

The vegetation of the coastal white sands at Taweela (Abu Dhabi Emirate)

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Figure 1. Typical overview of coastal white sand vegetation at Taweela with scattered perennials and a profusion of annuals. February 2007

Introduction

Taweela is a coastal area located ca. 40 km to the north-east of Abu Dhabi island, ca. 25 km from the border with Dubai Emirate. The coastal white sand vegetation immediately to the east of Taweela power station, extending to Ra's Ghanada and covering an area of ca. 8 sq. km., probably represents the best example of this endangered habitat type in the Emirate of Abu Dhabi.

As a result of rapid coastal development in the UAE, this unique area, which is also of high faunistic value, is potentially under severe threat from coastal development, in particular from planning related to the development of the Khalifa Port and associated industrial zone and the adjacent EMAL aluminium smelter project. The objective of this observational study, therefore, is to document a highly-endangered vegetation type and its flora, to re-state the outstanding conservation importance of the Taweela area, already highlighted by Aspinall (1999), and to place on record for the first time detailed data on the flora of the area.

The opportunity is also taken to provide an update and some corrections to Jongbloed (2003).

The results of this study are based on field observations undertaken by all three authors over the last few years, but with an emphasis on the wet winter of 2006/2007.

Environmental Setting

1. Climate

Details on the climate of the UAE have been given by Böer (1997) and Brown & Böer (2005a). The climate of the

Taweela area, as with the UAE in general, is of a bi-seasonal Mediterranean type, characterised by high temperatures and low rainfall. The summers (April to October) are distinctly hot, with daytime temperatures regularly exceeding 40 °C. Rainfall is generally restricted to the cooler winter months (November to March), when temperatures occasionally drop to below 10 °C at night. During the coolest periods of the winter, daytime temperatures are rarely in excess of 20 °C. Annual rainfall amounts vary considerably from one year to another, but the long-term mean value is about 80 mm for the coastal area between Abu Dhabi and Dubai. Potential evaporation (i.e. that water which would evaporate if present) far exceeds precipitation, probably by a factor in excess of 10 (Deil & Müller-Hohenstein, 1996), indicating the high degree of stress to which organisms are exposed. The area experiences high humidity, especially in the summer months.

2. Coastal sands

Coastal white sands differ in their composition and form from the inland desert sands which are of different origin (Feulner, 2005). Coastal sands are derived almost exclusively from marine organisms and carbonate sediments and consist to a large extent of CaCO₃. In contrast, the inland desert sands are composed predominantly of quartz grains, and they may appear distinctly red when the grains are coated with haematite (an iron oxide). They largely lack any significant CaCO₃ content.

Due to the general lack of pedogenesis owing to the

harsh climatic conditions, the substrate is characterised by the little-altered parent material. Soils, in the general sense of the meaning, are therefore not developed. Although the coastal white sands contain many nutrients, they are highly deficient in nitrogen, primarily due to the virtual absence of organic material, and as a consequence, soil fertility is extremely low.

Except in the immediate proximity of the shoreline or under other exceptional circumstances, coastal white sands do not appear to be influenced by salinity to any great degree, because they are invariably situated well above the high-tide line. This is reflected in the flora, which to a large extent is composed of glycophytes (i.e. species which are largely intolerant or only slightly tolerant of saline substrate conditions). Halophytes are generally restricted to certain microhabitats in the sand sheets, usually depressions, which are occasionally inundated.

Vegetation development on the coastal white sands

1. Water availability for vegetation

Inter-annual variation in the rainfall pattern is a feature which, due to the relatively low total amounts of precipitation received even in wet years, has a much more decisive influence on biological activity than, for instance, in more temperate regions of the world. In the Taweela area, as in many other regions of the UAE, this rainfall variability is reflected by the density, biomass production and species composition of the desert annual flora which develops for a short period during the winter and spring months. Heavy rain received at the onset of the cool period, when followed by occasional showers, as was the case in the 2006/2007 winter season, provides favourable conditions for the development of desert annuals, whereas the populations of these plants may be very low in dry years.

Stable sand sheets, such as coastal white sands, are generally favourable for plant growth in arid region ecosystems due to the capacity of coarse sand to store

water, often for substantial periods of time. This has been referred to by Noy-Meir (1973) as the "inverse texture effect", because it is the opposite to the situation in temperate climates, where sand is generally regarded as a poor substrate for plants and finer grained substrates are more beneficial. When it does rain, water percolates the upper sand layers rapidly (and is not lost through run-off). Whereas the upper regions tend to dry out quite quickly, the water is stored in the subsurface sand layers where it is protected from evaporation. Even plants with rather shallow rooting systems are able to tap into this water resource. It should be stressed that only stable sand sheets exhibit this "inverse texture effect", mobile sand dunes are extremely inhospitable environments for desert plants.

2. Vegetation and flora

The vegetation of the coastal white sands in the Taweela area is characterised physiognomically by a sparse cover of perennial dwarf shrubs and grasses (*Figure 1*). Vegetation cover of the perennials rarely exceeds 3%, indicating the harshness of the climate. In winters with good rainfall, desert annuals form open carpets, at least in favourable locations, and percentage cover of these annuals can reach 20%, though coverage values between 5% and 10% are more typical. A list of species typically occurring on the white sands is given in Appendix 1.

Much of the coastal white sand vegetation at Taweela can be assigned to the typical association of the *Cornulaco monacanthae-Sphaerocometum aucheri* according to the vegetation classification system of Braun-Blanquet (1928). This community was first formally described by Deil & Müller-Hohenstein (1996) from Jebel Ali, i.e. ca. 30 km to the east of Taweela. It probably extends with a similar species composition in suitable locations eastwards along the coast into eastern Oman, with Taweela possibly representing the western boundary of its occurrence. Kürschner (1986) recorded a "*Sphaerocoma aucheri* association" with a rather limited number of



Figure 2. The Caryophyllaceae *Sphaerocoma aucheri* is highly characteristic of the coastal white sand vegetation at Taweela. February 2007



Figure 3. Detail of flowering branches of *Sphaerocoma aucheri*.

Characteristic dwarf shrubs at Taweela include *Sphaerocoma aucheri* (Figures 2 and 3) and *Cornulaca monacantha* (Figure 4), the latter a Chenopodiaceae, the former a Caryophyllaceae which superficially strongly resembles a chenopod. Of the other dwarf shrubs, the Boraginaceae *Heliotropium kotschyi* is a regular associate, whereas the moderately salt-tolerant *Zygophyllum qatarense* is quite widespread, but nowhere dominant, and is sometimes lacking from large areas. Another moderately halophytic dwarf shrub, *Limonium axillare*, is also widespread and usually found in slight depressions

in the sands. It is striking that seedlings and young plants of *Helianthemum lippii* can be numerous, often flowering in their first year, but they rarely attain any significant height and give the appearance of being more of an annual or biennial (Figure 5), rather than a perennial, as is usually the case. Older plants are present, but are conspicuously less frequent.

The most widespread perennial grass is *Coelachyrum piercii* (Figure 6), which in the United Arab Emirates appears to be restricted to a stretch of coastline between Taweela and Ra's al-Khaimah, to the north-east.



Figure 4. The chenopod *Cornulaca monacantha* is widely distributed along the Arabian Gulf coast of the UAE on non-saline sands.

It is highly characteristic of the coastal white sands, but, in the north-east of the UAE, also occurs occasionally on red sands near the coast. The sedge *Cyperus arenarius* (Figure 7) is usually widespread and abundant. *Panicum turgidum* is a regular associate and locally common. This species is the dominant constituent on coastal white sands extending along the Arabian Gulf coast from the far west of the UAE to Kuwait in the north (Kürschner, 1998), and forms an open xeromorphic grassland in which *Sphaerocoma* and *Coelachyrum* are absent. *Pennisetum divisum*, a superficially similar tussock grass to *Panicum*, is occasionally present on the coastal white sands at Taweela, but is rather sporadic. *Sporobolus iocladius* is also common and widespread throughout the area.

Coelachyrum piercii, *Panicum turgidum* and *Pennisetum divisum* are perennial grasses whose roots are enclosed by a rhizosheath, a cylindrical covering of fine sand grains which remain attached to the roots by persistent root hairs and the secretion of a mucilage. It is believed that the rhizosheath promotes water absorption and protects the roots from drought. Furthermore, the rhizosheath provides an idea microhabitat for nitrogen-fixing bacteria, and it has been suggested that these may play an important role in enhancing soil fertility (see

Danin, 1996). However, it is quite striking that *Cyperus arenarius* does not possess such a rhizosheath, whereas *Cyperus conglomeratus*, an abundant sedge on inland dunes, does.

These and other perennials are accompanied by a profusion of annuals, particularly in wet years. The more regular species, i.e. also occurring in drier years, include: *Arnebia hispidissima*, *Herniaria hemistemon*, *Lotus halophilus* and *Oligomeris linifolia*, followed by *Hippocrepis areolata*, *Launaea capitata* and *Launaea mucronata*. Some annual species, such as the grasses *Cutandia memphitica*, *Rostraria pumila* and *Schismus barbatus* as well as *Eremobium aegyptiacum*, *Ifloga spicata*, *Paronychia arabica* and *Savignya parviflora* are noticeably rarer and virtually absent in drier years. Compared with the situation in Umm al-Qaiwain and Ra's al-Khaimah, further north-east along the UAE's Arabian Gulf coastline, the annual flora, even in wet years, is noticeably less diverse, with species such as *Astragalus annularis*, *Ononis serrata*, *Plantago boissieri* and *Reichardia tingitana*, which are common or even abundant in coastal dunes there, being absent from the Taweela area. Even *Silene villosa* does not appear to occur in the Taweela area, it not having been found despite a fairly intensive search for the species.



Figure 5. Numerous small individuals of *Helianthemum lippii*, often flowering at a very early age, are found on the coastal white sands at Taweela.



Figure 6. The perennial grass *Coelachyrum piercii* is highly characteristic of the coastal white sands east of Abu Dhabi island.



Figure 7. The sedge *Cyperus arenarius* is widespread along the Arabian Gulf coast of the UAE.



Figure 8. Coast white sand vegetation with *Halopyrum mucronatum* (foreground) and *Salsola drummondii* (background). The perennial grass *Halopyrum* is dormant during the summer, whereas *Salsola* is active and therefore green. See also Figure 9. August 2004.



Figure 9. Coast white sand vegetation with *Salsola drummondii*. See also Figures 8 and 11. August 2004

Conversely, a number of species were registered at Taweela that were initially not expected to be present, based on information in Jongbloed (2003). These are dealt with in more detail below, and include *Aizoon canariense*, *Cutandia memphitica*, *Paronychia arabica*, *Polycarpaea spicata*, *Rostraria pumila* and *Schismus barbatus*.

Locally, near Ra's Ghanadha, on the north-eastern fringe of the Taweela area, the halophytes *Halopyrum mucronatum* (Figure 8) and *Salsola drummondii* (Figure 9) are conspicuous elements in the vegetation of the coastal white sands, along with many other of the perennials mentioned above. Conversely, a number of annuals appear to be lacking. Such stands have been described by Deil & Müller-Hohenstein (1996) as the sub-association *Halopyretosum mucronati* of the *Cornulaco monacanthae-Sphaerocometum aucheri*, and appear to be developed in response to a slight increase in soil salinity.

As indicated above, it is evident that a distinct floristic gradient exists along the coastal zone in the UAE, with the floristically most diverse areas occurring in the north-east and the least diverse in the west. It is possibly no coincidence that a number of species have their western-most distribution limits in the UAE close to Abu Dhabi island, where the coastline, which, west of the island, runs more-or-less from west to east. Further east, it veers off in a north-easterly direction towards Ra's al-Khaimah and the Musandam peninsula. This probably correlates with an increase in rainfall with closer proximity to the Hajar Mountains, as well as a slight decrease in temperature.

4. Comments on the "Wildflowers to the UAE"

The "Comprehensive Guide to the Wildflowers of the United Arab Emirates" (hereinafter simply referred to as the "Wildflowers Guide") by M. Jongbloed (2003) currently represents the best available floristic literature for the UAE, although invaluable information is also contained in Western (1989). This section aims to rectify mistakes pertaining to the coastal flora in the Wildflowers Guide and to update information on the distribution of some species.

Aizoon canariense

The distribution of this species in the Wildflowers Guide (p. 109) should be extended further south-west to Abu Dhabi island, as the species was recorded in 2007 at Taweela. Furthermore, the species is common on the plains at the base of Jebel Hafit.

Cornulaca monacantha

The map in the Wildflowers Guide (p. 292) is inaccurate, in that *Cornulaca monacantha* is common along the entire Arabian Gulf coastline from the Sila'a Peninsula, in the far west, to Ra's al-Khaimah, in the north-east, as already highlighted by Western (1989). Jongbloed treats the morphologically very similar *C. arabica* as a synonym, which is open to interpretation. This taxonomically difficult species is characteristic of the sand sheets in the Liwa / Umm al-Zumal area in southern Abu Dhabi, extending locally northwards to Al Wathba, and its occurrence there should be indicated in the distribution

map on p. 292 together with *C. monacantha* (if it is to be treated as the same species as *C. monacantha*).

Fagonia indica / ovalifolia

Fagonia is a highly problematic genus, with the precise delimitation of species notoriously difficult. The extensive work of Beier (2005) has confirmed what had already been suspected by some observers, namely that *Fagonia ovalifolia* should be treated as a synonym of *F. indica*. The maps in the Wildflowers Guide (p. 546 and 547) can therefore be conveniently combined.

Halopyrum mucronatum

The map in the Wildflowers Guide (p. 69) gives a good indication as to the distribution of the species in the UAE. It has also been recorded from Zirku Island by the first author.

Heliotropium kotschy / bacciferum

Considerable confusion surrounds the taxonomic status of these two species and their precise differentiation. Our own observations indicate that only one taxon is involved along the coast of Abu Dhabi, and indeed, Mandaville (1990) treats the two as synonyms, referring to the widespread species of coastal regions as *Heliotropium bacciferum* Forssk.

However, according to Prof. A. Miller, Royal Botanic Garden, Edinburgh, (*pers. comm.*), there is no agreement amongst taxonomists as to what precisely constitutes *H. bacciferum*. Having examined the type specimen, he regards *H. bacciferum* as a small prostrate plant occurring on the Red Sea coast of Yemen. Accordingly, he suggests that all plants in the eastern part of the Arabian Peninsula should be treated as belonging to *Heliotropium kotschy* (Ledeb.) Guerke, which itself is a highly variable species. According to this interpretation, the distribution map in the Wildflowers Guide (p. 214) is, therefore, accurate, and references to *H. bacciferum* in both Mandaville (1990) and Brown & Böer (2005a) should be regarded as *H. kotschy*.

Whether the distinct montane species occurring in the UAE is in fact *H. bacciferum* or a completely different species is open to question. No useful distinguishing features from *H. kotschy* are given in the Wildflowers Guide (in fact the photograph of the noticeably small flowers of *H. bacciferum* (p. 210) matches the description of *H. kotschy* (on p. 214) more closely, and vice versa). Gary Feulner (*pers. comm.*) mentions that the leaves of the mountain plant are noticeably softer and broader.

Ifloga spicata

Ifloga spicata is more widespread than indicated in the Wildflowers Guide (p. 160). Its presence, albeit rare, in Taweela indicates a continuous distribution along a narrow to broad coastal strip from around Abu Dhabi island in the west to Ra's al-Khaimah in the north-east. The first author has also found the species on plains at the base of Jebel Hafit and also in adjacent areas of Buraimi (Oman).

Lasiurus scindicus

The photograph in the Wildflowers Guide (p. 73) unfortunately shows a species of *Cymbopogon*, not *Lasiurus*. Although the species is much favoured by domestic livestock and virtually impossible to identify with certainty when eaten back, *Lasiurus* appears to be less common in coastal areas than indicated in the Wildflowers Guide. The first author has so far only found it in such situations west of Jebel Dhanna, in the far west of the UAE, and just east of Abu Dhabi in a large enclosure protected from livestock grazing, where it was very local. However, it is fairly common in silty-sandy drainage channels at the base of Jebel Hafit, often in flower where the grazing pressure is less intense.

Mesembryanthemum nodiflorum

The map in the Wildflowers Guide (p. 110) gives a good overview of the current distribution of *Mesembryanthemum nodiflorum*. A single specimen was found and photographed in Taweela in 2007 by the third author. Furthermore, two of the authors (GB, SS) have found the species to be common on Zirku and Arzanah, thus adding two further offshore islands to its known distribution. The species was observed by the first author to be locally common both in 2005 and 2007 in Al Jazeera al-Hamra (Ra's al-Khaimah). It may possibly be more widespread along the coastline in disturbed areas.

Paronychia arabica / *Herniaria hirsuta*

The main photograph of *Paronychia arabica* in the

Wildflowers Guide (p. 265), which is described as a young specimen, in fact depicts a typical specimen of *Herniaria hirsuta*. **Figure 10** shows a typical example of *Paronychia arabica*. The distribution of this species needs to be updated, as it is found at Taweela and thus probably occurs along a narrow coastal stretch at least from Abu Dhabi island to Ra's al-Khaimah. *Herniaria hirsuta* was found to be locally common in Al Jazeera al-Hamra (Ra's al-Khaimah) in 2005.

Polycarpaea spicata

Polycarpaea spicata is far more widespread than indicated in the Wildflowers Guide (p. 268). It is found on coastal white sands and coastal plains and has been recorded from Taweela and Al Jazeera al-Hamra (abundant in the latter location), so that this species too probably has a continuous distribution from Abu Dhabi island to Ra's al-Khaimah. It has also been recorded by the first author on Zirku island, as well as Ras Laffan Industrial City (northern Qatar).

Rostraria pumila

Rostraria pumila (p. 88 in the Wildflowers Guide) was recorded in 2007 in Taweela as well as on coastal dunes from Umm al-Qaiwain to Ra's al-Khaimah, indicating a continuous distribution along the coastal strip from Abu Dhabi island to Ra's al-Khaimah. The first author has also recorded this annual grass from Jebel Hafit, where it is quite common in silty depressions on the surrounding plains.



Figure 10. Detail of the Caryophyllaceae *Paronychia arabica*. Note the conspicuous silver-white stipules. February 2007.

Salsola drummondii

Salsola drummondii is not just locally common, as indicated in the Wildflowers Guide (p. 299), but scattered and locally abundant along the entire coast from Sila'a in the west to at least Dubai in the east (e.g. on remaining coastal housing plots in Jumairah), and possibly further north-east. The habitat varies from slightly saline coastal white sands (Taweela / Ra's Ghanadha), disturbed sabkha (Khalifa City, Abu Dhabi) to coastal marshland (e.g. abundant on the Sila'a Peninsula). **Figure 11** shows a detailed view of a typical branch. Note the fresh green colour of the plant (see also **Figure 9**) which is quite different from the grey-green appearance of the vaguely similar and widespread *Salsola imbricata*.

Schismus barbatus

The distribution of this annual grass as given in the Wildflowers Guide (p. 90) is somewhat strange, having been recorded from Sabkhat Matti, Jebel Hafit and Musandam. In 2007, the authors found it in Taweela, Umm al-Qaiwain and Ra's al-Khaimah, where it is sporadic. The first author has also recorded it from higher elevations in Musandam (Sayh Plateau) and Jebel Hafit, as well as from the Sweihan-Al Hayer area, in eastern Abu Dhabi Emirate, where it was found to be locally common on stable sand sheets. This species is possibly distributed along the entire near-coastal region west of Abu Dhabi island, perhaps predominantly on rocky outcrops.

Sphaerocoma aucheri

The map in the Wildflowers Guide (p. 278) gives a good indication as to the distribution of the species in the UAE. It has also been recorded from Zirku Island by the first author. It is possible that the record from Jebel Hafit in the Wildflowers Guide is erroneous, as it can easily be confused with *Gymnocarpos decandrus* which is common on the mountain. **Figures 2** and **3** show *Sphaerocoma aucheri*.

Sporobolus iocladius

The map in the Wildflowers Guide (p. 95) gives a good indication as to the distribution of the species in the UAE, which is predominantly coastal. However, it has also been found by the first author well away from the coast in wadis, e.g. on Jebel Hafit and also in Aboule (near Buraimi, Oman).

Zygophyllum qatarense / *Z. mandavillei* / *Z. cf. migahidii*

The taxonomic status of perennial *Zygophyllum* species in the UAE is shrouded in confusion. The features that are used to distinguish them do not appear particularly reliable. This applies especially to *Z. mandavillei*, the *Zygophyllum* species generally thought to occur on inland plains, and its differentiation from *Z. qatarense*. According to Deil (2000), however, *Z. mandavillei* is restricted to a relatively small area of south-western Arabia. Mandaville (1990), whilst noting the taxonomic problems involved with the two species (even stating that the specimen depicted in the original description of *Z. mandavillei* is atypical), and pointing out the occurrence of intermediate forms between the two, does



Figure 11. Typical branch of *Salsola drummondii*. Note the characteristic pear-shaped leaves.

differentiate them. According to his distribution maps (based strictly on collection localities), *Z. mandavillei* appears to be confined to inland localities of the Rub al-Khali, whereas *Z. qatarense* is characteristic of coastal areas, but also occurring inland. If one were to adopt this approach, the maps in the Wildflowers Guide for the UAE (p. 554, 555, respectively) do appear to be reliable. Even along the coast, *Z. qatarense* displays quite substantial morphological variability, which in part is probably a response to varying substrate conditions (in particular salinity). In conclusion, therefore, until a thorough revision of the genus has been undertaken by experts, it seems advisable, in accordance with Deil (2000), to treat *Z. qatarense* and *Z. mandavillei* in the UAE as one taxon, namely *Z. qatarense*. This is also the view of Prof. A. Miller (*pers. comm.*), who regards the characteristics used to distinguish species in the original descriptions as unreliable, noting that in Oman only one variable taxon is involved.

Surprisingly, the highly distinctive *Zygophyllum* species that commonly occurs on the rocky slopes of Jebel Hafit is not differentiated in the Wildflowers Guide, but is apparently lumped under *Z. qatarense* (p. 555). However, it is markedly different from the taxa of the dunes and coastal areas, notably by the fact that it has grey tomentose leaves that are often 2-foliate. In fact, it appears to closely match the description of *Z. migahidii* provided by Mandaville (1990) for wadis and alluvial plains in parts of central Saudi Arabia (Brown & Sakir, 2004a). Until a precise determination has been carried out, the species of Jebel Hafit (and possibly of other mountain slopes of the UAE) should be referred to as *Zygophyllum cf. migahidii*.

5. Conservation aspects

The collection of sound information on the identity and distribution of natural and semi-natural habitats is a vital tool for effective conservation planning. This is even more pressing in the case of the coastal areas in the UAE, which are currently being affected by large-scale infrastructure development (Deil & Müller-Hohenstein, 1996; Brown & Böer, 2005b; Brown *et al.*, 2006). The vegetation of coastal areas, including that of the coastal white sands, is only superficially known in the country, particularly west of Abu Dhabi island. Western (1989) was the first author to give a brief introduction to the vegetation from Qatar to Ra's al-Khaimah. Deil & Müller-Hohenstein (1996) and Deil (1998; 2000) have covered specific aspects of the coastal vegetation, mainly in Dubai. More recently, general accounts, including that of the coastal white sands, have been published by Brown & Sakkir (2004b), Brown & Böer (2004, 2005a) and Brown (2006).

It is quite striking that, despite its conservation value and the degree of destruction which has been recognised, mainly by foreign scientists visiting the region (e.g. Deil & Müller-Hohenstein, 1996), the vegetation of coastal white sands has been all but ignored by researchers and authorities working in the UAE, and specifically within Abu Dhabi Emirate, except in the few isolated cases listed above. For instance, this vegetation type is not mentioned in the preliminary classification of vegetation of Abu Dhabi by Roshier *et al.* (1996), and, perhaps more surprisingly, coastal white sand vegetation is completely ignored by Loughland *et al.* (2004) in the recently published "Marine Atlas of Abu Dhabi", which claims to have "successfully documented the location and extent of coastal habitats throughout Abu Dhabi Emirate". It seems that in many cases, coastal vegetation is equated simply to mangroves, and other vegetation types are largely or completely ignored (as in the relevant chapters in Loughland *et al.*, 2004), even though mangroves occupy only a small total area of the Abu Dhabi coastline. As underlined by Deil & Müller-Hohenstein (1996), the statement of Zohary (1973) still applies, particularly for coastal areas, that "we are especially ignorant of the vegetation in the Arabian Peninsula".

Brown & Böer (2004) listed the coastal white sands of Abu Dhabi Emirate as a "priority habitat type", i.e. one of exceptional conservation value, stating that the remaining stands should be a focus of conservation efforts. As mentioned above, a strong case for protecting the Taweela area was made by Aspinall (1999), mainly on account of its outstanding avifauna, and to complement a wider network of protected areas already proposed (Aspinall, 1996). It is to be hoped that at this late stage, some sections of the Taweela area can be protected for posterity.

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Appendix 1. Species occurring on the coastal white sands at Taweela

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The following gives a list of species recorded from the coastal white sands in the Taweela area. Those species which are found predominantly in this habitat type in the UAE (although not necessarily exclusively) are labelled CWS. Information on abundance and distribution is based on observations from about eight separate locations scattered throughout the area and collected mainly in 2007 (i.e. in a season of good rainfall).

Aizoaceae

Aizoon canariense L. - Annual. Very rare. Only a few individuals recorded.

Mesembryanthemum nodiflorum L. - Annual. Extremely rare. Only a single individual recorded.

Asteraceae

Centaurea pseudosinaica Czerep. - Annual. Widespread and common.

Ifloga spicata (Forssk.) Sch. Bip. - Annual. Very rare and local.

Launaea capitata (Spreng.) Dandy. - Annual. Widespread and very common.

Launaea mucronata (Forssk.) Muschl. - Annual. Widespread and very common.

Senecio glaucus L. ssp. *coronopifolius* (Maire) C. Alexander. - Annual. Local.

Boraginaceae

Arnebia hispidissima (Lehm.) DC. - Annual. Widespread and very common.

Heliotropium kotschy (Ledeb.) Guerke - Perennial. Widespread and very common.

Brassicaceae

Eremobium aegyptiacum (Spreng.) Boiss. - Annual. Very local.

Savignya parviflora (Del.) Webb - Annual. Rare.

Caryophyllaceae

Herniaria hemistemon J. Gay - Annual. Widespread and very common.

Paronychia arabica (L.) DC. - Annual. Widespread, but rare.

Polycarpaea repens (Forssk.) Aschers. et Schweinf. - Perennial. Scattered, but rare.

Polycarpaea spicata Wight ex. Arn. - Annual. Scattered, rare (although easily overlooked) (CWS).

Sphaerocoma aucheri Boiss. - Perennial. Widespread and very common (CWS).

Chenopodiaceae

Cornulaca monacantha Del. - Perennial. Widespread and very common (CWS).

Salsola drummondii Ulbrich - Perennial. Very local.

Cistaceae

Helianthemum lippii (L.) Dum. Cours. - Annual/biennial (?), perennial. Widespread and very common.

Cynomoriaceae

Cynomorium coccineum L. - Perennial. Very rare. Parasite on *Zygophyllum qatarense*.

Cyperaceae

Cyperus arenarius Retz. - Perennial. Widespread and very common (CWS).

Cyperus conglomeratus Rottb. - Perennial. Occasional.

Fabaceae

Crotalaria persica (Burm. F) Merrill. - Perennial. Very rare. Only known from the Jebel Ali-Taweela area in the UAE (CWS).

Hippocrepis areolata Desv. - Annual. Widespread and locally very common.

Indigofera cf. *intricata* Boiss - Perennial. Very rare.

Lotononis platycarpa (Viv.) Pic. Serm. - Annual. Occasional.

Lotus garcinii DC - Perennial. Local and rare (CWS).

Lotus halophilus Boiss. & Spruner - Annual. Widespread and very common.

Geraniaceae

Monsonia nivea (Decne.) Dechne. ex Webb - Annual. Rare.

Orobanchaceae

Cistanche tubulosa (Schrenk) Wight. - Perennial. Rare. Parasite mainly on *Cornulaca monacantha*, occasionally *Zygophyllum qatarense*.

Plantaginaceae

Plantago ovata Forssk. - Annual. Very rare.

Plumbaginaceae

Limonium axillare O. Kuntze - Perennial. Scattered.

Poaceae

Coelachyrum piercii (Benth.) Bor - Perennial. Very common, locally abundant (CWS).

Cutandia memphitica (Spreng.) Boiss. - Annual. Rare.

Eragrostis cilianensis (All.) Vign. - Annual. Rare.

Halopyrum mucronatum (L.) Stapf - Perennial. Very local.

Panicum turgidum Forssk. - Perennial. Widespread and common.

Pennisetum divisum (Gmel.) Henr. - Perennial. Scattered.

Rostraria pumila (Desf.) Tzvelev - Annual. Scattered and locally common.

Schismus barbatus (L.) Thell. - Annual. Scattered and locally common.

Sporobolus iocladius (Nees ex Trin.) Nees - Perennial. Widespread and common.

Stipagrostis plumosa (L.) Munro ex T. Anders. - Perennial. Very rare.

Resedaceae

Oligomeris linifolia (Vahl) J. F. Macbr. - Annual. Widespread and very common.

Zygophyllaceae

Fagonia indica Burm. f. - Annual. Local. Mainly on consolidated ground such as tracks.

Zygophyllum qatarense Hadidi - Perennial. Widespread.

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