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Socotra Island - a special part of Yemen's natural heritage

The following paper was prepared for the workshop „Natural Areas and Biodiversity Conservation in Yemen" in Sanaa, organised by the Environment Protection Council of Yemen in cooperation with IUCN, and the First International Scientific Symposium on Socotra held at the University of Aden, both in March 1996.
It is presented here in a modified version in honour of Prof. Dr. E. A. Arndt's merits for ecological research in Yemen by training Yemeni students in the field of marine biology and the support of my own work in the country.

Abstract

The Socotra Archipelago is distinguished by geological peculiarities and a rich variety of species, including an exceptional number of endemics and relic species of remarkable biogeographic and developmental interest. The flora and fauna of the Archipelago appear to have been little affected by human activities. But a significant part of the available data dates back to turn-of-the-century expeditions. This in turn creates several problems for well-prepared nature protection and sustainable development concepts. The paper gives a brief overview on the natural history of Socotra Island under special consideration of the fauna.

Zusammenfassung

Der Archipel von Sokotra ist gekennzeichnet durch geologische Besonderheiten und eine beeindruckende Vielfalt an Arten, unter denen sich zahlreiche biogeographisch und entwicklungsgeschichtlich interessante Endemiten und Reliktformen befinden. Durch die traditionellen Nutzungsformen der Inselbewohner wurde die natürliche Umwelt Sokotras bisher nur wenig beeinträchtigt. Die derzeitigen Kenntnisse zur Flora und Fauna basieren aber zu einem Großteil auf Expeditionen, die um die Jahrhundertwende erfolgten. Das macht die Erarbeitung von Konzepten zum Schutz und zur nachhaltigen Entwicklung der Inselgruppe schwierig. Der Beitrag gibt eine Übersicht über wichtige Aspekte der Naturgeschichte der Inselgruppe unter besonderer Berücksichtigung der Fauna.

Key words

Yemen, Socotra, Natural History, Fauna, Nature Protection, Makrozoobenthos

Introduction

In the course of a guest lectureship at the University of Aden from 1982 to 1985, the author had the opportunity to do some field work in the southern part of Yemen, mainly around Aden. Beside this he visited Socotra Island six times between 1982 and 1996 staying there for one to two weeks each time. He took also part in a UNESCO Fact Finding Mission to Socotra in 1993, whose objective was to consider the establishment of this unique island as a Biosphere Reserve (WRANIK 1993 & 1995).

The Socotra Archipelago

„Dioscorida...is very large but desert and marshy, having rivers in it and crocodiles and many snakes and great lizards of which the flesh is eaten and the fat melted and used instead of olive oil. The island yields no fruit, neither vine nor grain. The inhabitants are few and they live on the coast towards the north, which from the side faces the continent. They are foreigners, a mixture of Arabs and Indians and Greeks who have emigrated to carry on trade there. The island produces the true sea-tortoise, and the land-tortoise and the white tortoise, which is very numerous and preferred for its large shells, and the mountain tortoise....“ - this is part of the oldest documented information on Socotra, called "Dioscorida", in the "Periplus of the Erythraean Sea", a shipping manual written in the first century A.D. by an unknown Greek sailor.

Nowadays, about 2000 years later, the Archipelago still belongs to the comparatively unexplored parts of the world. Apart from some 19th century travel accounts the island has been a relatively well-kept secret, virtually isolated from the rest of the world and effectively closed for foreign visitors because of military considerations and extreme natural conditions.

Especially during the time of the south-west monsoon, which blows from April to October, the island is often cut off completely. The winds blow in this period at velocities of over 15 metres per second. There is a build up of dangerous seas around the island which makes a vessel's approach impossible, and under these circumstances also air communication ceases. But until now even under "normal" weather conditions communications from the mainland by air and by boat are severely restricted by the lack of harbours, poor airport facilities and inadequate aircraft.

The Socotra Archipelago is situated in the north-western part of the Indian Ocean and comprises the four islands Socotra, Abd-el-Kuri, Semha and Darsa ("The Brothers"). The islands are separated from one another by relatively shallow seas and

from the mainland by a deep trench (Fig 1). Politically, the Archipelago is administered as a part of the Republic of Yemen.

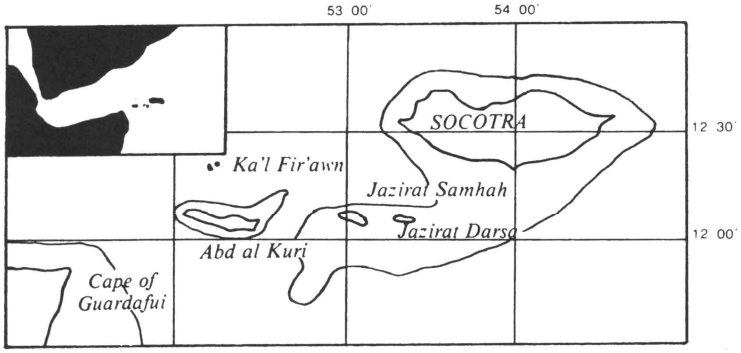


Fig. 1 Sketch map showing position of the Socotra Archipelago

Socotra itself is about 120 by 40 km and covers an area of 3625 km^2. It is composed of a basement complex of igneous and metamorphic rocks of Pre-Cambrian age overlain by sedimentary rocks, mainly limestone and sandstone. Topographically it can be divided into three main zones: the coastal plains, a limestone plateau and the Haghir mountains (Fig. 2).

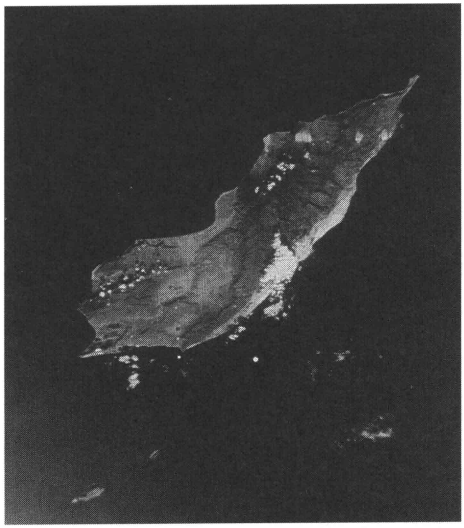


Fig. 2a Socotra, as seen from Gemini VII (Reproduced by kind permission of U.S. National Aeronautics and Space Administration)

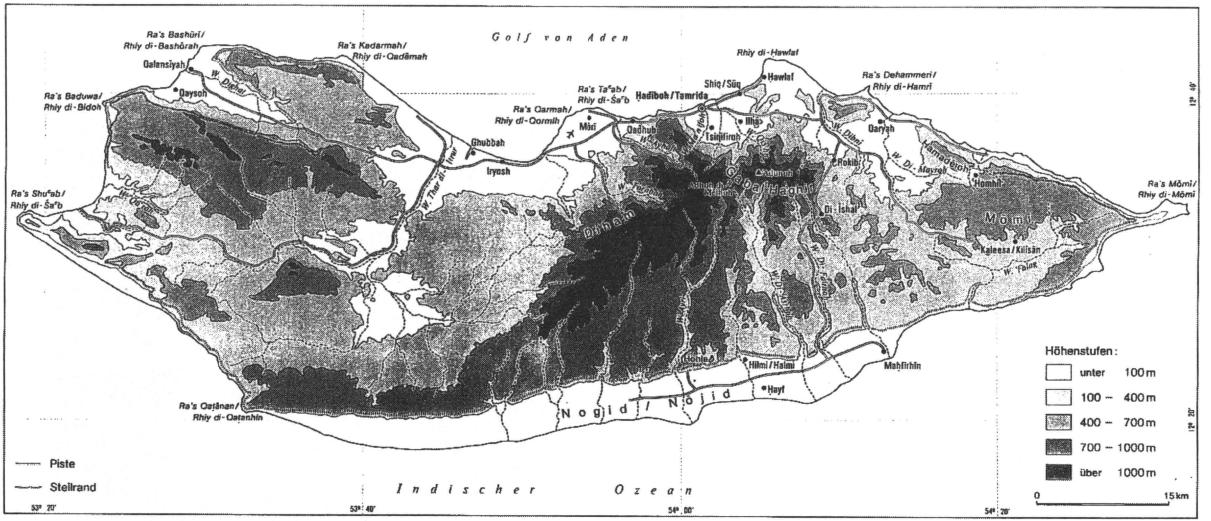


Fig. 2b Sketch map of the island Socotra

The coastal plains vary considerably in width. A limestone plateau extends over most of the island, averaging 300 to 700 m in altitude. It is dissected by a number of deep valleys and drops in steep, often almost vertical escarpments to the coastal plain or directly to the sea. The Haghir mountains in the north-west of the island rise up to a height of 1519 m.

The climate is monsoonal. There are no exact figures available on the annual temperatures and rainfall, but the climate is cooler and more temperate compared with the adjacent African and Arabian mainland. As far as it is known the mean annual temperatures vary between 28-37 °C and the mean annual rainfall varies between 130-170 mm per year. The mountains are frequently shrouded in clouds and heavy dews are common. These seem to be also a main water source for vegetation in these altitudes.

The Haghier massif forms the most important watershed on the island and numerous watercourses run both north and south from this region of higher rainfall and permanent springs (Fig. 3).

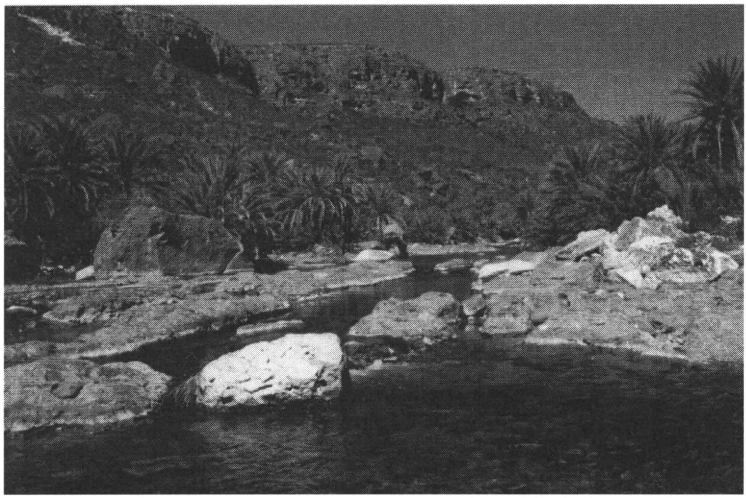
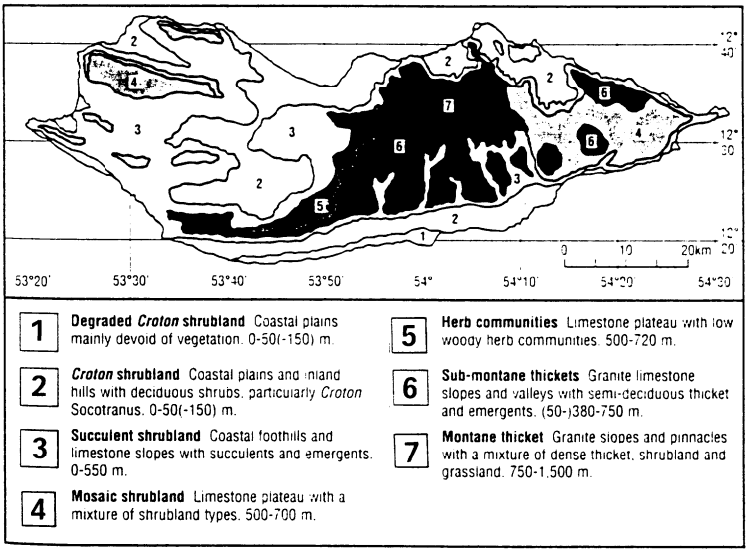


Fig. 3 Water course in the mountains.

Particularly on the northern slopes these streams are permanent in their upper reaches, whereas in the plains they are mostly sporadic carrying water only during the rains and just after. Some of the river estuaries retain water for most of the year. Even if not well known, there seems to be a relatively large underground karstic system and also undersea water springs are reported.

The island is sparsely vegetated and dominated by xeromorphic forms, which are well-adapted to the harsh climate, such as the desiccating winds of the summer

period. Only in sheltered valleys and higher mountain areas the vegetation is more luxuriant (MIES 1993 & 1995, DAVIS et al. 1994, ALEXANDER & MILLER 1996) (Fig.4 & 5).



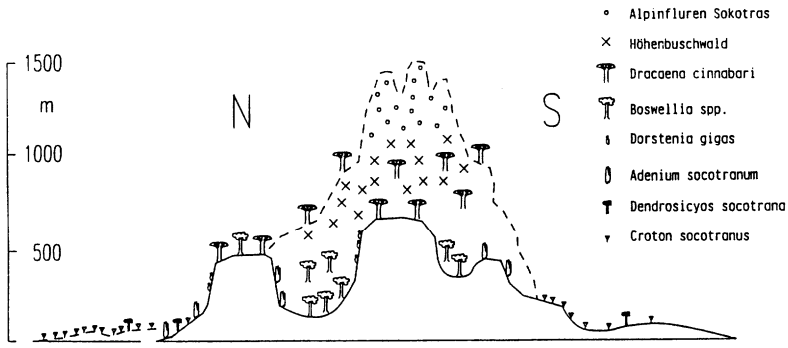


Fig. 4 Topographical division and the main vegetation types on Socotra (MILLER, in DAVIS et al.1994, MIES et al. 1995)

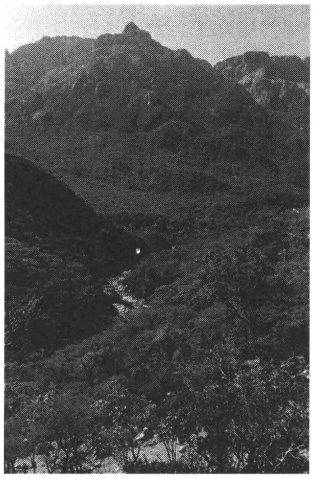


Fig. 5 The Wadi Ayhaft is one of the most densely wooded areas of the island and belongs to the sites under discussion for a protection concept. It is a submontane area of granite and limestone slopes with abundant running water.

Open deciduous shrubland of the coastal plains and low inland hills is dominated by the shrub Croton socotranus (Fig. 6).

Fig. 6 Open deciduous shrub land with *Croton socotranus*. The coastal plains contain

an increased percentage of endangered species due to grazing pressure, wood cutting, agricultural activities and the expansion of settlements.

It is the most common shrub in these regions, but is also a major source of wood for building and burning. At elevations up to about 500 meters grow the bizarre tree succulents, the desert rose, Adenium obesum socotranum, and the cucumber tree, Dendrosicyos socotranus (Fig. 7).

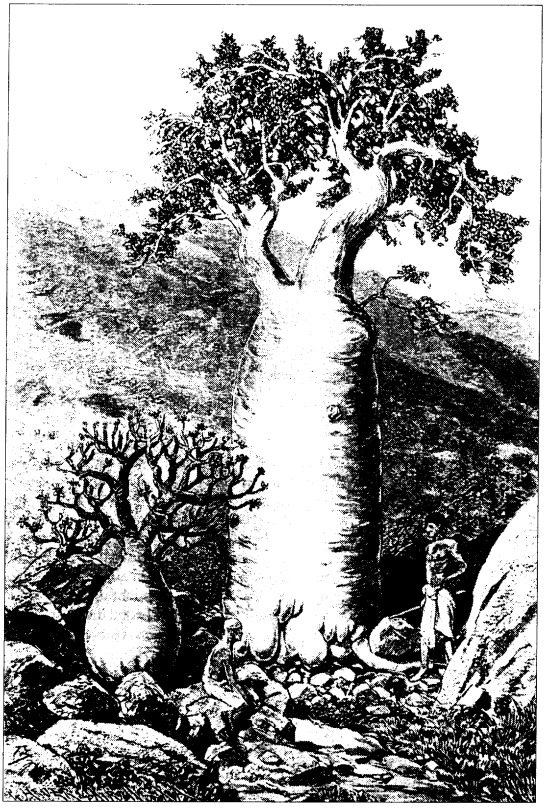


Fig. 7 The bizarre tree succulents *Adenium* and *Dendrosicyos* (SCHWEINFURTH 1887).

The latter grow up to 5 meters or so. The specimens are healthy, but rather old. Like in other species no seedlings or young trees can be observed. Therefore studies on the natural regeneration would be necessary and of great importance. Higher

altitudes are home of at least seven species of frankincense trees, three endemic Socotran aloes and wild pomegranate. The dragon's blood tree Dracaena cinnabari, which is one of the most famous botanical curiosities of the island, is restricted to the zones of submontane thicket and montane grassland (Fig. 8).

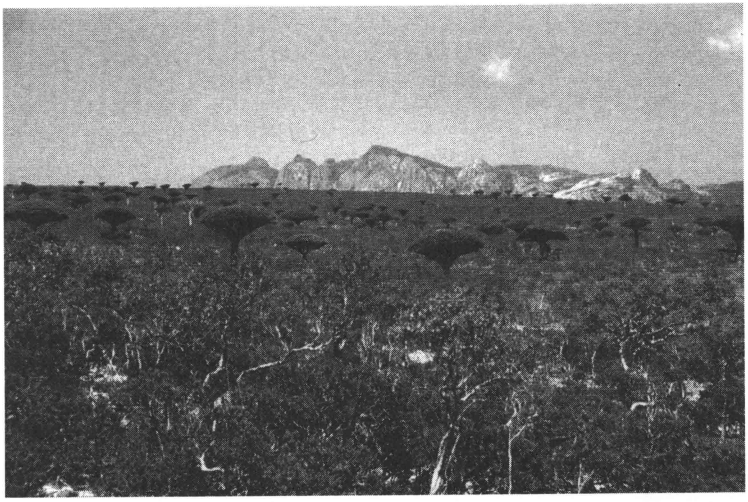


Fig. 8 The Dragon's blood trees are characterized by a mushroom-shaped silhouette. Diksam, in the centre of the island, is probably the best example of *D. cinnabari* woodland.

The granite slopes and pinnacles of the Haghier are fairly barren-looking and characterised by montane thicket, woody herbs and lichens.

Evolutionary history and biogeography

The fascinating and unique character of the flora and fauna of Socotra is related to its geological history. The island is probably part of a fault block separated off from the mainland by the same series of dislocations which produced the Gulf of Aden in late Tertiary times. KOSSMAT (1907) described Socotra as one of the „most isolated pieces of land" in the history of the earth. The high degree of endemism, as a result of this long isolation, makes the Archipelago of remarkable biogeographic and evolutionary interest and an important place in terms of global wildlife conservation.

Although the history of the island is in many details still imperfectly known, it is possible to suggest that some of the endemic species are relics of an ancient flora and fauna surviving in the Haghir massif, which is considered by geologists not to

have submerged since the Mesozoic (Uvarov & POPOV 1957). The absence of any indigenous mammals is a further indication of the island's ancient origin, presumably from a time before mammals appeared on earth.

In biogeographical terms terrestrial Socotra is in general more closely linked with Africa, but there are also interesting affinities with other areas, including some remote islands of the Atlantic Ocean. A possible explanation for such phenomena could be, that these related island species represent relics of an originally widespread African population, which became extinguished on the mainland by the more recent developments of the Ethiopian fauna. Further taxonomic studies are needed to clarify the status of the endemic species and their way of speziation, and there remains also a great need for further studies of the ecology of the individual species and their main habitats on the islands.

From the very scanty information on the marine fauna in the Gulf of Aden it is only possible to draw tentative biogeographic lines. It seems, that a zoogeographical boundary between an Arabian and a West Indian Ocean Subprovince runs from the coast of Somalia south of Cape Guardafui and Socotra Island in the West to the entrance of the Gulf of Oman in the east (KLAUSEWITZ 1989) (Fig. 9).

A very important factor for the determination of the boundaries seems to be cold water upwelling which probably constitute an efficient ecological barrier for warm-water-adapted species. Biogeographically Socotra could be a major overlap between the Arabian and Indian Ocean, with endemics from both regions represented. First investigations on the shallow water fish communities gave not only this picture of mingling different regional fauna, but also interesting indications of distinct and well-established communities. According to KAMP (personal information) the Archipelago is not simply a site where adjacent faunas mix, but in key fish indicators, only species belonging to one or the other of the biogeographic regions are present, their sister taxa being absent. More extensive inventory is required to confirm this.

Even if the island can not be considered as an untouched area, as a result of the vast isolation and the traditional rules, Socotra is relatively little affected by human activities in comparison with other island ecosystems. Until now, with the exception of some areas in the more exploited coastal plains, the whole island has been dominated by a traditional balance between man and the environment. At present there are no signs of over-exploitation of plant species with ethnobotanical values. Therefore Socotra is suggested to be one of the best preserved semi-arid tropical islands in the world.

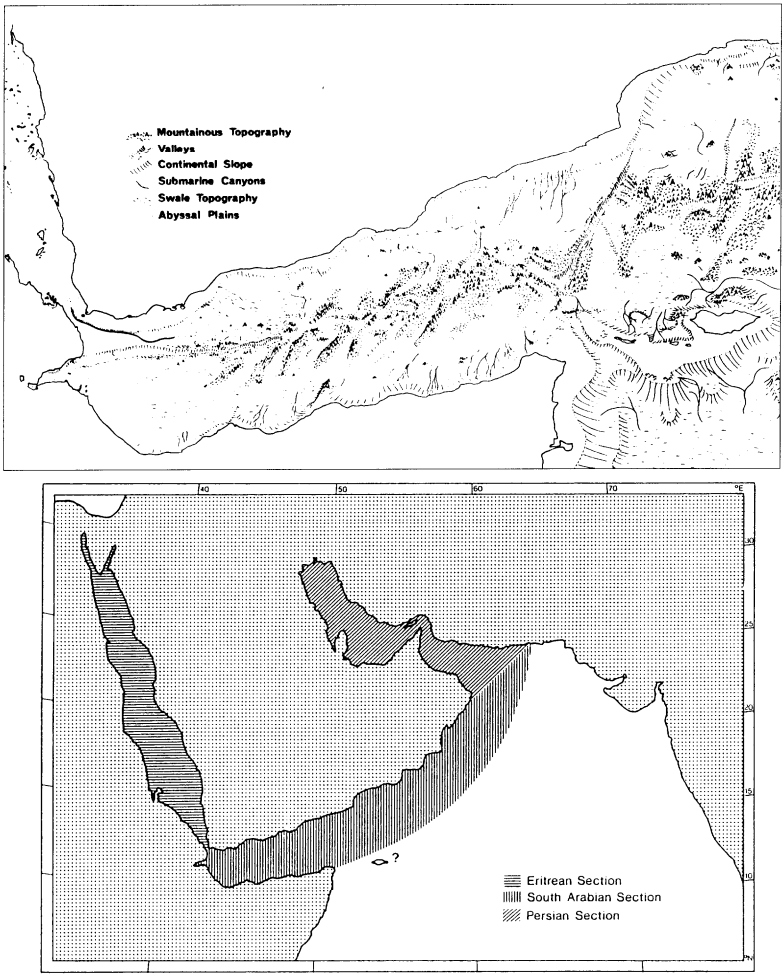


Fig. 9 The Gulf of Aden and map of the regional zoogeographic subdivisions, based on littoral fishes of the northwestern Indian Ocean (LAUGHTON 1970; KLAUSEWITZ 1989).

History of biological research

A significant part of the available data on the flora and fauna of Socotra dates back to turn-of-the-century expeditions. The first scientific exploration of the island was in 1880 by the botanist I.B. Balfour. An account of the recorded animals is given in 1881by BLANFORD, BUTLER, GODWIN-AUSTEN, GÜNTHER, SCLATER & HARTLAUB and WATERHOUSE. In 1881 the two Germans G. Schweinfurth and E. Riebeck spent six weeks on Socotra and recorded also numerous animals (MARTENS 1881, HARTLAUB 1881, PETERS 1882, TASCHENBERG 1883)(Fig. 7). The Bents, who where archaeologists, arrived the island in 1897. They were accompanied by E. N. Bennett, who collected a greater number of arthropods (DIXEY et al. 1898). Mainly insects and reptiles were obtained by an Austrian expedition in 1897 (STEINDACHNER 1903; KOHL 1907; BECKER, KRAUSS, REBEL 1931). The first specifically and more complex zoological survey was done by W. R. Ogilvie-Grant from the British Museum London and H. O. Forbes from Liverpool Museum in 1898. They spent three months on Socotra and visited also Abd-el-Kuri. Their records were summarised by FORBES (1903).

Some further geological, zoological and mainly botanical studies, such as the Oxford University Expedition in 1956 (BOTTING 1958), the Middle East Command Expedition in 1967 (DOE 1992), the University of Aden Expedition in 1982 (WRANIK et al. 1986) and the OSME Survey in 1993 (PORTER et al. 1996) were performed during the last decades, but failed to develop a comprehensive assessment of the island.

Still virtually nothing or only little is known about the ecology, distribution and population size of the majority of animal species. To date, for example, there has been very little work done on the southern and western plateau, the more isolated granite pinnacles, as well as the major part of the island's coastal waters. This, in turn, creates severe problems for a well-prepared protection strategy. Undoubtedly, there is a definite need for field surveys of any kind.

Terrestrial Biodiversity

Altogether some 850 plant species have been recorded so far, about 270 of which are considered to be endemic (ALEXANDER & MILLER 1996). Among them there are strange-looking remnants of ancient floras, which long ago disappeared from the surrounding mainland (Fig. 7 & 8). Equally fascinating is the land and freshwater fauna, with an exceptional number of endemics, but usually not so striking and, above all, comparatively poorly studied (Tab. 1 & 2).

Table 1 Taxonomic compilation of terrestrial and freshwater fauna Socotra Archipelago (Vertebrates)

taxonomic classification	species recorded	endemic (tentative)	main references	remarks
MAMMALIA	**13**	**0**		
Insectivora	1		DOE 1992	
Chiroptera	3		FORBES 1903; WRANIK et al. 1991; DOE 1992	
Carnivora	2		FORBES 1903	including domestic cat
Rodentia	2		FORBES 1903	uncertain status of *Mus musculus*
Artiodactyla	5		FORBES 1903	including livestock
AVES total	**112**	**6**	SCLATER & HARTLAUB 1881; HARTLAUB 1881; FORBES 1903; RIPLEY & BOND 1966; PORTER & STONE 1996	11 endemic subspecies need further taxonomic studies to clarify their status
breeding birds	31	6	PORTER & STONE 1996	
REPTILIA	**24**	**21**	BLANFORD 1881; GÜNTHER 1881; PETERS 1882; BOULENGER 1903; STEINDACHNER 1903	existence of larger species (crocodiles, giant lizards, land tortoises) uncertain
Sauria	19	16	ARNOLD 1986; SHOWLER 1996; RÖSLER & WRANIK in press; WRANIK in press.	three *Geckonidae* endemic to Abd-el-Kuri; the *Lacertidae Mesalina balfouri* also recorded from Semha
Serpentes	5	5	PARKER 1949; CORKILL & COCHRANE 1965	the record of *Echis coloratus* by BALFOUR (1880) is considered as a locality error
AMPHIBIA	0			no traces so far
PISCES (freshwater)	**1**		Health Department Aden (personal information)	introduction of *Aphanius dispar* within an anti-malaria campaign

Table 2 Taxonomic compilation of terrestrial and freshwater fauna Socotra Archipelago (Invertebrates)

taxonomic classification	species recorded [1]	endemic (tentative)	main references	remarks
MOLLUSCA	**62**		MARTENS 1883; CROSSE 1884; SMITH 1903	
Gastropoda (land)	56	about 80 %[2]	GODWIN-AUSTEN1881; SALVAT 1969	
Gastropoda (freshwater)	6		GODWIN-AUSTEN 1883	no traces of freshwater bivalves so far
ARACHNIDA	**34**		POCOCK 1899 & 1903	
Scorpiones	5	5	TASCHENBERG 1883; POCOCK 1899 & 1903;	
Solifugae	1	1	POCOCK 1903	
Araneae	25		POCOCK 1899 & 1903	
Opiliones	2	2	POCOCK 1903	
Acari			TASCHENBERG 1883; POCOCK 1903;	recorded (WRANIK)

CRUSTACEA	5	3	POCOCK et al. 1903	
Decapoda	3	1	TASCHENBERG 1883; POCOCK et al. 1903	two land crabs and one freshwater crab
Isopoda (land)	2	2	FERRARA & TAITI 1996	
Cladocera				recorded (DUMONT)
CHILOPODA	**6**	2	POCOCK 1899 & 1903; LEWIS & WRANIK 1990	one *Scutigeridae* recorded (WRANIK)
DIPLOPODA	**3**	3	POCOCK 1903	
INSECTA	**546**		TASCHENBERG 1883; FORBES 1903	
Thysanura				recorded (WRANIK)
Odonata	18	1	FORBES 1903; KIMMINS 1960; SCHNEIDER 1996	
Saltatoria	54	about 63 %[2]	BURR 1898 & 1903; KRAUSS 1907; UVAROV & POPOV 1957	
Dermaptera	6	0	BURR 1898 & 1903; KRAUSS 1907	
Blattaria	3	1	BURR 1899 & 1903; KRAUSS 1907	
Mantodea	3	3	BURR 1903; KRAUSS 1907; KALTENBACH 1982	
Isoptera	2	2	FORBES 1903; HARRIS 1954	
Heteroptera	28		KIRKALDY 1903; LINNAVUORI 1994	
Homoptera	6	5	KIRKALDY 1903; DOE 1992	*Aphis nerii* (WRANIK)
Coleoptera	72	about 35 %[2,3]	WATERHOUSE 1881; GAHAN 1903	
Tenebrionidae	20	20	KOCH 1970	
Hymenoptera	74	about 66 %[2]	KIRBY 1903; KOHL 1907; EMPEY 1973; SOIKA 1974	
Formicidae	3	0	COLLINGWOOD & AGOSTI 1996	
Neuroptera	12	8	KIRBY 1903; KIMMINS 1960; TJEDER 1974	
Diptera	75	?	RICARDO & THEOBALD 1903; BECKER 1931	
Nematocera	11	1	LEESON & THEODOR 1948; MATTINGLY & KNIGHT 1956	
Bombyliidae	16-17	9	GREATHEAD 1969	
Trichoptera	2		DOE 1992	
Lepidoptera	191	61	OGILVIE-GRANT, HAMPSON, WALSINGHAM 1903; REBEL 1931	

[1] the numbers are summarised from literature and can serve for the most groups only as a certain orientation [2] after KOCH 1970 [3] Coleoptera without Tenebrionidae

About 12 species of mammals are known from Socotra, but all of them have been introduced by man or may, as is the case with bats, occasionally have come from the mainland (WRANIK et al. 1991).

112 bird species have been recorded so far, 31 of which are known, or supposed, to breed. Among the landbirds at least 6 species, as well as 12 subspecies, are restricted to Socotra. More work is still needed to clarify the status of some of them, as for example the highly isolated population of Socotra *Buteo* (MARTINS & PORTER 1996). In addition to these endemic forms, Socotra holds a significant world population of some species, such as the Egyptian Vulture *Neophron percnopterus* (Fig. 10).

Fig. 10 The Egyptian Vulture (*Neophron percnopterus*) is a common and widespread resident on the island. Socotra is supposed to be the most important breeding area for this species in the Middle east.

The OSME Expedition (PORTER & STONE 1996) estimated the number of breeding pairs to be around 1 000. Along the coastline move also a greater number of migrant bird species, and might overwinter here in some cases. Some of the coastal habitats are exceptionally productive in terms of bird food, so that various waders, shore- and seabirds occur at times.

According to Birdlife International Socotra is one of 221 globally important Endemic Bird Areas (EBAs), as well as the south-west Arabian mountains on the mainland of Yemen. Yemen is thus unique amongst countries in the Middle East in having two EBAs, indicating its regional importance for biodiversity. So far 22 Important Bird Areas (IBAs) has provisionally identified on the Archipelago by Birdlife specialists, but this number is likely to increase with extended surveys (EVANS 1994).

The crocodiles, giant lizards and land tortoises referred to by the author of the Periplus have not been found so far, but this is not to say that they did not exist. It might be that the fauna of Socotra has changed substantially in some groups over the past at least 2000 years of human activities. Various reasons for an extinction of larger reptiles are conceivable. There may have been natural factors, such as climatic changes, but also grazing impacts and habitat degradation by the introduced and increased livestock (goats, sheep, camels, cattle, asses) or a pressure by predators, such as the introduced Civet Cat (*Viverricula malaccensis*). The larger reptiles may also have been hunted directly by the natives, either for food and trade, or because they were dangerous. BOULENGER (1903) mentioned trading of smaller lizards at Abd-el-Kuri and a widespread belief in some parts of Asia in the efficacy of reptile fat when rubbed over the body as a curative remedy for all sorts of illness. So it might

be that a Socotra *Varanus* became extinct due to the fact of being used as food and medicine in an environment where both are scarce . However, it is still unknown which larger reptile species, if any, have lived on the island, so that any discussion about the causes for their extinction is speculative. They are not mentioned in local legends and stories, so that a more detailed answer can be given only by searching for fossil remains, which might be waiting to be discovered. Suitable areas for such excavations would be the sediment of the caves. But apart from these lost inhabitants (?), Socotra remains rich and interesting as to the recent fauna too. Some 24 terrestrial reptile species have been reported from the Archipelago, about 21 out of them are considered to be endemic (Fig. 11).

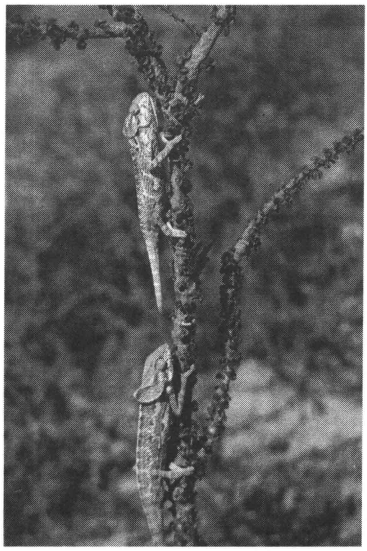


Fig. 11 Nothing is known about the position of the endemic *Chamaeleo monachus* within the group of African and Arabian chameleons. This marvellous species could be one potential candidate suffering from non-controlled animal collecting.

There is also an urgent need for research on invertebrates, which are mainly represented by a greater variety of molluscs and arthropods. The only known poisonous terrestrial species seem to be scorpions, spiders and centipedes.

Generally little is known about the fresh water biota in the numerous, mostly sporadic streams (Fig. 12).

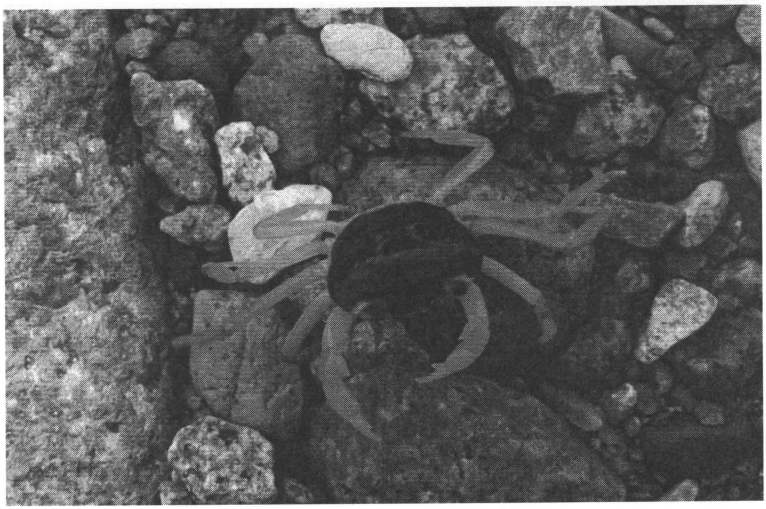


Fig. 12 The endemic fresh-water crab, *Potamon socotrensis*, which is common in the water-courses.

It is still controversial if there were true fresh water fishes on the island in former times. A few years ago a number of streams, estuaries and wells were stocked within an anti-malaria campaign with specimens of *Aphanius dispar* from the mainland. It seems, that they have formed stable populations and that the mosquito-larva eating fish effectively affect mosquito breeding in these waters. But the project was carried out without any research for possible side-effects within the freshwater communities.

So far no traces of amphibians have been found on Socotra, despite adequate water conditions and a number of species in the adjacent areas of Africa and Arabia, partly adapted to rather harsh conditions.

Marine Biodiversity and Fisheries Resources

The surface circulation in the north-western Indian Ocean is unique because its direction reverses twice a year under the alternate seasonal dominance of two opposing major wind systems. Gyre runs north-east from Somalia to western India, past the Socotra Archipelago and the coast of Oman during the period of the south-west monsoon. In this time the sea is subjected to vigorous surf in conjunction with falling sea surfaces temperatures. The extend and intensity of this seasonal Arabian sea upwelling has been described by CURRIE et al. (1973).

Beside the classic upwelling which is found along the surrounding mainland coast of Africa and Arabia, the strong tropospheric Findlater Jet, blowing from the Horn of

Africa across the Arabian Sea towards India, induces also open ocean upwelling due to wind stress curl (BAARS 1994). As with other comparable upwelling systems, there are profound effects on productivity. It is supposed, that in connection with upwelling a highly productive, but ephemeral benthic community is established, which is dominated by a variety of macroalgae (WCMC 1993). During the north-east monsoon the gyre reverse and bring warmer water, poor in nutrients, in the area.

Beside the extraordinary biological productivity by upwelling, the coastal waters play a role too as a haven for cetaceans, sea turtle species and a great variety of fishes and marine invertebrates. But also the marine environment of the Archipelago is still relatively poorly described.

The main coastal habitats are rocky cliffs, rock cobble beaches and sand beaches, sometimes continuations of 100 m high sand dunes or extended storm berm running parallel to the shore (Fig. 13).

Fig. 13 Coastal area near Hawlaf (east of Hadibo), where a sea port construction was started without any environmental impact assessment.

Some shorelines are gravel, characterised by alluvial matter washed down wadis from the mountains during flash floods. Mangrove (*Avicennia marina*) occur as small narrow belts and patches along inlets on the south-west coast and parts of the western half of the north coast. There are reports about very tall examples, standing up to 10 metres high. But in comparison with the zones marked as mangrove on older maps a greater number of areas seems to be already destroyed. Completing the picture of the coastal area are the estuaries that are a focus of human life.

The sublittoral zone is composed of sand scoured shallow rock and cobble/rubble and supports a rich macroalgal flora, which reflects the availability of nutrients through upwelling. A usually small, but locally significant seagrass coverage (*Halodule spp., Cymodocea serrulata*) occurs all around the island.

Coral is widespread through the Archipelago, although no biogenic reefs have been recorded so far. It can be supposed, that coral growth is likely to be restricted by cold upwelling. The living coral cover is variable, but there is little information on the species structure and distribution of coral assemblages. SCHEER (1964) visited Abd-el-Kuri and found it, surrounded by steep slopes, unsuitable for reef development. He described scattered corals (9 genera) interspersed with algal dominated communities.

The beaches of Socotra are, despite the vicinity of the larger settlements, astonishing clean. This is substantially caused by the fast turnover of sand, carrying litter and pollution from the beaches away to the sea. But the strong summer storms seem to be also so abrasive that the ground of shallow sublittoral areas is scoured by the sediment-laden water.

Even if not officially quantified (Table 3), the shelf area of the Archipelago is reported to be rich in fish, both pelagic and demersal. In comparison with the relatively low agricultural potential of the land side forms the marine life a substantial biological resource for a further development. The basis of commercial fisheries form tunas, kingfish and sharks, that is mainly carnivores and migratory offshore forms, whose food chain beneath is considerably fuelled by the seasonal upwelling production effects.

Table 3 Estimation of the potential yields and biomass for the region around Socotra (KESTEVEN et al. 1981).

Resource	Demersal*	Pelagic*
Biomass	55-116	112-224
Prospective Yield	10-20	39-78

* T x 1000

Fishing is mostly carried out from small boats. Therefore the main season is from September to May, when the sea is calm enough to put to sea. Meanwhile the traditional wooden *houri* have been replaced by fibreglass skiffs. Fishes are caught either with net or seine, which consists of ropes, floats and hooks. Brought to the surface, bigger fishes, especially sharks, are killed with a spear or a harpoon. They are

salted, dried and sold on the mainland. In shallow waters often small sinker-weighted nets are used. At present, in lack of sufficient official regulations from the mainland, a relatively effective traditional fisheries management system has evolved. There are local regulations, such as rules on gear usage, fishing rights or timing, which are widely accepted and re-evaluated on a seasonal base.

Shark fishery seems to be the only fishery to be currently threatened (Fig. 14).

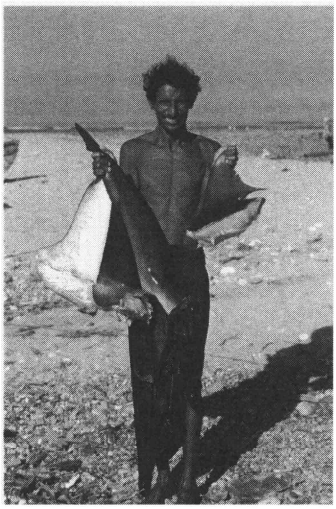


Fig. 14 Fisherman with shark fins

Because of its importance a further decline may have greater socio-economic consequences. But the disappearance of sharks, which are predators on the top of the food chain, may also lead to various ecological impacts.

During the eighties large Russian trawlers were licensed to fish around Socotra. At present there are reports of local fishermen on an increase of indiscriminate and excessive trawling by larger vessels, which could be highly damaging to spawning and feeding substrates. But at the moment unfortunately neither the island nor the mainland is able to execute the territorial sovereignty of the water around the Archipelago. With an improved infrastructure fisheries will undergo more fast a transition from these old, traditional and sustainable ways to new methods, that can be damaging if not applied correctly.

There seems to be a substantial commercial stock of spiny rock lobsters in the coastal waters of the Archipelago, which has been little exploited so far. Five species have been recorded, but at present fishery seems to be mainly confined to the most abundant *Panulirus homarus* (SAAD 1996). The lobsters are usually caught at night by trapping.

Abalone are the target of commercial fishery along the southeast coast of Oman, where *Haliotis mariae*, with a shell-length of about 10 cm, support annual catches of around 200 tonnes in shell-weight (SANDER 1982). Abalone (*Haliotis pustulata*), are also relatively common in the coastal waters around Socotra, but their size (length about 4-5 cm) and weight data are distinctly lower than those from Oman.

A sea cucumber survey was carried out in 1985, but around Socotra there were no stocks economically worthwhile to exploit.

Pearl oysters were fished on a commercial basis around Socotra towards the middle of this century. As a rule, diving was practised by people of African origin, hired for low rates of pay by the owners of the pearling boats (NAUMKIN 1993). The divers glamp their noses with two-pronged pegs, made of sheep- or cow-horn. The pearl oyster *Pinctada margaritifera* is still common. Pearling itself is now virtually extinct as an occupation, but recently a number of fishermen have started collecting of oysters on a commercial basis. They sell the whole shells, probably for industrial purpose, to merchants from the Gulf (Fig. 15).

But despite of this commercially oriented collecting of oysters any harvest of larger ornamental shells by fishermen seems to be relatively rare. There are giant clams (*Tridacna*), spider conchs (*Lambis*) and other attractive species even in the vicinity of fishing villages (Fig. 16).

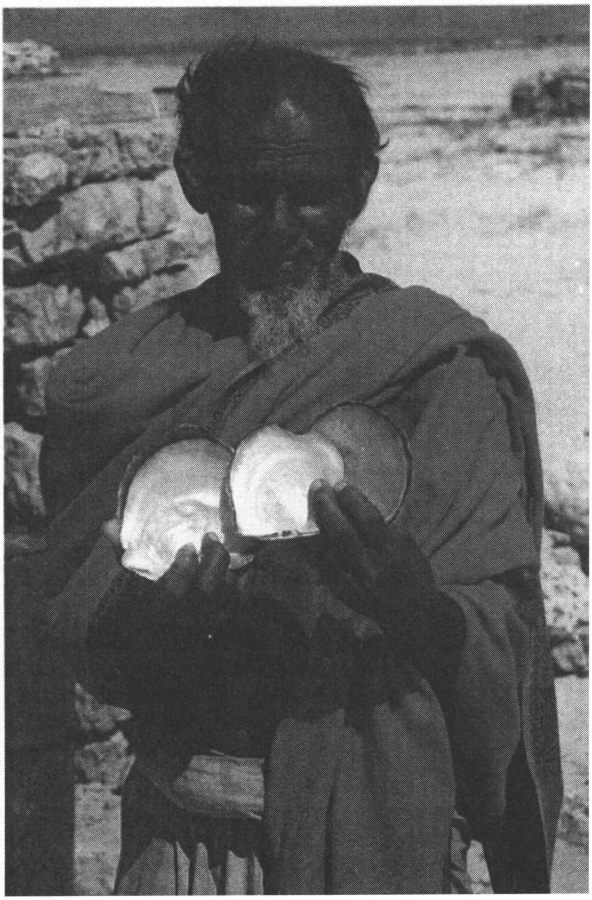


Fig. 15 Fisherman with shells of *Pinctada magaritifera*.

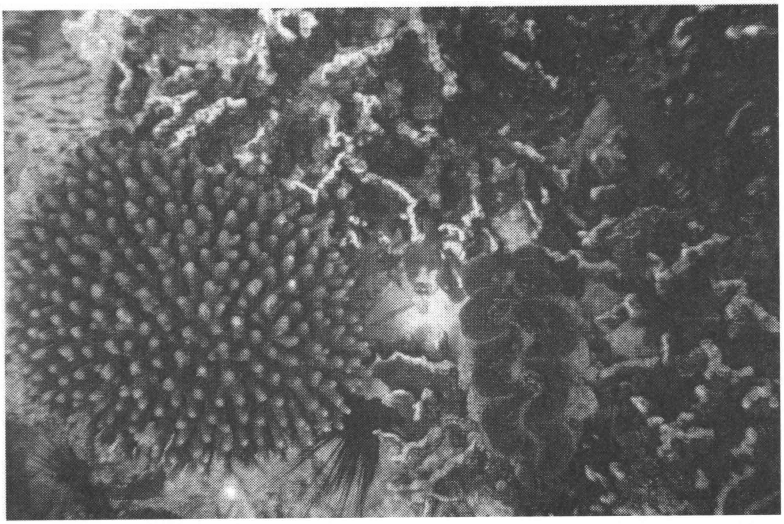
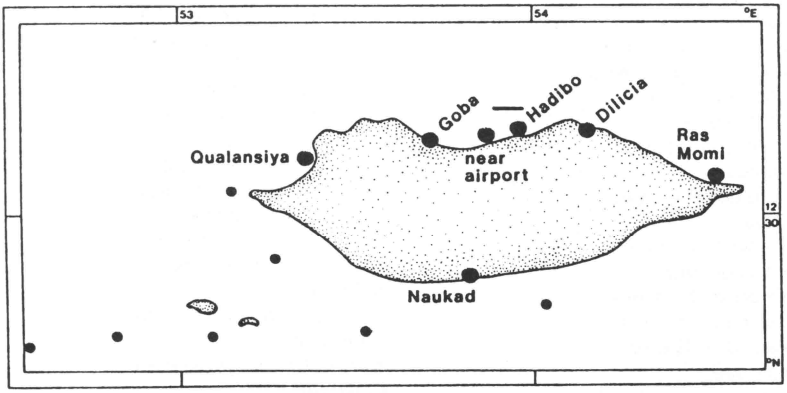


Fig. 16 Coral assemblage with *Tridacna* east of Hadibo.



see Table 4

Table 4 List of Makrozoobenthos (selected groups) recorded on and around Socotra Island (see map) during six missions between 1982 and 1996

MOLLUSCA
POLYPLACOPHORA
Acanthopleura vaillantii de Rochebrune
Chiton fosteri Bullock
Chiton peregrinus Thiele
Dinoplax cf. fossus Sykes
Onithochiton erythraeus Thiele
Schizochiton jousseaumei Dupuis
GASTROPODA
Haliotidae
Haliotis pustulata Reeve
Fissurellidae
Amblychilepas dubia (Reeve)
Diodora rueppellii (Sowerby)
Hemitoma panhi Quoy & Gaimard
Hemitoma subrugosa Thiele
Medusafissurella salebrosa (Reeve)
Scutus unguis (Linnaeus)
Patellidae
Cellana cylindrica (Gmelin)
Cellana rota (Gmelin)
Patella flexuosa Quoy & Gaimard
Acmaeidae
Patelloida profunda (Deshayes)
Trochidae
Clanculus pharaonius (Linnaeus)
Euchelus asper Gmelin
Monodonta nebulosa (Forskal)
Trochus dentatus Forskal
Trochus erythraeus Brocchi
Trochus kochi Philippi
Stomatellidae
Stomatella elegans Gray
Turbinidae
Turbo radiatus Gmelin
Neritidae
Nerita albicilla Linnaeus
Nerita longii Recluz
Nerita plicata Linnaeus
Nerita polita Linnaeus
Nerita textilis (Gmelin)
Planaxidae
Planaxis sulcatus (Born)
Littorinidae
Littorina kraussi Rosewater
Littorina glabrata (Philippi)
Cerithiidae
Cerithium caeruleum (Sowerby)
Cerithium columna Sowerby
Cerithium echinatum (Lamarck)
Cerithium nodulosum (Bruguiere)
Clypeomorus bifasciata (Sowerby)
Rhinoclavis sinensis (Gmelin)
Turritellidae
Turritella maculata Reeve
Vermetidae
Serpulorbis cf. variabilis Hadfield & Kay
Hipponicidae
Hipponix conicus (Schumacher)
Strombidae
Lambis truncata sebae Kiener
Strombus decorus Swainson
Strombus mutabilis Swainson
Xenophoridae
Xenophora corrugata (Reeve)
Cypraeidae
Cypraea annulus Linnaeus
Cypraea arabica Linnaeus
Cypraea caputserpentis Linnaeus
Cypraea cameola Linnaeus
Cypraea caurica Linnaeus
Cypraea clandestina Linnaeus
Cypraea erosa nebrites Melvill
Cypraea erythraeensis Sowerby
Cypraea felina Gmelin
Cypraea gracilis notata Gill
Cypraea helveola Linnaeus
Cypraea isabella Linnaeus
Cypraea lynx Linnaeus
Cypraea marginalis Dillwyn
Cypraea mauritiana Linnaeus
Cypraea moneta Linnaeus
Cypraea ocellata Linnaeus
Cypraea tigris Linnaeus
Cypraea turdus Lamarck
Cypraea vitellus Linnaeus
Naticidae
Polinices mammilla (Linnaeus)
Tonnidae
Tonna cf. cumingii (Reeve)
Cassidae
Cassis cornuta Linnaeus
Cypraecassis rufa (Linnaeus)
Cymatiidae
Cymatium nicobaricum (Röding)
Cymatium perryi Emerson & Old

Eulimidae
Melanella cumingii (A. Adams)
Bursidae
Bursa granularis (Röding)
Muricidae
Chicoreus ramosus (Linnaeus)
Murex pecten Lightfoot
Thaididae
Cronia konkanensis (Melvill)
Drupa morum Röding
Drupella cornus (Röding)
Drupella ricinus (Linnaeus)
Morula chrysostoma (Deshayes)
Morula granulata (Duclos)
Morula uva (Röding)
Nassa francolina (Bruguiere)
Thais bimaculatus (Jonas)
Thais hippocastaneum (Linnaeus)
Thais mancinella (Linnaeus)
Vexilla vexillum (Gmelin)
Buccinidae
Cantharus undosus (Linnaeus)
Columbellidae
Anachis fauroti (Jousseaume)
Columbella aspersa Sowerby
Pyrene flava (Bruguiere)
Nassariidae
Nassarius deshayesianus (Issel)
Nassarius persicus (Martens)
Fasciolariidae
Colubraria ceylonensis (Sowerby)
Peristernia nassatula forskalii (Tapparone-Canefri)
Harpidae
Harpa ventricosa Lamarck
Vasidae
Vasum turbinellus (Linnaeus)
Olividae
Ancilla castenea (Sowerby)
Oliva bulbosa (Röding)
Mitridae
Mitra mitra (Linnaeus)
Neocancilla clathrus (Gmelin)
Pterygia crenulata (Gmelin)
Strigatella nebrias (Melvill)
Conidae
Conus coronatus Hwass
Conus ebraeus Linnaeus
Conus flavidus Lamarck
Conus generalis maldivus Hwass
Conus geographus Linnaeus
Conus lividus Hwass
Conus miles Hwass
Conus nigropunctatus Sowerby
Conus obscurus Hwass
Conus parvatus sharmiensis Wils
Conus pennaceus Born
Conus rattus Hwass
Conus taeniatus Hwass
Conus terebra Born
Conus textile Linnaeus
Conus vexillum sumatrensis Hwass
Bullidae
Bulla ampulla Linnaeus
Siphonariidae
Siphonaria asghar Biggs
Siphonaria aspera Krauss
Siphonaria cf. javanica Lam.
Siphonaria ferruginea Reeve
Siphonaria kurracheensis Reeve
Siphonaria rosea Hubendick
BIVALVIA
Arcidae
Acar plicata (Dillwyn)
Arca ventricosa Lamarck
Barbatia foliata Forskal
Barbatia obliquata (Wood)
Barbatia setigera Reeve
Limopsidae
Limopsis multistriata Forskal
Glycymerididae
Glycymerus pectunculus (Linnaeus)
Mytilidae
Leiosolenus hanleyanus Reeve
Leiosolenus lima Lamy
Modiolus auriculatus (Krauss)
Musculus cumingianus (Reeve)
Pteriidae
Pinctada margaritifera (Linnaeus)
Pinctada radiata (Leach)
Pteria penguin (Röding)
Malleidae
Malleus malleus (Linnaeus)
Vulsella fornicata (Forskal)
Isognomidae
Isignomon legumen (Gmelin)
Pinnidae
Atrina vexillum (Born)
Pinna muricata Linnaeus
Streptopinna saccata (Linnaeus)
Gryphaeidae
Hyotissa hyotis (Linnaeus)

Spondylidae
Spondylus cf. marisrubri Röding
Lucinidae
Codakia tigerina (Linnaeus)
Pectinidae
Mimachlamys senatoria (Gmelin)
Scaeochlamys superficialis ruschenbergerii (Tryon)
Chlamys andamanica Preston
Nodipecten noduliferus (Sowerby II)
Pecten dorotheae Melvill & Standen
Haumea inaequivalis (Sowerby II)
Decatopecten plica (Linnaeus)
Carditidae
Cardites bicolor (Lamarck)
Chamidae
Chama pacifica Broderip
Chama limbula Lamarck
Cardiidae
Acrosterigma lacunosa (Reeve)
Fragum haemicardium (Linnaeus)
Tridacnidae
Tridacna maxima (Röding)
Cultellidae
Siliqua radiata (Linnaeus)
Veneridae
Circenita callipyga (Born)
Irus cf. macrophylla (Deshayes)
Periglypta puerpera (Linnaeus)
Tapes cf. deshayesi (Sowerby)
CRUSTACEA
Stomatopoda
Gonodactylus acutirostris De Man
Gonodactylus affinis De Man
Gonodactylus botti Manning
Gonodactylus lanchesteri Manning
Decapoda
Porcellanidae
Altaporcellana pygmaea (De Man)
Petrolisthes leptocheles (Heller)
Petrolisthes cf. militaris Heller
Petrolisthes ornatus Paulson
Petrolisthes unilobatus Henderson
Galatheidae
Galathea elegans Adam & White
Munida sp.
Xanthidae
Eripphia smithi McLeay
Grapsidae
Grapsus albolineatus Lamarck
Macrophthalmus boscii Audouin & Savigny
Ocypodidae
Ocypoda saratan (Forskal)
Uca inversa (Hoffman)
SCLERACTINIA
Acropora formosa (Dana)
Acropora microphthalma (Verrill)
Blastomussa merletti (Wells)
Favites abdita Ellis & Solander
Fungia moluccensis Horst
Galaxea astreata (Lamarck)
Galaxea fasicularis (Linnaeus)
Goniastrea retiformis (Lamarck)
Heteropsammia michelini (Edwards & Haime)
Leptastrea transversa Klunzinger
Lobophyllia hataii Yabe et al.
Pavona decussata (Dana)
Platygyra daedalea (Ellis & Solander)
Stylophora pistillata Esper

But also the data on molluscs and other benthic marine invertebrates are still insufficient (see Table 4). MARTENS (1883) gave a list of 24 marine gastropods and 12 bivalves. SAAD (1996) mentioned some 150 species, but because of difficulties in the identification this list must be considered as preliminary .

No real nesting surveys for marine turtles have been carried out so far, so that no data on the current status are available. But at least two species are suspected to nest on the islands of the Archipelago. These are the Green turtle *Chelonya mydas* and the Hawksbill *Eretmochelys imbricata*. Ogilvie-Grant & Forbes also mentioned bones of the Loggerhead *Caretta caretta* on a beach at Abd-el-Kuri (BOULENGER 1903). The capture of turtles seems to be a traditional practice of providing supplementary food for the local people especially during the summer monsoon when fishing is difficult.

A number of sightings are reported, but only few specific details are available on the occurrence of *Cetaceans*. The north-western Indian Ocean is a habitat for some 16 species of whales and dolphins, and all of them may occur, at least occasionally, in the waters around Socotra. According to FORBES (1903) the Sperm Whale *(Physeter macrocephalus)* must have been a frequent visitor to Socotra waters, judging by the amounts of *ambergris* which entered trade from the Archipelago throughout historical times.

The people of Socotra

The population of Socotra is estimated officially at 80 000, but this figure is probably much lower. The transhumant indigenous people of the interior are subsistent bedouins (farmers and pastoralists), while coastal dwellers engage mostly in fishing and trade.

Socotra has lagged seriously behind the mainland of Yemen in economic development. The production of livestock and coastal fishery are the most important parts of the local economy. A number of families practise subsistence farming with small-scale production of fruits and vegetables for local consumption, but the harsh climate restricts such cultivation to certain areas.

Especially the bedouins have a thorough knowledge of the flora and fauna. Many of the plants have traditional uses in medicines, cosmetic and hygiene preparations. The island was famed already in the ancient world as a source of several important plant products, such as Dragon's Blood (the resin of *Dracaena cinnabari*) and gums and resins from *Boswellia* and aloes.

At present there is a more provisional road system and electricity is only available for a few hours a day in the main coastal settlements.

Medical services are not more than the very basic. Respiratory diseases, especially tuberculosis, intestinal illness, malaria and other diseases are widespread. There are a lot of potential mosquito breeding locations on the island, such as open hand dug wells, open watering holes or even small natural depressions filled with rainwater. But the greatest source seems to be the brackish water bodies along the coastal estuaries, where fresh water flowing along is dammed into small ponds which

become polluted with vegetation growth, bacteria and with putrefying animal excreta and household refuse.

Rural water supply still mainly consist of open hand-dug wells and some centrifugal pumps. Only around Hadibo and in the Wadi Ayhaft is a water supply with help of water cistern in the mountains and an extended pipe system. But by lack of any special filtration and control of water quality exist a permanent potential danger of water-borne diseases. Side effects of this more comfortable water supply are an increased quantity of waste water and the support of mosquito breeding in water ponds formed by leakage of pipelines.

A rural sanitation is not existent, defecation in the open is commonly practised.

The solid waste mostly consists of metal cans and plastic with reduced amounts of organic materials, which is usually discharged unhesitatingly into the environment. Organic waste is eaten by birds, especially vultures. Probably thanks to these the waste dumps are not infested with rats.

Despite or because of these comparatively poor living conditions principles of cooperation, self-help and community labour are well established, and there is also a whole range of relevant traditional rules and practices which are of ecological importance. These „unwritten laws" include regulations which control the cutting of live wood, forbid the use of other than dead wood as firewood, regulate grazing and the cutting of vegetation as fodder and preserve important fruit bearing trees. Traditionally the local people practise rotational grazing. Known and applied for a long time have been also the practice of transplanting and sowing certain plants and protecting them from livestock while they grow. All important problems, including livestock management and development projects, are discussed and decided during meetings of local councils.

The opening of the island has stimulated plans to improve the poor living conditions and infrastructure. This marks a crucial turning point for the Archipelago, which represents a fragile ecosystem. Any inappropriate development may in due course lead to severe environmental damage, risking not only the survival of many of the endemic species.

How far the changes in the infrastructure, such as the development of sea- and airport facilities, a better road system and the availability of new sources of cash income, will affect the existing forms of land laws and the traditional style of living together can not be foreseen.

A first idea of possible conflicts in future is given by the situation in the vicinity of the larger coastal settlements, such as Hadibo and Qalansiyah, where life has already become more commercially oriented. Even if there are no great impacts visible yet, it seems that wood gathering occurs more systematically with the increased demand of timber for better housing. There are also localised grazing impact and first signs of a waste problem induced by an increased discharge of raw sewage and litter.

Two „key" projects for the development of infrastructure - the improvement of the airfield and the construction of a port near to Hadibo - have alreadey been started, the latter without an environmental impact assessment. Both will lead to an increasing influx of goods and technical facilities.

With a great probability the motor vehicle will become one of the most potent symbols of social and economic change. The growth in the number of 4-wheel drive vehicles during the last years is one of the already visible consequences of „opening" and a powerful stimulant to further change. As a consequence there will be not only a more excessive vehicle use on a widening network of tracks, but vehicles will carry also an increasing range and quantity of goods, water, purchased feed and weighty building materials from the larger settlements to the surroundings and back.

As a result of these processes the traditional economic activities will change, the traditional life style will become less attractive and the dependence of the people on local resources will greatly diminish. Possibly with the consequence that their knowledge and their understanding of the value of these resources is also diminishing with a consequent lessening of interest in using them with traditional skill and wisdom. The traditional patterns of work can also alter by an increase in labour migration and remittance money.

Accumulation of possessions are usually leading to greater individualism in many spheres of life resulting in the abandonment of the self-imposed restraints on the exploitation of natural resources, and think in terms of the short-term advantages to be gained from an immediate exploitation of available resources. Undoubtedly a key role plays the livestock (Fig. 17).

Fig. 17 The greater number of livestock graze freely without any restriction, only sheep are actively herded.

There are no exact data available. The only existing figure is the following estimation from 1985: Goats about 70 000, sheep about 17 000, camels about 500 and

cattle about 1 800. However, the actual numbers seem to be already clearly at the maximum levels that water and vegetation can support. As yet there is no practicable way to provide supplementary fodder and water during the summer time, so drought and disease continue to provide a control on livestock numbers. But if livestock are enabled by water supply and importation of supplementary food to survive such periods and consequently increase in number, or even if a disruption of the complicated patterns of seasonal livestock movement occurs, it can be expected that the present fragile equilibrium between vegetation, man and livestock will be destroyed very quickly. The vegetation plays also a key role in holding the soil onto the slopes and reducing the surface run off of water. Any removal of the vegetation cover, which could also be forced by a less strict control of the higher demand of wood for various purposes, would result in accelerated soil erosion and the loss of surface water through increased run-off rates - a dangerous, inestimable spiral for the island and all biota as well.

These are only a few aspects of a great number of different natural factors and socio-economic processes which are linked in a complex and net-like manner making the process of development and any prediction for the future difficult (Fig. 18).

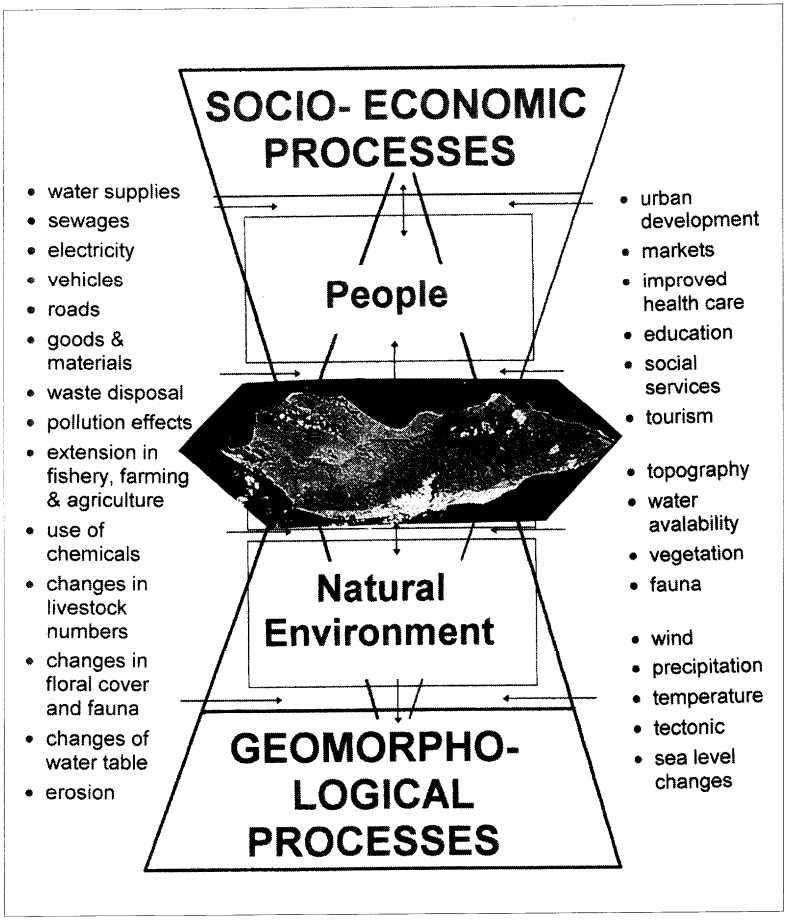


Fig. 18 Simplified web of natural and social interactions.

Conservation and Management

Prior to unification there was no specific wildlife conservation nor protected areas legislation in either of the two parts of Yemen. Nowadays the responsibility for wildlife conservation in the Republic of Yemen lies with the Ministry of Agriculture and with the Environmental Protection Council (EPC), and both have taken a variety of measures to set up a frame for wildlife laws, a site protection system as well as environmental education activities. Yemen has also ratified the Convention on Biodiversity in 1996.

Nevertheless, the ecological data base in the country is still relatively poor and there are also problems to control regulations.

For a number of years the Socotra Archipelago has been identified by IUCN, UNESCO and other international organisations as a very high priority, with a proposal to be nominated for recognition under the Man and Biosphere Programme. A number of major recommendations for critical areas and concepts of protection exist, arising from various surveys and reviews, such as the report of the UNESCO Fact Finding Mission 1993 with an outline of a development programme and a proposal of four preliminary core zones for protected areas (EUROCONSULT 1994). Various data on the island are published in a great range of journals, but neither necessarily available to, nor written in a suitable form for Yemeni decision makers.

Therefore at present many details of the most effective strategy of development and conservation are still unclear. A simple establishment and maintenance of large protected areas could cause not only problems of acceptance among the local people, but would also be not sufficient as a concept for sustainable development. Any management plan for the Archipelago should seek to attain harmony between development and protection, under active participation and involvement of the local people. Therefore potential revenue sources for the local population must be developed and these may, as a part of international programmes, include small-scale tourism, the cultivation and export of native plants, or the collection and storage of seeds and cuttings for propagation .

More detailed studies are needed to determine control and protection of sensitive or critical habitats, so that suitable and effective conservation strategies can be implemented. Little is known about the population size and distribution of species. Some forms seem to be restricted to certain areas on the island and exist probably in relatively tiny populations. This makes them extremely vulnerable. For species that have already severely reduced in numbers, survival might be difficult to ensure, even if apparently adequate conservation measures are introduced.

But flora and fauna of the Archipelago are not only endangered by habitat destruction. More trade usually leads to an introduction of alien species. Introduced species, animals and plants as well, can upset natural ecological balances permanently, sometimes resulting in mass extinction.

Another unsolved problem is the increased uncontrolled collection of endemic organisms by individuals and foreign institutions, perhaps also for commercial reasons. Nowadays already a number of Socotra succulent plant species are offered in catalogues on the international market. Commercial interest has also been expressed on some plant extracts of medical importance, such as aloe juice.

In the National Environment Action Plan of the country of Yemen the establishment of National Protected Area on Socotra was identified as one of the priority actions, which was subsequently incorporated into the Yemen First Five Year Plan (1996-2000). A High Committee for Development of Socotra works since January 1996. This multidisciplinary body has the task to prepare a Master Plan for Development of the Archipelago in co-operation with the UNDP, GEF and EU initiatives, which will integrate biodiversity conservation, environmental management and development objectives.

Socotra provides both, an opportunity and challenge for mankind. Fortunately the concept and value of conservation is still high on the agenda of the Sokotri. It is to be hoped that local and national efforts to protect Socotra's unique wildlife are successful and that the island's uniqueness is maintained for the benefit and pleasure of future generations.

Acknowledgements

At this point I would like to express my gratitude to all those Yemenite colleagues and institutions who helped me during my work in the country and took part in one and the other activity in the field.

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