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## A contribution to the flora of Wadi Andur (Dhofar, Southern Oman)

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*Contributo alla flora di Wadi Andur (Dhofar, Oman meridionale)* – Wadi Andur percorre centralmente una vasta area pre-desertica situata alle spalle di Jabal Samhan (Dhofar orientale). Viene presentato un contributo alla flora di questa zona sulla quale, date le difficoltà di accesso, si avevano finora scarse conoscenze. Fra le specie raccolte *Schweinfurthia latifolia* è nuova per l'Oman, *Zygophyllum qatarense* è nuovo per il Dhofar; altre specie, *Cornulaca monacantha*, *Farsetia dhofarica*, *Herniaria maskatensis* e *Polycarpa repens*, sono da considerare rare per questa regione. Viene discussa anche la presenza nell'area di Andur di *Boswellia sacra* che finora è risultata presente solo sulle montagne di Hasik e sulle montagne alle spalle di Jibjat.

**Key-words:** *Boswellia sacra*, Burseraceae, Dhofar, flora, Oman, Wadi Andur.

### Introduction

Behind Jabal Samhan, the highest mountain of Dhofar (about 2000 m), there is a vast pre-desert area delimited to the west by Wadi Salafan, which unites the towns of Jibjat (south) and Dhahabun (north), and to the east by the north-eastern slopes of the Hasik mountains (Fig. 1). This area, approximately 3.000 km<sup>2</sup>, is difficult to access because the lack of roads or permanent settlements, and is practicable only by off-road vehicles, through poorly marked or improvised tracks in the wadi beds.

Numerous wadis descend from the northern slopes of Jabal Samhan, reuniting after a few kilometres to form wider wadis (Wadi Salafan, Wadi Halit, Wadi Andur) which are directed north, perpendicularly to the mountain chain, and converge, for 40-50 km, in

the vast wadi system that crosses all of Dhofar up to the boundary with Saudi Arabia.

Wadi Andur and its tributaries go across the centre of this vast pre-desert area slightly degrading northwards (from approximately 700 m at the foot of the first northern buttresses of Jabal Samhan to 400 m near Barzabazum, for a length of about 50 km), and on which rise flat rocky hills almost devoid of vegetation.

The interest to visit the area of Andur was motivated by the scarcity of floristic information, and the necessity of verifying the possible presence of *Boswellia sacra* (the frankincense tree) that was indicated by Elqassani (1984) in Wadi Andur and by Miller & Morris (1988) in the wadis behind Jibjat in the vicinity of Dahabun and Barzabazum.

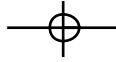


Fig. 1 – The Andur area behind Jabal Samhan (eastern Oman). The squares indicate the points of plant collection. The broken line indicates the ancient route followed by the caravans for the transportation of frankincense from Hasik to Andur, to the storehouse located north-east of Wadi Dowkah (black star), near the large Wadi Sahnut.

### Floristic collections at Wadi Andur

From the village of Barbazum it is possible to reach Wadi Halit, and from there, through a track that winds between low rocky hills, small depressions, and wadi beds, to reach Wadi Andur. At  $17^{\circ}34.224'N$ ,  $54^{\circ}42.171'E$  and 502 m a.s.l., the wadi holds sufficient permanent water to allow the development along the edge of the bed of a strip of wetland vegetation (*Phragmites australis*, *Schoenoplectus littoralis*, *Eleocharis genicu-*

*lata* and *Juncus rigidus*), and in proximity of the riverbanks of a woody or shrubby vegetation of palms (*Phoenix dactylifera* and *Nanorrhops ritchieana*). Around this oasis (Fig. 2) the pre-desertic vegetation is dominated by succulent shrubs of *Suaeda vermiculata* and *Zygophyllum qatarense*. Carrying on south, towards Jabal Samhan, Wadi Andur presents a rather wide bed in which converge numerous tributaries descending from Jabal Samhan. The soil is either sandy or formed of gravels and large calcareous pebbles, often of remark-



able size. Sporadic *Acacia senegal*, *Maerua crassifolia* trees and *Maytenus senegalensis* shrubs appear among perennial herbs of *Schweinfurthia latifolia*, *Rhazya stricta*, *Gaillonia aucheri*, *Crotalaria persica*, *Lavandula macra* as well as *Pulicaria glutinosa*, *P. omanensis* and *P. crispa* (Fig. 3). In the gravel and on the sand it is possible to find a fairly good number of annual herbs.

### Collected plants

The list reports 83 taxa; the abbreviations indicate the investigated localities:

S. 9: Pre-desertic area of Wadi Andur, from the permanent water of the Wadi (oasis) up to 20 km towards south; coord.: 17°34.224'N-17°25.611'N, 54°42.171'E-

54°48.946'E, alt. 502-690 m; 14 settembre 2003.

S. 14: Oasis of Wadi Andur and surrounding area; coord.: 17°34.224'N, 54°42.171'E, alt. 502 m; 17 marzo 2005.

S. 15: Pre-desertic area of Wadi Andur, 2 km south of the oasis; coord.: 17°33.629'N, 54°42.701'E, alt. 520 m; 17 marzo 2005.

S. 25: Pre-desertic area of Wadi Andur, from the oasis up to 6 km towards south; coord.: 17°31.085'N, 54°45.050'E; alt. 560 m; 14 febbraio 2006.

+ new species to Oman.

\* new species to Dhofar.

All the specimens are kept in FT (Tropical Herbarium Studies Centre, Florence).

### MAGNOLIOPSIDA

#### ACANTHACEAE

*Blepharis scindica* T. Anderson, S. 14, S. 9, S. 25

#### AMARANTHACEAE

*Aerva artemisioides* Viehr. & O. Schwartz subsp. *batharitica* A.G. Miller, S. 25

*Aerva javanica* (Burm. f.) Juss., S. 14, S. 25

#### APOCYNACEAE

*Rhazya stricta* Decne., S. 25

#### ASTERACEAE

*Iphiaea scabra* DC. S. 25

*Iphiaea senecionoides* (Baker) A. Anderb., S. 25

*Launaea castanosperma* E.G. Davies, S. 15

*Pluchea arabica* (Boiss.) Qaiser & Lack., S. 14, S. 25

*Pulicaria crispa* (Forssk.) Benth. ex Oliver, S. 25

*Pulicaria glutinosa* (Boiss.) Jaub. & Spach subsp. *glutinosa*, S. 15, S. 25

*Pulicaria omanensis* Gamal-Eldin ssp. *Omanensis*, S. 9, S. 14

*Pulicaria* sp., S. 9

*Vernonia* sp., S. 9, S. 25

#### BORAGINACEAE

*Arnebia hispidissima* (Lehm.) DC., S. 14, S. 15, S. 25

*Heliotropium bacciferum* Forssk., S. 14, S. 15

*Heliotropium brevilibre* Boiss. (= *H. calcareum* Stokes), S. 25

*Heliotropium fartakense* O. Schwartz, S. 14, S. 15

*Heliotropium mariflorum* Stocks, S. 15

#### BRASSICACEAE

*Diplotaxis harra* (Forssk.) Boiss., S. 14

*Farsetia dhofarica* Jonsell & A.G. Miller, S. 15, S. 25

*Farsetia linearis* Decne. ex Boiss., S. 25

#### BURSERACEAE

*Boswellia sacra* Flueck. (only on the mountain slopes behind Jibjat)

#### CAPPARACEAE

*Boscia arabica* Pestalozzi, S. 15

*Cleome albescens* Franch. subsp. *omanensis* Chamb. & Lamond, S. 15

*Cleome austroarabica* Chamb. & Lam., S. 14, S. 15, S. 9

*Cleome brachycarpa* (Forssk.) Vahl ex DC., S. 14, S. 15

*Maerua crassifolia* Forssk., S. 15

#### CARYOPHYLLACEAE

*Cometes surattensis* L., S. 14

*Gypsophila montana* Balf. f. subsp. *somalensis* (Fr.) M. Gilbert, S. 15

*Herniaria maskatensis* Bornm., S. 15

*Polycarpha repens* (Forssk.) Asch. & Schweinf., S. 14

#### CELASTRACEAE

*Maytenus senegalensis* (Lam.) Exell, S. 25

#### CHENOPODIACEAE

*Cornulaca monacantha* Delile, S. 15

*Halothamnus bottae* Jaub. & Spach, S. 15, S. 25

*Salsola rubescens* Franch., S. 25

*Suaeda vermiculata* Forssk. ex J.F. Gmel., S. 15, S. 25

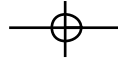




Fig. 2 – The Wadi Andur Oasis, swampy vegetation along the water.



Fig. 3 –Wadi Andur: *Schweinfurthia latifolia* in the bed of the wadi.

**CISTACEAE**

*Heliantemum citrinum* Ghaz., S.9

**CUCURBITACEAE**

*Cucumis prophetarum* L. subsp. *prophetarum*, S. 14, S. 15

**EUPHORBIACEAE**

*Andrachne aspera* Spreng. var. *aspera*, S. 25  
*Chrozophora oblongifolia* (Delile) Spreng., S. 14

**FABACEAE**

*Acacia senegal* (L.) Willd., S. 25  
*Cassia holosericea* Fresen., S. 14, S. 15  
*Crotalaria persica* (Burm. f.) Merrill, S. 15  
*Indigofera coerulea* Roxb., S. 14  
*Indigofera oblongifolia* Forssk., S. 9  
*Indigofera semitrijugata* Forssk., S. 15  
*Taverniera aff. multinoda* Thulin., S. 15  
*Tephrosia apollinea* (Delile) DC., S.14

**GERANIACEAE**

*Monsonia heliotropoides* (Cav.) Boiss., S. 14, S. 15

**LABIATAE**

*Lavandula macra* Baker, S. 25

**LENTIBULARIACEAE**

*Utricularia minor* L., S. 9

**NYCTAGINACEAE**

*Boheravia elegans* Choisy, S. 9

**OROBANCACEAE**

*Cistanche rosea* Baker, S. 25

**PLUMBAGINACEAE**

*Limonium axillare* (Forssk.) Kuntze, S. 15

**POLYGALACEAE**

*Polygala erioptera* DC. subsp. *erioptera*, S. 14

**RHAMNACEAE**

*Ziziphus leucodermis* (Baker) O. Schwartz, S. 14

**RUBIACEAE**

*Gaillonia aucheri* (Guill.) Jaub & Spach., S. 14, S. 9

*Kohautia caespitosa* Schnitzl., S. 15

**SCROPHULARIACEAE**

*Anticharis glandulosa* Asch., S. 14  
*Lindenbergia indica* (L.) Vatke, S. 25  
*Lindenbergia muraria* (Roxb.) Brühl, S. 14  
+ *Schweinfurthia latifolia* Baker ex Oliver, S. 9, S. 25  
*Schweinfurthia papilionacea* (L.) Boiss., S. 9, S. 25

**URTICACEAE**

*Forsskaolea tenacissima* L., S. 9, S. 14

**ZYGOPHYLLACEAE**

*Fagonia indica* Burm.f., S. 15  
*Fagonia schweinfurthii* (Hadidi) Hadidi, S. 14, S. 15  
*Tribulus terrestris* L., S. 14  
*Zygophyllum album* L.f., S. 14  
\* *Zygophyllum qatarense* Hadidi, S. 15, S. 25  
*Zygophyllum simplex* L., S.14, S. 15

**LILLOPSIDA****ARECACEAE**

*Nanorhops ritchieana* (Griff.) Aitch., S. 25  
*Phoenix dactylifera* L., S. 14

**CYPERACEAE**

*Cyperus longus* L., S. 14  
*Eleocharis geniculata* (L.) Roem. & Schult., S. 9  
*Schoenoplectus litoralis* (Shrad.) Palla, S. 14

**JUNCACEAE**

*Juncus rigidus* Desf., S. 14, S. 9

**POACEAE**

*Cenchrus ciliaris* L., S. 14  
*Cenchrus pennisetiformis* Hochst. & Steud., S. 14  
*Dichanthium foveolatum* (Delile) Roberty, S. 14  
*Lasiurus scindicus* Henard, S. 15  
*Phragmites australis* (Cav.) Trin. ex Steud., S. 14  
*Sporobolus spicatus* (Vahl) Kunth, S. 14

**TYPHACEAE**

*Typha angustata* Bory & Chaub., S. 15

**Floristic relevancies**

The collected specimens represent 83 taxa. Among these, some have a significant phytogeographical rele-

vance since they are new to Oman or to Dhofar or are rare being known only from few localities or growing at the margins of their geographical region.

Among the new species to Oman there is *Schwein-*



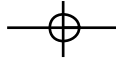


Fig. 4 – Wadi Andur: A) *Schweinfurthia latifolia* (flowers) - B) Habit.



Fig. 5 – A) The pre-desert area of Wadi Sahnut north-east of Wadi Dowkah; B) The ruins of the ancient frankincense storehouse on the left bank of the wadi.

*furthia latifolia* (Scrophulariaceae) collected in the gravels of the Wadi Andur bed (where *S. papilionacea* grows as well). *S. latifolia* was considered endemic of southern Yemen, and known from few collections in Hadramaut, i.e. rocks at Mukalla, 60-90 m a.s.l.; on sand at Wadi Bin Ali, 600 m a.s.l.; on the sandy wadi's bed at Huraidha, 800 m a.s.l. (Miller et al., 1982). The Wadi Andur individuals (Fig. 4) present longer stems (70-100 cm) compared with the Yemenite populations (up to 45 cm tall); however, the characteristic tuberculated ornamentation of the seeds is identical in both of them.

Among the new species to Dhofar *Zygophyllum qatarense* (Zygophyllaceae) is particularly abundant near the Andur Oasis; this species can be distinguished from *Z. album* by the presence of a singular leaf at the apex of the petiole.

Among the rare species there are *Farsetia dhofarica* (Brassicaceae) reported only in the central desert of Oman by Ghazanfar (2003). At Wadi Andur *Farsetia dhofarica* is sporadically present on sandy soils. Also the endemic species to Oman and Yemen, *Herniaria maskatensis* (Caryophyllaceae), is to be considered rare in Dhofar. The species is reported only for the Al Hاللانيyah islands at the eastern extremity of Oman (Ghazanfar, 2003), and therefore Wadi Andur, besides being the southernmost locality, is also the first in continental Dhofar. Among the rare species is *Cornulaca monacantha* (Chenopodiaceae), found at the Wadi Andur Oasis; this semi-succulent species is reported for Dhofar in Miller & Morris (1988) without a precise locality indication; it is cited also in Ghazanfar (2003) as present only in a single locality of Central Oman, in the Masirah island, and in Northern Oman. Also *Policarpaea repens* (Caryophyllaceae) is rare; the species is reported by Miller & Morris (1988) in Dhofar and by Ghazanfar (2003) in some sandy desert or sub-desert areas of Northern Oman.

### **The presence of *Boswellia sacra* in the area of Andur**

Wadi Andur, Wadi Barbazum, and Wadi Dhabun, east of Thumrayt and behind Jabal Samhan, are frequently indicated as areas where *Boswellia sacra* grows. During our research on the populations of

*Boswellia* in Dhofar, already partially concluded (Raffaelli et al., 2003a, b; Raffaelli et al., 2006), we studied the area of Andur, for a total of 5 days in subsequent periods, with the aim to verify the true presence of *Boswellia sacra*. From Barbazum, through Wadi Halit, we reached Wadi Andur and traveled along this wadi up to the first northern slopes of Jabal Samhan, but during this itinerary we did not find frankincense trees. Our opinion is that *Boswellia sacra* is not currently present on the rocky-gravelly plateau engraved by the Andur area wadis. It grows further south, southeast, starting from the first northern slopes of Jabal Samhan and the mountains behind Hasik, on a mountainous area of significant extension even if smaller than the total surface of Andur. The area of Andur crossed by the homonymous wadi was apparently an important communication route in ancient times used by the caravans that transported frankincense from the Hasik mountains. The presence of a fort in Andur could be attributed to the need to protect the caravans and the frankincense loads coming from Hasik, going towards Andur and, then, to the other collection deposits. One of these storehouses is still recognizable today and is located between Thumrayt and Wadi Dowkah (17°22.920'N, 54°06.275'E, 629 m a.s.l.), near the major Wadi Sahnut (Figs. 5a, b). Since the Andur area was certainly connected with frankincense, although only for the passage of the caravans and the precious loads, one could misleadingly think that this was a collection area of the resin, with abundant frankincense trees.

Overall, *Boswellia sacra* is currently present on the Hasik mountains, and probably in the northern wadis of Jabal Samhan, while in the Andur area it was observed only in the south-western margin, between Wadi Salafan and the mountains behind Jibjat, along the Barbazum-Jibjat track, about 10 km before Jibjat. In this rough mountainous area, *Boswellia sacra* grows profusely inside narrow rocky canyons, with a density of 2/3 individuals each 70/100 m<sup>2</sup>.

### **Acknowledgments**

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**Abstract:** Wadi Andur covers the central part of a vast pre-desert area located behind Jabal Samhan (eastern Dhofar). A contribution to the area's flora, of which till now scarce data was available owing to the inaccessibility, is presented. Among the species collected, *Schweinfurthia latifolia* is new to Oman; *Zygophyllum qatarense* is new to Dhofar. Other species like *Cornulaca monacantha*, *Farssetia dhofarica*, *Herniaria maskatensis* and *Polycarpaea repens* are rare in this region. The presence in the Andur area of *Boswellia sacra*, so far recorded only on the Hasik mountains and on the mountains behind Jibjat, is discussed.