by T.A. Cope. Also recorded by Mandaville as a "weed" at Khasab. Locally common in Hajar Mtns.

Rostraria cristata (L.) Tzvelev
Rare. Single location near spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal. ID by H. Scholz. Also recorded by Mandaville (1985) from 'Ayn as-Sih, isthmus and Birkat al-Khalidiyah. Single Hajar Mtn record from Diftah oasis (Jongbloed 2003).

Rostraria pumila (Desf.) Tzvelev
Locally common. Terraced fields and waste ground to at least c.1000 m. ID by G.M. Brown. Recorded by Mandaville at Khasab and Birkat al-Khalidiyah as a ruderal. Found on sand flats in UAE (Jongbloed 2003).

Schismus barbatus (L.) Thell.
Rare. Two peri-anthropic localities at c.1000-1150 m. ID by G.M. Brown.

Stipa capensis Thunb.
Common. Up to c.1500 m. Locally hyperabundant, esp. as ruderal. ID by L. Boulos.

Stipa mandavillei Freitag [Cope (2007)]
Rare. High elevation. Rocky slopes. Endemic to Jebel Akhdar, Ru'us al-Jibal and possibly Dhofar.

Stipa parviflora Desf.* **
Single record, but possibly overlooked. Open slope at high elevation. ID by H. Scholz. *Fig. 5.1.15*.

Stipagrostis plumosa (L.) Munro ex T. Anders. [Jongbloed (2003)]
Generally common and widespread in UAE (and in Arabia generally) but less so in mountains, per Jongbloed (2003). However, the subsequent recognition of *S. raddiana* at high elevations makes it possible that field identifications of the two species have previously been conflated.

Stipagrostis raddiana (Savi) De Winter
Locally common at higher elevation. Open plateaux and hillsides. ID by H. Scholz. The morphology is closest to what is depicted in Boulos (FoE) and Cope (2007) as *S. paradisea,* now synonymised by Ghasemkhani *et al*. (2008). Also recorded from N. Oman (Ghazanfar 1992a) and S. Iran (Ghasemkhani *et al*. 2008). [Syn. *Stipagrostis paradisea* (Edgew.) De Winter] [Note: As many as thirteen *Stipagrostis* spp. have been recorded from the UAE, neighbouring Oman and S. Iran (Ghazanfar 1992a, Jongbloed 2003, Karim & Fawzi 2007, Ghasemkhani *et al*. 2008). Several of these are found in gravel, rocky or mountain habitats in the circum-Arabian area and could also be present in the Ru'us al-Jibal.] *Fig. 5.3.34*.

Tetrapogon villosus Desf.
Locally common. Up to at least 1450 m. ID by G.M. Brown, H. Scholz and per Boulos (FoE). Common at low elevations in Hajar Mtns. *T. villosus* is recognised as a species that can survive heavy grazing pressure and tolerate defoliation in combination with water stress (Deil & Al-Gifri, 1998).

Tricholaena teneriffae (L.f.) Link
Locally common. Favours gravel wadis. To at least 1450 m. ID by G.M. Brown. Common in wadis at low to medium elevations in Hajar Mtns.

Poaceae sp. 1
Rare. Single photographic record. Slope at 1200 m. Erect stem; leaves narrowly linear, ribbed; spikelets clustered in evenly spaced axils; all parts finely bristled. Pending expert determination, it is not treated here as a species restricted to the Ru'us al-Jibal or new to Eastern Arabia. *Fig. 5.2.1*.

Poaceae sp. 2
Rare. Single photographic record of dry plant past seed. Stem erect, woody, with sessile capsules, 4-5 segmented, persistent, sub-round, at evenly spaced intervals, each flanked by two dry, blade-like bracts. Pending expert determination, it is not treated here as a species restricted to the Ru'us al-Jibal or new to Eastern Arabia. *Fig. 5.2.2.*

The following additional Poaceae species have been recorded from the Musandam region but are not confirmed to have been recorded from the Ru'us al-Jibal as defined for purposes of this Checklist. However, based on the habitat and distribution as stated in the relevant references, it is not unreasonable to expect that they might occur in the Ru'us al-Jibal. Accordingly, they are mentioned here for the sake of completeness but have been disregarded in compiling the statistics presented in the accompanying paper.

Chloris barbata Sw. [Ghazanfar (1992a)]
Coll'd by Braund (Ghazanfar 1992a). Elevation per Cope (2007): 0-1050 m. Common in Western Hajar Mtns.

Dactyloctenium aegyptium (L.) P.Beauv. [Ghazanfar (1992a)]
Collected by Braund. Also collected by JPM at Khasab, weed. Elevation per Cope (2007): 0-1500 m.

Dichanthium foveolatum (Delile) Roberty [Mandaville (1985)]
Jazirat al-Ghanem, c.20 m. Common in UAE on sand and offshore islands. Elevation per Cope (2007): 0-1700 m.

Digitaria nodosa Parl. [Mandaville (1985)]
Jazirat al-Ghanem, c.20 m. Also at low to medium elevations in Hajar Mtns.

Eragrostis minor Host [Mandaville (1985)]
Birkat al-Khalidiyah, Khasab, ruderal.

Melanocenchris abyssinica (R. Br. Ex Fresen.) Hochst. [Cope (2007)]
Single record. Elevation per Cope (2007): 150-1050 m.

Phalaris paradoxa L.* [Cope (2007)]
Single record. Elevation per Cope (2007): 0-2400 m.
Schismus arabicus Nees [Mandaville (1985)]
Birkat al-Khalidiyah. Elevation per Cope (2007): 0-900 m.
Tragus berteronianus Schult. [Mandaville (1985)]
Birkat al-Khalidiyah. Elevation per Cope (2007): 0-1700 m. Common in Eastern Hajar Mtns.

ANGIOSPERMAE: EUDICOTYLEDONAE

ACANTHACEAE
Blepharis ciliaris L.
Occasional. Up to c.1500 m, more common at low-medium elevations. [Syn. *B. edulis* (Forssk.) Oers]
Justicia heterocarpa T. Anderson* [Jongbloed (2003)]
Rare. Single location along mountain front N of Ra's al-Khaimah.

AIZOACEAE
Aizoon canariense L.
Locally common. SW Ru'us al-Jibal at low elevation, below c.400 m. Also upper W. Khabb Shamsi to 600 m+. *Fig. 3.3.8.*

AMARANTHACEAE
Aerva javanica (Burm.f.) Juss. ex Schult.
Rare. On disturbed ground, usually near cultivation. Locally common in Hajar Mtns.
Pupalia lappacea (L.) Juss. var. *velutina* (Moq.) Hook. f.
Rare. Few scattered records from west flank of Musandam, to c.750 m. ID per Collenette (1985), Miller & Cope (1996) and Boulos (1999). Plants at one remote location have persisted over 15 years at a shaded site in a deep, narrow tributary wadi, on thin soil and rubble over bedrock, near abandoned stone dwellings. Not recorded between Musandam and Batinah coast of Oman (c.200 km), where it is found as a ruderal (Ghazanfar 2003). *Fig. 5.3.32.*

ANACARDIACEAE
Pistacia khinjuk Stocks.*
Rare. Single locality, ca. 20 scattered trees on sheltered cliffs along c. 2 km of a single rugged wadi at 350-450 m. ID by L. Boulos. Common on western slopes of central Zagros mountains, at elevations from c.750-1250 m (Zohary 1963).

APIACEAE (formerly UMBELLIFERAE)
Ammi majus L.
Locally common to hyperabundant. Silt in wadis, slopes, gravel terraces and fallow fields, to at least c.1250 m. ID by L. Boulos.
Daucus subsessilis Boiss.* [Jongbloed (2003)]
Rare. Single record of this wild carrot from UAE, Wadi Bih, by Böer & Chaudhary.
Ducrosia anethifolia (DC.) Boiss.
Rare. Scattered localities at 250-1550 m in S and Central Ru'us al-Jibal. ID by L. Boulos.
Pimpinella sp. [Ghazanfar (2007)]
[Note: *Pimpinella etbaica* Schweinf. is recorded by Ghazanfar (2007) from the west coast of the Musandam. Western (1989) recorded *P. eriocarpa* Banks & Sol. as uncommon in the Musandam (although Jongbloed (2003) considers it at least locally common in Hajar Mtn wadis) but *P. eriocarpa* is not mentioned by Ghazanfar (1992a, 2007). Apart from the uncertainty as to nomenclature, it is not clear that any of the records is from a site within the Ru'us al-Jibal as defined for purposes of the Checklist. Thus the possible presence of *Pimpinella* sp. is mentioned here for the sake of completeness but has been disregarded in compiling the statistics presented in the accompanying paper.]
Pycnocycla caespitosa Boiss & Hausskn.
Occasional. From c.500-1550 m. On silt among boulders. Grazed. Rare at higher elevation in Hatta area of Hajar Mtns.
Scandix pecten-veneris L.*
Locally common. Plantation and wadi environments, medium elevation.
Torilis leptophylla (L.) Reichenb. f.*
Single record from E Ru'us al-Jibal, <500 m. ID by I.R. Curtis. [Note: *Torilis* specimens from several other areas of the the Ru'us al-Jibal have been ID'd as *T. nodosa*. Plants at another East Coast location also appear to be *T. nodosa*, but the author's field discrimination between *Torilis* spp. cannot be considered authoritative. The single record of *T. leptophylla* is mentioned here for the sake of completeness but has been disregarded in compiling the statistics presented in the accompanying paper.]
Torilis nodosa (L.) Gaertn.*
Locally common. Wadi and peri-agricultural environments, up to at least 1000 m. ID by L. Boulos. See also *T. leptophylla*.
Torilis stocksiana (Boiss.) Drude* [Mandaville (1985)]
Single record by Mandaville above Birkat al-Khalidiyah, 200 m, N Ru'us al-Jibal. [Note: Ghazanfar (2007) records *T. stocksiana* as the only *Torilis* species collected in N Oman, from Jebel Akhdar, and identifies it as a species of moist, cultivated and irrigated locations. The single record from Birkat al-Khalidiyah (a site otherwise excluded) is therefore mentioned here for the sake of completeness but has been disregarded in compiling the statistics presented in the accompanying paper.]

APOCYNACEAE
Nerium oleander L.
Rare. Single location at spring, 'Ayn as-Sih, 470 m, N Ru'us al-Jibal. [Syn. *N. mascatense* DC]
Rhazya stricta Decne.
Rare. Generally absent, but common in lower Wadi Khabb, S Ru'us al-Jibal, in wadi and on adjacent terraces, c.200-300 m, where it is indicative of severe overgrazing. *Fig. 6.1.10.*

ASCLEPIADACEAE
Calotropis procera (Aiton) W.T. Aiton
Rare. Isolated specimens only, in wadi silt, to c.1000 m. Not a mountain species. Rare in Hajar Mtns, too.
Desmidorchis arabica (N.E. Br.) Meve & Liede
Occasional. Moderate elevations. Endemic to the mountains of the UAE and Northern Oman. [Syn. *Caralluma arabica* N.E. Br.]

Glossonema varians (Stocks) Benth.
Rare. Up to 1900 m.

Pergularia tomentosa L.
Rare. Low-medium elevations. SE Ru'us al-Jibal only. Favours disturbed ground.

Periploca aphylla Decne.
Common. Above c.500 m. Favours rock ledges. Often grazed. Seedling erect and turgid with opposite leaves, does not closely resemble the mature plant. Occasional in Hajar Mtns. *Fig. 5.5.12.*

ASTERACEAE (formerly COMPOSITAE)

Anthemis odontostephana Boiss.*
Locally common. All elevations. Single record (Karim 2002) from Hajar Mtns to the S, but recorded by Mandaville (1977) from Jebel Aswad in the Eastern Hajar Mtns, SE of Muscat, c.430 km distant.

Artemisia cf. *olivieri* J.Gay & Besser.* [Jongbloed *et al*. (2000)]
Single record from UAE, Wadi Bih, by Böer & Chaudhary. Pending confirmation, it is mentioned here for the sake of completeness but has been disregarded in compiling the statistics presented in the accompanying paper.

Artemisia sieberi Besser*
Common. Above c.900 m, increasing above 1000 m. Favours areas of alluvial or colluvial soil cover. Co-dominant at high elevations, c.1200 m+, but greatly reduced by turn-of-the-century drought. A principal component of "*Artemisia steppe*." [Syn. *Seriphidium sieberi* (Besser) Bremer & Humphries] [Note: This is the species identified in most earlier Arabian literature as *Artemisia herba-alba Asso* or *Seriphidium herba-alba* (Asso) Soják. It was once thought to be a phenotypically plastic species with a widespread distribution from the Mediterranean to Iran, but, as understood today, it is limited to the westernmost Mediterranean area (N. Kilian, *pers. comm*.). Kilian also considers that phylogenetic analyses of DNA markers supports the inclusion of *Seriphidium* within *Artemisia*.] *Fig. 5.4.1.* See also *Figs. 3.1.6, 3.1.12, 3.1.13, 3.1.19, 3.1.22, 3.2.1* and *3.3.1*.

Atractylis cancellata L.
Rare. Up to at least 1600 m.

Calendula arvensis L.
Occasional. In silt and fallow fields to 1200 m+.

Carduus pycnocephalus L.*
Rare. Ruderal, c.250 m to at least 1200 m. ID by M. Jongbloed. [Syn. *Carduus arabicus* Jacq. Ex Murray]

Centaurea wendelboi Wagen.*
Locally common. Bedrock outcrops and steep gullies. Above c.1000 m. *Fig. 5.4.5*. See also *Fig. 3.3.1*.

Cichorium intybus L.
Single record from N Ru'us al-Jibal, c.1350 m (Kilian, *pers comm*.) Also recorded on plains W of Ru'us al-Jibal.

Crepis kotschyana Boiss. **
Rare, but possibly overlooked. Silt among rocks. 250-1350 m. ID by N. Kilian. Otherwise known from southern Iran. [Note: Western recorded *Crepis* sp. as locally common in the Ru'us al-Jibal (Jongbloed *et al*. 2001). Kilian believes material determined as *C. foetida*, collected by Radcliffe-Smith from near Khasab (at c.100 m elevation) (Ghazanfar 1992a), by Western from near Masafi in the northern Hajar Mtns and by Whitcombe from Jebel Akhdar is *C. kotschyana*. Plants observed and collected by the author are not foetid. *C. micranthus* has been recorded by Karim from Masafi in the northern Hajar Mtns (Karim & Fawzi 2007).] *Fig. 5.1.6*.

Cymbolaena griffithii (A.Gray) Wagenitz* [Jongbloed *et al*. (2000)]
Rare. Two records, by Braund (Ghazanfar 1992a) and Western (Jongbloed *et al*. 2000). Similar in appearance to local *Filago* spp.

Echinops atrox Kit Tan* [N. Kilian, *pers. comm*.]
Rare. A collection by M. Gallagher from 'Ayn as-Sih, a unique site within the Ru'us al-Jibal, constitutes the holotype for this species. Two additional records exist from Dhofar. The determination is preliminary as the taxonomy of this genus is currently undergoing revision (N. Kilian, *pers. comm*.).

Echinops erinaceus Kit Tan
Occasional. To 1900 m+. Often on talus or scree. Endemic to the Hajar Mtns. The determination is preliminary as the taxonomy of this genus is currently undergoing revision (N. Kilian, *pers. comm*.).

Eclipta prostrata (L.) (L.)
Single location at improved hillside spring adjacent to small terraced plantation, c.750 m, with *Adiantum capillus-veneris*.

Filago desertorum Pomel
Occasional and widespread. From silt at Birkat al-Khalidiyah (Mandaville) up to high elevations. ID by L. Boulos. See *Fig. 3.3.6.*

Filago pyramidata L.
Rare, but possibly not always distinguished from *F. desertorum* (*F. pyramidata* is short but erect). ID by L. Boulos (Jongbloed 2003); provisional photo ID by N. Kilian. Also recorded from Northern Oman in fields and waste ground (Ghazanfar 1992a). *Fig. 5.3.16.*

Garhadiolus hedypnois Jaub. & Spach * **
Rare. High elevation. Few specimens from fields, gravel terraces, and stony slopes at 1150-1500 m in northern Ru'us al-Jibal. ID by L. Boulos (as *Hedypnois rhagadioloides*) and N. Kilian. Kilian mentions that this species was collected from the same area by Radcliffe-Smith in 1976, but the record was never published. [Syns. *Garhadiolus angulosus* Jaub. & Spach, *Hedypnois rhagadioloides* (L.) F.W. Schmidt] *Fig. 5.1.7.*

Helichrysum glumaceum DC.
Occasional. c.800 m and above. Plateaux and slopes among rocks. [Note: *H. makranicum* (Rech f. & Esfand.) Rech. f. has been recorded from the Ru'us al-Jibal and the Hajar Mtns but N. Kilian (*pers. comm*.) considers *H. makranicum* to be synonymous with *H. glumaceum*. Kilian's view is consistent with the author's field observations, which do not permit consistent discrimination between two species.]

Helichrysum luteoalbum (L.) Rchb. [Ghazanfar (1992a)]
Rare. Single record from open plateau with

abandoned cultivation, 1450 m. Ghazanfar states typical habitat as moist areas in date plantations. A cosmopolitan weed. [Syns. *Pseudognaphalium luteoalbum* (L.) Hilliard & Burtt; *Gnaphalium luteoalbum* L.]

Ifloga spicata (Forssk.) Sch. Bip.
Rare, but easily overlooked. Single location, tributary of Wadi Bih, c. 250 m, in silt beside wadi. Common in Hajar Mtns.

Iphiona scabra Decne.
Rare. Southernmost Ru'us al-Jibal only. Up to c.700 m. Common in Hajar Mtns. *Fig. 6.1.6*.

Jurinea berardioides (Boiss.) O. Hoffm.*
Occasional. Above c.900 m. ID by I.R. Curtis. [Syn. *Aegopordon berardioides* Boiss.] *Fig. 5.4.19.*

Jurinea carduiformis (Jaub. & Spach) Boiss.*
Rare. Occasional in wet years, c.1100-1700 m+. Generally on stony plateaux but control by grazing inferred from presence of multiple scattered plants in fenced field at 1550 m. Typically prostrate but may grow as a stalked plant after good rain and/or within protective vegetation. [Syn. *Outreya carduiformis* Jaub. & Spach] *Fig. 5.3.22.*

Koelpinia linearis Pall.
Rare, but possibly overlooked. Few specimens from along trail to NE of As-Saye, on gravel terrace at c.1200 m and silt among rocks at 1600 m. Also rare in Hajar Mtns. All records known to the author are from carbonate rocks, not ophiolite.

Lactuca dissecta D. Don*
Locally common. Single locality, in silt beside gravel wadi. ID by L. Boulos. Also recorded by Mandaville at Birkat al-Khalidiyah.

Lactuca orientalis (Boiss.) Boiss.* **
Occasional, 500-1900 m. In silt among rocks, including field margins and wadi beds. ID by Norbert Kilian. [Syn. *Scariola orientalis* (Boiss.) Soják] *Fig. 5.1.8.*

Lasiopogon muscoides (Desf.) DC. [Jongbloed *et al*. (2000)]
The record in Jongbloed *et al*. (2000) (from "high mountains") is now considered uncertain and no reliable record is known from the Ru'us al-Jibal (M. Jongbloed *pers. comm*., N. Kilian *pers. comm*.). Accordingly, *L. muscoides* is mentioned here for the sake of completeness but has been disregarded in compiling the statistics presented in the accompanying paper. *L. muscoides* is similar in appearance to *Filago* spp. and *Cymbolaena griffithii*.

Launaea bornmuelleri (Hausskn. ex Bornm.) Bornm.
Common. Above c.700 m. Global range is from Strait of Hormuz across Eastern Arabia and the Hadramaut to Somalia (N. Kilian, *pers. comm*.). [Note: This is the species identified in most earlier eastern Arabian literature as *Launaea spinosa* (Forssk.) Sch. Bip. but N. Kilian (*pers. comm*.) advises that '*Launaea spinosa*' of Oman and UAE is actually *L. bornmuelleri* . . , a common mistake in the literature. The true *L. spinosa* is only superficially similar and is restricted to the northern coastal mountains of the Red Sea."] *Fig. 5.4.20.*

Launaea capitata (Spreng.) Dandy
Occasional. Up to c.1000 m, usually on silt.

Launaea massauensis (Fresen.) Sch. Bip. ex Kuntze
Occasional. Wadi environment or among rocks, up to c.1000 m.

Launaea procumbens (Roxb.) Ramayya & Rajogopal [Jongbloed (2003)]
Rare. Weed of irrigated fields and gardens.

Matricaria aurea (Loefl.) Sch. Bip.*
Locally common. Plateaux and fields in central Ru'us al-Jibal. *Fig. 3.3.5.*

Notobasis syriaca (L.) Cass.* **
Rare. Single record. Upper wadi at 1100 m. ID by Nael Fawzi and per Boulos (FoE). [Syn. *Cirsium syriacum* (L.) Gaertn.] *Fig. 5.1.11.*

Pallenis hierochuntica (Michon) Greuter
Locally common. Up to c.1550 m. [Syns. *Asteriscus hierochunticus* (Michon) Wiklund; *Asteriscus pygmaeus* (DC.) Coss. & Durieu]

Pentanema divaricatum Cass.
Locally common to hyperabundant. Weed in abandoned fields, slopes. c.150-1600 m.

Phagnalon schweinfurthii Schultz Bip. ex Schweinf.
Occasional. c.700-1900 m+. Distinctive where well developed, but often heavily grazed and limited to stunted specimens in protected cracks or silty crannies among rocks, e.g., in area of J. Harim and J. Jais (J. Bil Ays). Occasional at medium to high elevations in Hajar Mtns, including Jebel Akhdar. [Syns. *P. viridifolium* Decne. ex Boiss.; *Phagnalon schweinfurthii* Schultz Bip. ex Schweinf. var. *androssovii* (B. Fedtsch.) Qaiser & Lack] [Note: Mandaville (1985) and others have recorded *P. viridifolium* from the Ru'us al-Jibal and the Hajar Mtns to the south, including the Jebel Akhdar. However, after review of museum specimen N. Kilian (*pers. comm*.) considers all UAE and Northern Oman records to be a single species, *P. schweinfurthii*. Kilian's view is consistent with the author's field observations, which do not permit consistent discrimination between two species. *Fig. 5.4.22*.

Pulicaria edmondsonii Gamal-Eldin
Locally common. Low to moderate elevations, c.150-1200 m, exceptionally to 1500 m in E Ru'us al-Jibal. Endemic to the mountains of the UAE and Northern Oman. *Fig. 5.4.23*.

Pulicaria glutinosa (Boiss.) Jaub. & Spach subsp. *glutinosa*
Rare. S Ru'us al-Jibal only. Up to 500 m. Common in Hajar Mtns. *Fig. 6.1.9.*

Pulicaria undulata (L.) C.A. Meyer ssp. *undulata*
Locally common. In fallow or abandoned fields up to at least 1000 m. [Syns. *P. crispa* (Forssk.) Oliv. ssp. crispa; *Francoeuria crispa* (Forssk.) Cass. ssp. *crispa*]

Reichardia tingitana (L.) Roth
Locally common. All elevations. See *Fig. 3.3.8.*

Senecio breviflorus (Kadereit) Greuter
Rare. Low elevation. Gravel wadis, rocky slopes. Common in Hajar Mtns. [Syn. *Senecio flavus* ssp. *breviflorus* Kadereit] [Note: This species has previously been confused with *Senecio flavus* (Decne.) Sch. Bip., a Mediteranean species (N. Kilian, *pers. comm*.); see, e.g., Jongbloed (2003).]

Senecio glaucus L. subsp. *coronopifolius* (Maire) C. Alexander

Locally common. Opportunistic. Gravel wadis at 250 m to rocky plateaux at 1200-1500 m. Rare in Hajar Mtns.

Sonchus oleraceus L.

Occasional. All elevations to at least 1550 m. Often grows through protective shrubs.

Tripteris vaillantii Decne. [Jongbloed (2003)]

[Syn. *Osteospermum vaillantii* (Decne.) T. Norl.] [Note: The single record of this species in the Ru'us al-Jibal is a high elevation collection attributed to C. Lehmann and deposited with the herbarium at the Sharjah Natural History Museum as SDP558 (Jongbloed *et al*. 2000). The source of the determination is unknown and the specimen could not be located in 2009. However, a photograph by Lehmann, labeled by Jongbloed as *Osteospermum vaillantii*, shows instead *Reichardia tingitana* var. *arabica* (N. Kilian, *pers. comm.*; cf. Collenette (1985) at p. 163), casting doubt on the original determination. Accordingly, *T. vaillantii* is mentioned here for the sake of completeness but has been disregarded in compiling the statistics presented in the accompanying paper. *T. vaillantii* is absent from most of the Hajar Mtns to the south of the Ru'us al-Jibal and is rare in the Jebel Akhdar, but can be locally common at all elevations in the Eastern Hajar Mtns (Mandaville & Bovey 1978, T. Harrison *pers. comm*. 2010).] *Fig. 5.3.36.*

Urospermum picroides (L.) F.W. Schmidt

Occasional to more than 1000 m. Gravel wadis.

Vernonia arabica F.G. Davies

Occasional. Low to moderate elevation. c.150-950 m, exceptionally to c.1250 m in S and E Ru'us al-Jibal. *Fig. 5.4.25*.

Zoegea purpurea Fresen.

Common. Up to c.1700 m+.

BERBERIDACEAE

Leontice leontopetalum L.* **

Rare. Single locality in silt of abandoned fields at 1500-1600 m. ID by L. Boulos. *Fig. 5.1.9*. See also *Figs. 1.3.2 and 3.2.1*.

BIGNONIACEAE

Tecomella undulata (Roxb.) Seem

Rare. Single location, introduced grove at town of Limah on Gulf of Oman.

BORAGINACEAE

Anchusa aegyptiaca (L.) DC.

Rare. Single specimen beside gravel wadi at Sal Dhayah, a terraced bowl, c.425 m. Occasional in Hajar Mtns.

Anchusa hispida Forssk.

Rare. Flat, disturbed ground from 700 m to at least 1250 m. [Syn. *Gastrocotyle hispida* (Forssk.) Bunge]

Arnebia decumbens (Vent.) Coss. & Kralik

Locally common. Plateaux at 500-1600 m. ID by L. Boulos. Rare in Al-Ain/Buraimi area. *Fig. 5.3.3.*

Arnebia hispidissima (Lehm.) DC.

Locally common in SW Ru'us al-Jibal only. Low elevation, below c.300 m. [Caveat: Possible field misidentification of *A. decumbens*.]

Asperugo procumbens L.* **

Locally hyperabundant. Weed of cultivated and fallow fields and nearby mesic sites at higher elevations. Four locations at 1000-1550 m. ID per Collenette (1985) and Boulos (2000). Single N. Oman record at Wakkan in Ghubrah bowl, c.1500 m, peri-agricultural. *Fig. 5.1.3.* See also *Fig. 3.2.2.*

Cordia sp. aff. *quercifolia* Klotzsch*

Rare. Single locality, few plants as cliff dwellers on S facing slopes at c.500 m in the western Ru'us al-Jibal. Sampling required rock climbing, courtesy of Dee McEnery and Barbara Couldrey. Original ID by L. Boulos as *C. sinensis* Lam. Ghazanfar (*in press*) has proposed that these plants are more likely *C. quercifolia* or *C. crenata* Delile subsp. *crenata*. Specimens are consistent with the description of *C. quercifolia* by Ghazanfar (*in press*), particularly the finely reticulate venation, and they lack what is said to be the distinguishing feature of *C. sinensis*, i.e., the presence of tufts of hairs in the axils along the midrib of the leaf undersurface. [Note: These large shrubs, originally conspicuous, died back substantially during the extreme drought of 1999-2004 and could not be found in mid-2008, but at least the largest specimen was observed again in early 2010, following two winters with above average rain. (B. Couldrey, *pers comm.*)] *Fig. 5.5.5.*

Echiochilon persicum (Burm. f.) I.M. Johnst.

Occasional, c.800-1250 m. [Syn. *E. thesigeri*, per Ghazanfar (*in press*)]. [Note: The Hajar Mtn species identified and depicted in Jongbloed (2003) as *E. thesigeri* corresponds best to the description given by Ghazanfar (*in press*) for *E. callianthum* Lönn.]

Ehretia obtusifolia Hochst. ex DC.

Rare. Single locality, as cliff dweller in gorge of W. Khabb Shamsi at c.275 m. Locally common at a small number of localities above c.800 m in Hajar Mtns.

Heliotropium bacciferum Forssk.

Locally common at moderate to high elevation (c.500-1250 m) on silty ground, including fallow or abandoned fields. IDs by L. Boulos. Single additional UAE/Oman record from Qarn Nazwa, a rocky hill in the Dubai-Sharjah desert. [Note: Jongbloed (2003) correctly distinguishes the montane species in question from *H. kotschyi* (Bge.) Gürke, the most common *Heliotropium* in the UAE (Western 1989), which is found in coastal regions and on sand and silt plains inland, including fallow agricultural plots. Confusion has nevertheless arisen because Mandaville (1990) had synonymised *H. kotschyi* with *H. bacciferum* and his usage was reprised in Brown & Böer (2005b), wherein *H. kotschyi* is discussed as "*H. bacciferum*". Brown has subsequently confirmed that to the north, in Saudi Arabia, Qatar and Kuwait, both species can be found along the Arabian Gulf coast (G.M. Brown, *pers. comm.*). The definitive nomenclature remains uncertain, however, since the type specimen of *H. bacciferum* is from south-western Arabia, and may therefore prove distinct from all of the East Arabian species (Brown *et al.* 2007). Boulos (2000, FoE vol. 2) mentions that *H.*

fartakense, also of south-western Arabia, has been considered a subspecies of *H. bacciferum*. The author is acquainted with *H. fartakense* and considers that it cannot belong to the same species as the Ru'us al-Jibal species in question.] See *Fig. 5.5.9.*

Heliotropium brevilimbe Boiss.

Occasional. Up to at least 1200 m, esp. in silt. Common on gravel terraces in Hajar Mtns. [Syn. *H. calcareum* Stocks] See *Fig. 5.5.9.*

Heliotropium lasiocarpum Fisch. & C.A. Mey.

Rare. Two locations, near abandoned cultivation at 1200 and 1500 m.

Heliotropium sp. aff. *strigosum* Willd.

Rare. Single location on slope above fallow cultivation, c.900 m. Rare in Hajar Mtns. ID per Boulos FoE, Ghazanfar (1992a). Same as photo of "*H. rariflorum*" in Collenette (1985), but latter does not match photograph and description of *H. rariflorum* in Jongbloed (2003). *Fig. 5.3.20.*

Lappula spinacarpos (Forssk.) Asch. ex Kuntze

Locally common. Wadi banks at 250 m to plateaux at 1250 m. Locally common in Hajar Mtns.

Paracaryum intermedium (Fresen.) Lipsky

Rare. Medium-high elevations. Absent except in wetter years. Occasional in Hajar Mtns, where also absent except in wetter years.

Trichodesma sp.

Rare. Few scattered specimens, including one in wadi at 1450 m, in shelter of *Astragalus fasciculifolius*. *T. enetotrichum* R.R. Mill. is locally common in Hajar Mtns.

Boraginaceae sp. 1 * **

Rare. Peri-agricultural. 800-1000 m. Flower small, purple-blue, distal. Elongated, separated bracts. Seed oblong, spinose, yellow. Flowers in March. Tim Harrison (*pers. comm.*) has suggested that this may be a species of *Paracaryum*. *Fig. 5.2.4.*

Boraginaceae sp. 2

Locally common, single locality on open slopes at 1300 m, smaller plants in sheltered cracks with other annuals. Erect to semi-erect, 10-30 cm, softly hairy, yellow-green, leaves opposite and elliptical to lanceolate with a distinct centre-line, five-petaled white flowers widely separated, fruit a rounded sub-pyramidal nutlet(?). Pending expert determination, it is not treated here as a species restricted to the Ru'us al-Jibal or new to Eastern Arabia. *Fig. 5.2.5.* See also *Figs. 3.3.2* and *3.3.3*.

BRASSICACEAE (formerly CRUCIFERAE)

Arabidopsis pumila (Stephan ex Willd.) N. Busch* [Ghazanfar (2003)]

Rare. Rocky slopes c.2040 m. Not recorded elsewhere in Arabia. [Note: Ghazanfar (2003) evidently repeats or seconds the record by Miller & Cope (1996). If the elevation given is correct, the site can only be the radar installation at the summit of Jebel Harim, the highest point in the Ru'us al-Jibal. Boulos (1999) recorded *Arabis nova* Villars from Jebel Harim, but Miller & Cope (1996) expressly caution that small plants of *A. nova*, such as most of those from Arabia, have been mistaken for *A. pumila*. It is considered most probable that both of the foregoing records from Jebel Harim (*A. pumila* and *A. nova*) refer to the same species. Ghazanfar's determination of *A. pumila* is accepted for purposes of the Checklist.]

Brassica tournefortii Gouan

Rare. Within or near cultivation up to c.1000 m.

Cakile arabica Velen. & Bornm.* [Jongbloed (2003)]

Rare. Recorded from the UAE, Wadi Bih, by Böer & Chaudhary, and by Mandaville from Jazirat al-Maqlab (Telegraph Island) and silt at Birkat al-Khalidiyah. All sites are low elevation.

Capsella bursa-pastoris (L.) Medik. [Jongbloed (2003)]

Rare. Scattered locations. Sandy soil in plantations or gardens.

Cardaria draba (L.) Desv.

Rare. Plantation weed, 1000-1500 m.

Clypeola aspera (Grauer) Turrill*

Occasional, but easily overlooked. c.500 to at least 1400 m.

Clypeola jonthlaspi L.*

Rare. Among rocks at c.1200 m. Also recorded from the Musandam region by Böer & Chaudhary (1999) and Ghazanfar (2003). *Fig. 5.3.9.*

Diplotaxis harra (Forssk.) Boiss.

Locally common. Up to at least 1650 m. Often a cliff plant, very distinct from growth form on gravel plains and terraces in Hajar Mtns, where it can be hyperabundant. Up to at least 2400 m in Jebel Akhdar. *Fig. 5.4.8*. See section 14 and compare *Fig 5.5.6*.

Erophila verna (L.) Bess.* [Ghazanfar (2003)]

Rare. Shaded places on terrace walls. 500-1000 m. Not recorded elsewhere in Arabia. [Note: Ghazanfar repeats this record from Miller & Cope (1996).]

Eruca sativa Mill.

Rare, but possibly overlooked. Single location. Fallow fields at Sharmilah, c.1000 m.

Erucaria hispanica (L.) Druce

Common. Up to at least 1350 m. On terraces, open plateaux and slopes. Common on gravel terraces in Hajar Mtns. See *Fig. 3.2.5.*

Farsetia aegyptia Turra

Locally common. Above c.700 m. Plateaux and hillsides. *Fig. 5.4.12.* See also *Figs. 3.1.5* and *3.1.23.*

Farsetia stylosa R. Br. [Jongbloed (2003)]

Occasional. Records are from central Ru'us al-Jibal. [Syn. *F. ramosissima* Hochst. ex Fourn.]

Heterocaryum szovitsianum (Fisch. & Mey.) DC.* [Jongbloed et al. (2000)]

Rare. Single location in fenced plot at c.1000 m.

Malcolmia africana (L.) R. Br.

Rare. High elevation (?) to at least 1525 m. On stony flats. Also sandy wadi banks (Ghazanfar 1992a). Single location known to the author. Jongbloed (2003) gives record from J. Qi'wi and scattered Hajar Mtn records, including J. Hafit. *Fig. 5.3.26.*

Morettia parviflora Boiss.

Rare. Low elevations, up to c.600 m. Common on wadi banks in Hajar Mtns.

Notoceras bicorne (Aiton) Amo

Occasional. Wadi environment, terraces, disturbed ground up to at least c.1500 m.

Physorrhynchus chamaerapistrum (Boiss.) Boiss.

Locally common. S Ru'us al-Jibal only. Up to c.750 m. Common in Hajar Mtns. *Fig. 6.1.8.* [Note: The anomalous absence of *P. chamaerapistrum* in most of the Ru'us al-Jibal was recognised early, in a letter from A.R.Western to J.P. Mandaville dated 8 July 1985.]

Sinapis arvensis L.

Rare. Plantation environment. Up to at least 1150 m.

Sisymbrium erysimoides Desf.

Locally common. Up to at least 1600 m. Slopes, segetal, mesic microhabits. Other *Sisymbrium* spp. possibly not distinguished.

Zilla spinosa (L.) Prantl. [Ghazanfar (2003)]

[Note: Ghazanfar (2003) says this species is recorded only from Musandam, but that is considered erroneous. It is occasional along the Hajar Mtn front in the Mahdhah area and the author has never seen it N of that area, although Jongbloed (2003) knew of a record near Dibba. Error may have arisen in transcribing geographic coordinates or a Musandam location may have been (erroneously) assumed because the collection is apparently by R. Ash (Ghazanfar 1992a), who was known to have collected extensively in the Musandam, but also collected in the Western Hajar in Oman. This record is mentioned here for the sake of completeness, but *Z. spinosa* is not considered to occur in the Ru'us al-Jibal and has been disregarded in compiling the statistics presented in the accompanying paper.]

Brassicaceae sp. 1

Rare. Single photographic record from waste ground adjacent to cultivated field, c.1500 m. Erect, slightly hairy, with clusters of small, distal yellow flowers and erect, blade-shaped, tuberculate leaves with toothed margins. Perhaps an agricultural or weed species. Pending expert determination, it is not treated here as a species restricted to the Ru'us al-Jibal or new to Eastern Arabia. *Fig. 5.2.6.*

Brassicaceae sp. 2

Rare. Single photographic record near seasonal habitation in eastern Ru'us al-Jibal, c.1200 m. Stems semi-erect, spreading, slightly hairy; leaves broad, ovate, slightly toothed, distinctly veined and apparently glabrous; flowers dark pink. Pending expert determination, it is not treated here as a species restricted to the Ru'us al-Jibal or new to Eastern Arabia. [Note: This could possibly be a relatively well-developed specimen of *Malcolmia africana* (compare *Fig. 5.3.26*). Accordingly, it has also been disregarded in compiling the statistics presented in the accompanying paper.] *Fig. 5.2.7.*

CAMPANULACEAE

Campanula erinus L.

Locally common. Low-medium elevations.

In Hajar Mtns, recorded from Jebel Masafi, rare from Hatta area (Karim 2002) and single record from N. Oman (Ghazanfar 1992a). *Fig. 3.3.6.*

CAPPARACEAE

Cadaba spp.

[Note: Ghazanfar (2003) at Figs. 221-223 shows records from NE Musandam (Limah or Sal al-'Ala?) of *Cadaba heterotricha*, *C. farinosa* and *C. baccarinii*. The habitat of the first two is said to be rocky slopes and gravel plains; the habitat for the third is the foothills of the Dhofar escarpment. Records for all three spp. are primarily from Dhofar, with no records shown from between Dhofar and Musandam. Ghazanfar (1992a) lists Dhofar specimens not shown in Ghazanfar (2003). The author has encountered only a single *Cadaba* species outside Dhofar (near Jebel Muqayleet, S of Wadi Jizzi, at c.900 m). An error is strongly suspected, or perhaps the Musandam specimens are anthropogenic. The records are mentioned here for the sake of completeness, but *Cadaba* spp. are not considered to occur in the Ru'us al-Jibal and have been disregarded in compiling the statistics presented in the accompanying paper.]

Capparis cartilagenia Decne.

Common. 5-1000 m. Hanging plant, common on cliffs (including coastal cliffs). In Hajar Mtns, present only on carbonate rocks.

Capparis spinosa L.

Common. Up to c.1000 m. Cliff plant.

Cleome austroarabica Cham. & Lam. subsp. *muscatensis*

Rare. Scattered sites, especially on or near base of cliffs. Low elevation. Locally common on lower rubble slopes near Baqeel, an agricultural settlement in Wadi Khabb, apparently benefitting from overgrazing. Summer flowering.

Cleome brachycarpa DC.

Rare. SW Ru'us al-Jibal only. Below 500 m.

Cleome noeana Boiss.

Single specimen, J. Yabana. Common in northern Hajar Mtns. [Note: Following Jongbloed (2003), on the authority of Miller & Cope (1996) *C. noeana* as used here encompasses the plants described in Western (1989) and Jongbloed *et al*. (2000) as *C. dolichostyla* Jafri and *C. quinquenervi*a DC.] *Fig. 6.1.2.*

Cleome rupicola Vicary

Rare. Three scattered locations, c.450-1100 m. Common in N Hajar Mtns.

Cleome scaposa DC

[Note: Miller & Cope (1996) show a Musandam record for *Cleome scaposa*, which Ghazanfar (2003) has disregarded. The author has not recorded this species N of the Hatta area, i.e., the northern border of contiguous Oman, where it occurs on gravel plains. The record is mentioned here for the sake of completeness, but *C. scaposa* is not considered to occur in the Ru'us al-Jibal and has been disregarded in compiling the statistics presented in the accompanying paper.]

Maerua crassifolia Forssk. [Ghazanfar (2003)]

Rare. Scattered records by Ghazanfar (2003), Karim & Fawzi (2007) and A.E.C. Fisher (*pers. comm.*). Known sites are low elevation. The author has never

encountered *M. crassifolia* in the Ru'us al-Jibal.

CARYOPHYLLACEAE

Arenaria leptoclados (Reichnb.) Guss. [Jongbloed *et al.* (2000)]
Single plant recorded by Karim (2002) from Wadi Khabb Shamsi. Also found at medium and high elevation in Jebel Akhdar. [Note: Possible confusion with *A. serpyllifolia*. Ghazanfar (2003) says: "The Oman material from the Hajar mountains is referable to *A. leptocladus*, differing from the more robust *A. serpyllifolia* L. in its distribution and habitat, the latter typically a field weed or a mountain plant."] See *Fig. 5.3.2.*

Arenaria serpyllifolia L.*
Locally common. Up to at least 1200 m, esp. on silt terraces. "Chickweed." ID by L. Boulos and per Boulos (FoE). Not recorded from Hajar Mtns immediately to the S, but recorded as rare (Karim 2002) in the Hatta area. [Note: Photographic evidence from the spring site at 'Ayn as-Sih appears to show a sympatric *Arenaria* sp. with thin, opposite leaves. See also note under *A. leptocladu*s.] *Fig. 5.3.1.*

Cometes surattensis L.
Locally common in southern Ru'us al-Jibal only. Low elevations. Rare records from mid-Wadi Bih and Wadi al-'Ayn. Locally common in Hajar Mtns. *Fig. 6.1.3.*

Dianthus crinitus Sm.
Locally common. Above 1000 m. ID by L. Boulos. Occasional at high elevation in Hajar Mtns of N. Oman, including Jebel Akhdar, the southernmost extent of this northern species.

Gymnocarpos decandrus Forssk.
Common, from c.500 m to at least 1600 m, often at high elevation as cushions within steppe vegetation. Apparently grazed at highest elevation sites. In Hajar Mtns, locally common as scattered cushions on broad gravel terraces between Juwaif and Mahdhah, c.550-600 m. *Fig. 5.4.16.* See also *Figs. 3.1.16* and *3.3.1*.

Gypsophila bellidifolia Boiss.
Rare. Wadi or ravine environment. Low to moderate elevation. Occasional in Hajar Mtn wadis.

Herniaria hemistemon J. Gay
Occasional. Up to at least 1600 m.

Herniaria hirsuta L.
Rare. Wadis, plateaux. Low to medium elevation. ID by M. Jongbloed.

Minuartia meyeri (Boiss.) Bornm.* [Ghazanfar (2003)] *Fig. 5.3.21.*
Rare, but possibly overlooked. 1500 m. [Note: Both *Minuartia* species found in the Ru'us al-Jibal are also found in south-west Asia and north-western Saudi Arabia.]

Minuartia picta (Sibth. & Sm.) Bornm.* **
Rare, but possibly overlooked. Open ground on stony plateau at 1100 m. ID by L. Boulos. *Fig. 5.1.10.*

Paronychia arabica (L.) DC.
Locally common. Low-medium elevation on terrace or slopes.

Polycarpaea robbairea (Kuntze) Greuter & Burdet
Locally common. On stony flats or plateaux at low and medium elevation (to 1100 m). *Fig. 3.3.8.*

Polycarpaea spicata Wight ex. Arn.
Occasional, but easily overlooked. Wadi environment. Low elevation in tributary of W. Bih.

Polycarpon tetraphyllum (L.) L.
Occasional, but easily overlooked. Wadi and field environments to c.1200 m.

Pteranthus dichotomus Forssk.* [Jongbloed et al. (2000)]
Single record by Böer & Chaudhary from UAE, Wadi Bih.

Sclerocephalus arabicus Boiss.
Occasional. S Ru'us al-Jibal only, at low elevation.

Silene apetala Willd.
Occasional. Up to c.1600 m.

Silene austroiranica Rech. f., Aellen & Esfand.
Occasional. Up to c.1525 m. Wadi environment, runnels. ID by M. Jongbloed. Occasional in Hajar Mtns.

Silene cf. *linearis* Decne.
Locally common. Two locations known to the author: W. Naqab at c.250 m and J. Yibir at c.1200 m. ID per Western (1989). Western (1989) says: "Common on open mountain slopes east and south of Dibba to Hatta." [Note: Ghazanfar (2007) mentions that *S. linearis* is possibly conspecific with *S. austroiranica*.]

Spergula fallax (Lowe) E.H.L. Krause
Occasional. Opportunistic. To at least 900 m.

Spergularia diandra (Guss.) Boiss.
Occasional. Opportunistic. To at least 1100 m. ID by L. Boulos.

CHENOPODIACEAE

Chenopodium murale L.
Rare. Weed, disturbed ground around dwellings, cultivation or trails. Up to at least 1600 m.

Chenopodium album L.
Rare. Weed, disturbed ground around dwellings or cultivation. Up to at least 1000 m.

Haloxylon salicornicum (Moq.) Bunge ex Boiss.
Rare in mountains generally. Locally common up to c.500 m in peri-anthropic habitats, e.g., in silt at Birkat al-Khalidiyah and Rawdhah bowl; in bowl of Wadi Awsaq; and near fields on terraces in lower Wadi Naqab. Also atop J. Ayuzah, SE Ru'us al-Jibal, at c.1000 m. Common on silt, sand and gravel plains adjacent to Ru'us al-Jibal and Hajar Mtns. Predominance is an indicator of overgrazing. [Syns. *Hammada elegans*, *Hammada schmittiana*]

CISTACEAE

Helianthemum kahiricum Delile [Jongbloed (2003)]
Western (1989) says: "Uncommon . . . restricted distribution on rough mountain limestone. Main concentrations recorded on Jebel Hafit and in Ra's al-Khaimah." Common on J. Hafit (Karim 2002). Not collected by the author and not distinguished in the field from *H. lippii*. *Fig. 5.3.19.*

Fig. 5. Selected flora of the Ru'us al-Jibal
5.1. Ru'us al-Jibal species newly recognised in the UAE and Oman by this study.

Fig. 5.1.1. ***Adonis dentata.*** **Record and photo by Barbara Couldrey. See also** ***Fig. 3.3.7.***

Fig. 5.1.2. ***Aegilops kotschyi***

Fig. 5.1.3. ***Asperugo procumbens.*** **See also** ***Fig. 3.2.2.***

Fig. 5.1.4. ***Bellevalia*** **sp. aff.** ***longipes***

Fig. 5.1.5. ***Chaenorrhinum rubrifolium***

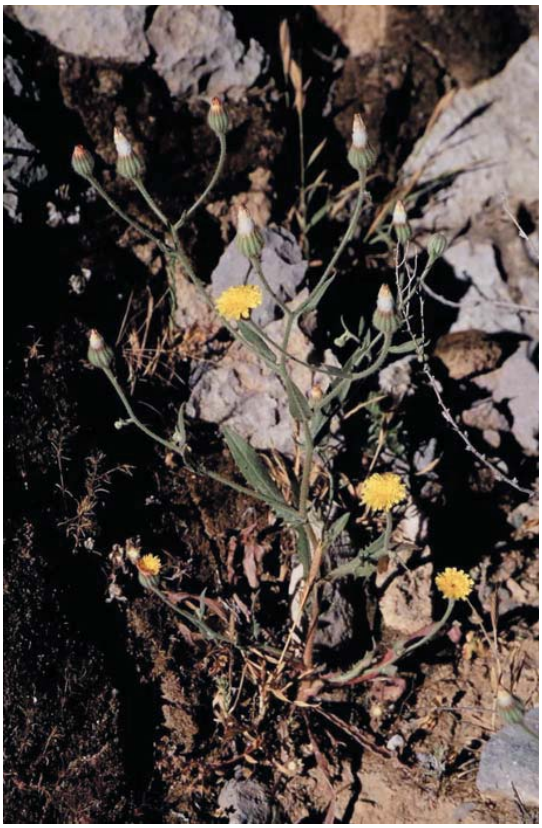


Fig. 5.1.6. *Crepis kotschyana*

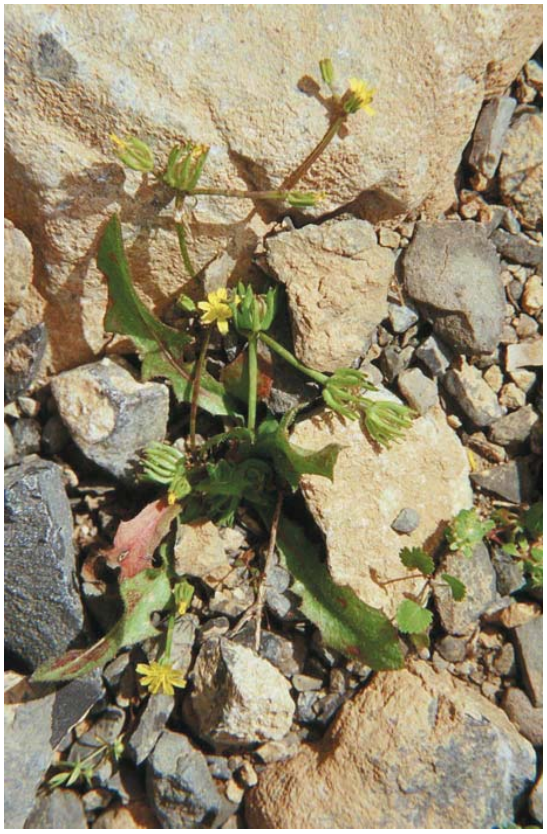


Fig. 5.1.7. *Garhadiolus hedypnois*

Fig. 5.1.8. *Lactuca orientalis*

Fig. 5.1.9. ***Leontice leontopetalum.*** **See also** ***Figs. 1.3.2*** **and** ***3.2.1.***

Fig. 5.1.10. ***Minuartia picta.*** **This photo of the specimen sent for expert determination shows the author's erroneous preliminary identification as "*Spergularia diandra*(?)". It compares very well with the illustration of *M. picta* in *Flora of Egypt.***

Fig. 5.1.11. ***Notobasis syriaca*****. This specimen, the only known collection from Eastern Arabia, is in the herbarium at the Sharjah Natural History Museum.**

Fig. 5.1.12. ***Poa bulbosa***

Fig. 5.1.13. ***Poa*** **sp.aff.** ***asirensis***

Fig. 5.1.14. ***Rosularia adenotricha***

Fig. 5.1.15. ***Stipa parviflora***

Fig. 5.1.16. ***Teucrium oliverianum***

Fig. 5.1.17. ***Valerianella szovitsiana***

Fig. 5.2. Some still unidentified species from the Ru'us al-Jibal

Fig. 5.2.1. Unidentified Poaceae sp. 1, seen at c.1100 m on open slopes.

Fig. 5.2.2. Unidentified Poaceae sp. 2, possibly a grain species, from a small fallow field in the Sahasa area, c.1450 m.

Fig. 5.2.3. Unidentified *Astragalus* sp., seen at a peri-agricultural site, c.800 m.

Fig. 5.2.4. Unidentified Boraginaceae (*Paracaryum*?) sp. 1, seen at two peri-agricultural sites, c.800-1000 m.

Fig. 5.2.5. Unidentified Boraginaceae sp. 2, seen at open sites and sheltered sites with other annuals, c.1300 m (see also *Figs. 3.3.2* and *3.3.3*).

Fig. 5.2.6. Unidentified Brassicaceae sp. 1, adjacent to cultivation at 1500 m (see *Fig. 3.2.2*).

Fig. 5.2.7. Unidentified Brassicaceae sp. 2, near seasonal habitation in the eastern Ru'us al-Jibal, c.1200 m.

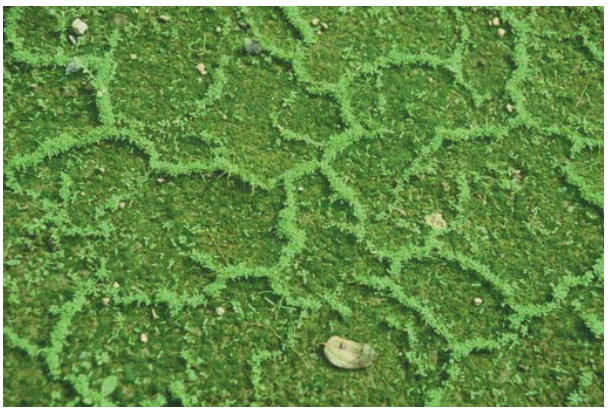


Fig. 5.2.8. A medley of diminutive unidentified species, some growing in polygonal traces, in the damp soil of an abandoned field beside a gravel wadi, shaded by trees and steep, north-facing cliffs, c.450 m.

Fig. 5.3. Some Ru'us al-Jibal species not illustrated in other regional references

Fig. 5.3.1. ***Arenaria serpyllifolia***

Fig. 5.3.2. ***Arenaria*** **sp. (possibly** ***A. leptocladus*****)**

Fig. 5.3.3. ***Arnebia decumbens***

Fig. 5.3.4. ***Astragalus*** **sp. aff.** ***schimperi.*** **See also** ***Fig. 1.3.3.***

Fig. 5.3.5. ***Avena barbata***

Fig. 5.3.6. ***Bromus danthoniae***

Fig. 5.3.7. *Bromus fasciculatus*

Fig. 5.3.8. *Chesneya parviflora*

Fig. 5.3.9. *Clypeola jonthlaspi*

Fig. 5.3.10. ***Cymbopogon jwarancusa.*** **The several** ***Cymbopogon*** **species found in the UAE and Northern Oman are difficult to distinguish when not in seed. See also** ***Fig. 5.4.7.***

Fig. 5.3.11. Enneapogon desvauxii

Fig. 5.3.12. ***Eragrostis cilianensis***

Fig. 5.3.13. *Eragrostis ciliaris*

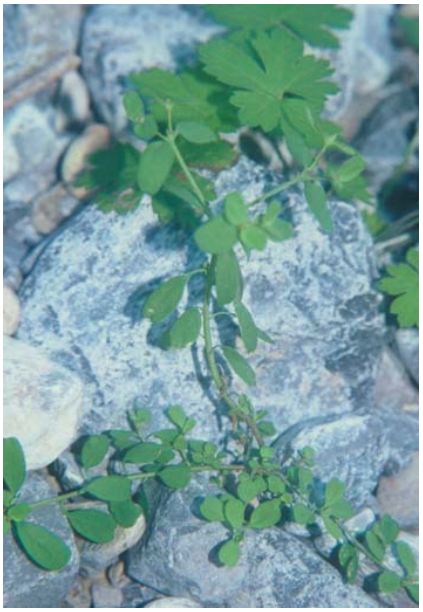


Fig. 5.3.14. *Euphorbia inaequilatera*

Fig. 5.3.15. *Fagonia schimperi*

Fig. 5.3.16. *Filago pyramidata*

Fig. 5.3.17. *Gastridium phleoides*

Fig. 5.3.18. *Geranium trilophum*

Fig. 5.3.19. *Helianthemum kahiricum* (photo from Saiq Plateau, Jebel Akhdar, Oman)

Fig. 5.3.20. *Heliotropium* sp. aff. *strigosum*

Fig. 5.3.21. *Herniaria hirsuta*

Fig. 5.3.22. ***Jurinea carduiformis*** **This species is normally prostrate but stalked plants may be locally common after rain.**

Fig. 5.3.23. ***Lallemantia royleana***

Fig. 5.3.24. ***Lamarckia aurea***

Fig. 5.3.25. ***Linaria simplex***

Fig. 5.3.26. ***Malcolmia africana*****. See also** ***Fig. 1.3.3*****.**

Fig. 5.3.27. ***Orobanche cernua*** **among** ***Artemisia sieberi*****.**

Helianthemum lippii (L.) Dum. Cours.
Common. Open, stony slopes and plateaux, c.500-1900 m+. ID by L. Boulos. Variable in appearance (Ghazanfar 2003). In Ru'us al-Jibal, dimorphic specimens can be seen in close proximity: (1) small, grey-green leaves with dense, curving branches, vs. (2) larger, medium green leaves with straight branches. *Fig. 5.4.17.*

Helianthemum salicifolium (L.) Mill.*
Locally common. Above c.900 m. In Hajar Mtns, rare J. Hafit (Karim 2002) and Hatta (Karim & Fawzi 2007). In Kuwait, found at low elevation.

Helianthemum stipulatum (Forssk.) Christen.* [Ghazanfar (1992a)]
Rare. Single specimen collected by Braund. Ghazanfar (2003) considers Braund's specimen to be *H. lippii*. This record is mentioned here for the sake of completeness, but is disregarded for purposes of the discussion and analysis in the accompanying text.

CONVOLVULACEAE

Convolvulus acanthocladus Boiss.
Common. Above c.500 m (lower in northernmost Ru'us al-Jibal, near Khasab). Increasingly common above c.800 m and co-dominant above c.1100 m as cushions within "steppe" vegetation, to summits at 2000 m. In Hajar Mtns, found at 900-1000 m on ridge of Jebel Qitab, SW of Fujeirah (where wild olive trees are also present) but otherwise absent to S for c.130 km. Re-appears in Mahdhah area of N. Oman, where present occasionally along ophiolite mountain front and foothills at c.600-800 m, continuing southwards to Ibri area. Tomentose growth form of Ru'us al-Jibal plants is distinct from more rectilinear growth form in foothills of N. Oman (see Section 14). Present but very rare in Jebel Akhdar (Ghazanfar 1992a) and J. Kawr, where growth form is tomentose. Common at summit of Jebel Aswad in Eastern Hajar Mtns, SE of Muscat, c.430 km from Ru'us al-Jibal (Mandaville 1977). Single specimen recorded by the author at Selma Plateau (c.1800 m) in the Jebel Bani Jaber range to the E of Jebel Aswad. *Fig. 5.4.6.* See also *Figs. 3.1.1, 3.1.4, 3.1.5, 3.1.8, 3.1.9, 3.1.11, 3.1.13, 3.1.15, 3.1.16, 3.1.17, 3.1.21, 3.1.23* and *3.3.1* and compare *Fig. 5.5.4.*

Convolvulus ulicinus Boiss.*
Occasional. c.500-1900 m+, esp. on bedrock slopes. ID by L. Boulos. Also rare in Jebel Akhdar.

Convolvulus virgatus Boiss.
Rare. Scattered locations in Ru'us al-Jibal, up to c.1200 m. Grazing probably a factor since occasional large, healthy plants found at inaccessible cliff sites. Common in Hajar Mtns.

Cuscuta planifora Ten.
Locally common after rains. Up to at least 1600 m. Various hosts, including annuals (e.g., *Asphodelus tenuifolius*).

CRASSULACEAE

Crassula alata (Viv.) Berger subsp. *alata** [Jongbloed (2003)]
Rare. Low elevation. Recorded by Böer & Chaudhary from UAE, Wadi Bih, and by Mandaville from Wadi Khasab, 100 m.

Rosularia adenotricha (Wall ex Edgw.) Jansson subsp. *adenotricha** **
Rare. Single locality in southern Ru'us al-Jibal, but probably overlooked elsewhere. On silt and organic debris in shaded vertical clefts or hollows in cliffs at 1200-1300 m. Leaves sometimes form a prostrate mat easily mistaken for the common mountain liverwort *Plagiochasma rupestre*. ID by L. Boulos. *Fig. 5.1.14.*

Sedum hispanicum L.*
Locally common. Up to at least 1200 m. Also recorded from northernmost Hajar Mtns. See *Fig. 3.3.6.*

Umbilicus botryoides Hochst. ex A. Rich* [Mandaville (1985)]
Recorded by Mandaville at J. Harim, 1850 m, in shade of boulders. [Note: It is probable that the two *Umbilicus* spp. recorded from the Ru'us al-Jibal are the same, and they have been so treated (as *U. horizontalis*) in compiling the statistics presented in the accompanying paper. Jongbloed (2003) does not mention *U. botryoides* and Boulos (1999) considers it to be an Afro-tropical species.]

Umbilicus horizontalis (Guss.) DC.*
Locally common in silt in damp, shaded cracks or under rock overhangs from c.500 m to at least 1750 m. ID by L. Boulos. Recorded from Masafi, less than 35 km S of the Ru'us al-Jibal, but otherwise very rare or absent in the Hajar Mtns to the south. [See note under *U. botryoides*.] See *Fig. 3.3.3.*

CUCURBITACEAE

Citrullus colocynthis (L.) Schrad.
Rare. Up to at least 1000 m. Usually near habitation or trail.

Cucumis prophetarum L.
Occasional. Up to at least 1200 m. Usually in or near trail. Probably spread as seeds by herbivores.

DIPSACACEAE

Scabiosa olivieri Coult.*
Locally common in south and central Ru'us al-Jibal, after rain. All elevations. Single record outside Ru'us al-Jibal, from northern Hajar Mtns. In Kuwait, found on gravel plains at low elevation.

Pterocephalus brevis Coult. [Jongbloed et al. (2000)]
Rare. Ru'us al-Jibal records by Western (from a scree slope at 1500 m) and Böer & Chaudhary. Also rare in Hajar Mtns (Karim & Fawzi 2007). [Note: The author suspected that the Ru'us al-Jibal records might be mistaken identifications of *Scabiosa olivieri*, which is not recorded by the aforementioned collectors, but examination of Western's herbarium specimen at the Sharjah Natural History Museum confirms the identification.] *Fig. 5.3.31.*

EUPHORBIACEAE

Andrachne aspera Spreng.
Occasional. Up to c. 700 m, exceptional to 1000 m. Wadi or sheltered habitat.

Andrachne telephioides L.
Rare. Few records in stony wadis at medium elevation.

Chrozophora oblongifolia (Delile) Spreng.
Rare. Up to c.1350 m. Favours gravel wadis or disturbed ground. Common in Hajar Mtns. Summer flowering.

Dalechampia scandens L.
Rare. Single locality, few plants as cliff dwellers in W. Khabb Shamsi gorge at c.250-350 m. In Hajar Mtns, limited to plantations (Jongbloed 2000). Oman records are from Dhofar only (Ghazanfar 1992a).

Euphorbia arabica Hochst. & Steud. ex Boiss.
Rare, but easily overlooked. Single record from East Coast, near Limah.

Euphorbia falcata L.
Rare, but possibly overlooked. Single record from Sal Dhayah, a cultivated plateau area, c.500 m. ID by L. Boulos.

Euphorbia granulata Forssk.
Occasional. Low to moderate elevations (up to 1100 m+). Common in Hajar Mtns.

Euphorbia inaequilatera Sond.
Rare, but possibly overlooked. Single location, wadi environment, low elevation. ID by M. Jongbloed. *Fig. 5.3.14.*

Euphorbia larica Boiss.
Common to c.1000 m, but absent in some areas. Rocky slopes and gravel terraces. Absent above c.1200 m. Common and characteristic in Hajar Mtns. *Fig. 5.4.11.*

Euphorbia peplus L.
Rare, but possibly overlooked. Two locations, wadi environment, low elevation. ID by L. Boulos.

FABACEAE (LEGUMINOSAE)

Argyrolobeum roseum (Camb.) Jaub. & Spach
Locally common. Up to c.1100 m.

Astragalus arpilobus Kar. & Kir. subsp. *hauarensis* Boiss.
Rare. Single location in fallow field in southern Ru'us al-Jibal, 1000 m. [Syn. *Astragalus hauarensis* Boiss.]

Astragalus crenatus Schultes
Occasional. Up to at least 800 m. [Syn. *A. corrugatus* Bertol.]

Astragalus fasciculifolius Boiss. subsp. *arbusculinus* (Bornm. & Gauba)*
Common. From c.400 m to at least 1600 m. Favours slopes and wadi banks. Absent from the Hajar Mtns immediately to the S, and from the Jebel Akhdar, but recorded by Mandaville (1977) from Jebel Aswad in the Eastern Hajar Mtns, SE of Muscat, c.430 km distant. The very similar *A. spinosus* occurs in central and northern Saudi Arabia and in Kuwait and was occasionally reported from the Ru'us al-Jibal. However, the identity of the Ru'us al-Jibal species as *A. fasciculifolius* has recently been confirmed (Ghazanfar 2007). The author has seen *A. spinosus* in Kuwait, where it is distinguishable from *A. fasciculifolius*, and believes it has not been encountered in the Ru'us al-Jibal. *Fig. 5.4.3.* See also *Figs. 3.1.22* and *5.5.3*.

Astragalus hamosus L.
Rare. Single records from two cultivated plateau areas, 500-1000 m. Not generally considered a mountain species.

Astragalus sp. aff. *schimperi* Boiss.
Locally common at single locality, c.1525 m in E Ru'us al-Jibal. Flower pale mauve, pod shape and configuration resembles *A. schimperi* Boiss. var. *subsessilis* (see Boulos FoE; Karim & Fawzi 2007), but plant and seeds are glabrous and leaves have notched apices. Pending expert determination, it has not been treated as distinct from *A. schimperi* in compiling the statistics presented in the accompanying paper. *A. schimperi* is recorded by Western (1989) from Umm al-Qaiwain and Hatta, and by Ghazanfar from Northern Oman, but is apparently rare. *Fig. 5.3.4.*

Astragalus tribuloides Delile
Occasional. In silt of wadis, fields and slopes from 150 m to at least 1300 m. Some plants hirsute. Rare but widespread in Hajar Mtns.

Astragalus sp. 1
Single photographic record. Near cultivation at c.800 m. Cluster of three pendant, glabrous, strongly curved, banana-shaped pods; leaves have notched apices. Pending expert determination, it is not treated here as a species restricted to the Ru'us al-Jibal or new to Eastern Arabia. *Fig. 5.2.3.*

Chesneya parviflora Jaub. & Spach.
Rare. Single location in SE Ru'us al-Jibal, on edge of Dibba Zone. In silt at base of cliff adjacent to cultivation, low elevation. Additional scattered specimens reported from Dibba Zone but not recorded from Hajar Mtns generally. ID by S. Ghazanfar. *Fig. 5.3.8.*

Crotalaria aegyptiaca Benth.
Rare. Five widespread localities, all at low-medium elevation. Common at low elevation in Hajar Mtns. *Fig. 6.1.4.*

Hippocrepis constricta Kunze
Rare, but easily overlooked. Two records, W. al-Waeeb, c. 250 m (ID by M. Jongbloed) and 'Aini, c.750 m.

Hippocrepis unisiliquosa L. subsp. *bisiliqua* (Forssk.) Bornm.*
Common. c.700 m to at least c.1400 m.

Indigofera coerulea Roxb.
Rare. Single locality on rocky slopes near cultivation at c.500 m in N Ru'us al-Jibal.

Lotononis platycarpa (Viv.) Pic.-Serm.
Rare. Single wadi bank location in Wadi Bih. Low elevation. Occasional in Hajar Mtns.

Medicago laciniata (L.) Mill.
Occasional. Up to c.1300 m.

Ononis reclinata L.* [Jongbloed (2003)]
Rare. Single record from Ru'us al-Jibal.

Ononis sicula Guss.
Rare. Silt between rocks at medium elevations.

Rhynchosia minima (L.) DC.
Rare. Locally common at single locality, Jebel Ayuzah in SE Ru'us al-Jibal, in wadi at 700 m. Otherwise single record. Locally common in Hajar Mtns.

Senna italica Mill.
Occasional. Up to c.1000 m, esp. near cultivation. Distributed by foraging mammals? [Syn. *Cassia italica*]

Taverniera cuneifolia (Roth) Arn.
Rare. Low-medium elevation. One locality in SE Ru'us al-Jibal, single specimens in SE and SW. Common in Hajar Mtns. [Syn. *Taverniera glabra* Boiss.] *Fig. 6.1.12.*

Tephrosia apollinea (Delile) DC.
Very common and locally dominant. Mostly in and adjacent to stony wadis below 700 m, exceptionally to c.1250 m, but also colonises talus and disturbed roadsides at medium elevations, e.g., along the road over the pass at Aqabat Oso from W. Bih to W. Khabb Shamsi, reaching c.1000 m. Absent at high elevation. All specimens collected by the author in the Ru'us al-Jibal and Hajar Mtns. have been ID'd by L. Boulos as *T. purpurea* (L.) Pers. subsp. *leptostachya* Brummitt. *T. apollinea*, *T. purpurea* and *T. persica* are very similar (some experts consider them to be identical) and were not distinguished by the author in the field. The use of *T. apollinea* here follows Western (1989) and Jongbloed (2003), the two best-known comprehensive floras of the UAE; the plant is well known to UAE naturalists by that name.

Trigonella hamosa L.
Occasional. Low-medium elevation, ruderal.

Trigonella stellata Forssk.
Common. Ruderal in wadi, field or plateau environment. Up to at least 1525 m. *Fig. 3.3.5*.

Vicia monantha Retz.
Rare. Cultivated areas. Up to at least 1300 m (Western 1989).

Vicia sativa L.
Locally common. Medium elevations. Cultivation and peri-agricultural.

FUMARIACEAE

Fumaria parviflora Lam.
Rare, but possibly underrecorded due to similarity to the common fern *Onychium divaricatum*. Plantations, wadis and shaded sites to at least 1350 m. *Fig. 3.3.2*.

GENTIANACEAE

Centaurium pulchellum (Swartz) Druce
Rare. Up to at least 1525 m.

GERANIACEAE

Erodium laciniatum (Cav.) Willd. [Mandaville (1985)]
Occasional. Reported by Mandaville (1985) from isthmus and disturbed wadi sites at low elevation. In Hajar Mtns, locally common at low elevations.

Erodium neuradifolium Delile
Common. Elevations up to at least 1750 m. ID per Western 1989. [Note: *Erodium* spp. were not distinguished by the author in the field and the presence of additional spp. cannot be excluded.] See *Fig. 3.3.5*.

Geranium biuncinatum Kokwaro*
Rare, but probably overlooked. Two confirmed locations, c.400-900 m. ID by L. Boulos. Also recorded by Mandaville. See also *G. muscatense*.

Geranium muscatense Boiss.
Common. Elevations up to at least 1750 m. Damp or shaded silt. [Note: The three recognised *Geranium* species are not normally distinguishable by field inspection. Unless otherwise specifically identified, all *Geranium* spp. have been considered as *G. muscatense*.] *Fig. 3.3.2*.

Geranium trilophum Boiss.
Rare, but possibly overlooked. Up to 1450 m, including on open slopes. ID per Collenette (1985) and Ghazanfar (2007). Also recorded by Mandaville (1985) (from Jazirat al-Ghanem) and Ghazanfar (2007). See also *G. muscatense*. *Fig. 5.3.18*.

LAMIACEAE (formerly LABIATAE)

Lallemantia royleana (Benth.) Benth.*
Rare. Wadi banks at 250 m to slopes at 1400 m. *Fig. 5.3.23*.

Lavandula subnuda Benth.
Common. Wadi banks and slopes up to c.1250 m.

Leucas inflata Benth.
Locally common. Moderate elevation, c.300-1200 m. Among rocks or gulleys.

Ocimium forsskaolii Benth.
Rare, but possibly overlooked. Plantations and fields; single record from wild site.

Salvia aegyptiaca L.
Locally common. Up to at least 1800 m.

Salvia macrosiphon Boiss.
Occasional. From c.500 to c.1500 m. Stony slopes. [Note: Ghazanfar (*in press*) has concluded that confirmed UAE and Oman records are of *S. macrosiphon*, rather than the similar *S. spinosa* L., which has also been reported. None of the authors recording either of these names have recorded the other, and the two have been considered as a single species in compiling the statistics presented in the accompanying paper.]

Salvia mirzayanii Rech. f. & Esfandiari*
Rare. High elevation. Single locality, on plateau summit E of J. Harim at 1500 m, estimated few dozens of plants. Recorded by Mandaville at c.1450-1850 m on W flank of J. Harim. Mandaville described it as "aromatic . . . with rather showy blue-violet flowers" and as a "characteristic eastern species." It seems to have become absent in the area of Jebel Harim since 1979, most probably due to overgrazing. *Fig. 5.3.33*.

Satureja imbricata (Forssk.) Briq.
Locally common. From 250 m up to at least 1900 m. Among rocks. Also found in N. Oman from 700-2000 m (Ghazanfar 1992a). [Syns. *Micromeria biflora* (D.Don) Benth.; *M. imbricata* (Forssk.) C.Chr.]

Teucrium oliverianum Ging. Ex Benth.* **
Rare. Several plants within fenced cultivation at 1000 m. *Fig. 5.1.16*.

Teucrium polium L.* [Jongbloed (2003)]
Sterile specimens considered "most probably" *T. polium* were recorded by Mandaville (1985) from two locations: Jazirat al-Ghanem, 40 m, and J. Harim, 2000 m. The latter, at least, now seems much more

likely to be the similar *T. stocksianum*, today reasonably common in the same area but not recorded by Mandaville. Ghazanfar (*in press*) considers both to be *T. mascatense*, which she synonymises with *T. stocksianum*. These records are mentioned here for the sake of completeness, but *T. polium* has been disregarded in compiling the statistics presented in the accompanying paper.

Teucrium stocksianum Boiss.

Occasional. Medium to high elevations (to 1900 m+). Probably reduced by grazing. ID by L. Boulos. Also common above c.500 m in Hajar Mtns. [Note: Ghazanfar (*in press*) synonymises *T. stocksianum* with *T. mascatense* Boiss. and considers that the differences between them are variable and fall within variations explained by habitat (aridity). *T. stocksianum* is nevertheless recognised here because, from a field perspective, (1) the plants found in the Ru'us al-Jibal, although variable, never achieve the (consistent) morphology of *T. mascatense* seen in the Jebel Akhdar (dense, strongly revolute leaves and compact distal inflorescences); and (2) *T. mascatense* in the Jebel Akhdar is common only at significantly higher elevations (2300 m+) and, where present, is generally a much more dominant floral element.] *Fig. 5.4.24*; compare *Fig. 4.1.15* (*T. mascatense*).

Ziziphora tenuior L.*

Rare. Scattered records at high elevation, 1250-2000 m. ID by L. Boulos. *Fig. 5.3.37*.

LINACEAE

Linum corymbulosum Reichb.

Locally common. Above c.1100 m. IDs by L. Boulos. Occasional in Hajar Mtns but found there at medium elevations. Ghazanfar (2007) considers this species an escape from cultivation.

MALVACEAE

Abutilon fruticosum Guill. & Perr.

Rare. Few inaccessible specimens as cliff plants in Wadi Khabb Shamsi narrows. Visual ID by S.A. Ghazanfar. Also recorded by Mandaville at two isthmian localities associated with extended modern habitation. Rare in Hajar Mtns (single UAE record).

Althaea ludwigii L.*

Rare. Few localities at abandoned fields, 1450-1600 m.

Hibiscus micranthus L.

Rare. Four locations only, at Qida (plantation), two isthmian island sites by Mandaville expedition, and one isthmian location by the author. Occasional in Hajar Mtns. These records are mentioned here for the sake of completeness, but *H. micranthus* has not been treated as a Ru'us al-Jibal species in compiling the statistics presented in the accompanying paper.

Malva parviflora L.

Locally common. Weed in abandoned plantations or disturbed ground, to at least 1600 m. Can be locally hyperabundant. See *Figs. 3.2.5* and *3.3.5*.

MELIACEAE

Melia azederach L.

Rare. Cultivated at c.700 m at Ra's al-Maq, overlooking the East Coast. Recently cultivated at a few other terraced settlements within the UAE by foreign agricultural labourers. The species is mentioned for the sake of completeness, but *M. azederach* has not been treated as a Ru'us al-Jibal species in compiling the statistics presented in the accompanying paper.

MENISPERMACEAE

Cocculus pendulus (J. Forst.) Diels

Locally common. Sea level up to c.700 m. Common on cliffs near sea.

MIMOSACEAE

Acacia ehrenbergiana Hayne

Rare. Two Ru'us al-Jibal records: (1) Wadi Khabb, southern Ru'us al-Jibal, several trees on coarse gravel slope beside wadi at base of ascent trail, c.375 m; (2) Wadi Khabb Shamsi, eastern Ru'us al-Jibal (by G.M. Brown). Possibly overlooked when not in flower, since growth form in Wadi Khabb is atypical and resembles *A. tortilis*. Also recorded by Mandaville at Al-Maksar, Qida and Birkat al-Khalidiyah. All records are low elevation sites associated with human habitation, cultivation and/or passage. Occasional in Hajar Mtns, especially on gravel plains. *Fig. 5.5.1*.

Acacia tortilis (Forssk.) Hayne

Common up to c.800 m. Occasional to c.1350 m but generally stunted except on protected flats or agricultural terraces (where it may thrive). *Fig. 5.5.2*. See also *Figs. 3.1.23*, *3.1.26* and *3.2.6*.

Prosopis juliflora (Sw.) DC.

Rare. Single specimen, Sal Dhayah, in wadi near agricultural labourers' habitation, c.500 m. Active introduction is suspected. The species is mentioned for the sake of completeness, but *P. juliflora* has not been treated as a Ru'us al-Jibal species in compiling the statistics presented in the accompanying paper.

MORACEAE

Ficus cordata Thunb. subsp. *salicifolia* (Vahl) C.C. Berg

Common. Up to c.500 m, exceptionally to 900 m in protected gorges (e.g., Wadi Zibat). Single location at 1200 m above East Coast, at winter settlement built into cliffs (Ar-Ra'alah), where *F. johannis* is absent. Normal situs is wadi banks but on the East Coast it is found, at low elevations, on open slopes overlooking the sea. *Fig. 5.4.13*.

Ficus johannis subsp. *johannis* Boiss.

Common. c.500-1600 m+. Normal situs is wadis and runnels. Cultivated in mountain settlements; often found at mouth of cisterns. Little overlap in elevation with *F. c. salicifolia*. Occasional in Hajar Mtns. above c.700 m. *Fig. 5.4.14*.

MORINGACEAE

Moringa peregrina (Forssk.) Fiori

Common. Up to c.800 m, esp. on cliffs and scree. Little overlap with the morphologically similar Arabian almond *Prunus arabica*. *Fig. 2.1.4*.

NYCTAGINACEAE

Boerhavia diffusa L.

Rare. Single location above W. Khabb Shamsi gorge. Occasional in Hajar Mtns.

Boerhavia elegans Choisy

Rare. Common in Hajar Mtns. *Fig. 6.1.1*.

OROBANCHACEAE

Orobanche cernua Loefl.

Rare. 1000-1850 m. *Fig. 5.3.27*.

PAPAVERACEAE

Papaver sp(p).

Rare. Red poppy. Scattered Ru'us al-Jibal locations, many near cultivation or trail, 1100 m+. [Note: Jongbloed (2000) and Ghazanar (2003) mention Ru'us al-Jibal records of both *Papaver dubium* L. var. *laevigatum* (M. Bieb.) Kadereit and *Papaver decaisnei* Hochst. & Steud ex Elkan. Ghazanfar (2003) considers that the relationship between those taxa and the identity of the Oman species remains tentative. Ghazanfar's draft Red Data Book for the UAE recognises only *P. decaisnei* Elkan. All red poppies in the Ru'us al-Jibal have been treated as a single species in compiling the statistics presented in the accompanying paper.] See *Fig. 3.3.2*.

Roemeria sp(p).*

Rare. Dark blue-purple poppy. In and near fallow fields in scattered locations at 750-1600 m. [Note: Jongbloed (2003) mentions two purple poppies, *R. hybrida* (L.) DC. and *R. refracta* DC., from two Ru'us al-Jibal locations, but speculates that they may be the same. They have been treated as a single species in compiling the statistics presented in the accompanying paper.] See *Figs. 3.3.2* and *3.3.7*.

PLANTAGINACEAE

Plantago afra L.

Occasional. Med-high elevations to at least 1525 m. Common in Hajar Mtns.

Plantago amplexicaulis Cav.

Occasional. Med-high elevations to at least 1500 m. Locally common in Hajar Mtns.

Plantago ciliata Desf.

Locally common. Gravel terraces, fallow fields. Scattered locations, medium to high elevation.

Plantago notata Lag.*

Occasional. High elevation. Scattered locations, mostly ruderal, c.1000-1500 m. Also very rare in Al-Ain area, on sandy soil (Karim & Fawzi 2007). *Fig. 5.3.29*.

Plantago ovata Forssk.

Occasional. 250 m up to at least 1525 m.

PLUMBAGINACEAE

Dyerophytum indicum (Gibs ex wight) Kuntze

Occasional. Up to c.600 m. Common in Hajar Mtns. Often a cliff plant in Ru'us al-Jibal.

POLYGONACEAE

Emex spinosa (L.) Campd.

Locally common. Weed in cultivated and abandoned fields. Up to at least 1200 m.

Pteropyrum scoparium Jaub. & Spach

Locally common. Generally absent but can be common on coarse, poorly consolidated, low gravel banks or terraces, usually where wadis are broadest (e.g., W. Khasab, uppermost W. Bih and debouchement of W. Khabb Shamsi). Occasional in Hajar Mtns. Endemic to the mountains of the UAE and Northern Oman but possibly conspecific with *P. aucheri* of Iran.

Rumex vesicarius L.

Locally common. Up to at least 1600 m.

PORTULACACEAE

Portulaca olereaca L.

Rare. Two records: one near cultivation, c.750 m; second at spring at 'Ayn as-Sih, 470 m.

PRIMULACEAE

Anagallis arvensis L.

Locally common. Up to at least 1625 m.

Asterolinon linum-stellatum (L.) Duby*

Locally common, but easily overlooked. Wadis and sheltered sites to at least 1350 m, also stony plateaux at 1100 m+. *Fig. 5.4.2*. See also *Fig. 3.3.3*.

RANUNCULACEAE

Adonis dentata Delile*

Rare. Single location at c.1000 m, near small fenced plot. Recorded by B. Couldrey. ID by L. Boulos and R.J. Hornby. *Fig. 5.1.1*. See also *Fig. 3.3.7*.

RESEDACEAE

Ochradenus arabicus Chaudhary, Hillcoat & A.G. Miller

Locally common. Widespread and occasional at all elevations to c.1550 m, usually on flat ground (including abandoned terraces). Similar unpredictable distribution in Hajar Mtns. Flowering plants attract many flies and small wasps. See *Figs. 3.1.21, 3.1.22, 3.1.23, 3.3.4* and *3.3.9.*

Ochradenus aucheri Boiss.

Locally common. Very common on rubble slopes at low elevation in mid-Wadi Bih. Otherwise, few scattered sites at low elevation. Locally common in Hajar Mtns, especially on ultrabasic rock.

Oligomeris linifolia (Vahl.) J.F. Mcbr.

Rare. 250-1200 m. Wadi bank, gravel terrace and field environment.

Reseda sp.

Rare. Single location, low gravel terraces at wide junction of tributary in upper Wadi Bih, c.300 m. Leaves broad, entire but folded. Similar plants from Hajar Mtns ID'd by L. Boulos as *R. aucheri* Boiss. var. *bracteata* (Boiss.) Abdallah & de Wit.

RHAMNACEAE

Ziziphus spina-cristi (L.) Willd.

Common. Up to c.1500 m. Wadis and wadi banks, some slopes. Cultivated for fruit and for coppicing. See *Figs. 3.1.23, 3.1.24, 3.2.6* and *5.5.13*.

ROSACEAE

Prunus arabica (Oliv.) Meikle*

Common. Above c.600 m. Dominant tree above

c.800 m, outside wadis. Stunted on exposed slopes. [Syn. *Amygdalus arabica*] Little overlap in elevation with the morphologically similar *Moringa peregrina*. Absent from the Hajar Mtns immediately to the S, and from the Jebel Akhdar, but recorded by Mandaville (1977) from Jebel Aswad in the Eastern Hajar Mtns, SE of Muscat, c.430 km distant. The author found it common in the area of the Selma Plateau (c.1800-2200 m), in the Jebel Bani Jaber range to the E of Jebel Aswad. *Figs. 3.1.1*, *3.1.4*, *3.1.6*, *3.1.7*, *3.1.9*, *3.1.12*, *3.1.13*, *3.1.15*, *3.1.16*, *3.1.21* and *3.1.22*.

RUBIACEAE

Callipeltis cucullaris (L.) Steven

Locally common. Among rocks. All elevations to at least 1600 m. ID by L. Boulos.

Galium aparine L.

Occasional. In silt of fields and slopes, especially sheltered sites, c.500-1450 m. ID by R.J. Hornby. Rare in Hatta area (Karim 2002). [Note: The author did not distinguish in the field among three very similar *Galium* spp.: *G. aparine*, *G. ceratopodum* and *G. tricornutum*, all of which have been recorded from the Ru'us al-Jibal. Photographic records confirm a Ru'us al-Jibal *Galium* sp., sometimes lush, with tuberculate-pubescent and distinctly mucronate leaves, consistent with *G. aparine*, except that the axillary flower cymes are invariably very short. *G. ceratopodum* has been the subject of several expert determinations (see note below under *G. ceratopodum*). Records of *G. tricornutum* are mentioned here for the sake of completeness, but its occurrence is considered uncertain and it has been disregarded in compiling the statistics presented in the accompanying paper.]

Galium ceratopodum Boiss.*

Occasional. In silt of fields and slopes, especially sheltered sites, c.500-1450 m. ID by L. Boulos. Rare in Hatta area (Karim 2002). [Note: Each of three *Galium* specimens collected by the author from the Ru'us al-Jibal has been ID'd as *G. ceratopodum*. Two other very similar *Galium* spp. have also been recorded from the Ru'us al-Jibal: *G. aparine* and *G. tricornutum*. These are discussed above in the note under *G. aparine*.] *Fig. 5.5.7*. See also *Fig. 3.3.3*.

Galium decaisnei Boiss.

Locally common, but easily overlooked. All elevations. Included in Jongbloed (2003) as *Galium setaceum* Lam. [Syn. *Galium setaceum* Lam. subsp. *decaisnei* (Boiss.) Ehren.] See *Fig. 3.3.6*.

Galium tricornutum Dandy* [Jongbloed (2003)]

Occasional in wadis, hillsides, fields, per Jongbloed (2003). Records of *G. tricornutum* are mentioned here for the sake of completeness, but its occurrence is considered uncertain and it has been disregarded in compiling the statistics presented in the accompanying paper. See note under *Galium aparine*.

Plocama aucheri (Guill.) M. Backlund & Thulin

Occasional. Locally common on rubble slopes at low elevation. Rare above c.700 m, absent above c.1100 m. Common in Hajar Mtns, locally dominant on gravel outwash plains. [Syns. *Jaubertia aucheri* Guill., *Gaillonia aucheri* (Guill.) Jaub. & Spach] [Note: According to recent molecular studies, the genus *Plocama* has been expanded to include the UAE and Oman species of the genera *Jaubertia*, *Gaillonia*, *Pseudogaillonia* and *Pterogaillonia* (Ghazanfar, *in press*).]

Plocama calycoptera (Decne.) M. Backlund & Thulin

Rare, but possibly overlooked due to similarity to *P. hymenostephana*. From c.200 m to at least 1600 m. Wadi beds to open ridges. ID by L. Boulos. Also recorded from N Oman (Ghazanfar 1992a). [Syn. *Pterogaillonia calycoptera* (Decne.) Lincz.] See note under *Plocama aucheri*.

Plocama hymenostephana (Jaub. & Spach) M. Backlund & Thulin

Occasional. From c.400 m to at least 1600 m. Among rocks. [Syn. *Pseudogaillonia hymenostephana* (Jaub. & Spach) Lincz.] See note under *Plocama aucheri*.

Valantia hispida L.*

Rare, but possibly overlooked. Wadi environment from c.250 m up to at least 1200 m. ID by L. Boulos.

RUTACEAE

Haplophyllum tuberculatum (Forssk.) A. Juss.

Rare. Three localities on wadi banks at low elevation, one near abandoned fields. Common in Hajar Mtns. *Fig. 6.1.5*.

SAPINDACEAE

Dodonaea viscosa Jacq.

Locally common. Above c.500 m, flat wadis and stunted among rocks on open plateaux and gentle slopes. In the Jebel Akhdar, common with juniper in highest vegetation zone, to summits at 3000 m. In Hajar Mtns, common but restricted to wadi banks. *Fig. 5.4.9*. See also Section 14 and *Figs. 3.1.1*, *3.1.3*, *3.1.5*, *3.1.8*, *3.1.9*, *3.1.21* and *3.1.23*.

SCROPHULARIACEAE

Anticharis arabica Endl.

Occasional. From gravel wadis at 250 m to open hillsides at 1600 m. Rare in Hajar Mtns.

Anticharis glandulosa Asch.

Rare. Two locations in and above W. Naqab, c.300-750 m. Occasional in Hajar Mtns.

Chaenorrhinum rubrifolium (DC.) Fourn. subsp. *gerense* (Stapf) D.A. Sutton **

Rare. Single Ru'us al-Jibal location. Soil within stony scree. This is the unidentified species depicted in Jongbloed (2003) at p. 544. ID by L. Boulos. Locally common in Masafi area of Hajar Mtns, single record from Mahdhah area. *Fig. 5.1.5*.

Linaria simplex Desf.

Rare but probably overlooked. Two locations: one on bedrock slopes at c.900 m above W. Sha'am. ID by L. Boulos; second at spring at 'Ayn as-Sih, 470 m, where *Linaria* sp. also recorded by Mandaville (1985). *L. simplex* Desf. and *L. tenuis* (Viv.) Spreng. are recorded as rare species from the Hajar Mtns (Jongbloed 2003). *Fig. 5.3.25*.

Misopates orontium (L.) Rafin.
Occasional. Up to at least 1500 m. Among rocks.
Nanorrhinum floribundum (Boiss.) Tackh. & Boulos(?)*
Rare. Two plants only: gravel wadi environment at 250 m (ID by L. Boulos) and rocky gulley at c.800 m. [Syn. *Kickxia floribunda* (Boiss.) Tackh. & Boulos]
Nanorrhinum hastatum (R. Br. Ex Benth.) Ghebr.
Occasional. Wadi environment and shelter among rocks up to at least 1250 m. [Syn. *Kickxia hastata* (R. Br. Ex Benth.) Dandy]
Nanorrhinum ramosissimum (Wall.) Betsche
Rare. Wadi environment and shelter among rocks up to at least 800 m. [Syn. *Kickxia ramosissima* (Wall.) Janchen]
Scrophularia arguta Aiton
Common. Up to c.1200 m. Often beside fallow fields and in soil among rocks.
Scrophularia deserti Delile
Rare but widespread. Up to c.1550 m.

SOLANACEAE
Lycium shawii Roem. & Schult.
Occasional. Up to c.1000 m. Heavily grazed.
Solanum incanum L.
Occasional. c.500-1600 m. Disturbed ground near habitation. Rare in Hajar Mtns immediately to south, but reportedly common in N. Oman foothills (Ghazanfar 1992a).
Solanum nigrum L.
Occasional. Shaded sites among rocks and near habitation or cultivation. Up to at least c.1250 m.

THYMELAEACEAE
Thymelaea mesopotamica (C. Jeffrey) B. Peterson*
Locally common. Stony plateaux at 1400-1600 m in N Ru'us al-Jibal. ID by L. Boulos. *Fig. 5.3.35.*

TILIACEAE
Grewia erythraea Schweinf.
Occasional. Up to c.1000 m. Normally heavily grazed to cushion. Rare in Hajar Mtns.
Grewia tenax (Forssk.) Fiori
Rare. Two localities. Few plants as quasi-cliff dwellers in Wadi Khabb Shamsi narrows at 250-350 m; record from mtns near Sha'am. Also rare in Hajar Mtns at moderate elevations (700-1000 m). *Fig. 5.5.8*.
Grewia villosa Willd.
Rare. Single locality, few plants as cliff dwellers in Wadi Khabb Shamsi gorge at 250-350 m. Also rare in Hajar Mtns. Found only on carbonate rocks (J. Sumayni, J. Ghaweel, J. Qatar).
Corchorus depressus (L.) Stocks.
Rare. Two localities at low elevation, one in silt plain behind landslide dam.

URTICACEAE
Forsskaolea tenacissima L.
Locally common along Wadi Bih and in S of Ru'us al-Jibal, up to c.600 m (exceptionally to 1100 m). In shelter of rocks, boulders and cliffs. In most of the Ru'us al-Jibal, the wadi and wadi bank niche of this species seems to be filled by *Parietaria alsinifolia*. Common in wadi environments in Hajar Mtns.
Forskaolea viridis Ehrenb.
Rare. Single location in W. Khabb Shamsi narrows. ID by M. Jongbloed. Locally common in Hajar Mtns.
Parietaria alsinifolia Delile
Common. Gravel wadi environment, esp. in shade; abandoned dwellings. Low-medium elevation. To a great extent, this species appears to fill, in the Ru'us al-Jibal, the niche of *Forsskaolea tenacissima* in the Hajar Mtns.

VALERIANACEAE
Valerianella szovitisiana Fisch. & C.A. Mey* **.
Locally common at single locality, c.1250 m. On gentle, stony slope among other annuals (e.g., *Zoegea purpurea*, *Callipeltis cucullaris*, *Anagallis arvensis*, *Paracaryum intermedium*, *Scabiosa olivieri*). ID by L. Boulos. *Fig. 5.1.17*.

VIOLACEAE
Viola cinerea Boiss.
Common. All elevations. Wadi and plateau environments.

ZYGOPHYLLACEAE
Fagonia bruguieri DC
Occasional. Low elevation. [Note: Early field records from higher elevations may be unreliable due to non-recognition of *F. schimperi*.]
Fagonia indica Burm. f.
Common, especially in S Ru'us al-Jibal. Up to c.500 m. Predominance may be an indicator of overgrazing. Common in Hajar Mtns.
Fagonia schimperi C. Presl.*
Locally common. c.750-1600 m. ID by L. Boulos. Medium to dark green, grooved stem, long spines at widely spaced nodes. Most common *Fagonia* of the higher Ru'us al-Jibal. *Fig. 5.3.15*.
Fagonia schweinfurthii (Hadidi) Hadidi [Jongbloed (2003)]
Rare, but possibly not distinguished from other *Fagonia* spp. Single record from UAE, Wadi Bih, by Böer & Chaudhary.
Tribulus terrestris L.
Rare. S Ru'us al-Jibal only. Low elevation.

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Fig. 5.3.28. *Pennisetum orientale*

Fig. 5.3.29. *Plantago notata*

Fig. 5.3.30. *Poa sinaica* (?)

Fig. 5.3.31. *Pterocephalus brevis*. This specimen, collected by A.R. Western, is in the herbarium at the Sharjah Natural History Museum.

Fig. 5.3.32. *Pupalia lappacea*

Fig. 5.3.33. *Salvia mirzayanii*. See also *Fig. 1.3.3*.

Fig. 5.3.34. ***Stipagrostis raddiana*****, the common** ***Stipagrostis*** **species of the high Ru'us al-Jibal. The morphology of the spikelets is very close to what has been depicted as** ***S. paradisea*** **in** ***Flora of Egypt*** **and Cope (2007) and synonymized by Ghasemkhani** ***et al.*** **(2008).**

Fig. 5.3.35. ***Thymelaea mesopotamica***

Fig. 5.3.36. ***Tripteris vaillantii*** **(syn.** ***Osteospermum vaillantii*****) (photo from Saiq Plateau). The sole record of this species in the Ru'us al Jibal has been determined to be erroneous. It is rare in the Jebel Akhdar but locally common in the Eastern Hajar Mountains.**

Fig. 5.3.37. ***Ziziphora tenuior***

Fig. 5.4. Common and characteristic species of the Ru'us al-Jibal

Fig. 5.4.1. ***Artemisia sieberi.*** **See also** ***Figs. 3.1.6, 3.1.12, 3.1.13, 3.1.19, 3.1.22, 3.2.1*** **and** ***3.3.1.***

Fig. 5.4.2. ***Asterolinon linum-stellatum***

Fig. 5.4.3. ***Astragalus fasciculifolius.*** **See also** ***Figs. 3.1.22*** **and** ***5.5.3.***

Fig. 5.4.4. ***Brachypodium distachyum***

Fig. 5.4.5. ***Centaurea wendelboi.*** **See also** ***Fig. 3.3.1.***

Fig. 5.4.6. ***Convolvulus acanthocladus.*** **See also** ***Figs. 3.1.1, 3.1.4, 3.1.5, 3.1.8, 3.1.9, 3.1.11, 3.1.13, 3.1.15, 3.1.16, 3.1.17, 3.1.21, 3.1.23*** **and** ***3.3.1*** **and compare** ***Fig. 5.5.4.***

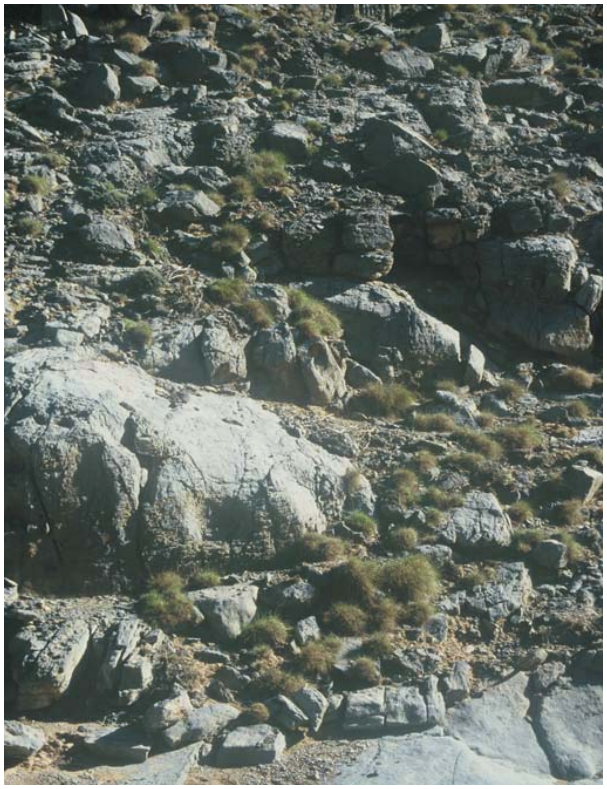

Fig. 5.4.7. ***Cymbopogon jwarancusa*****. This hillside near As-Sayh, at c.1300 m, is dominated by tufts of** ***C. jwarancusa*****. See also** ***Figs. 3.1.1*****,** ***3.1.8*****,** ***3.1.9*****,** ***3.1.11*****,** ***3.1.17*****,** ***3.1.18*****,** ***4.1.11*** **and** ***5.3.10*****.**

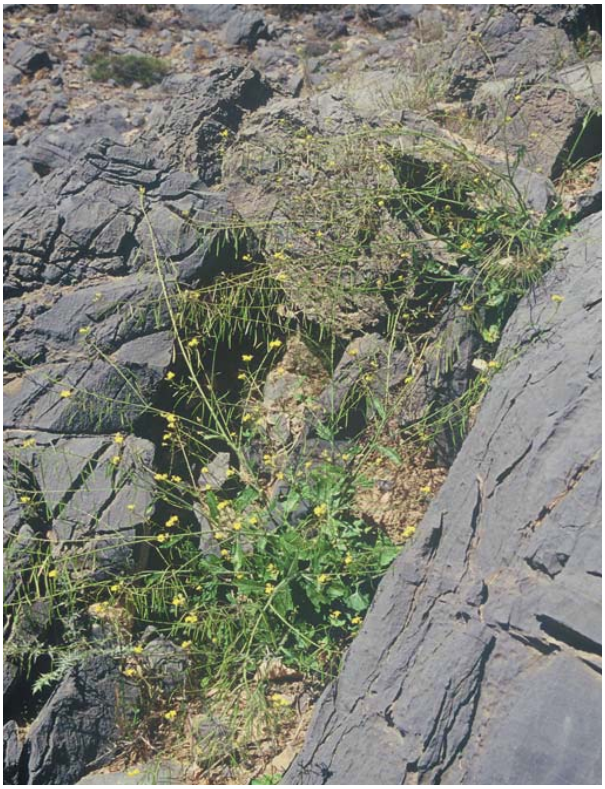

Fig. 5.4.8. ***Diplotaxis harra.*** **This rock or cliff-dwelling form is typical of the Ru'us al-Jibal. Compare with Fig. 5.5.6, which shows the morphology common in the foothills and gravel outwash plains of the Hajar Mountains to the south (see Section 14).**

Fig. 5.4.9. ***Dodonaea viscosa*** **dominates the higher ground adjacent to cultivation at Ra's al-Maq c.750 m. See also** ***Figs. 3.1.1*****,** ***3.1.3*****,** ***3.1.5*****,** ***3.1.8*****,** ***3.1.9*****,** ***3.1.21*** **and** ***3.1.23*****.**

Fig. 5.4.10. ***Ephedra pachyclada*** **in flower. See also** ***Figs. 3.1.7*****,** ***3.1.13*** **and** ***3.1.22*****.**

Fig. 5.4.11. ***Euphorbia larica*** **(photo from Hajar Mountains). See also** ***Fig. 3.1.21.***

Fig. 5.4.12. ***Farsetia aegyptia.*** **See also** ***Figs. 3.1.5*** **and** ***3.1.23.***

Fig. 5.4.13. ***Ficus cordata salicifolia.*** **Normally confined to wadi beds, on the east coast of the Musandam this species is also common on hillsides at lower elevations.**

Fig. 5.4.14. ***Ficus johannis.*** **The white bark is distinctive. This species is one of the only deciduous trees found in the UAE and Northern Oman. Within mountain settlements it is cultivated for its fruit and often colonises traditional cisterns.**

Fig. 5.4.15. ***Helichrysum glumaceum.*** **This species has recently been synonymized with** ***H. makranicum*** **by N. Kilian, based in part on specimens and information provided by this study.**

Fig. 5.4.16. ***Gymnocarpos decandrus*** **(dry). See also** ***Figs. 3.1.16*** **and** ***3.3.1*****.**

Fig. 5.4.17. ***Helianthemum lippii*** **is highly variable in its morphology. The plant on the left has relatively large, broad leaves and is yellow-green in colour; the plant on the right has small, narrow leaves and is grey-green.**

Fig. 5.4.18. *Ixiolirion tataricum*

Fig. 5.4.19. *Jurinea berardioides*

Fig. 5.4.20. *Launaea bornmuelleri.* See also *Figs. 3.1.18* and *3.1.21*.

Fig. 5.4.21. *Moraea sisyrinchium. See also Fig. 3.2.1.*

Fig. 5.4.22. *Phagnalon schweinfurthii*

Fig. 5.4.23. ***Pulicaria edmondsonii***

Fig. 5.4.24. ***Teucrium stocksianum***

Fig. 5.4.25. ***Vernonia arabica***

Fig. 5.5. Some additional Ru'us al-Jibal species and botanical phenomena

Fig. 5.5.1. *Acacia ehrenbergiana*. These few trees found in the Ru'us al-Jibal are atypical in branching from a single basal trunk, in the manner of *A. tortilis*. The author had passed them in Wadi Khabb a number of times without distinguishing them, until they were seen bearing yellow flowers.

Fig. 5.5.2. *Acacia tortilis*. Above about 800 metres, *A. tortilis* generally thrives only on or adjacent to agricultural terraces. At 1250 metres, this large specimen in upper Wadi Shah is one of the highest, but from this point another small tree could be seen somewhat higher still, at about 1350 metres, adjacent to a steep wadi. See also *Figs. 3.1.23, 3.1.25* and *3.2.6*.

Fig. 5.5.3. "De-barked" *Astragalus fasciculifolius*. During the extreme drought of 1999-2003, *A. fasciculifolius* plants were regularly observed with their tops removed and the stump stripped to expose the core. The animals responsible (goats or possibly donkeys) were presumably seeking out nutritional or medicinal components.

Fig. 5.5.4. ***Convolvulus acanthocladus*** **is a dominant species in the high Ru'us al-Jibal but it is essentially absent in the Hajar Mountains for c.135 km to the south. It reappears along the mountain front in the Mahdhah area of Northern Oman, where it exhibits the rectilinear morphology shown here, which is distinct from the tomentose morphology of Ru'us al-Jibal plants. See Section 14 and compare** ***Fig. 5.4.6*****.**

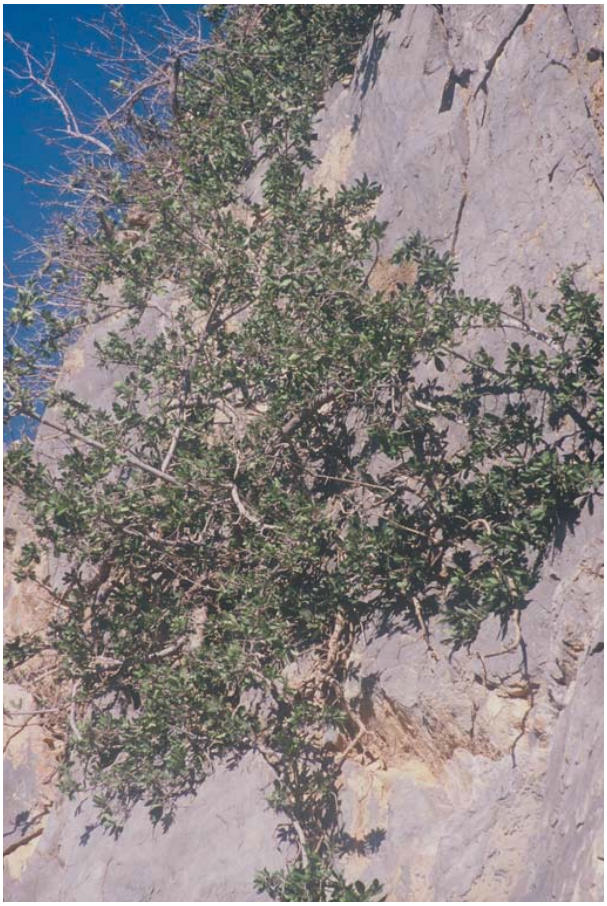

Fig. 5.5.5. ***Cordia*** **sp. aff.** ***quercifolia.*** ***T*****he identity of this straggling shrub remains provisional. Only a handful of plants are known from a single locality, where they are found on south-facing cliffs and ledges inaccessible to browsing animals. They were feared to have perished in the exceptional drought of 1999-2003, but the largest specimen (shown here) was reportedly substantially restored as of spring 2010.**

Fig. 5.5.6. ***Diplotaxis harra*** **is common as a small annual on gravel terraces along and within the Hajar Mountain front, as shown here. This morphology is distinct from that of the cliff-dwelling form common in the Ru'us al-Jibal. Compare** ***Fig. 5.4.8*** **and see Section 14.**

Fig. 5.5.7. ***Galium*** **sp. See note in the Checklist under** ***Galium aparine.***

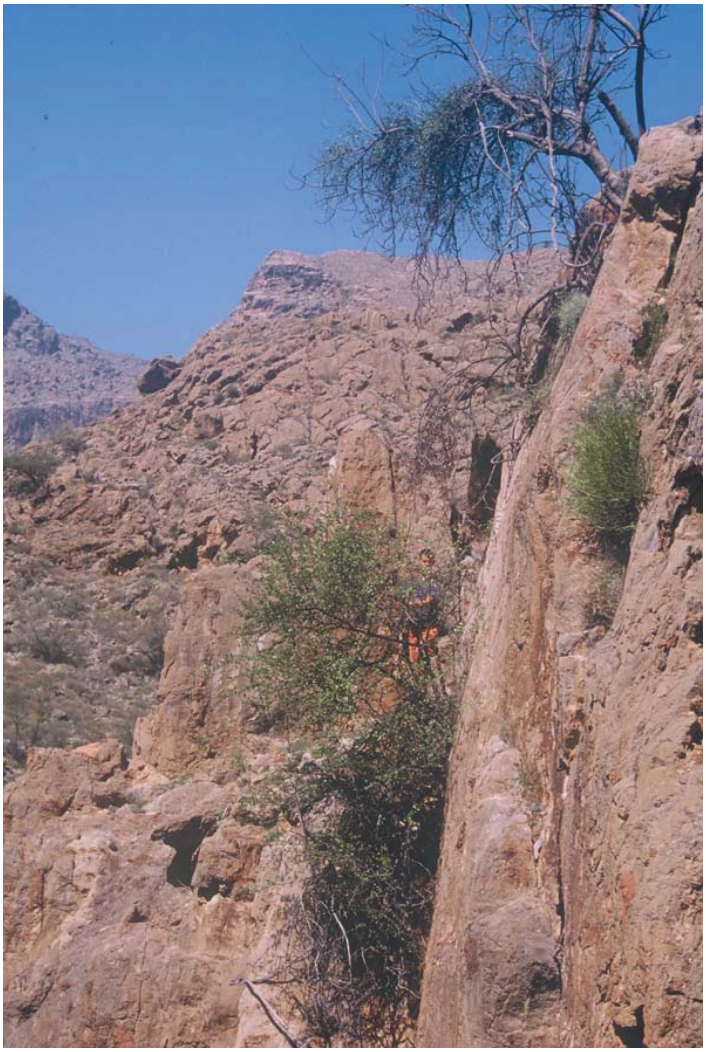

Fig. 5.5.8. ***Grewia tenax*** **is found as a cliff-dwelling species in the area of the Wadi Khabb Shamsi narrows.**

Fig. 5.5.9. ***Heliotropium bacciferum*** **(left foreground) and** ***H. brevilimbe*** **(syn.** ***H. calcareum*****) (right foreground) are shown together at c.1200 m in the eastern Ru'us al-Jibal. The species discussed here as** ***H. bacciferum*** **occurs in the Ru'us al-Jibal and along the west coast of the Arabian Gulf in Saudi Arabia, Qatar and Kuwait. It has been erroneously equated by several authors with the species identified in Western (1989) and Jongbloed (2003)** ***as H. kotschyi.***

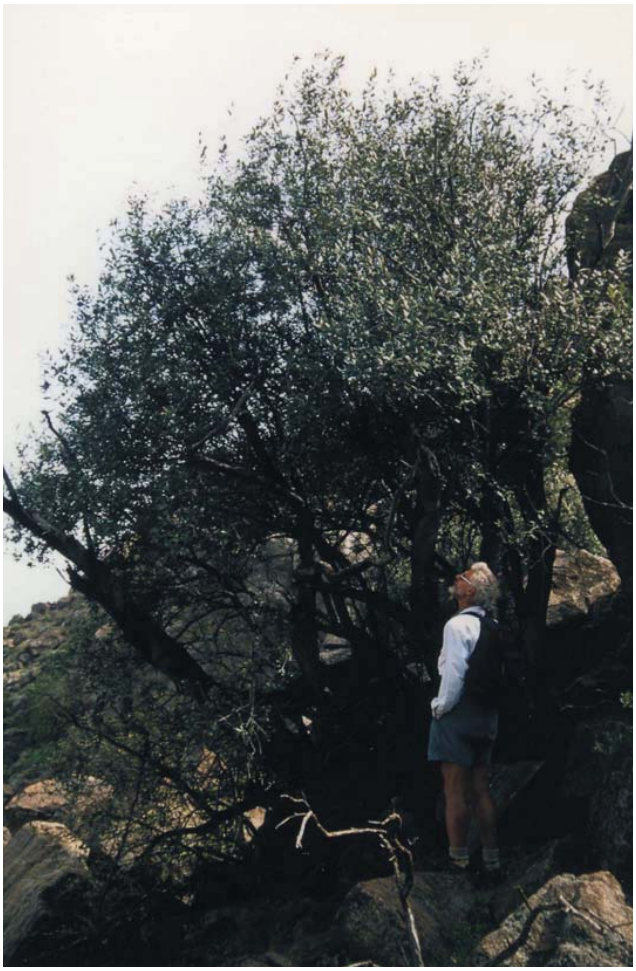

Fig. 5.5.10. The wild olive *Olea europaea* in good condition at 1000 metres on Jebel Qitab, c.65 km south of the Ru'us al-Jibal, in March 1998. Compare *Fig. 5.5.11*.

Fig. 5.5.11. Barren wild olive trees at the same locality as *Fig. 5.5.10*, in December 2006.

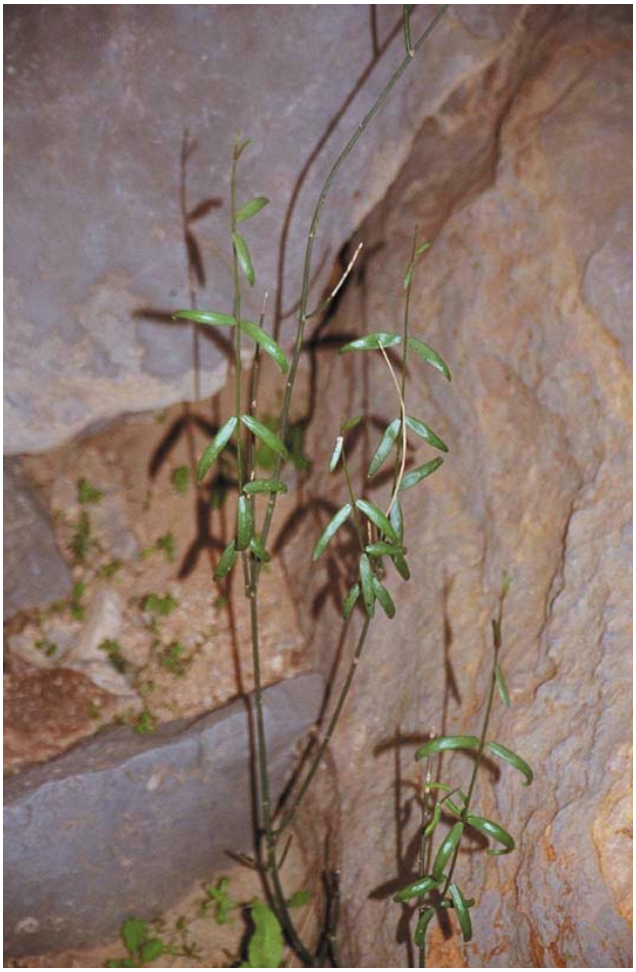

Fig. 5.5.12. The enigmatic seedling of the milkweed *Periploca aphylla.*

Fig. 5.5.13. Traditionally, the *sidr* tree, *Ziziphus spina-christi,* was regularly coppiced for lumber in the Ru'us al-Jibal. See also *Figs. 3.1.23* and *3.1.24.*

Fig. 6. Some common Hajar Mountain species that are absent or very rare in the Ru'us al-Jibal

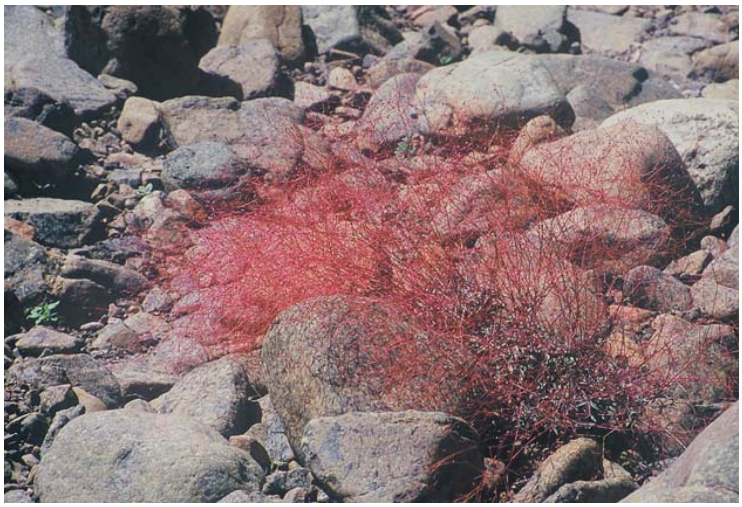

Fig. 6.1.1. ***Boerhavia elegans***

Fig. 6.1.2. ***Cleome noeana***

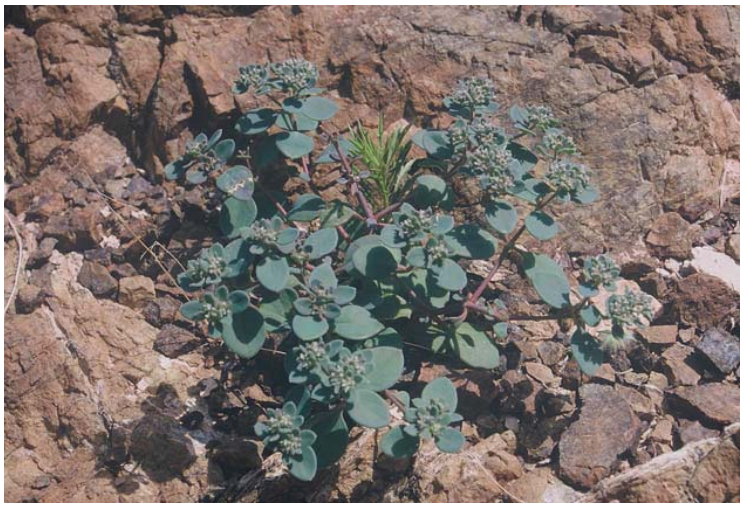

Fig. 6.1.3. ***Cometes surattensis***

Fig. 6.1.4. *Crotalaria aegyptiaca*

Fig. 6.1.5. *Haplophyllum tuberculatum*

Fig. 6.1.6. *Iphiona scabra*

Fig. 6.1.7. *Lindenbergia arabica*

Fig. 6.1.8. *Physorrhynchus chamaerapistrum*

Fig. 6.1.9. *Pulicaria glutinosa.* See also *Fig. 1.5.1.*

Fig. 6.1.10. *Rhazya stricta*

Fig. 6.1.11. *Saccharum griffithii*

Fig. 6.1.12. *Taverniera cuneifolia*

SHORT NOTE

Fresh water input to Khor Hulaylah: an unusual feature of Ra's al-Khaimah's wetland

by Robert E. Llewellyn-Smith

Introduction

Khor Hulaylah is the largest coastal wetland in the Emirate of Ra's al-Khaimah, United Arab Emirates. It occupies an approximate area of 6.6 sq. km, and comprises a winding creek with areas of mangrove, intertidal mudflats, and salt marsh habitat on the landward side, sheltered from the Arabian Gulf by a prominent sand bar (*Fig. 1*).

It is located just north of the town of Rams, in a narrow land corridor of 5 km between the Arabian Gulf and the mountains of the Musandam region (the Ru'us al Jibal range). From west to east, once past the wetland, elevation increases rapidly from sea level to over 600 m and higher to over 1600 m just a few kilometres further north and east (Jebel Rahabah, *Fig. 2*, rises to 1550 m+). The mountain front forms an arc behind the village of Dhayah, and is dissected by a number of deeply incised wadis through the more or less flat-lying carbonate sediments. This topography serves to channel and focus rainfall runoff and alluvium into the Dhayah plain, an alluvial fan which in turn supports a lush date palm garden oasis, irrigated through boreholes.

Where the Dhayah plain meets the coast, a line of four distinct brackish surface water pools is evident (*Sites 1 to 4, Fig. 1 & Table 1*), probably supplied by seepage of fresh groundwater from the Dhayah plain. Inspection of the geology maps for the area (Ellison *et al*., 2006) shows that this line exists at the interface where alluvial fan gravel deposits meet the coastal intertidal and supratidal deposits.

The present note reports on the ecology associated with this brackish environment, which is integral to the wetland ecosystem at Khor Hulaylah, but not evident in Ra's al-Khaimah's three other coastal wetlands to the south (Khor Julfar, Khor Ra's al-Khaimah, Khor Muzahmi).

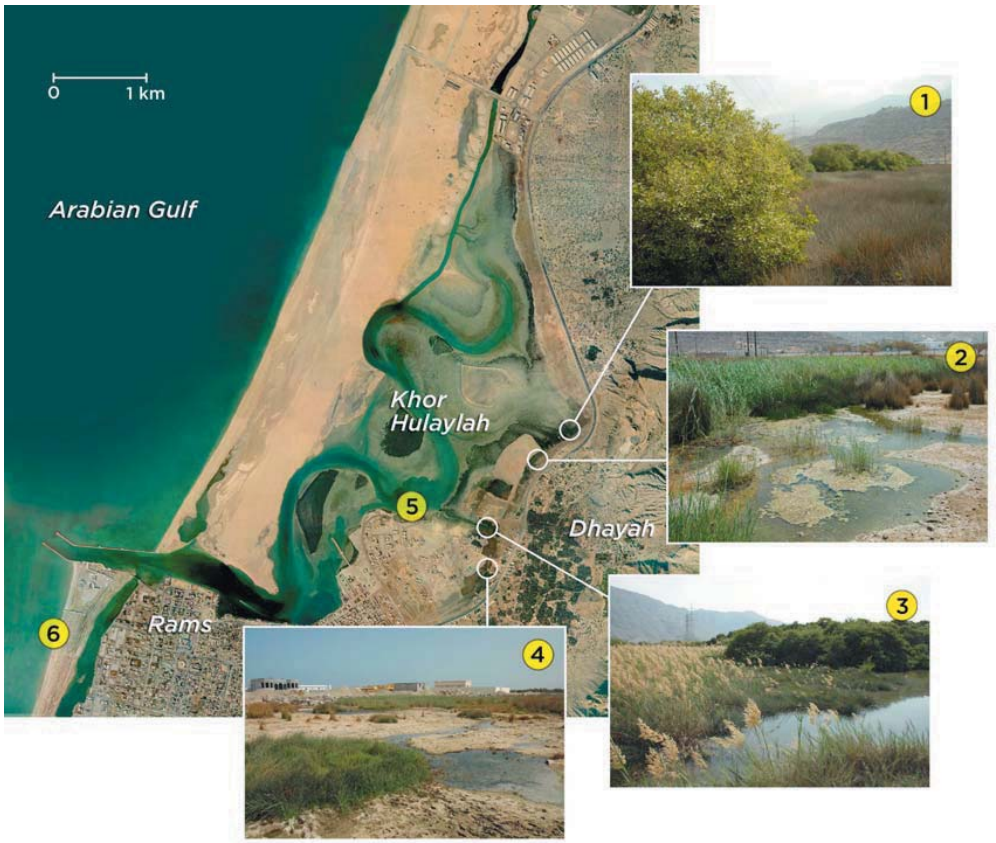

Fig. 1: Khor Hulaylah showing location of main brackish water pools (1-4), and comparison sites (5, 6)

Fig. 2: Khor Hulaylah wetland with Jebel Rahabah (1550 m+) providing a dramatic mountain backdrop (Picture: R. Llewellyn-Smith).

Study findings

Salt marsh conditions and associated vegetation exist due to the presence of a mix of saline sea water at high tide and brackish water from a water table that is close to the surface, perhaps combined with high local ambient temperatures.

Evidence for the input of freshwater comes firstly from the local vegetation, particularly from two species, the common reed *Phragmites australis*, and the sedge *Cyperus laevigatus*. Both species are found near or in fresh or brackish water (Jongbloed, 2003). *P. australis* prefers freshwater areas, but can tolerate brackish environments and is common in estuarine habitats. These two species are found at three of the four study sites (*Site 2, 3 & 4, Fig.1 & Table 2*). They are, however, not found at Ra's al-Khaimah's three other coastal wetlands further south. Similarly, the rush *Juncus rigidus* is an indicator of salt marsh conditions. It occurs in extensive stands in the area. It probably provides the UAE's best example of this localised species. Other common salt tolerant plants at Sites 1 to 4 on drier saline ground are *Cressa cretica*, *Alhagi graecorum* and *Tamarix* sp.

Another compelling indicator is the presence of the fresh and brackish water snail *Melanoides tuberculata*, which can be found (occasionally) in pools at the shoreline of Khor Hulaylah (*pers. comm*. Gary Feulner).

Salinity tests using a YSI 556 multiparameter hand-held probe, confirm the brackish nature (Table 2), where salinity in parts per thousand (ppt) is below 18 at Sites 1 to 4, compared with 38.14 in the creek (Site 5) and 37.98 in the open sea (Site 6).

Salinity tests at the other 3 wetlands, conducted on another occasion but on the same day, showed similar values to the Hulaylah creek at Site 5, further reinforcing the unusual brackish qualities of Sites 1 to 4.

A further indication of fresh water input is the height of the mangroves (*Avicennia marina*), at Sites 1 and 3 (*Fig. 1*). Here, the mangroves are dense and tall, growing up to 7 m. They then decrease steadily in size to generally below 2 metres towards the creek. This is in agreement with studies showing that increased growth of *A. marina* is achieved at lower salinity levels (Hogarth, 1999).

Cultural evidence also supports the existence of freshwater in this area as, in the past, villagers from Rams and Dhayah used to collect water for drinking from Ain Dhayah (Site 3), hence Ain in Arabic, meaning a spring. Mud was also collected which was said to have healing properties for skin problems.

Table 1. Location and description of brackish pools (1-4) and comparison sites (5,6) at Khor Hulaylah.

Site	GPS Coordinates	Vegetation	Remarks
1	Between N 25° 54.021 E 056° 03.530 and N 25° 53.888 E 056° 03.373	*Avicennia marina* *Juncus rigidus*	A series of high (up to 5 m), dense mangrove stands, adjacent to *Juncus rigidus*, covering an approximate area of 0.4 ha, and arranged in distinct channel lines extending towards the main creek. Permanent surface water is present even at low tide. *Cressa cretica*, *Alhagi graecorum* and *Tamarisk* sp. occur nearby on drier ground.
2	N 25° 53.756' E 056° 03.203'	*Phragmites australis* *Cyperus laevigatus* *Cressa cretica* *Alhagi graecorum* *Tamarix sp.* *Juncus rigidus*	An approximate area of 0.07 ha. Original extent unknown due to land reclamation nearby. Surface water visible. No mangroves present.
3	***Ain Dhayah:*** ***- north pool:*** N 25° 53. 468' E 056° 03.063' ***- south pool:*** N 25° 53. 405' E 056° 03.067'	*Avicennia marina* *Phragmites australis* *Cyperus laevigatus* *Cressa cretica* *Alhagi graecorum* *Tamarix sp.* *Juncus rigidus*	Two open pools, overlooked by tall (7 m), dense mangroves. The ponds are connected to the main creek by a 700 m long natural channel, lined by mangroves, and fringed with *Juncus rigidus*. The *Juncus* ends abruptly, giving way to intertidal mudflats with open mangrove cover.
4	N 25° 53. 208' E 056° 02.996'	*Phragmites australis* *Cyperus laevigatus* *Juncus rigidus*	Surface water ponds with *Phragmites australis* and *Cyperus laevigatus*. No mangroves present.
5	N 25° 53. 526' E 056° 02.567'		Open creek
6	N 25° 52. 776' E 056° 00.423'		Sea

Table 2. Water properties at each site (average of 3 readings taken on 23.03.10)

Water properties	Site 1	Site 2	Site 3	Site 4	Site 5 (Khor)	Site 6 (Arabian Gulf) (reading taken from shoreline)
Time	0826	0851	0921	0951	1012	1053
Temp. ºC	27.24	24.42	30.95	26.62	24.68	25.92
Salinity (ppt)	7.98	10.82	11.23	17.47	38.14	37.98
pH	7.54	7.05	7.42	7.46	8.16	8.18

Note:
Water salinity ranges based on dissolved salts in parts per thousand (ppt) are commonly:

Fresh water < 0.5
Brackish water 0.5 - 30
Saline water 30 - 50
Brine > 50

Table 3. Comparison of water salinities at RAK's four coastal wetlands, taken on 10.04.10 (average of readings taken at three different locations at each Khor)

	Khor Muzahmi	Khor Ra's al-Khaimah	Khor Julfar	Khor Hulaylah
Temp ºC	27.08	28.11	29.05	28.04
Salinity (ppt)	39.23	39.44	39.24	38.74
pH	8.2	8.06	8.26	8.21

The pools support various fish species. Killifish *Aphanius dispar* were observed at Sites 1, 2 and 3. Also recorded at Site 3 (Ain Dhayah) are Crescent-banded *Terapon jarbua*, which is usually seen hunting killifish in the shallow water; Milkfish *Chanos chanos*, and Common Silver-Biddy *Gerres oyena*. A conspicuous red-legged mangrove crab considered to be *Metapograpsus thukuhar* (*pers. comm.* Richard Hornby), occurs in the main pool at Ain Dhayah, as does the freshwater snail *Melanpides tuberculata.* The insects found in this area are varied, and include the dragonfly *Orthetrum sabina* and damselfly *Ishnura* sp. Other dragonflies that have been found among reeds in the marsh include *Anax parthenope* and *Diplacodes lefebvrei* (*pers. comm.* Gary Feulner).

Mallard, Red-wattled Lapwing and Marsh Harriers in winter months are common, along with Clamorous Reed Warbler, identified by its distinctive grating song. Richardson and Aspinall (1998) report 'Eastern' Reed Warbler, Lichtenstein's sandgrouse after dusk, Common Kingfisher and irregular sightings of Indian Pond Heron, Squacco Heron, Night Heron and Great Snipe.

Recommendations for further study and protection

The freshwater input at Khor Hulaylah is unique among Ra's al-Khaimah's four wetlands, and rare in the UAE's other wetlands along the Arabian Gulf coast. However, land reclamation for residential purposes has reduced the area of salt marsh habitat, and the remaining sites described here continue to be at risk. Their survival is probably due to their position underneath a major powerline, discouraging infill for residential or commercial use.

All sites would benefit from further studies to ascertain the importance of this habitat to insects, which have been little investigated.

Just inland at Dhayah, further studies should be undertaken to provide a better understanding of the hydrology of the site. If combined with a study of agricultural and other water usage, comparing recharge versus uptake, a picture of the health of the overall hydrological regime could be established. This would provide useful information to aid in sustainable management of the valuable groundwater resource, as salt water incursion due to excessive water extraction has damaged similar agricultural areas in Ra's al-Khaimah.

Education and recreation opportunities could be exploited, particularly at Ain Dhayah, which could accommodate an interesting nature trail using bird hides and a boardwalk passing by the pools, and traversing through the different zones of mangroves, rushes, reeds, mudflats and open creek.

Protection of Ain Dhayah and the mangrove area at Site 1 (*Fig.1*) have been specifically included in a wider conservation proposal for the Hulaylah wetland to the Government of Ra's al-Khaimah, and supports earlier calls for protection (Aspinall,1996).

Acknowledgements

The Government of Ra's al-Khaimah is acknowledged for supporting this study. The author is thankful to Mustafa Khalifa for his field assistance, and to Simon Aspinall, Richard Hornby, Veryan Pappin, Gary Feulner, Ron Loughland and Ayoob Al Ghafari for their helpful comments and species identification during work on the Hulaylah Nature Reserve proposal in 2006 and 2007. Thank you to Dr Basheer Ali and Gary Feulner for their valuable comments on earlier drafts of this paper.

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Quaternary Sea Levels: Recent Evidence from Abu Dhabi

by Thomas Stevens, Anthony Kirkham and Graham Evans

Fig. 1. A zeuge on the coastal sabkha several kilometres west of Tarif represents an outlier of Pleistocene, large-scale, cross-bedded aeolianite capped by Pleistocene marine limestone encrusted with barnacles. It was from this zeuge that the sample of marine limestone was dated as ca 128.7 +/- 11.3 ka by optically stimulated luminescence dating. The top of the zeuge is about 12 feet above the background coastal sabkha surface.

There is considerable evidence on the coast of Abu Dhabi indicating changes of sea level during the Quaternary. For instance, there are lines of beach ridges on the sabkha plain with elevations between 1-2m above the present high water mark, several kilometres inland from the present strandline. These have ages of between 4000-5000 yrs BP and indicate an earlier period of slightly higher sea level than that of today (Evans *et al*., 1969; Patterson & Kinsman, 1977).

On Marawah Island, west of Abu Dhabi, an horizon of fossil coral occurs at approximately present day high water mark. Ages of between 168-280 ka were obtained for these corals using uranium dating (Evans & Kirkham, 2002). Assuming that the coral, when living, must have been covered by 2 - 3 m of water it indicates another high sea level of approximately this amount above that of the present.

Also, many small rock outcrops called zeugen (Kirkham, 1998; *Fig. 1*) in the tidal channels and on the barrier islands and coastal plain of Abu Dhabi show evidence of higher sea level, although these have proved difficult to date. The zeugen consist partly of a cross-stratified limestone which is of aeolian origin (an aeolianite locally known as 'miliolite'). This is capped in many places by a thin, calichified marine limestone separated from the underlying aeolianite by a marked erosion surface. Attempts have been made to date stratigraphic equivalents of this capping limestone using radiocarbon dating (Williams & Walkden, 2002) but the dates obtained, around 30 ka BP, are close to the limits of the dating technique and Williams and Walkden regarded them as unreliable.

In spite of the fact that no actual convincing dates have been obtained previously from this capping marine limestone, it has been assumed by comparison with the general world pattern of sea level changes that it had been deposited during the penultimate high sea level episode of the last interglacial, *i.e.*, at approximately 125 ka (Williams & Walkden, 2002, Evans *et al*., 2002, Evans & Kirkham, 2005).

However, Wood *et al*. (2006) reported that they had obtained reliable radiocarbon ages from the capping marine limestone of between 24.2 - 28.8 ka BP. They stated that these ages were further confirmed by dates

obtained from quartz grains in the limestone using the optically stimulated luminescence technique. Such data therefore suggested that the capping rock is very much younger than had previously been assumed. Furthermore, as the level of the Arabian Gulf is considered to have been very low at that time, with large areas of the present Gulf floor exposed (Kassler, 1973) and the shoreline many kilometres seaward of its present position, the dates implied that the Arabian coastal margin and areas such as Abu Dhabi were at a much lower elevation relative to today. Thus, as pointed out by Wood *et al*. (2006), for the coast to have attained its present level, with the marine limestone of the capping rock at a few metres above present sea level, it would require the area to have been uplifted by approximately 80 m (*i.e*., approximately 3 mm yr $^{-1}$) during the last 25 kyrs. This seemed very unlikely to the present authors.

Recently, in an attempt to check this unlikely scenario, a new sample of the capping limestone was collected and dated using the standard single-aliquot regeneration (SAR) optically stimulated luminescence technique on sand-sized quartz (Murray & Wintle, 2000; 2003) at the Department of Geography, Royal Holloway, University of London, with dose rates calculated using ICP-MS. The data set and tests applied are to be published in detail but interestingly, the results gave an age of 128.7 +/- 11.3 ka, considerably greater than that obtained by Wood *et al*. (2006). Furthermore, it suggests that the limestone capping the zeugen was deposited during the last interglacial interval, as had previously been assumed and which agrees with world wide evidence of a period of higher sea level or one very close to that of today. This seems a much more likely scenario than proposed by Wood *et al*. (2006). However, more age determinations are needed to test between the two competing ideas. Samples collected in November 2010 are awaiting shipment to the UK for dating and the results obtained should settle this interesting problem.

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Crimson Speckled Footman moths occuring preferentially on *Heliotropium kotschyi* during migration through Abu Dhabi

by Oscar Campbell

Picture after Fibiger & Legrain (2009).

The striking and beautiful Crimson Speckled Footman *Utetheisa pulchella*[1] occurs across most of the Eastern Hemisphere and has one of the most extensive distributions of any moth. Over much of its range, including the UAE, it is a well-known migrant and I have noted it regularly in spring (mainly February to March) and, much less frequently, in autumn. The species was particularly obvious on passage through Abu Dhabi in March 2010, associated with an expected selection of migrant butterflies such as Long-tailed Blue Lampides boeticus, Painted Lady *Vanessa cardui*, Caper White *Anaphaeis aurota* and Desert White Pontia glauconome.

During a visit to Lulu Island, Abu Dhabi on 19th March, I found all these species, and many Crimson Speckled Footman moths (numbering at least 80 individuals, compared to 12 noted on 11th March). Unlike the more free-flying butterflies, the moths were not evenly distributed throughout the island. They frequented flat, very sparsely vegetated plains situated in the island centre. These plains comprise mostly coarse sand with a flora predominately of *Salsola imbricata* and scattered but locally frequent examples of *Heliotropium kotschyi* and *Zygophyllum* sp. *Indigofera colutea* and *Tribulus* sp. are much less common (on the flat plains) but numerous on adjacent (and much more extensive) areas of undulating fine sand. All these shrubs grow as low, isolated bushes and are mostly less than two feet in stature. Virtually without exception, the moths favoured *H. kotschyi* and inspection of these plants resulted in up to 10 moths settled within. As *H. kotschyi* was rather sparse (relative to *S. imbricata* and *Zygophyllum*), the distribution of moths was therefore very clumped. Most individuals clung vertically to the outer stalks of the plants. On disturbance, they flew readily but only for a short distance and invariably settled into another patch of *H. kotschyi* within a metre or so. I spent some time searching and only ever found moths in this plant; disturbance of other species (both on the plains and elsewhere on the island) failed to

[1] Fibiger & Legrain (2009) indicate that, as well as U. pulchella, two other very similar (although apparently less common) congeners have recently been recognised in the UAE. Confident separation of these three species may require examination of genitalia and, in the absence of specimens, has not been attempted for the purposes of this note.

produce a single moth. Later the same day I visited Ra's al Akhdhar on Abu Dhabi island. This comprises a strip of shady Ghaf (*Prosopis cineraria*) woodland with quite extensive, fringing clumps of *Zygophyllum* on the sunnier edges of bare sand. *H. kotschyi* is very uncommon here but, on one of the only plants I found, I was not too surprised to locate several moths. Careful searching of the much more abundant *Zygophyllum* drew a blank. The only moths I found utilising vegetation other than *H. kotschyi* were four at Abu Dhabi Golf and Equestrian Club on 20th March; these were all settled on the grass of the racetrack. I have never recorded *H. kotschyi* at this site.

As would be expected for a wide-ranging migrant, the larvae of this moth are reported to feed on a wide selection of herbaceous plants. However, both Walker & Pittaway (1987) and Fibiger & Legrain (2009) explicitly mention that species of *Heliotropium* are a preferred larval foodplant in Arabia and this, doubtless, is the reason for the moth's preference for this plant. In light of this, however, it may seem peculiar that no individuals from amongst the many observed exhibited signs of breeding behaviour (such as copulation or egg-laying). Indeed, nectaring was not recorded either and all individuals appeared simply to be resting. This lack of activity may be due to the fact that these moths, although readily day-flying, are primarily nocturnal. Searching at night may more readily reveal such behaviour. Alternatively, inspection of stands of *H. kotschyi* where groups of moths have been observed earlier in the season may prove worthwhile and lead to the location of larvae.

Acknowledgements

I am grateful to Gary Feulner who provided useful and constructive comments that greatly improved this short note.

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Torpedo Jars from Sir Bani Yas, Abu Dhabi

by Robert Carter, Jacques Connan, Seth Priestman and Roberta Tomber

The Emirates Natural History Group has provided a grant from its Conservation Fund for the pilot study of a collection of pottery from a Christian monastery site on the island of Sir Bani Yas (late 6th/early 8th century AD) (Carter 2008) The material consists of sherds from a kind of amphora known as a Torpedo Jar, so called because of its elongated shape. The project has also analysed other samples gathered from Iran and India. Torpedo Jars were chosen for study because they are common and ubiquitous between the 4th and the 10th Centuries AD, having a very wide distribution in the western Indian Ocean stretching from Iraq, along the Arabian and Iranian coasts, down the western coast of India as far as Sri Lanka, and along the east coast of Africa (Tomber 2007). They, or more likely their contents, are therefore considered to be a significant item of international trade at this time.

Lined with a black layer of bitumen (naturally occurring tar), the jars are thought to have been used to transport liquid foodstuffs, which, by analogy with Mediterranean amphorae, may have been wine. Although a source in southern Mesopotamia has long been assumed, no kilns are known, and no previous provenance analyses have been conducted. Given the extensive timeframe of their production and variations in shape seen within the group, production may have been the result of more than one workshop.

The analyses supported by the ENHG were chiefly intended to indicate their provenance, using petrographic analysis of Thin Sections taken from the samples. This technique identifies the mineral fragments included in the clay, potentially allowing a match to be made with a source area with compatible geology. It also allows the sherds to be grouped according to the similarity of their mineral inclusions, which could allow the identification of separate production centres within a source area. In addition, bitumen samples from the jars were sent for analysis by Professor Jacques Connan (Strasbourg University, France), also to determine provenance.

Eleven fragments of Torpedo Jar from Sir Bani Yas were thin sectioned and analysed by Roberta Tomber in the Department of Conservation and Scientific Research at the British Museum, along with four samples of other fabrics from the site, for comparative purposes. Additionally, 20 Iranian samples were thin sectioned and analysed, the work on the Iranian material being supported by the British Institute of Persian Studies. The Iranian samples were derived from the Williamson Collection (Priestman and Kennet 2002), and comprised 17 from Torpedo Jars as well as samples from two other Sasanian/Islamic classes whose source in southern Mesopotamia has also been assumed: Turquoise Glazed Ware (2 samples) and Honeycomb Ware (1 sample). Further financial support for the project was provided by the Society for Arabian Studies.

The results from this pilot study are extremely encouraging. Within the Torpedo Jar samples, two main "fabric families" (samples united by the same range of rock and mineral inclusions but with some variation in proportions and size), suggestive of two separate sources, were identified. A third fabric group from Sir Bani Yas, represented by a single sample, was also indicative of a different source in the region. The raw materials for all the Torpedo Jar fabrics would be available within Mesopotamia, but further work is needed to rule out additional or alternative source regions, particularly in southwest Iran.

The pilot provenance analysis of the bitumen from the Sir Bani Yas jars has also taken place, and suggests that the bitumen consistently originated from western Iran (Khuzestan, Fars). This is consistent with earlier studies of bitumen taken from Torpedo Jars in Kuwait and Sri Lanka, which also came from western Iran (Luristan) (Connan & Carter 2007, Stern et al. 2007, Connan 2010).

At this early stage of the study, the bitumen source, therefore, does not appear to originate from exactly the same sources as the jars, though all are well within reach of each other via the traditional transport routes along the Tigris and its tributaries, and through the foothills of the Zagros mountains. One might tentatively hypothesise that the jars would have been manufactured very close to the source of their contents (speculated to be wine produced in the foothills of the mountains), while the bitumen would have been brought from Luristan to line the jars. The use of this bitumen, as opposed to bitumen from the famous and prolific source located at Hit, on the Middle Euphrates, may be due to the relative ease of transport to the wine-growing/ceramic producing region.

These hypotheses require further exploration and testing but promise to help sub-divide what to date has been an undifferentiated group. The combined results of the pilot studies will be prepared for publication, after which funding will be sought for a larger research project incorporating similar material from elsewhere in the Arabian Gulf and India Ocean littoral.

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Helm Field Guides: Birds of the Middle East (second edition). **By Richard Porter and Simon Aspinall. 2010. Christopher Helm (an imprint of A&C Black Publishers Ltd.), 36, Soho Square, London W1D 3QY. 384 pages. ISBN 978-0-7136-7602-0. Price: UK Pounds 26.99**

The second edition of the Helm *Field Guides: Birds of the Middle East* appeared in August 2010 and represents a significant development from the original, published fourteen years earlier. The first thing to strike the reader is the size of the book: containing 20% fewer pages (384 as opposed to 468) and shedding 50 grams in the process, the new field guide is closer to being just that - a portable, pocket-sized book ideal for use in the field.

Inside, further-reaching differences immediately become apparent. Gone are the separate plates and species accounts, each double-page spread now containing text and maps on the left and plates on the right, vastly improving the ease of use. The maps themselves are no longer grossly simplified (and rather angry-looking) red-on-white design, instead featuring green and orange shading to represent resident and migrant breeding ranges respectively, with blue hatching to show passage migrant/wintering range. Habitat notes are included in the main text and as the status comments of the original have been incorporated into the maps, these are replaced with a note where required. One minor mapping disappointment is the regional map on the inside cover, in which the various shades of grey are harder to interpret than the white-on-grey of the original, and Cyprus has been 'lost' from the region altogether. On the other hand, the contents page sensibly divides up the species accounts / plates by families, instead of unhelpfully lumping them in to two 200-page chunks, one for species accounts and the other for plates.

The meat of any field guide is in the species accounts and plates, and here the second edition capitalises on the work that went into the original by limiting major revisions to taxa where there have been significant advances in field identification. Laridophiles will be very pleased to see that 'large white-headed gulls' have been given the detailed treatment they need, now occupying three plates and featuring two extremely helpful comparison tables. Chiffchaffs have also been examined more thoroughly, taking into account recent advances in identification and taxonomic understanding, and Hume's Whitethroat has now been afforded full species status. In more general terms, the use of bold italics for salient identification features has been used to much better effect. Plate 130: Phylloscopus Warblers III, for example, clearly demonstrates the increased accessibility of the textual information in the second edition when compared to the species accounts for plate 90 in the first. It is also pleasing to see that vagrants are included alongside their congeners, instead of being relegated to a couple of catch-all plates at the end.

Evaluating the illustrations in the two editions produces mixed feelings. Each drawing is afforded more space and the drawings are better organised, exemplified by the Greylag Goose illustration now being housed on the same plate as those of the other grey geese. Even in the numerous instances where the old plates have been re-used, this attention to the layout improves the 'feel' of the plates. Additional species and plumages are illustrated in the second edition, such as Ashy Drongo and juvenile Crested Honey Buzzard, though where is the female plumage of the latter (the plumage most likely to cause confusion with European Honey Buzzard)? Some plates have undoubtedly been improved, such as the shearwaters and the majority of the waders, though it is questionable if these were the most in need of revision from a regional perspective. It is frustrating to find that several plates of congeners that are both challenging to identify and well-represented within the region, such as the smaller unstreaked *Acrocephalus* warblers and female/first-winter wheatears, remain in their original format. Worse still one or two plates, namely terns and skuas, have arguably deteriorated in quality compared to the originals. One further disappointment, in at least the copy under review, is that the reproduction of the plates has rendered them a shade darker than in the first edition, reducing the resolution of feather detail on the images of darker birds and increasing the contrast (thus reducing the life-likeness) of the majority of the plates.

Regardless of the reservations about the plates, however, the practical advances in usability and the improved content encompassed in the second edition of *The Birds of the Middle East* render it a must-have book for anyone interested in the birds of this fascinating region.

Finally, in a UAE context, it is pleasing to note that the book counts among its main sponsors the Environment Agency - Abu Dhabi, EAD. This was apparently instrumental in allowing all of the new plates to be commissioned, and EAD deserve credit for their support of a book that is of value throughout the region, not just in the United Arab Emirates.

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Breeding Birds of the United Arab Emirates. By Simon Aspinall. 2010. Environment Agency - Abu Dhabi, PO Box 45553, Abu Dhabi. 241 pages. ISBN 9948-408-22-5. Price: UAE dirhams 100.

In 1996 Simon Aspinall, the UAE's foremost ornithologist, published Status and Conservation of the Breeding Birds of the United Arab Emirates. This was an attempt to map all the breeding bird species in the UAE and was based on fieldwork, much of it carried out by the author, on behalf of the National Avian Research Centre, now part of the Environment Agency - Abu Dhabi. This book provided a wealth of newly-published information on the status of breeding birds in the UAE and was the key reference on the subject for many years. The current volume is an updated, and significantly enhanced, version of the original. So how does it measure up, and what improvements are evident?

The book begins with an overview of breeding bird habitats in the UAE, followed by a chapter on conservation of birds in the country. After this, the species accounts, forming the backbone of the book, begin. Some 100 species are treated in total, with all regular breeders covered in-depth. The format is similar to the original version: typically each entry starts with a statement about the species' world and Arabian ranges and some comments on general breeding ecology. This is followed by a summary of 'present' knowledge (see below for an explanation of the qualifying quotation marks here) of status in the UAE and a population estimate. The accuracy of the latter varies from a precise number of pairs to 'guestimations' (to use the author's own term) that may be as vague as 1000-10,000. Such estimates are surprisingly common and reflect just how little basic population data (let alone precise trends) is known about many species.

In the next section, sites that are particularly important for each species (where appropriate) are then highlighted, and, finally, potential threats (and possible mitigations, recommended monitoring strategies etc) are outlined.

Each account has at least one generously sized photograph of the species in question, and a map illustrating national distribution. These maps are based on the **Atlas of the Breeding Birds of Arabia** (ABBA) project and include all available records up to 2005. The maps allow a species breeding distribution to be assessed at a glance and feature 'dots' of three sizes that seemingly indicate the three breeding evidence codes (possibly, probably and confirmed) used by ABBA. I use 'seemingly' here because this fact seems not to be explicitly mentioned in the text! Compared to the original volume, the maps have been extensively updated as new observations have been made and the text, whilst clearly still based on the original, has been updated and, in some cases, significantly expanded.

The level of detail in the species accounts is impressive, with that for priority species (for example, Socotra Cormorant and Red-billed Tropicbird) stretching to up three pages. At the same time, the writing style is accessible and authorative. This, coupled with the clear, uncluttered layout, make this an easy volume to either rapidly access something specific or to thoroughly peruse. Coverage is very thorough; a number of species are included simply on the basis of one record implying the possibility of breeding. Such records may originate from the UAE, or even from surrounding countries such as Oman or Saudi Arabia.

As with the original volume, the author has made a serious attempt to highlight nationally significant sites for bird populations in the UAE. Many of these are classified as 'Important Bird Areas' or 'Middle East Wetland Inventory' sites, as appropriate. This means that the majority of really significant areas for biodiversity in the UAE are listed. The problem is, of course, that many of the same sites were similarly listed in the 1996 version of the book, and, in the interim, have received no formal protection whatsoever. Indeed, as is noted, many of the sites listed have suffered (and still are suffering), often very severely, from spiralling development. Sadly, there seems little chance of any abatement of this, and any future edition may well have a rather shorter list of gazetted sites.

My main grumble with this book is that it appears to have had an overly long gestation period. In a country where bird populations and habitats are in such dynamic flux, five years between completion of the maps and text and publication is very unfortunate. This is partially remedied by a 'stop press' section and some additional recent data has been inserted, albeit in rather a piecemeal fashion, into the species accounts. Even so, the maps and population estimates of a number of species are likely to be well out of date already and, in the case of rapidly expanding species (Namaqua Dove, for example) are clearly so. Indeed, the introduction specifically states that 'In another five years, the distribution maps will certainly need revision once more'.

As a specific example of this, I visited Dalma Island in October 2010. There, in a few hours, I recorded three resident species (Chestnut-bellied Sandgrouse, Purple Sunbird and Indian Silverbill) that could well be breeding locally but are not mapped as such. Indeed, the former two species are not mapped for either of the squares that cover Dalma at all. Of course, such omissions may reflect lack of observers, rather than increases in range.

One further gripe is the small but significant number of typographical errors in the text. These include misspelling the author's name on the front cover (!) and a confusing caption to the important map on page 21.

This is a striking and beautifully presented book. Right from the front cover, a stunning portrait of Collared Kingfisher, one of the UAE's most spectacular breeding birds, it grabs one's attention. As might be expected, given that Hanne and Jens Eriksen have provided many of the images, stunning photography is a feature throughout and it is primarily due to it these that this scholarly work manages to come across, in the best sense of the term, as a coffee-table volume. Whilst primarily the definitive statement on current knowledge of the UAE's breeding birds and a vital tool to inform policy-makers, it will also hopefully inspire members of

the public at large to an interest in the wonderful avifauna in the UAE and its conservation. The latter would be at not a moment too soon. To this end, this book deserves a prominent place in every local bookshop and library. An edition translated into Arabic would be especially welcome.

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Atlas of the Breeding Birds of Arabia. By Michael C. Jennings. Fauna of Arabia, Vol. 25. SenckenbergGesellschaft fur Naturforschung, Frankfurt a.m., Germany & King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia. ISBN 978-3-929907-83-4.
Available from: Andrea Murdoch (Ms), Karger Libri International Subscription Agency Ltd., Petersgraben 31, 4009 Basle. Phone: +41 61 306 15 23. Fax: +41 61 306 15 67
(http://www.libri.ch/App_Web/DE/services/faunaofarabia.aspx#03).
Price: 169 Swiss Francs plus 35 SWF postage

As an occasional visiting birdwatcher to the Arabian Peninsula over the last fifteen years, I am delighted to have been given the opportunity to review the new *Atlas of the Breeding Birds of Arabia*.

This is a very impressive tome, both in the high standard applied by author Michael C. Jennings to the textual information, and to the quality of the print. Many such books fall into the trap of over-elaboration and can thus turn themselves into the sort of volume that, once put down, are difficult to pick up again. This is certainly not the case here and I found myself reading on, not because of writing a review, but because of interest in the subject matter, and the ease of its presentation.

This is a work of epic proportions, taking a quarter of a century to complete, during which time, as the author states, virtually all the literature concerning Arabian Ornithology and some museum collections have been examined, as well as 40 field surveys having been carried out. Given the vastness and inaccessibility of much of the area, the effort involved cannot be underestimated, with all but a small proportion of the most remote areas having been covered to some extent, and it must be satisfying indeed for those who undertook the work, to see this beautifully produced book as an end product.

This book will be the standard reference work on the breeding birds of Arabia for the foreseeable future and lays down the baseline for the next person prepared to undertake such a task. It replaces the previous major reference work, Colonel Richard Meinertzhagen's "Birds of Arabia" (1954). The author, unusually for a work such as this, gives scant credit to this predecessor. In his Preface, he explains fully his reasons for this stance. Suffice it to say that this section is well worth reading in full, with no punches pulled!

Before arriving at the species accounts, the book gives a comprehensive review of all aspects of Arabian Ornithology with areas covered including, amongst others, Endemism, Climate, Geology and Topography, Vegetation, Habitat and Habitat change, illustrated with over one hundred high quality photographic images. The latter topic has been of particular interest to me during visits, with the influence of man upon the natural environment, obvious in so many ways, and its consequent effects upon the Flora and Fauna of the region. The book provides a good insight into the challenges which the area has faced and will continue to face in the future, especially in respect to human exploitation, and it is to be hoped that those with the authority to affect these issues will read and take on board the cautionary note sounded here.

Situated, as it is, at the meeting place of the three Old World biogeographic realms, the Arabian Peninsula has a wide species diversity, with representatives of all three realms breeding in the area. The main body of the book is dedicated to the species accounts and provides full coverage of each of the 273 species known to breed, each with an attractive vignette and a large, clear Distribution Map. In addition, there are short species accounts, covering the 24 additional species which are not yet regarded as regular or permanent breeding species in Arabia.

The standard species accounts aim to provide detailed information on zoogeographic affinities, world range and taxonomy and to provide a broad statement on the status of the particular species within Arabia. This again is a monumental effort, mostly by the author himself, with contributions from others on particular species and, given that there is always a finite limit to the available space within one volume, succeeds very well. Attempts have also been made to estimate the numerical size of the individual species breeding populations, including a section of tabulated data on breeding birds. While the reasons for attempting such a project are fully understandable, it is debatable how much value such figures can have, in relation to particular species. Cream-coloured *Courser Cursorius cursor*, is a good example. As a nomadic breeder, any extrapolation of population figures, as here, requires so many assumptions as to make their value questionable. But this is just a minor issue, done with the right intentions, and should not detract from what is an outstanding publication.

The *Atlas of Breeding Birds of Arabia* is likely to be the standard reference work on subject for years to come, and, despite its not inconsiderable price, is an essential addition to the library of all who are serious about the Ornithology of the region.

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Arthropod Fauna of the United Arab Emirates, Vol. 3. Dar Al Ummah Printing, Publishing, Distribution and Advertising, PO Box 39975, Abu Dhabi, UAE. (info@daralummah.ae) **ISBN 978-9948-15-616-1.**

The editor said it best himself. Antonius (Tony) van Harten, the coordinator of the UAE Insect Project and editor of the resulting *Arthropod Fauna of the United Arab Emirates*, was the 2010 recipient of the Sheikh Mubarak bin Mohammed Award for Natural History, the UAE's premier natural history award, given annually to acknowledge significant research contributions. In accepting his award, Tony admitted that at the outset of the project he believed the arthropod fauna of the UAE would prove to be relatively limited and that 3 to 4 years would be sufficient to get to know the majority of it.

Now, after 6-1/2 years, three large volumes have been published, identifying and describing thousands of species, a fourth volume has just been published, and an estimated 3 to 4 more years will be needed to publish the remainder of the information that has already been gathered. The UAE Insect Project, which surveys both insects and other arthropods, has turned up hundreds of records new to science and (so far) nearly 1500 new to the UAE. Many entire insect families had not previously been recorded. Tony asked rhetorically, "*Who had ever expected that the diversity of arthropods in this country would be that enormous*?"

Tony rightly emphasised the critical role played by the project's farsighted originator and sponsor, H.H. Sheikh Tahnoon bin Zayed Al Nahyan of Abu Dhabi. Not only did Sheikh Tahnoon finance the research and printing (in an attractive, high quality format), but it was he who took the initiative to establish the project in the first place, and who identified and recruited a well-qualified specialist to carry it out.

Vol. 3 of *Arthropods of the UAE* was published in late 2010. It follows the format of the earlier two volumes, in that the sections on individual taxonomic groups are written by different international specialists - in this case 51 in all, representing 20 countries. The latest volume is 700 pages and includes more than 1000 species and several hundred colour photographs. These cover 52 families, mainly in five taxonomic Orders: Orthoptera (grasshoppers, locusts and crickets), Coleoptera (beetles), Hymenoptera (mostly wasps), Lepidoptera (mostly moths) and Diptera (flies). Vol. 3 is also the first to include spiders, featuring more than 30 species of Salticidae (jumping spiders), including one that mimics an ant.

The text is not always easy reading for the non-specialist, but the excellent photographs of most species will give interested naturalists a better understanding of the diversity of arthropod species found in the UAE, not to mention some insight into the arcane world of arthropod taxonomy. The photographs will also facilitate the identification of individual organisms within the groups covered, although the volumes should not be mistaken for field guides. The members of many insect groups remain confusingly similar and for some (especially Diptera) the distinguishing photographs or drawings are typically of diagnostic body parts rather than the whole organisms.

The text also provides information about range and habitat, where those are known. This furnishes useful context for local observers. Among other things it gives an indication whether the UAE is part of the core territory of a species (as it is for many Eremic zone taxa), or whether we are likely to be a marginal habitat.

For naturalists resident in the UAE, a particular highlight of Vol. 3 is its coverage of Tenebrionids (Coleoptera: Tenebrionidae) - the mostly black, largely nocturnal beetles so common in arid regions. Vol. 3 describes and illustrates some 65 Tenebrionid species. Several of these are species frequently seen, dead or alive, in the UAE's sand deserts, so Vol. 3 will help to satisfy the curiosity of the many casual but interested visitors to the local dunes.

The Tenebrionid author (Wolfgang Schawaller) nevertheless cautions that a number of current classifications must be considered tentative because of limited observations, insufficient knowledge of ranges, and the confused state of much pre-existing taxonomy. This emphasises the iterative and interactive nature of the modern taxonomic enterprise. Taxonomists need a critical volume of material and observations in order to reach robust conclusions, but many potential observers tend to ignore a taxon in the absence of a preliminary framework, because there seems little hope of making progress towards an identification. Conversely, initial steps towards establishing intellectual order, however tentative, encourage the additional observation and collection that permit refinements.

Another highlight of Vol. 3 is the treatment of the Order Orthoptera (grasshoppers, locusts and crickets) - a second group that looms large within the Arabian arthropod fauna. An illustrated partial account of UAE grasshoppers and locusts was given in 2000 by Michael P.T. Gillett in *Tribulus* Vol. 10.2, but the new volume lists more than 65 species and is accompanied by 26 photographs taken in life that may make this difficult group more accessible to interested amateurs than the photographs of pinned specimens in Gillett (2000). The checklist in Vol. 3 includes all but two of the species mentioned by Gillett, both said by him to be rare, although Gillett's nomenclature is updated for a few other species.

A third group that is well illustrated and worthy of special mention is the wasps of the Family Vespidae, which are generally large and conspicuous (e.g., the Oriental hornet *Vespa orientalis*, the Arabian paper wasp *Polistes wattii*, and several colourful species of potter wasps, *Delta* spp.). Vol. 3 lists and illustrates 42 species, of which 28 are first records. Records of at least 10 additional species are acknowledged independent of the Insect Project, and the discovery of many further species is forecast.

In comparison with the magnitude of the effort represented by these volumes, it is a minor complaint that certain existing UAE records have been overlooked or discounted, with the result that even some insects relatively well-known locally have been omitted or described as "new" to the UAE. Perhaps the best example of the latter, from Vol. 2, is the brightly coloured bombardier beetle *Pheropsophus africanus*,

which can fire a chemical blast from its posterior that irritates and discolours the skin in a manner similar to nitric acid.

This problem is understandable for records not published in the traditional scientific literature, but as a matter of methodological prudence the UAE Insect Project has also ignored even known studies for which reference specimens could not be located or confirmed. A major casualty of this policy were the studies of UAE bees and wasps made in the early 1980s by Ian Hamer and Giles Roche of Abu Dhabi and reported in various editions of the *Bulletin* published by the Emirates Natural History Group-Abu Dhabi.

In rare cases, omissions can be somewhat more misleading. For example, prior surveys of UAE tiger beetles (Coleoptera: Carabidae: Cicindelinae) by Weisner have revealed at least a dozen species, but only four of those were collected and identified in connection with the UAE Insect Project (also in Vol. 2). Weisner is referenced in the Vol. 2 account of tiger beetles (by Ron F.F.L. Felix) but the extent of Weisner's study and results are not indicated, either expressly or otherwise. The only concession is a general acknowledgement in the introduction that since a light trap was the principal collecting device, collecting by hand and pitfall trap will increase the number of non-flying species significantly.

The accounts of most taxonomic groups in *Arthropod Fauna of the UAE* are the most comprehensive available, but the same bias in collection methods inevitably affects the results for many taxa. For example, in Vol. 3 it is expressly stated in relation to Family Bostrichtidae (wood borers) that collection solely by light and Malaise traps means that our knowledge of the actual number of taxa in this group "remains fragmentary". The good news is that this means there is still ample room for efforts by future researchers.

The published series has been praised internationally and I know from personal experience that it is in demand, perhaps more so as it is not marketed commercially. Last December, when snowstorms made me an involuntary tourist in the greater London area, friends took me to a natural history bookshop specialising in entomology. On learning that I was from Dubai, the proprietor immediately asked if I could help him to obtain more copies of *Arthropod Fauna of the UAE*.

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ملاحظات الى المساهمين

تريبولوس هي مجلة تصدر منذ العام 1991 عن جمعية الإمارات للتاريخ الطبيعي التي تأسست في أبوظبي في العام 1976 لتكون أول منظمة بيئية غير حكومية في دولة الإمارات العربية المتحدة، وتتبع لها كل من جمعية الإمارات للتاريخ الطبيعي في العين وجمعية دبي للتاريخ الطبيعي.

وقد قامت الجمعية خلال الفترة ما بين ١٩٧٦ و ١٩٩٠ بإصدار 42 عددا من النشرات الخاصة بها وذلك بمعدل ثلاثة أعداد سنوياً.

تتوفر أعداد تريبولوس والنشرات على الموقع الإلكتروني لجمعية الإمارات للتاريخ الطبيعي في العين www.enhg.org.

بعد ذلك أصبحت تريبولوس تصدر مرتين سنوياً وبقياس ورق الطباعة العادي خلال الفترة الممتدة بين العامين ١٩٩١ و٢٠٠٦ ، ثم شهدت اعتباراً من العدد ١٧ (٢٠٠٧) زيادة في عدد صفحاتها وباتت تصدر سنوياً.

تهدف المجلة إلى تكوين مجموعة من السجلات والمقالات وأوراق العمل المتعلقة بمواضيع ذات صلة بالتاريخ الطبيعي والتراث والجيولوجيا وعلم الإحاثات وعلم الآثار وتاريخ المنطقة الجنوبية الشرقية من شبه الجزيرة العربية، مع التركيز على دولة الإمارات العربية المتحدة والمناطق المجاورة.

ترحب المجلة بالمقالات والملاحظات والتعليقات القصيرة وغيرها من مساهمات المقيمين بدولة الإمارات العربية المتحدة أو غيرهم، على ألا يكون قد جرى نشرها في مكان آخر، وذلك وفق التعليمات المذكورة أدناه.

إن المعلومات الواردة في المجلة دقيقة بقدر ما يمكن لهيئة التحرير واللجنة الاستشارية أن تحدده ، ولا تعبر النصوص الواردة فيها إلا عن رأي مؤلفيها فقط.

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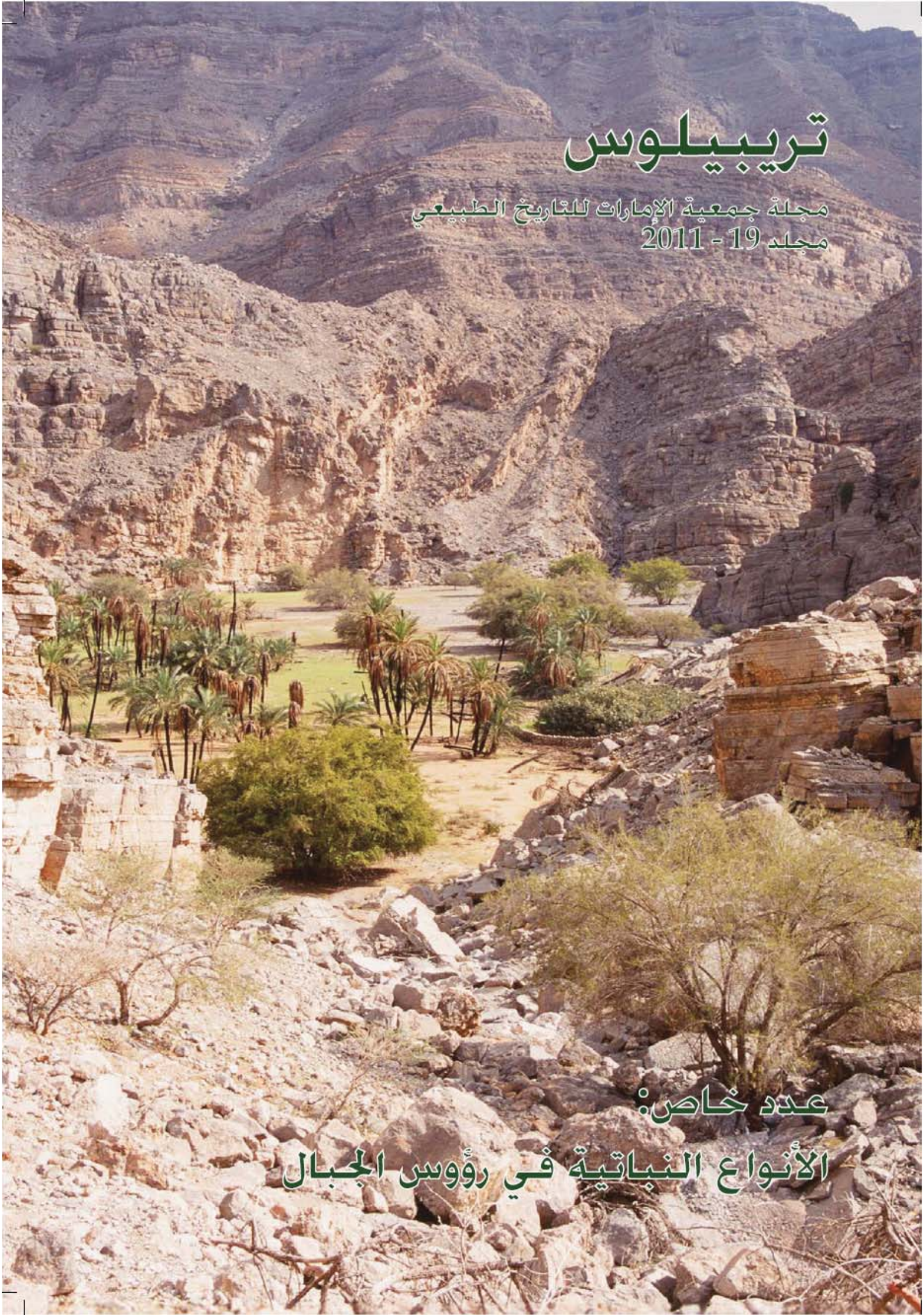
تسليم النصوص

يجب تسليم نسخة إلكترونية من النص، على أن يسبق النص مقتطف مختصر وأن يذكر في نهايته عنوان المؤلف، بما في ذلك عنوان بريده الإلكتروني.

كذلك يجب تسليم نسخة إلكترونية من الصور والرسومات والخرائط، على أن تكون على درجة عالية من الوضوح لإتاحة الإمكانية لإعادة نشرها.

يجب إدراج المراجع حسب الترتيب الزمني لنشرها، مع ذكر اسم المؤلف وتاريخ النشر بين قوسين إلى جانب العنوان واسم الناشر وبلد النشر، ويمكن في المقالات الصحفية استخدام الاختصارات التقليدية التي تستخدم عادة في العناوين.

يجب ذكر الأسماء العلمية بعد المصطلحات اللاتينية، كما يجب إضافة الأسماء باللغة الإنجليزية واللغة العربية في حال وجودها.



تريبيلوس

مجلة جمعية الإمارات للتاريخ الطبيعي
مجلد 19 - 2011

عدد خاص:

الأنواع النباتية في رؤوس الجبال