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First Observations on the Flora and Vegetation of Three Islands in the NW Persian Gulf (Iran)

By

Hossein Akhani*) and Ulrich Deil**)

With 6 Figures

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Summary

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Dara, Booneh (Ghamar) and Ghabre Nakhoda are three small islands located in the Northwest of the Persian Gulf. So far there are no botanical records from Ghabre Nakhoda and Dara Islands, and only 16 species were known from Booneh island. The flora and vegetation of these islands was studied during three expeditions in 2010 and 2011. The vascular plant flora was documented by 121 herbarium specimens. The vegetation on Dara and Ghabre Nakhoda was analysed by transects and by vegetation mapping. On Booneh, 12 vegetation relevés were sampled. The flora is analysed according to life forms and phytogeographical elements and the vegetation is compared with other regions of the Persian Gulf.

In total 80 species of flowering plants were recorded on these islands, 20 on Ghabre Nakhoda, 52 on Dara and 64 on Booneh. Ghabre Nakhoda is the smallest island (3 hectares) with topsoil consisting of only shell particles. The vegetation is dominated by a dense annual turf with *Malva parviflora, Calendula arvensis* s. l. and *Senecio glaucus* and mosaics of small halophytic patches with *Suaeda vermiculata* and *Halocnemum strobilaceum*. Dara's topsoil consists of sandy and silty sediments.

*) Prof. Dr. H. Akhani (corresponding author), Department of Plant Sciences, School of Biology, University of Tehran, P.O. Box 14155-6455, Tehran, Iran; e-mail: akhani@khayam.ut.ac.ir

**) Prof. Dr. U. Deil, Department of Geobotany, Faculty of Biology, University of Freiburg, Schaenzlestrasse 1, 79104 Freiburg, Germany; email: ulrich.deil@biologie.uni-freiburg.de

It has a small-scale structured internal tidal zone with a mosaic of different halophyte communities. The sand dunes are colonized by *Salsola rosmarinus* and by an annual floor consisting of *Launaea mucronata* and *Brassica tournefortii*. The tidal muddy part is dominated by hyperhalophytes of succulent *Chenopodiaceae*. Booneh is the longest island (6.5 km length) with sandy and silty soils and muddy tidal areas. The vegetation types are very similar to Dara. On several islands, the annual halotolerant plant communities of the class Frankenietea pulverulentae are well developed.

Phytogeographically the area is characterized by a mixture of Irano-Turanian, Saharo-Sindian and Mediterranean elements. The Mediterranean introgressions are related to the pronounced winter maximum of the precipitation and to the fact that the study area is not absolutely frost free. Therefore, many tropical elements recorded from the islands in the Strait of Hormuz are missing here. Flora and fauna of the non-habited and not grazed islands are valuable for the conservation of the biodiversity of the Near East. The islands should be protected also in respect to their avifaunistic relevance.

Zusammenfassung

Akhani H. & Deil U. 2012. First observations on the flora and vegetation of three islands in the NW Persian Gulf (Iran) [Erste Beobachtungen über die Flora und Vegetation von drei Inseln im NW Persischen Golf (Iran)]. – Phyton (Horn, Austria) 52 (1): 73–99, with 6 figures.

Dara, Booneh (Ghamar) und Ghabre Nakhoda sind drei kleine Inseln im NW des Persischen Golfes im Ästuarbereich von Khowre Musa. Bisher gibt es keinerlei botanische Beobachtungen über Dara und Ghabre Nakhoda, und von Booneh waren nur 16 Pflanzenarten bekannt. Die Flora und Vegetation dieser Inseln wurde auf drei Exkursionen in den Jahren 2010 und 2011 erforscht. Dabei wurde die Gefäßpflanzenflora mit 121 Herbarbelegen dokumentiert. Die Flora wird nach Lebensformen und pflanzengeographischen Elementen analysiert, die Vegetation mit anderen Küstenregionen des Persischen Golfes verglichen. Die Vegetation auf Dara und Ghabre Nakhoda wurde mit je zwei Transekten erfasst und kartiert. Auf Booneh wurden 12 Vegetationsaufnahmen erstellt.

Insgesamt wurden auf den drei Inseln 80 Gefäßpflanzenarten gefunden: 20 Arten auf Ghabre Nakhoda, 52 auf Dara und 64 auf Booneh. Die Oberfläche der kleinsten Insel Ghabre Nakhoda besteht aus Muschelpflaster. Sie trägt eine dichte Annuellenflur von *Malva parviflora, Senecio glaucus* und *Calendula arvensis* s. l., und einen kleinen Halophytenbestand mit *Suaeda vermiculata* und *Halocnemum strobilaceum*. Dara besteht hauptsächlich aus Sand- und Siltsedimenten und besitzt eine fein gegliederte innere Tidezone mit einem Mosaik verschiedener Halophytenbestände. Die Sanddünen sind von *Salsola rosmarinus*-Büschen kolonisiert und von Annuellen wie *Launaea mucronata* und *Brassica tournefortii*. Im Tidebereich siedeln sukkulente Chenopodiaceen. Booneh als längste Insel (6.5 km) zeigt auf Sanden eine ähnliche Vegetation. Vegetationskundlich gut ausgeprägt auf mehreren der Inseln ist eine halotolerante Therophytenflur der Klasse Frankenietea pulverulentae.

Pflanzengeographisch zeichnet sich das Gebiet durch eine Mischung von iranoturanischen, saharo-sindischen und mediterranen Geoelementen aus. Die mediterranen Floreneinstrahlungen hängen mit dem ausgeprägten Winterregenmaximum zusammen und mit der Tatsache, dass das Untersuchungsgebiet nicht absolut frostfrei ist. Daher fehlen viele tropische Geoelemente, die auf den Inseln in der Straße

von Hormuz vorkommen. Flora und Fauna der unbewohnten und nicht beweideten Inseln sind von Bedeutung zur Erhaltung der Biodiversität im Nahen Osten. Die Inseln sollten daher, auch im Hinblick auf ihre avifaunistische Bedeutung, unter Schutz gestellt werden.

1. Introduction

The Persian Gulf is a shallow water body with ca. 251,000 km^2 stretching from the Strait of Hormuz to the coasts of SW Iran and E Kuwait with a length of ca. 1000 km and wide ranging from 50 to 380 km. The average depth of Persian Gulf is only 50 meter with a maximum of 90 m. As a result of the shallow water, many islands occur close to the coast. About 57 islands are known from the Persian Gulf, over half of them belong to the Iranian territory.

According to Höpner & Kazem Maraschi 1999, the Iranian coast is among the most underexplored coasts of the world. The floristic exploration of the Persian Gulf Islands started with Bornmüller 1894. Some other islands have been studied in the 20th and 21th century, including Kish Island (Termeh & Moussavi 1982, Ghahreman & al. 2007), Hormoz, Qeshm and neighbouring islands (Kunkel 1977, Ghahreman & Attar 1996). The most comprehensive plant list of Iranian Islands resulted from a national project which listed 363 taxa of flowering plants belonging to 212 genera and 62 families (Ershad 2006), collected from 26 islands. The specimens are kept at the herbarium of Plant Pests and Diseases Research Institute (IRAN). Most botanical explorations of Iranian islands concentrated on larger islands in particular those located in the province of Hormozgan.

The first author investigated the flora and vegetation of the mentioned islands in the context of a larger project dealing with the flora and vegetation of southern Khuzestan which was supported by the Office of Environment of the Mahshahr Petrochemical Special Economic Zone. The aims of this study are: (i) documenting and analysing the halophytic and coastal flora and vegetation of hitherto botanically unexplored Persian Gulf islands; (ii) investigating the zonation of plant communities along habitat gradients and documenting them by transect studies and vegetation maps; (iii) analysing the phytogeographical spectrum of the halophytic and psammophytic flora of this part of southern Iran; (iv) comparing the plant communities with plant assemblages in surrounding areas, and (iv) highlighting the conservation importance of three pristine islands in a vulnerable and heavily industrialized area of southern Khuzestan.

2. Study Area

2.1. Location, Size and Substrate

All the three islands are located in the NW of the Persian Gulf at the mouth or inside of Khowre Musa estuary (Figs. 1, 2).

Khowre Musa in the province of Khuzestan is a very interesting estuary system in the Persian Gulf with extraordinary tidal courses forming the roots of a large tree (Fig. 1). In this area the Persian Gulf extends northwards into a wide channel which is ca. 32 km wide at the base. This channel is branched northwards into two smaller channels. The water of the western channel has the extraordinary depth of 89 m at the knee is turning from N-S- to W-E-direction. The enormous water volume passing during every tidal cycle is probably the main reason for such a highly dynamic geomorphological system (HÖPNER & KAZEM MARASCHI 1999).

Five islands exist in the Khowre Musa estuary: One, an island with ca. 4.5 km length, is wrongly mentioned in most maps as Ghabre Nakhoda. This island is covered by sea water during high tide and supports only sparse vegetation of highly hygrohalophytic plants. During low tide the area of this Island increases and outreaches to the second island also named "Ghabre Nakhoda". Ghabre Nakhoda is without any human settlement and serves as an important habitat for sea birds. The third island is a muddy tidal flat ground called by local people "Hade Vaseteh". Here sparse vegetation consisting of *Halocnemum strobilaceum* is found. Dara is the fourth one located at the mouth of the Khowre Musa (Fig. 1). Until now, there are no botanical records for Ghabre Nakhoda and Dara Islands. Booneh (Ghamar) is the fifth island and the longest one located east of Dara. A small part of this island is used for navigation control. Booneh was visited during a short botanical survey by ESKANDARI and TEHRANI on April 18, 2002. They collected 16 vascular plant species there (ERSHAD 2006, SAEIDI MEHRVARZ & SHAHI SHAVVON 2008).

Ghabre Nakhoda (30°18′22″N, 48°54′34″E to 30°18′23″N, 48°54′47″E) is the smallest of the studied islands with only 3 hectares size and a circumference of 835 meters. The shape is triangular with a W-E extension of 345 m (Fig. 2, A). Its width is 120 m at the Western end and 95 m in the middle. It is located 20 km SW of a Petrochemical Complex and 35 km SW of Mahshahr. The island is not inhabited and its name refers presumably to the buried body of a dead Capitain or his daughter. In most official maps the name of this island is confused with a larger tidal muddy land located ca. 2 km further to the NE. The surface is covered by a shell layer which has, according to National Geosciences Database of Iran (HASSANZADEH 2000), a depth of more than one meter. The shell layer is nearly pure with very little fine substrate (sands and soil particles) in-between. There is a depressed part in the westernmost part of the island where the soil is muddy. The island serves as an important habitat for many nesting sea birds and for migratory birds.

Dara or Deyreh (30°6′5″N, 49°5′55″E to 30°6′8″N, 49°7′1″E) is an island with 1.8 km by 1 km (140 hectares). The highest point rises up to 4 m a. s. l. (Fig. 2, B). Dara is located 36 km south of the Petrochemical complex and 49 km south of the city of Mahshahr. At the south-eastern corner an

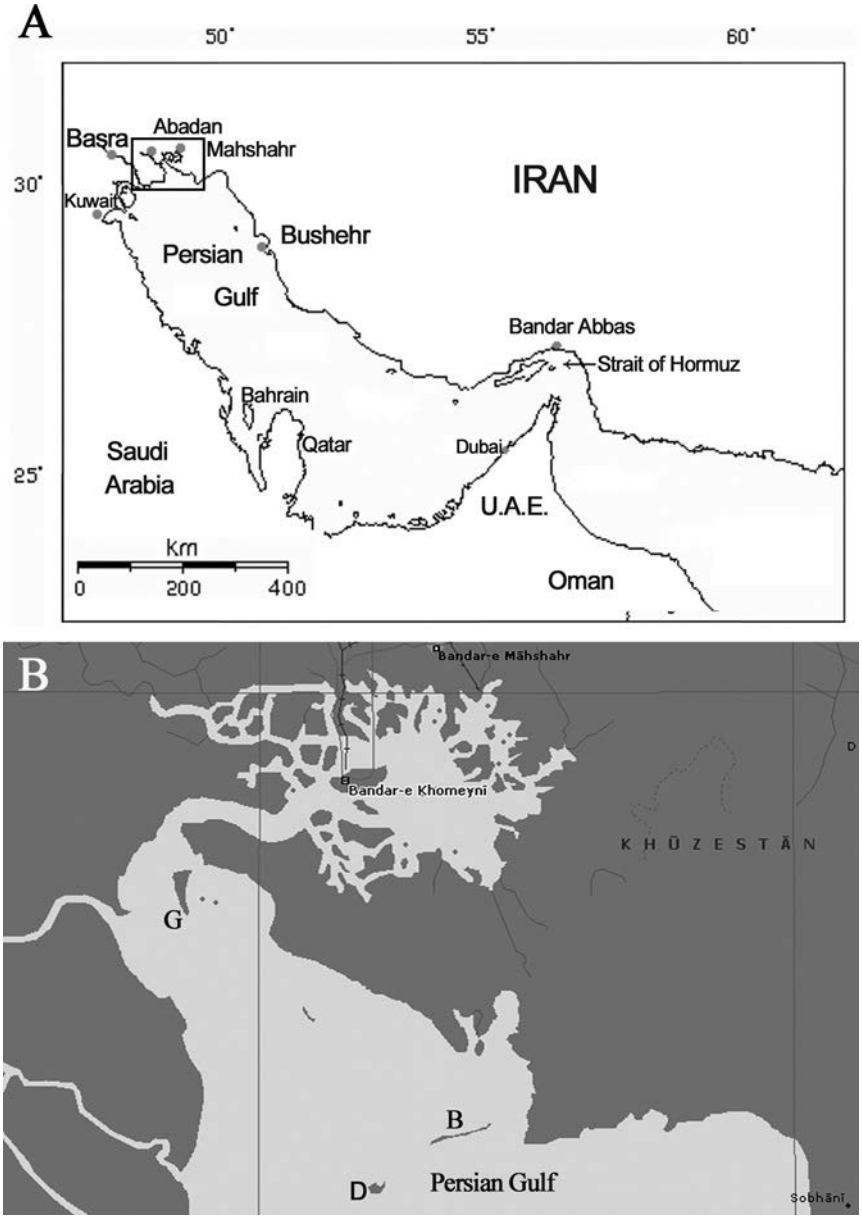

Fig. 1. Study area. A: Map of the Persian Gulf showing the location of the studied area; B: Map of Khowre Musa estuary showing the position of the studied islands (B = Booneh, D = Dara, G = Ghabre Nakhoda).

arm-like barrier of 640 m length extents into the sea. At the northern shore a deep gully allows sea water to enter the center of the island ending in a saline muddy arc at the central-western side. During high tide, the island is split into two branches. Most of the elevated parts are covered by sand dunes; the centre is covered by a mosaic of muddy and silty salt affected soils. The heterogeneity of the substrates results in a high abiotic diversity of Dara.

Booneh or Ghamar (30°7′52″N, 49°9′4E to 30°9′13″N, 49°12′47″E) is a long and very narrow island (Fig. 2, C) of 134 hectares area and a length of 6.7 km. The width varies from 469 m to only 37 m. Soils are rather homogenous. Shallow sand dunes predominate, mud and silt occur in a small isolated depression in the westernmost tip of Booneh. Hyperhalophytic plant communities occur there. Of special avifaunistic relevance are extended *Lycium shawii* patches as nesting sites for a large population of sea birds.

2.2. Climate

The climate of the islands can be interpolated from two synoptic climatic stations nearby. Mahshar is located N and Abadan W of the area. The observation period is 19 and 54 years, respectively. The climatic diagram of Mahshahr is shown in Fig. 3. Mean annual temperature is 25.5 °C with a mean maximum of 45.2 °C in July (absolute maximum 51 °C) and a mean minimum of 8.1 °C in January (absolute minimum of –2.6 °C). The ombroclimate of the area shows a severe arid period from March to October. Mean annual precipitation is 213.4 mm with a winter maximum in January.

According to the Global Bioclimate Classification system of Rivas-Martinez, applied to Iran by Djamali & al. 2011, the study area has a Tropical Desertic (Trd) bioclimate. The relative air humidity is high from November to March (52–74%) and lower from May to August (26–35%). Abadan station has a still drier climate with only 156 mm mean annual rainfall. The mean annual temperature is 25.4 °C with a mean maximum of 45.3 °C in July and a minimum of 7.3 °C in January. The absolute maximum recorded at this station is 53 °C (Iranian Meteorological Organization: <www.irimo.ir>).

3. Material and Methods

3.1. Observation Period

Ghabre Nakhoda was visited on March 9–10th, 2010 and Dara on April 7–8th, 2010 in an expedition jointed by Mr. A. H. Pahlevani (Plant Pests and Diseases Research Institute). Booneh was investigated on March 17, 2011 in an expedition accompanied by Mr. A. R. Nurmohammadi, Mrs. N. Samadi and Mrs Z. Alinaghizadeh.

3.2. Sampling, Documentation and Analysis of Floristic Data

A total number of 121 flowering plant specimens have been collected from the three islands (Table 1). All herbarium vouchers are stored in the "Halophytes and C4

Plants Research Laboratory" of the School of Biology, University of Tehran (Hb. H. AKHANI). Some duplicates are deposited in the herbarium of Plant Pests and Diseases Research Institute (IRAN) and at the Botanischer Garten und Botanisches Museums Berlin (B). Plant nomenclature used in this paper follows mostly Flora Iranica (RECHINGER 1963–2010), updated by recent taxonomic treatments (e.g. AKHANI & al. 2007, TZVELEV 1976). Life forms and chorotypes in Tab. 1 are according to field observations or as given in Flora Iranica.

3.3. Sampling and Analysis of Vegetation Data

Zonation of different vegetation types from the shoreline to the interior of the land is a characteristic feature of coastal ecosystems (DEIL 1998, 1999, 2000). To study the sequence of plant communities and the floristic turnover along ecological gradients, transect sampling was applied. Transects were partly continuous, partly discontinuous. All vascular plants were recorded. Cover-abundance was estimated according to the Braun-Blanquet-scale (BRAUN-BLANQUET 1964).

On Ghabre Nakhoda 50 plots were sampled along two transects passing the length (271 m) and width of the island (92m) (see Fig. 2, A), each 2×2 m in size. Most plots were placed in 10 m distance, except for narrower vegetation zonation, where a shorter distance (5 m) was applied. A few plots were placed outside the transects (see open triangles in Fig. 2, A).

On Dara Island two transects were realized (Fig. 2, B). The first transect with 29 plots of 6 m distance in-between was 233 m long. It passed from the high saline soils of the inner lagoon via the dunes of the narrow northern barrier. The second transect runs through the western part of the island starting from the NW coast via the broad sand dunes towards the internal lagoon. This transect had a total length of 700 m. It was divided into three sections: In the first section 22 plots were recorded continuously across a 369 m long vegetated zone from the coast to the western margin of the inner depression. The distance from the center of each plot was 20 m, except two plots taken in 5 m distance to cover small vegetation zones. The second section consisted of 233 m of non-vegetated and therefore not sampled saline flat ground. The third section, represented by 5 plots, included tidal areas with hygrohalophytic plants. Along this transect, two plot sizes have been applied: 2×2 m for herbal and low shrub vegetation types and 10×10 m for dune vegetation with large shrubs.

Because of time limitations it was not possible to carry out sampling of transect data and vegetation mapping on Booneh Island. Only 12 relevés were taken to record the main vegetation types. Based on life forms and physiognomy of the plant communities three different plot sizes (2×2, 5×5 and 10×10 m) have been used here.

The phytosociological data of the transects are documented in the Tables 2 to 4, the relevés from Booneh Island in Tab. 5. To study the distribution of the different plant communities, the vegetation of Ghabre Nakhoda and Dara Islands was mapped based on transect data, on vegetation relevés as well as GPS data collected in the field and satellite maps available through Google Earth.

No attempt is made at the moment to describe plant communities in a formal way. This requires larger data sets from larger areas. However, some common species combinations are compared with plant communities described from the Arabian Peninsula and the Mediterranean area (DANIN & ORSHAN 1999, DEIL 1999, 2000, GHAZANFAR & FISHER 1998, RIVAS-MARTÍNEZ & al. 2002).

Table 1. Recorded vascular plant species of the studied Persian Gulf Islands.

Abbreviations: **Island names:** B = Booneh (Ghamar), D = Dara, G = Ghabre Nakhoda; **life forms:** An. = annual, Cham. = chamaephyte, Geo. = geophyte, Hem. = hemicryptophyte, Par. = Parasite, Phan. = phanerophyte; **chorotypes:** Cos. = Cosmopolitan, ES = Euro-Siberian, End. = endemic to Persian Gulf area and S. Iran, IT = Irano-Turanian, M = Mediterranean, Pl. = Pluriregional, SS = Saharo-Sindian, Tr. = Tropical. Species reported from Booneh Island by Ershad 2006 are underlined.

Name	B	D	G	Life form	Chorotype	Herbarium voucher
Aizoaceae						
Mesembryanthemum nodiflorum L.	X	X		An.	SS-M	20831-D, 21927-B
Alliaceae						
Allium olivieri Boiss.	X			Geo.	IT	No voucher
Asphodelaceae						
Asphodelus tenuifolius Cav.	X	X		An.	SS-M	20821-D, 21901-B
Asteraceae						
Calendula arvensis L. s.l. *	X		X	An.	M-SS-ES	20722-G, 21938-B
Ifloga spicata (Forssk.) Schultz.-Bip.		X		An.	SS	20841-D
Lactuca cf. *serriola* L. (sterile)			X	An.	Pl.	20717-G
Launaea mucronata (Forssk.) Musch.	X	X		An.	SS	20843-D, 21898-B
Senecio glaucus L.	X	X	X	An.	SS-IT-ES	20720-G, 21907-B, 20840-D
Sonchus oleraceus L.		X	X	An.	Cos.	20721-G, 20857-D
Sonchus tenerrimus L.	X		X	An.	ES-M-SS (Pl)	20718-G, 21942-B
Avicenniaceae						
Avicennia marina (Forssk.) Vierh.		X		Phan.	Tr.	20824-D (cultivated)
Brassicaceae						
Brassica tournefortii Gouan	X	X		An.	M (SS, IT)	20833-D, 21905-B
Erucaria hispanica (L.) Druce	X	X		An.	M-SS	20826-D, 21909-B
Hornungia procumbens (L.) Hayek		X		An.	Pl	21932-B
Caryophyllaceae						
Loeflingia hispanica L.		X		An.	M	21926-B
Paronychia arabica (L.) DC.	X	X		An.	SS	20852-D, 21939-B
Polycarpon tetraphyllum (L.) L.	X	X	X	An.	M-IT	20708-G, 20851-D, 21920-B
Silene apetala Willd.	X	X		An.	M-IT	20853-D, 21940-B
Silene austro-iranica Rech.F. Aellen & Esfand.	X			An.	IT	Eskandari & Tehrani 38142

Spergula fallax (Lowe) E. H. L. Krause	X		X	An.	SS	20710-G
Spergularia diandra (Guss.) Heldr.	X	X	?	An.	M-IT-SS	20854-D, 21933-B
Chenopodiaceae						
Atriplex leucoclada Boiss.	X	X	X	Hem.	IT-SS	20707-G, 20830-D, 21895-B
Beta vulgaris L. subsp. *maritima* (L.) Archangeli			X	An.	IT-M-SS	20719-G
Bienertia sinuspersici Akhani		X		An.	End.	No voucher
Caroxylon imbricata Forssk.	X	X		H, Cham.	SS	20859-D, 21924-B
Caroxylon jordanicola (Eig) Akhani & E. H. Roalson	X	X		An.	SS	20860-D, 21923-B
Chenopodium murale L.	X	X		An.	PL	20825-D, 21897-B
Cornulaca aucheri Moq.	X	X		An.	IT-SS	20837-D
Halocnemum strobilaceum (Pall.) M. Bieb.	X	X	X	Cham.	IT-SS-M	20715-G, 20822-D, 21934-B
Suaeda aff. *maritima* (L.) Dumort.	X	X		An.	End.	20818-D
Suaeda vermiculata Forssk. ex J. F. Gmelin	X	X	X	Cham.	SS (IT)	20714-G, 21911-B
Salicornia sinus-persica Akhani	X	X		An.	End.	20823-D
Salsola rosmarinus (Ehrenb. & Boiss.) Akhani	X	X		Cham.	IT (SS)	20817-D
Cistaceae						
Helianthemum lippii (L.) Pers.	X			H, Cham.	SS	21906-B
Helianthemum salicifolium (L.) Mill.	X	X		An.	IT-M	20842-D, 21917-B
Crassulaceae						
Crassula alata (Viv.) Berger	X			An.	M-IT	21922-B
Cuscutaceae						
Cuscuta sp.	X	X		An. (Par.)	Pl	20861-D, 21941-B
Fabaceae						
Astragalus annularis Forssk.	X	X		An.	IT-SS	20848-D
Astragalus crenatus Schultes	X			An.	IT-SS	21937-B
Hymenocarpus circinnatus (L.) Savi	X			An.	M	No voucher
Lotus halophilus Boiss. & Sprung.	X	X		An.	M	20844-D, 21918-B
Medicago laciniata (L.) Miller	X			An.	M-SS	21925-B
Ononis serrata Forssk.	X	X		An.	M (SS)	20849-D, 21921-B
Prosopis juliflora (Sw.) DC.	X			Phan.	–	No voucher (cultivated)
Trigonella stellata Forssk.	X			An.	SS	Eskandari & Tehrani 38453
Frankeniaceae						
Frankenia pulverulenta L.	X	X		An.	PL	20838-D, 21919-B

Name	B	D	G	Life form	Chorotype	Herbarium voucher
Fumariaceae						
Fumaria parviflora Lam.			X	An.	PL	20705-G
Geraniaceae						
Erodium cf. neuradifolium Delile ex Godron		X		An.	M-IT	20845-D
Erodium pulverulentum (Cav.) Willd.	X			An.	M-IT (SS)	21894-B
Hyacinthaceae						
Bellevalia cf. *macrobotrys* Boiss.	X	X		Geo.	IT	20846-D
Bellevalia saviczii Woron.	X			Geo.	IT	21902-B
Iridaceae						
Gladiolus italicus Mill.	X			Geo.		21914-B
Gynandriris sisyrinchium (L.) Parl.	X			Geo.	M-IT	21913-B
Myrtaceae						
Eucalyptus camaldulensis Dehnh.	X			Phan.	Cult.	21896-B (Cultivated)
Malvaceae						
Malva parviflora L.	X	X	X	An.	Cos.	20711-G, 21936-B, 20856-D
Neuradaceae						
Neurada procumbens L.	X	X		An.	SS	20832-D
Orobanchaceae						
Cistanche tubulosa (Schenk) Wight	X	X	X	Geo. (Par.)	IT.SS	20706-G, 20855-D, 21862-B, 21893-B
Cistanche laxiflora Aitch. & Hemsl.	X			Geo. (Par.)	IT	Eskandari & Tehrani 33506
Plantaginaceae						
Plantago coronopus L.	X	X		An.	PL	20827-D, 21899-B
Plumbaginaceae						
Limonium iranicum (Bornm.) Lincz.	X	X	X	Cham.	IT	20723-G, 21912-B, 20820-D
Poaceae						
Anisantha fasciculata (C. Presl) Nevski (= *Bromus fasciculatus* C. Presl.)	X	X		An.	M-IT	20863-D, 21931-B, Det.: H. Scholz
Bromus rubens L.			X	An.	ES-IT-M	20713-G
Cutandia memphitica (Spreng.) Benth.	X	X		An.	SS$^{(N.\ Iran)}$	20828-D, 21930-B
Cynodon dactylon (L.) Pers.	X	X		Hem.	Cos.	20836-D, 21943-B
Halopyrum mucronatum (L.) Stapf	X			Hem.	Afro-Asian Tr.	21915-B

Hordeum marinum HUDSON subsp. *gussoneanum* (PARL.) THELL.			X	An.	M-IT	20704-G
Parapholis incurva (L.) C. E. HUBBARD			X	An.	Pl.	20709-G
Polypogon maritimus WILLD.		X		An.	M-IT	20858-D
Rostaria pumila (DESF.) TZVELEV (= *Lophochloa pumila* (DESF.) BOR)	X			An.		21929-B, 20862-D
Schismus barbatus (L.) THELL.	X	X		An.	Pl.	20864-D
Sphenopus divaricatus (GOUAN) REICHENB.	X	X	X	An.	M-IT	20712-G, 20835-D
Stipa capensis Thunb.	X	X		An.	Pl	21900-B, 20834b-D
Stipagrostis plumosa (L.) MUNRO ex T. ANDERS.	X			Hem.	Pl.	21910-B
Trisetaria linearis FORSSK.**		X		An.	SS	20834a-D
Polygonaceae						
Emex spinosus (L.) CAMPD.	X	X		An.	M (SS)	20839-D, 21908-B
Primulaceae						
Anagallis arvensis L.	X	X		An.	Pl.	20819-D, 21916-B
Resedaceae						
Oligomeris linifolia (VAHL.) MACBR.		X	X	An.	SS	20716-G, 20829-D
Scrophulariaceae						
Linaria albifrons (SIBTH. & SM.) STEUDEL	X			An.	M (SS)	21935-B
Scrophularia deserti DEL.	X	X		An.	SS	20850-D, 21903-B
Solanaceae						
Lycium shawii ROEMER & SCHULTES	X			Cham.	SS	21904-B

* *Calendula arvensis* L. s. str. was not reported from Iran (RECHINGER 1989). The two specimens cited above are not similar but using the identification key of Flora Iranica the sample from Ghabre Nakhoda (20722-G) was identified as *C. arvensis* L. s. str. and that of Booneh (21938-B) as *C. sancta* L., respectively. HEYN & al. (1974) discussed the taxonomic complexity of this group and mentioned that *C. arvensis* is an extremely variable group with many forms. Based on numerous specimens collected and observations made by the first author, most of these forms occur in Khuzestan.

** Only one record in N. Iran (BOR 1970).

4. Results

4.1. Flora

4.1.1. Species Number

A total number of 80 species of vascular plants has been identified from the three islands (Table 1). These are the first floristic records for Ghabre Nakhoda and Dara, and 48 new records for Booneh. The latter island with 64 species and Dara with 52 species are colonized by more species than Ghabre Nakhoda (only 20 taxa). *Poaceae* and *Chenopodiaceae* are the species-richest families with 15 and 12 species, respectively.

4.1.2. Life Forms

Most species on the three islands are annuals (71%). The only native nano-phanerophyte on the islands is *Lycium shawii*, growing on Booneh. On this island some trees have been cultivated around the governmental building including *Eucalyptus camaldulensis, Phoenix dactylifera* and *Prosopis juliflora*. According to information from our boat driver *Avicennia marina* trees have been introduced by local people on Dara Island. Up till now only one large individual survived in the inner gully. The presence of seven geophytes on the islands is surprising. Usually this life form is diversified in Iranian highlands and mountain area, rarely on saline soils and in coastal habitats. Interesting endemic species of SW Iran are *Allium olivieri* and *Bellevalia savizii* (Wendelbo 1990, Akhani 2004b).

4.1.3. Phytochorology

All three main phytogeographical elements of the desert regions of SW Asia and N Africa are represented in these islands. An analysis of Irano-Turanian, Mediterranean and Saharo-Sindian species shows that 27 species (36%) are either Mediterranean only, or have a common Mediterranean range with any or both of the Irano-Turanian and Saharo-Sindian chorotypes. 30 species (39%) have an Irano-Turanian range alone or jointed with Saharo-Sindian and/or Mediterranean range, and 36 species (46%) are Saharo-Sindian only or occurring within one/or within two other phytochoria.

Two grass species observed in the study area are of special interest: *Trisetaria linearis* is widely distributed in sandy habitats of North Africa,

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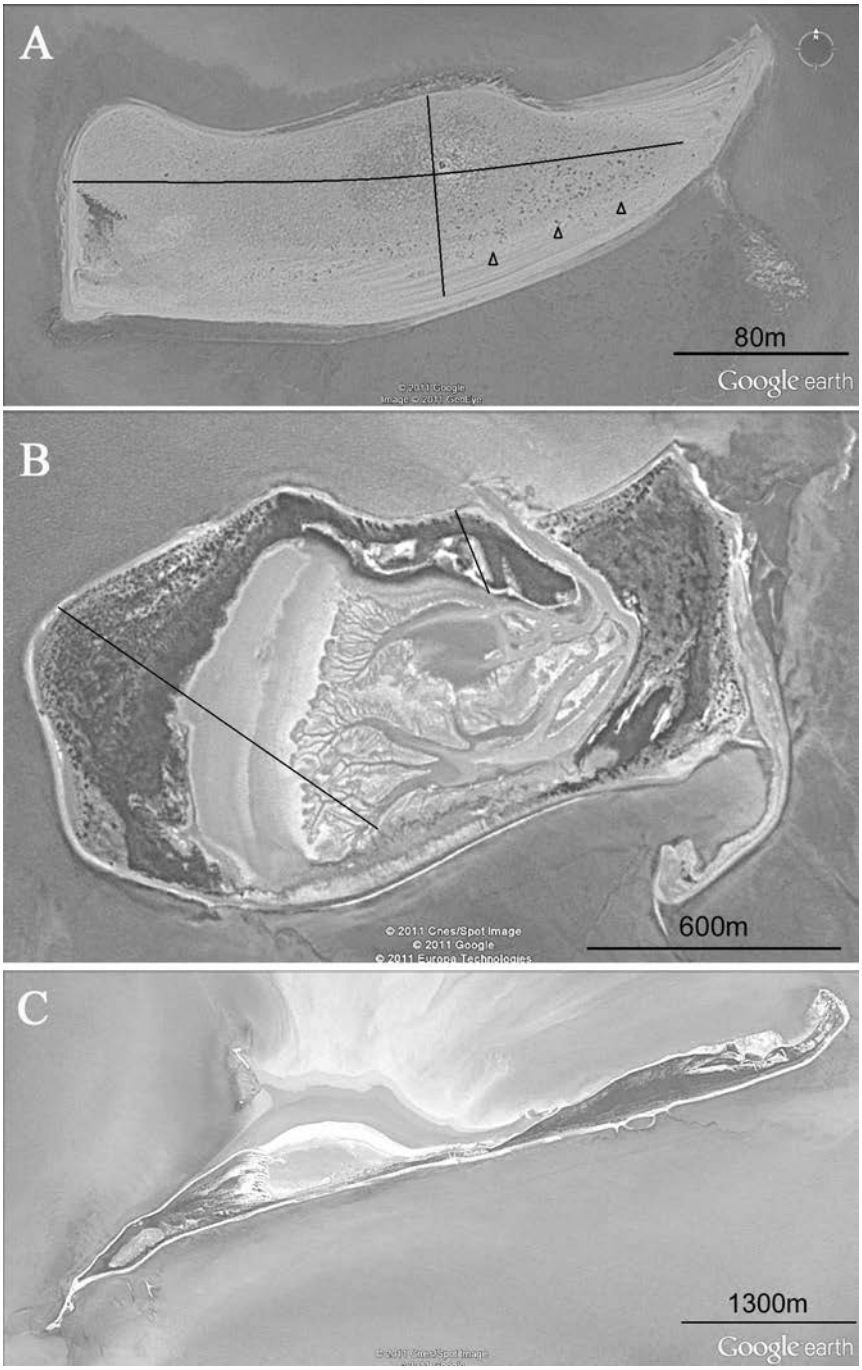
Fig. 2. A: Satellite image of Ghabre Nakhoda Island; the black dot in the center of the island is the location of a grave (قبر). – B: Dara Island; note the gully which allows entering of sea water during high tide to the inner part of the island and forming anastomous tidal courses ending in an arc-like saline depression in the western-center of the island. – C: Booneh (Ghamar) Island (courtesy of Google Earth). The lines in A and B show the position of vegetation transects.


A
80m
Google earth
B
© 2011 Cnes/Spot Image
© 2011 Google
© 2011 Europa Technologies
600m
C
1300m
Google earth

Syria and Iraq (Bor 1970). From Iran this annual was known until now only from the Golestan Province in northern Iran. *Halopyrum mucronatum*, a halotolerant perennial with above-ground runners, was known from the central and eastern side of the Iranian south coasts.

4.2. Vegetation

4.2.1. Ghabre Nakhoda

The vegetation map (Fig. 5) and the species combination along the transect (Tab. 2) show three vegetation zones on this island. The outer fringe with unvegetated shell layer is followed by a narrow *Senecio glaucus* zone (only on the southern side of the island) and further inland by a mixed *Malva parviflora-Calendula arvensis* zone, and finally replaced by a *Malva parviflora* zone in the central part. *Malva parviflora* is abundant there and forms dense and nearly monospecific stands. *Bromus rubens* and *Atriplex leucoclada* range over all three zones. A small depression in the western part with highly saline soil is covered by patches of *Suaeda vermiculata* and *Halocnemum strobilaceum*.

The dominance of *Malva parviflora* on the island is of great interest. It might be the result of the undeveloped soil layer above the shells. This annual has a weedy character growing usually in disturbed and nutrient-rich habitats. It occurs in southern Iran frequently along roadsides and in some natural vegetation types. The large bird population living on Ghabre Nakhoda provides enough nutrients to the soil, which consists mainly of shells and is very poor in fine particles. Apparently only a few species can compete with *M. parviflora* in this area. Based on long-term studies by Abbott & al. 2000 on Carnac Island in Western Australia, *M. parviflora* dominates half of the island there.

4.2.2. Dara

The results of the two transects along the main habitat gradients (Tab. 3 and 4) and the vegetation map (Fig. 6) show that there are six vegetation zones in the island including (1) a *Salsola rosmarinus* zone. This chamaephyte stabilizes the sandy coastal hillocks. Between the dwarf shrubs grow halo-psammophytic annuals such as *Launaea mucronata, Senecio glaucus, Erodium* cf. *neuradifolium, Cutandia memphitica* and *Brassica tournefortii*. (2) a zone bearing all the species of the first zone except for *Salsola rosmarinus*. With more distance from the sea shore and reduced dune depth other species such as *Stipa capensis, Emex spinosus, Neurada procumbens* and *Cynodon dactylon* occur in this zone. (3) A narrow zone between psammophytes and hyperhalophytes is dominated by halotolerant annuals like *Mesembryanthemum nodiflorum, Sphenopus divaricatus, Spergularia diandra* and *Frankenia pulverulenta*. (Plot 3,50–3,52 in transect Tab. 4, plot 3,23 and 3,28 in transects Tab. 3). (4) In the

Table 2. Vegetation along two transects through Ghabre Nakhoda Island. Plot numbers 9.1 to 9.11 represent vertical transect and 9.14 to 9.33 horizontal transect, respectively (see Fig. 2 A for the position of transects). Other plots have been recorded outside of the transects.

Plot number	9,1	9,2	9,3	9,33	9,34	9,35	9,36	9,37	9,38	9,39	9,40	9,41	9,42	9,32	9,4	9,31	9,49
Relevé area (m)	4	4	4	4	16	4	4	4	4	4	4	4	4	4	4	4	4
Herb/Shrub height (cm)	25	30	30	20	20	30	30	40	30	25	20	25	30	30	50	40	50
Total cover (%)	40	20	60	40	60	40	30	30	25	15	60	60	40	55	70	60	30
	Senecio zone													Transition			
Senecio glaucus	1	2	3	3	3	3	3	3	3	2	2	1	3	3	1	1	1
Calendula arvensis	.	+	+	+	+	.	.	.	.		+	.	.	3	4	4	2
Malva parviflora	.	.	.	.	.	.	.	.	.	.	.	+	.	1	1	1	+
Suaeda vermiculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Halocnemum strobilaceum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bromus rubens	.	1	2	1	2	1	1	+	.	1	3	3	2	1	1	1	1
Atriplex leucoclada	.	+	+	.	r	1	.	.	.	.	r	.	.	+	1	.	2
*Spergula fallax/Spergularia diandra***	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Oligomeris linifolia	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	1
Cistanche tubulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 2 continued

Plot number	9,20	9,22	9,29	9,30	9,43	9,44	9,46	9,47	9,48	9,50	9,14	9,15	9,16	9,17	9,18	9,19	9,21	9,23	9,24	9,25	9,5	9,28	9,45	9,26	9,27	9,6	9,7	9,8	9,9	9,10	9,11	9,12	9,13
Surface area (m)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Herb/Shrub height (cm)	40	50	50	50	20	40	40	50	40	40	30	35	35	50	50	50	50	80	100	100	80	80	40	110	80	100	80	100	100	80	80	40	30
Total cover (%)	75	80	60	60	65	70	60	60	60	60	40	60	60	30	30	10	70	90	90	90	75	70	40	85	75	70	90	80	70	70	90	100	60
	Malva parviflora-Calendula arvensis zone																							*Malva-parviflora* zone								HS-SV*	
Senecio glaucus	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calendula arvensis	4	4	3	3	4	4	4	4	4	4	2	2	2	1	1	1	2	2	1	1	1	2	1	.	.	.	.	.	.	.	.	.	.
Malva parviflora	1	2	2	1	+	2	2	2	+	1	2	4	3	3	3	2	3	4	5	5	4	2	3	5	4	4	5	4	4	4	5	.	.
Suaeda vermiculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2
Halocnemum strobilaceum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3
Bromus rubens	.	.	+	.	1	1	+	1	+	1	.	.	.	+	+	.	.	1	1	1	1	1	1	1	1	1	1	2	1	1	1	.	.
Atriplex leucoclada	.	.	.	2	.	r	1	.	.	1	.	1	.	.	+	.	.	.	.	.	1	2	2	2	1	2	1	1	1	1	1	.	.
*Spergula fallax/Spergularia diandra***	.	+	.	.	.	.	.	1	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	.
Oligomeris linifolia	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cistanche tubulosa	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

* *Halocnemum strobilaceum-Suaeda vermiculata* zone
** During field studies both species have been confused.

Table 3. Vegetation along a transect on the northern side of Dara Island.

Plot number	3,6	3,7	3,8	3,9	3,10	3,11	3,12	3,1	3,14	3,15	3,16	3,17	3,18	3,19	3,20	3,21	3,22	3,23	3,24	3,25	3,26	3,27	3,28	3,29	3,30	3,31	3,32	3,33
Relevé area (m^2)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	4	100
Herb/Shrub height (cm)	35	30	20	35	15	10	20	30	40	40	40	40	40	40	30	35	50	60	50	50	40	40	20	100	110	100	60	100
Total cover (%)	35	40	45	60	80	80	90	80	80	60	90	90	80	90	50	95	100	50	90	80	80	70	60	95	90	80	60	75
Salicornia sinus-persica	1	3	2	1	1	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Suaeda aff. *maritima*	3	1	.	+	.	.	.	+	2	1	2	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Halocnemum strobilaceum	1	.	2	4	4	5	5	5	3	2	3	4	3	2	3	3	2	1	3	4	3	3	.	.	.	.	.	.
Limonium iranicum	.	.	.	.	.	.	.	.	2	3	3	3	3	2	.	3	4	3	4	3	3	2	.	.	.	.	.	.
Suaeda vermiculata	.	.	.	.	.	.	.	.	1	1	1	2	2	4	2	3	3		1		1	3	.	.	.	.	.	.
Spergularia diandra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	3	.	.	.	.	.
Sphenopus divaricatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	2	.	.	.	.	.
Mesembryanthemum nodiflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	.	.
Senecio glaucus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	3	3	3	3
Launaea mucronata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	2	1	1
Anisantha fasciculata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	1
Cuscuta spec.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	1	
Lotus halophilus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	2	.
Brassica tournefortii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	1		2
Cynodon dactylon	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	
Asphodelus tenuifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Erodium neuradifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	1
Salsola rosmarinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Rostaria pumila	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.
Ononis serrata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1			
Bienertia sinuspersici	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Atriplex leucoclada	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
Stipa capensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Plantago coronopus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Silene apetala	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Hornungia procumbens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Polypogon maritimus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.

Table 4. Vegetation along a transect passing the western side of Dara Island.

Plot number	3,34	3,35	3,36	3,37	3,38	3,39	3,40	3,41	3,41b	3,42	3,43	3,44	3,45	3,46	3,47	3,48	3,49	3,50	3,51	3,52	3,53	3,54	3,55	Gap	3,1	3,2	3,3	3,4	3,5
Relevé area (m^2)	100	100	100	100	100	100	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4
Herb/Shrub height (cm)	100	100	100	100	100	100	100	120	100	100	120	100	100	110	100	120	110	100	30	40	25	30	20		35	20	20	40	30
Total cover (%)	40	50	50	70	80	80	65	50	80	100	75	80	60	75	70	85	80	60	35	40	55	30	20		35	60	60	40	80
Launaea mucronata	1	1	3	3	4	4	3	2	2	2	2	2	2	3	2	1	1	1	.	.	.	.	.		.	.	.	.	.
Senecio glaucus	2	1	2	3	2	3	3	3	2	4	4	3	3	3	3	3	2	2	1	.	.	.	.		.	.	.	.	.
Erodium neuradifolium	.	+	1	1	1	1	2	1	1	.	1	1	1	1	1	.	.	.	.	.	.	.	.		.	.	.	.	.
Salsola rosmarinus	3	3	3	2	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Cutandia memphitica	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Trisetaria linearis	.	.	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Brassica tournefortii	.	.	.	1	1	1	3	1	1	1	1	2	1	.	2	2	2	.	.	.	.	.	.		.	.	.	.	.
Anisantha fasciculata	.	.	.	+	1	1	1	1	1	.	.	.	+	.	1	.	.	+	1	.	.	.	.		.	.	.	.	.
Emex spinosus	.	+	.	.	+	1	.	.	.	+	.	1	.	1	.	1	3	1	.	.	.	.	.		.	.	.	.	.
Lotus halophilus	.	.	.	1	1	.	.	1	.	1	2	2	3	1	1	1	1	1	.	.	.	.	.		.	.	.	.	.
Cuscuta spec.	.	.	.	2	2	1	1	1	3	1	1	2	.	1	1	.	.	.	.	.	.	.	.		.	.	.	.	.
Stipa capensis	.	.	.	.	1	1	.	1	1	1	+	.	.	1	1	1	2	3	1	.	.	.	.		.	.	.	.	.
Ononis serrata	.	.	.	.	.	1	.	+	2	1	.	1	.	.	.	.	+	.	.	.	.	.	.		.	.	.	.	.
Cynodon dactylon	.	.	.	.	.	.	.	1	.	3	.	.	.	.	1	2	.	.	.	.	.	.	.		.	.	.	.	.
Plantago coronopus	.	.	.	.	.	.	.	1	1	.	.	+	1	1	.	.	.	.	1	.	.	.	.		.	.	.	.	.
Silene cf. *apetala*	.	.	.	.	.	.	.	.	1	1	1	1	.	.	+	1	1	+	.	.	.	.	.		.	.	.	.	.
Helianthemum spec.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	1	1	1	.	.	.	.	.	.		.	.	.	.	.
Astragalus spec.	.	.	.	.	.	.	.	.	1	+	1	1	+	+	1	.	.	.	.	.	.	.	.		.	.	.	.	.
Asphodelus tenuifolius	.	.	.	.	.	.	.	.	.	1	1	+	.	1	+	+	.	.	.	.	.	.	.		.	.	.	.	.
Neurada procumbens	.	.	.	.	.	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.		.	.	.	.	.
Mesembryanthemum nodiflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.		.	.	.	.	.
Spergularia diandra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	r	.	.	.		.	.	.	.	.
Sphenopus divaricatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.		.	.	.	.	.
Frankenia pulverulenta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.		.	.	.	.	.
Suaeda vermiculata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.		.	.	.	.	.
Halocnemum strobilaceum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	2		.	+	.	2	.
Salicornia sinuspersica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		3	1	4	1	4
Suaeda aff. *maritima*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		2	.	.	1	.
Bienertia sinuspersici	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		1	.	.	2	.
Chenopodium murale	.	.	.	.	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Anagallis arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.		.	.	.	.	.
Atriplex leucoclada	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Sonchus oleraceus	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.
Schismus barbatus	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.		.	.	.	.	.
Rostaria pumila	.	.	.	+	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.

transect passing the northern side of the island (Tab. 3) there is a zone dominated by *Suaeda vermiculata, Limonium iranicum* and *Halocnemum strobilaceum*. This zone is very narrow and discontinuous in the W-E transect (Tab. 4) where only scattered individuals of *Suaeda vermiculata* were observed. (5) The N-S transect ends with a fifth zone (Tab. 3, plots 3,6 to 3,13) dominated by the hygrohalophytes *Halocnemum strobilaceum, Salicornia sinus-persica* and *Suaeda* aff. *maritima* approaching finally muddy salt marshes of the gully entering the inside of the island. (6) The W-E transect passes a pure *Halocnemum strobilaceum* zone and then due to increasing salinity a large saline flat without any vegetation. The end of this connects to an extensive nerve of tidal rills and grooves where *Salicornia sinus-persica* and *Suaeda* aff. *maritima* cover large parts of the area with some individuals of *Halocnemum strobilaceum* and *Bienertia sinus-persici* occurring on slightly elevated parts between the tidal nerves (Table 4, plots 3,1 to 3,5).

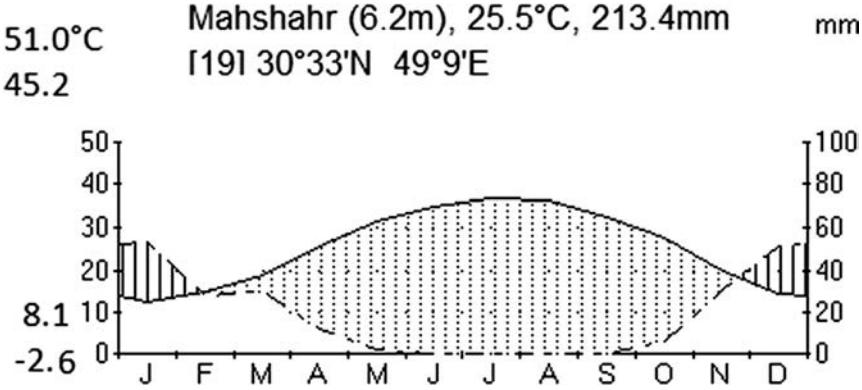


Fig. 3. Climatic diagram of Mahshahr station after the method of WALTER & LIETH 1967.

4.2.3. Booneh

The vegetation of Booneh was studied based on a limited number of randomly collected relevés sampled in different habitats from East to West on the island (Table 5). According to the relevés and further field observations, the following vegetation types occur on Booneh: Large parts are covered by an ephemeral community of halotolerant and psammophilous annuals such as *Senecio glaucus, Erodium* cf. *neuradifolium, Emex spinosus, Medicago laciniata* and *Launaea mucronata*. Dwarf shrub vegetation with *Salsola rosmarinus* occurs on the dunes along the southern side of the island. Patches of *Halopyrum mucronatum* may indicate a stronger saline influence on sand dunes as compared to Dara Island. On the northern fringe of the middle and western parts of the island grow large patches of *Lycium shawii* (not documented by relevés). With increasing salinity sea-

Table 5. Vegetation on coastal dunes and saline soils on Booneh Island.

Plot number	35,1	35,2	35,3	35,1	35,7	35,1	35,1	35,9	35,4	35,5	35,6	35,8
Relevé area (m^2)	4	25	25	25	100	25	100	25	100	100	25	25
Herb/Shrub height (cm)	20	20	20	30	110	70	100	70	110	120	40	60
Total cover (%)	65	70	80	80	50	70	60	40	70	100	40	60
Senecio glaucus	3	2	2	4	3	2	1	2	1	1	.	.
Emex spinosus	3	3	2	2	1	1	1	.	1	1	.	.
Medicago laciniata	2	2	2	1	.	1	.	.	1	1	.	.
Launaea mucronata	+	1	1	1	1	.	.	1	.	.	.	.
Erodium spec.	+	+	1	1	1	1	2	1	.	.	.	.
Malva parviflora	+	+	2	.	.	3	.	.	1	5	1	.
Brassica tournefortii	.	1	.	.	1	.	1	.	.	.	.	.
Chenopodium murale	.	.	.	.	.	1	.	.	+	.	.	.
Cynodon dactylon	.	+	1	1	.	.	.	.	.	.	.	.
Lotus halophilus	.	.	.	+	.	.	.	+	.	.	.	.
Stipa capensis	+	.	.	.	.	.	.	1	.	1	.	.
Cistanche tubulosa	.	.	.	.	+	.	.	1	.	.	.	.
Calendula arvensis	.	+	.	.	.	.	.	.	.	1	.	.
Cutandia memphitica	.	.	1	.	1	.	.	.	.	.	.	.
Salsola rosmarinus	.	.	.	.	2	3	1	.	.	.	.	.
Limonium iranicum	.	.	.	.	.	.	1	2	.	.	.	.
Halopyrum mucronatum	.	.	.	.	.	.	2	.	.	.	.	.
Suaeda vermiculata	.	.	.	.	.	.	.	2	3	2	3	.
Caroxylon imbricatum	.	.	.	.	.	.	.	.	1	1	.	.
Spergularia diandra	.	.	.	.	.	.	.	.	1	1	.	.
Sonchus tenerrimus	.	.	.	.	.	.	.	.	1	+	1	.
Atriplex leucoclada	.	.	.	.	1	.	.	.	1	1	.	.
Mesembr. nodifl.	.	.	.	.	.	.	.	.	2	.	.	.
Halocnemum strobil.	.	.	.	.	.	.	.	.	.	.	.	4
Salicornia sinuspersica	.	.	.	.	.	.	.	.	.	.	.	1
Neurada procumbens	.	1	.	.	.	.	.	.	.	.	.	.
Cuscuta spec.	.	.	.	.	1	1	1	+	.	.	.	.
Asphodelus tenuifolius	.	.	.	2	.	.	.	.	.	.	.	.
Anisantha fasciculata	.	.	.	.	.	.	2	1	.	.	.	.
Bellevalia saviczii	.	.	.	.	.	.	.	.	.	1	.	.
Gladiolus italicus	.	.	.	.	.	.	.	.	.	+	.	.
Anagallis arvensis	.	.	.	.	.	.	.	.	.	r	.	.
Gynandriris sisyrinchium	.	.	.	.	.	.	.	.	.	1	.	.
Hymenocarpus circinn.	.	.	.	.	r	.	.	.	.	.	.	.
Rostaria pumila	.	.	.	.	r	.	.	1	.	.	.	.
Spergula fallax	.	.	.	.	.	.	.	1	.	.	.	.
Parapholis incurva	.	.	.	.	.	.	.	+	.	.	.	.
Polycarpon tetraphyllum	.	.	.	.	.	1	.	+	.	.	.	.
Paronychia arabica	.	.	+	.	.	.	.	.	.	.	.	.
Schismus barbatus	+	.	.	.	.	.	.	.	.	.	.	.
Astragalus crenatus	.	r	.	.	.	.	.	.	.	.	.	.
Ononis serrata	.	.	.	r	.	.	.	.	.	.	.	.

wards or towards the depression on the westernmost tip of the island, this shrubland is replaced firstly by *Suaeda vermiculata* and finally by *Halocnemum strobilaceum* and *Frankenia pulverulenta*. The scrubland in the centre of the island provides the best nesting places for a large seabird population. The birds use not only the upper parts of *Lycium* shrubs for nesting but also collect dried branches to build very large nests on the ground (Fig. 4 F). Around the nests a species-rich plant cover occurs consisting of shrubby halophytes (*Suaeda vermiculata, Caroxylon imbricatum*), weedy annuals (*Malva parviflora, Calendula arvensis, Medicago laciniata, Chenopodium murale*) and even some geophytes (*Allium olivieri, Bellevalia saviczii, Gynandriris sisyrinchium* and *Gladiolus italicus*).

5. Discussion

5.1. Phytogeography

Remarkable in the phytogeographical spectrum of the studied islands is the high proportion of Mediterranean elements. This is congruent with the flora of Failaka Island (Kuwait) further west. In general, Mediterranean elements contribute only a small portion to the Iranian flora (Zohary 1973). A comparison with the Flora of Nizzana Dune Research Site in the Negev desert shows that there are at least 31 species (39%) in common between both areas (Tielbörger & al. 2008).

The introgression of species of Mediterranean chorotype into the northernmost part of the Persian Gulf can be explained with the clear winter precipitation maximum (Fig. 3) together with the fact that the Khuzestan Plain and the Khowre Musa Estuary are not absolute frost-free. According to the climate classification in Djamali & al. 2011, the study area falls into the same category as the northern part of the Persian Gulf, i.e. the tropical desertic bioclimate. The Persian Gulf around the Strait of Hormuz, however, exhibits also a clear winter rain regime. But frost never occurs. This allows the occurrence of tropical geoelements, e.g., the genera *Acacia, Prosopis, Cassia, Dodonaea, Ziziphus, Tephrosia* and species like *Blepharis ciliaris, Taverniera cuneifolia* or *Corchorus depressus* (see Flora of Hormoz, Kunkel 1977). The occurrence of frost also influences the distribution of coastal halophytes and defines the northern limit of *Halopeplis perfoliata*, which is replaced geographically and ecologically further to the north by *Halocnemum strobilaceum* (Freitag 1991).

The strong representation of Irano-Turanian species in the study area is of great interest, because the islands are flat and do not provide elevated rocky habitats suitable for colonizing Irano-Turanian species in Saharo-Sindian parts of Iran. This fact gives evidence for the reassessment of the phytogeographical position of southern Iran as a province of the Irano-Turanian phytochorion which is intermingled with a large number of Saharo-Sindian and Mediterranean elements (see Akhani 2007).

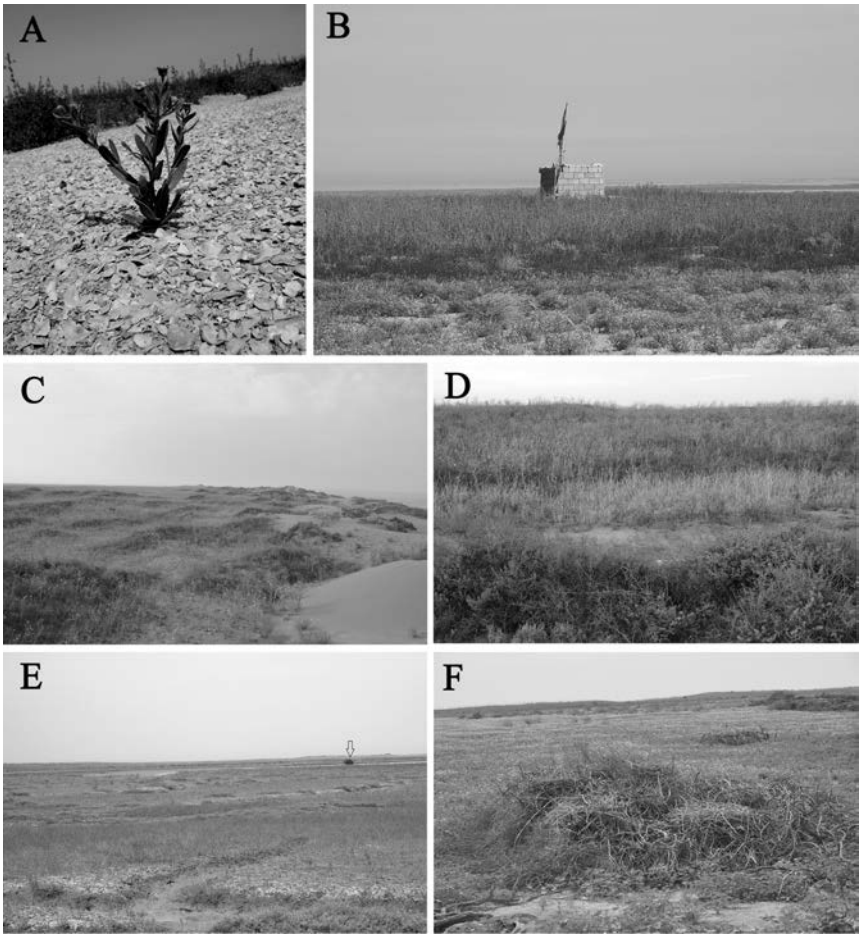


Fig. 4. View of the studied islands. – A: *Calendula arvensis* growing on pure shell layer in Ghabre Nakhoda Island. – B: View of the central part of Ghabre Nakhoda Island showing a grave place surrounded by *Malva parviflora* and *Senecio glaucus* facies in foreground. – C: Sand dunes of the western side of Dara Island. Dunes are colonized by *Salsola rosmarinus* shrubs, associated with halo-psammophilous annuals such as *Launaea mucronata*. – D: Part of a transect along the northern side of Dara Island: The *Suaeda vermiculata-Limonium iranicum-Halocnemum strobilaceum* zone in foreground is followed by a small *Mesembryanthemum nodiflorum* transition zone replaced by *Launaea mucronata* in the background. – E: *Salicornia sinus-persica* community with *Suaeda* aff. *maritima* and individuals of *Halocnemum strobilaceum* along tidal courses in the central parts of Dara Island. The black spot in the background of the picture marked by an arrow is the only remaining *Avicennia marina* shrub, cultivated by fishermen several years ago on the island. – F: Landscape of Booneh Island showing a *Senecio glaucus* facies and a bird nest built from *Lycium shawii* branches.

A comparison of the flora of the studied islands with the flora of the neighbouring Khowre Musa Estuary and with the Estuary of the Mond protected area of Busher Province further to the south is of interest when discussing the absence of some widespread species. In both inland areas halophytic and hygrophytic species such as *Suaeda aegyptiaca, Phragmites australis* and various species of *Tamarix* occur very frequently. None of these were discovered in any of the three islands. An explanation for the missing of *Phragmites* and *Tamarix* might be that the studied islands do not provide fresh or brackish groundwater. The ecological study of *Tamarix* in Iranian saline habitats shows that this salt secreting genus needs some kind of fresh water flow at least in parts of its annual life cycle in order to remove accumulated salt from the shrubs (Akhani 2004a). *Phragmites* and *Tamarix* are occurring along non- or less-saline groundwater flow along the Mond River (Mehrabian & al. 2009). The absence of *Suaeda aegyptiaca* seems to be related to the lack of anthropogenic activities on these islands.

5.2. Plant Communities and Vegetation Pattern

The vegetation of the islands belongs to two different formation classes: 1) annual (ephemeral) turfs germinating after rainfall and finishing their life cycle within few weeks, and 2) open shrubland in damp salt marshes and coastal dunes with salt spray, dominated by dwarf woody perennials (chamaephytes).

The annual turfs belong to three ecological groups. One type is dominated by widespread and common annuals such as *Senecio glaucus, Launaea mucronata, Brassica tournefortii, Astragalus annularis, Iphloga spicata, Trigonella stellata*, some of them with rather weedy and ruderal character like *Malva parviflora* or *Calendula arvensis* s. l. The second group comprises non-ruderal psammophytes like *Cutandia memphitica, Neurada procumbens, Ononis serrata, Schismus barbatus* and *Loeflingia hispanica*. The latter is a character species of the Mediterranean dune lawn order Malcolmietalia, others are diagnostic species of the Cutandietea memphiticae, a class of ephemeral dune vegetation and of Saharo-Sindian distribution. A third group forms a unique vegetation type, an ephemeral halotolerant pioneer community in small, episodically inundated depressions (see transects Tab. 3 and 4 from Dara, Figs. 4 D, 6). This group is characterized by *Frankenia pulverulenta, Mesembryanthemum nodiflorum, Parapholis incurva, Sphenopus divaricatus, Spergularia diandra, Hordeum marinum* subsp. *gussoneanum*, and *Polypogon maritimum*. The stands on the studied Persian Gulf Islands are also recorded from Eastern Saudi Arabia (Mandaville 1990) and Kuwait (Abbadi & El-Sheikh 2002). They can be interpreted as impoverished eastern outliers of the associations Parapholido incurvae-Frankenietum pulverulentae and Polypogono

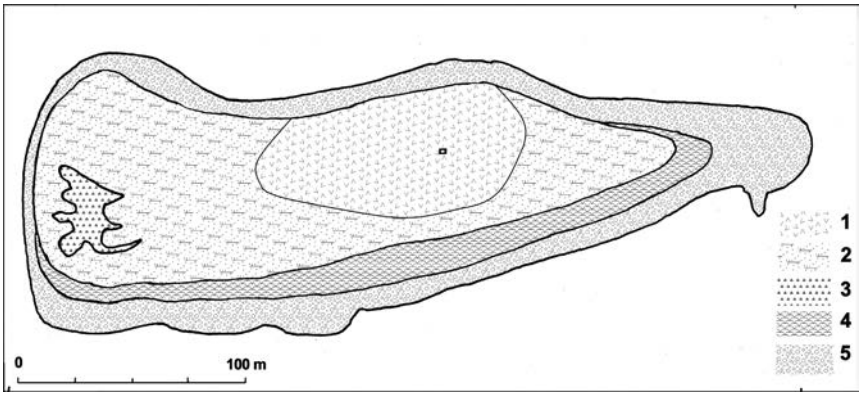


Fig. 5. Vegetation map of Ghabre Nakhoda Island. 1: *Malva parviflora* zone, 2: *M. parviflora-Calendula arvensis* zone; 3: *Suaeda vermiculata-Halocnemum strobilaceum* zone; 4: *Senecio glaucus* zone; 5: unvegetated zone of shell particles.

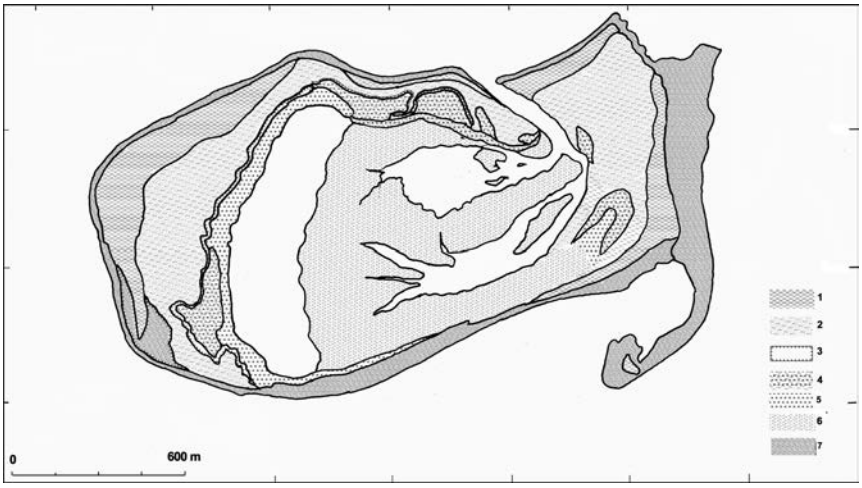


Fig. 6. Vegetation map of Dara Island. 1: *Salsola rosmarinus* zone; 2: *Launaea mucronata* zone; 3: *Mesembryanthemum nodiflorum* zone; 4: *Halocnemum strobilaceum-Suaeda vermiculata-Limonium iranicum* zone; 5: *Halocnemum strobilaceum* zone; 6: *Salicornia sinus-persica* zone (mixed partly with *Suaeda* aff. *maritima* and *Halocnemum strobilaceum*); 7: unvegetated zone of coastal sands.

maritimi-Hordeetum marini (alliances Mesembryanthemion, respectively, Hordeion marini, class Frankenietea pulverulentae) (Rivas-Martínez & al. 2002).

The shrublands are dominated by perennial succulent and non-succulent, salt-tolerant *Chenopodiaceae* (*Halocnemum strobilaceum, Salsola rosmarinus, Suaeda vermiculata*) and grasses (*Halopyrum mucronatum*),

intermingled with annual hygrohalophytes such as *Bienertia sinuspersici, Salicornia sinus-persica, Caroxylon jordanicola*, and subshrubs like *Limonium iranicum*. The syntaxonomy of these communities is not yet clear (see Danin & Orshan 1999, Deil 2000 and Akhani 2004a for a preliminary synopsis). *Halopyrum mucronatum* for example is the name giving and characteristic species for the class of embryonic dune vegetation around the Arabian Peninsula (Halopyro-Sporoboletea, Deil 1998, 2000).

The zonation of the plant communities on the islands show similarities but also peculiarities compared to the coastal zonation complexes along the Persian Gulf coasts and the Arabian Peninsula (Deil 1998, 1999, 2000, Akhani 2004a, Mehrabian & al., 2009). The general pattern is similar to other coastal areas, a sequence of species-poor communities along a gradient of salinity and soil moisture. The vegetation types of hypersaline soils of the tidal zone and saline depressions occurring in all three islands are similar to most of the studied coasts in the area (*Halocnemum strobilaceum* and *Suaeda vermiculata* zone, used alternatively in various publications about SW Asia under *S. fruticosa*) occurring also in hypersaline inland flats. A peculiar feature of this type of vegetation is the association of *Limonium iranicum* – an Irano-Turanian element – with *Halocnemum strobilaceum* and *Suaeda vermiculata*. The same plant community was found around the tidal courses of Khowre Musa near Khowre Deuragh (ca. 40 km North of the study area). A comparison of the vegetation of the islands with that of the nearest inland coast shows that *Salicornia sinus-persica* and *Suaeda* aff. *maritima* stands often colonize the tidal courses and channels of Khowre Musa. This community is also recorded from southern Khuzestan and the Mond river estuary in Bushehr (Mehrabian & al., 2009).

A unique aspect of the vegetation of the islands is the dense plant cover on a very poor top soil layer, that consists only of shell particles in Ghabre Nakhoda (Fig. 4 A) on the one side and a very dense annual coastal dune vegetation in Dara and Booneh (Fig. 4. C–F, Tables 2–5). This type of vegetation is unknown in inland areas, probably because grazers and anthropogenic activities are absent on the islands. Vegetation types reported from Failaka island in Kuwait, the nearest island located 100 km SW of Dara, show a remarkable difference regarding the coastal sand vegetation (Abbadi & El-Sheikh 2002). The large bird population living on the studied islands may play a major role in formation and diversification of the flora and vegetation structure of the area not only by seed dispersal but also by contributing to soil fertility and by causing moderate physical soil disturbance, which favoures many annual species.

5.3. Conservation Value

The three islands studied here are very important for a large sea bird population using the islands and their vegetation for reproduction, nesting

and feeding. The isolation of the islands and their almost virgin status are of great value for sustaining the biodiversity of the flora and avifauna of southern Khuzestan and the Persian Gulf. They can further serve as an isolated laboratory for ecological investigations. The extensive petrochemical industries already destroyed large parts of the coastal vegetation in southern Khuzestan. Therefore it is strongly recommended to protect these islands in order to conserve their habitat and biodiversity and to support further investigations.

According to a report published on the shell resources in the Persian Gulf by the Iranian National Geosciences Database (HASSANZADEH 2000), the exploitation of shells in the Ghabre Nakhoda Island is suggested. Furthermore there is a high risque that the islands will be used in the future for industrial planning, navigation, military and touristic purposes. In spite of the virginity of the vegetation of the area, a main threat to the islands is the accumulation of plastic bottles and garbage by sea waves.

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Recensio

Westrich Paul 2011. Wildbienen. Die anderen Bienen. – 8°, 168 Seiten, zahlreiche Farbfotos; geb. – Verlag Dr. Friedrich Pfeil, München, 2. Aufl. – € 20,40. – ISBN 978-3-89937-136-9.

Der vorliegende Bildband ist eine für allgemein an der Natur Interessierte gedachte Einführung in die Kenntnis der Wildbienen. Von der sinnvollen Auswahl der Themen, über den wissenschaftlich einwandfreien und dabei doch verständlich bleibenden Text bis zu den ausgezeichneten bis einzigartigen Fotos besticht das Buch und hinterläßt einen ausgezeichneten Eindruck. Der Rezensent hält es zumindest im deutschsprachigen Raum, wenn nicht weltweit, für die beste und umfassendste Einführung dieser Art.

Der erste Abschnitt gilt einer allgemeinen Charakteristik, dem Erkennen und Bestimmen von Wildbienen. [„Artname“ wird p. 13 in zweierlei Sinne gebraucht. Richtig: der wiss. Artname besteht aus zwei Teilen, dem Gattungsnamen und dem