Non-Native Plants Species and Biodiversity of Socotra Island, Yemen

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Abstract

Socotra Island has significant ecological and economic importance at local, national and global scales. Invasive plant species are often considered as potential competitors of native species due to their usual greater capacity for colonization and expansion. The spread of alien plant species has long been recognized as one of the most significant environmental changes due to its ability to decrease biodiversity and alter ecosystem processes. In areas with homogeneity population of wild invasive species especially Argemone mexicana, 32 random sites were randomly detected. Ninety six Quadrates plots were laid down to study the interaction between the invasive plant and the native species especially with conservation attention of endemic plant species. The main aims is to provide base informatics data to establish comprehensive habitat surveillance programs to enable early detection and rapid response of IAS, prevent both intentional or accidental introductions of harmful invasive alien species to the Socotra Island and reduce the likelihood of alien species invasions by decreasing stresses on vulnerable at-risk ecosystems and species . This study was conducted to identify the different types of invasive species present, the rate and pattern of invasion, its intensity, association of invaders and their habitat preference in the Socotra ecosystem. Vegetation sampled in 96 quadrats, each 10 m _ 10 m; through a combination of random and systematic sampling recorded 42 plant species of 36 genera belonging to 24 families with around 10% was recorded as invasive species. Diversity indices like richness, evenness, Simpson and Shannon-Wiener have been analyzed.

Key words: Socotra Island, invasive species. Biodiversity, Yemen, exotic species, Species richness

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Introduction

Invasive alien species are biological pollution, able to persist and spread in their new environments. According to the World Conservation Union (IUCN), invasive alien species are the second most significant threat to biodiversity, after habitat loss. In their new ecosystems, invasive alien species become predators, competitors, parasites, hybridizers, and diseases of our native and domesticated plants and animals. The impact of invasive alien species on native ecosystems, habitats and species is severe and often irreversible, and it often takes several years before the extent of the problem is recognized.

It is widely known that island ecosystems are particularly vulnerable to IAS, and that their impacts are especially severe (Veitch and Clout, 2002). Island species are especially vulnerable to human induced changes, due to their isolation from other landmasses. Thousands of species have been extinguished or are at risk from invasive aliens, especially on islands but also on continents. This is because island endemics are often less able to adapt to the presence of IAS than species that are more-widely spread. IAS has been identified as one of the main causes of ongoing declines and extinctions on islands and other ecosystems. For example, the deliberate introduction of African tropical pasture grasses to the Amazon basin holds the potential to increase the importance of fire and inhibit the recovery of abandoned pasture areas to tropical forest. Flammable grasses would thus tend to convert forest areas into grasslands and savannas, with reduced biomass and transpiration. Such change would exacerbate the problem of atmospheric carbon dioxide accumulation as well as promote warmer and drier conditions throughout the region (George, 2004). Further, environmental destruction, including habitat fragmentation, and global climate change are extending the range of many invaders.

The rate of human-assisted plant movement is considerably higher than from natural migration, and as a consequence many ecosystems are threatened by the invasion of exotic species (Simberloff, 2005). Invasive exotic species may out-compete native plants because they typically exhibit high individuals and population growth rates, high reproductive capacities characterized by short life cycles, easily dispersed seeds and efficient utilization of environmental resources (Orians, 1986). Mack (1996) observed that species with high migration rates are among the most troublesome exotic plants. Ultimately, these attributes can lead to a reduction in native plant diversity and detrimental changes in ecosystem structure and function (Vitousek, 1990).

Biological invasions by non-native species constitute one of the leading threats to natural ecosystems and biodiversity, and they also impose an enormous cost on agriculture, forestry, and fish. Natural barriers such as oceans, mountains, rivers, and deserts that allowed the intricate convolution of species and the development of unique ecosystems have been breached over the past five centuries, and especially during the twentieth century, by rapidly accelerating human trade and travel raises, and other human enterprises, as well as on human health.

Invaders can change whole ecosystems by altering hydrology, fire regimes, nutrient cycling, and other ecosystem processes. Often the same species that threaten biodiversity also cause grave damage to various natural resource industries.

Pathways of invasion include direct trade in ornamental or horticultural alien species that are later found to be invasive; alien species that hitch-hike on goods and packaging materials; and the ships, planes, trains, and vehicles. New deliberate introductions must be assessed as to the threat they may present and introduction should be permitted on the basis of a risk analysis and environmental impact assessment. The use of native plants and non-invasive alien plants for gardening and other purposes should however promote. Laws regulating trade in plant species on the Black List would be a first step in the right direction to reduce the impact of these species.

Islands present important opportunities to manage invasive species due to their isolation by water from other landmasses, means that we can more-effectively prevent new introduction and eradicate previous ones than the case at mainland sites. In many places around the world people are successfully fighting back against the threat of invasive species. There are numerous examples of projects that have succeeded in the prevention, eradication or control of IAS, with the associated positive outcomes for native species, ecosystems, and people's livelihoods.

Invasive species pose a future challenge on Socotra, particularly with increasing access and transport to the island. The irreversible impacts of invasive species on Hawaii Archipelago illustrate the problem that can be posed on oceanic islands and the need to effectively address this issue on Socotra.

Objectives

The present study was conducted on an international heritage site reserve that has been established to protect the Socotra Island from the establishment, new introduced and spread of invasive alien plants with their severe impacts on ecological and economic systems.

The objective of the present study is to survey the ecological characteristics of Socotra ecosystem with an emphasis on the quantitative analysis of:

1- Biogeographically distribution pattern of Invasive species.
2- Functional group composition of plant communities and plant species diversity.
3- Relationship between invasive species and distribution protected areas.
4- To develop informatics capacities of the stresses of invasive species on

to vulnerable at-risk ecosystems and species.

However, no previous research has been conducted on the distribution and inventory of invasive alien species in this protected area as this happens to be first report.

MATERIALS AND METHODS

STUDY SITE :

Socotra island (Yemen) is the largest and most easterly island of Indian Ocean archipelago, lying approximately 240 km east of the Horn of Africa (and 380 km south of the Arabian Coast (Ras Fartak in Yemen), located between latitudes 12°19' and 12°42' N and longitudes 53°18' and 54°32 E (Fig. 1). The other main islands in the group are Abd al Kuri, and Semhah and Darsa called the Brothers. Socotra, the largest island, is about 130 by 35 km and covers an approximate area of 3625 km^2 (Wranik. 1996). Socotra is one of the most isolated landforms on Earth, of continental origin (i.e., not of volcanic origin). The archipelago was once part of the super continent of Gondwana and detached during the Middle Pliocene about 6 million years ago. The main island has three geographical terrains: the narrow coastal plains, a limestone plateau permeated with karstic caves, and the Haggehier Mountains. The mountains rise to 1,525 m. The climate is generally tropical desert, with rainfall being light, seasonal (winter) and more abundant at the higher ground in the interior than along the coastal lowlands. The total population of Socotra is 50,000 and consists of shepherds (of sheep, goats, and dwarf cattle). The case for Socotra as a site of Outstanding Universal Value rests largely on its high plant diversity and levels of endemism. Of its 850 plant species belonging to 430 genera, 307 species (37%) and 15 genera are endemic. Botanists rank the flora of Socotra among the ten most endangered sets of island flora in the world. The main threats to biodiversity are excessive woodcutting; unplanned infrastructural development; an expanding population of goats and spread of invasive alien species. Lack of scientific information on IAS has potential impacts on Socotra biodiversity that might have otherwise been avoided. Invasive alien species are now recognized as one of the greatest biological threats to environmental and economic well-being.

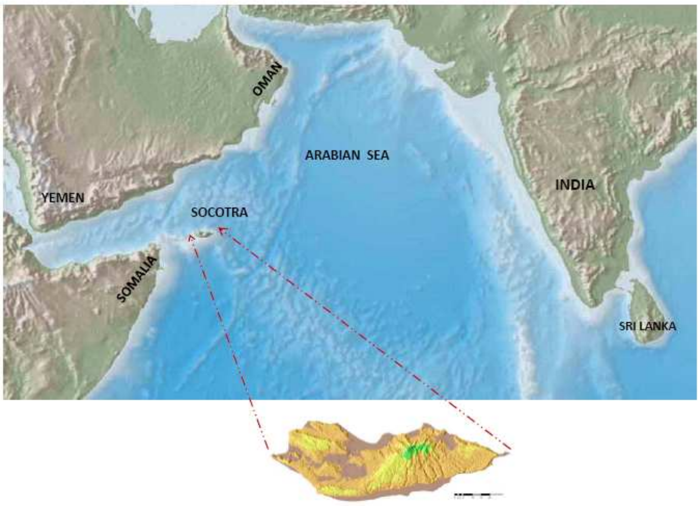

Fig.1: Location of study area

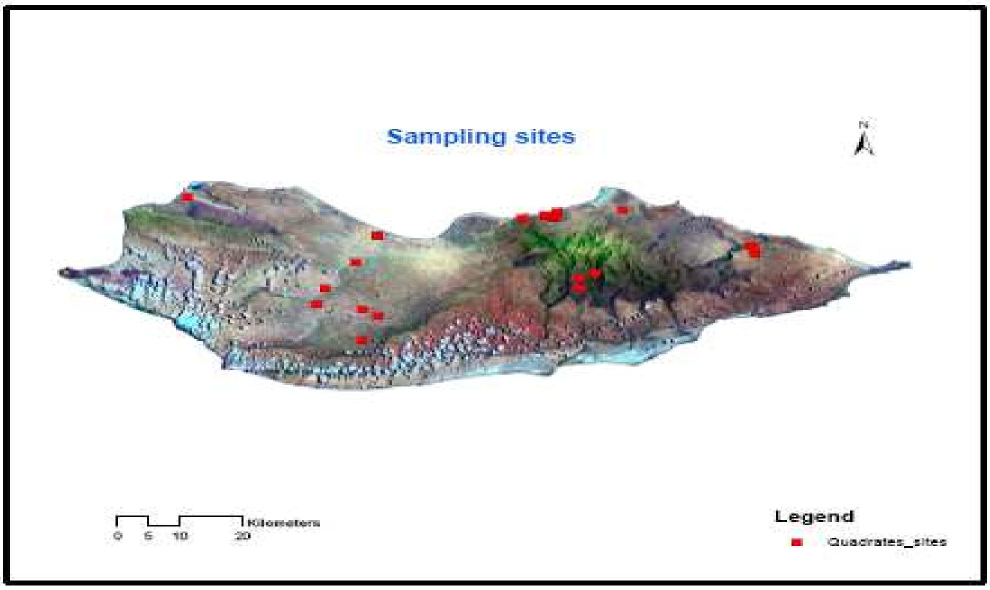

Fig. 2: Sampling Sites

Methodology :

A number of field visits were undertaken to several potential target areas in an attempt to select the best sites of sampling, with the help of team work of Socotra Conservation Development Program (SCDP) gather with information collected from local people. In general, sites sampling is based on the nature of the areas sampled the expected distribution of target species. Spatial information, land cover classification map, habitat diversity and other data from (SCDP). The decision, made after other consultants from (SCDP) specialists, was based on the following specific criteria:

Selected areas have to be diverse in terms of micro-environmental conditions such as vegetation cover, altitude and slope to be good representatives of roadsides, valleys, and nearby settlements where the dense population of wild spread invasive species occur.

In areas of homogeneity population of wild invasive alien species, randomly quadrates of 10 m x 10 m were laid down, most sampling sites were found under high shrub land and tree habitats (Fig. 2), replicate was carried out three times for each sampling chosen sites (Brower, *et al.*, 1977).

The species, number of individuals, family, life form, use, and socotrean names were recorded. Species were classified according to IUCN status of endemic species. Taxonomic keys of Socotra's flora are used as a fundamental tool for identifying specimens and assessing whether they should be further examined as possible exotics. The final identification of introduced species was confirmed with taxonomic specialist, Socotra Conservation Development Program and Agriculture Research and Extension Authority (AREA), Taiz, Yemen.

Three categories were distinguished from the areas: (1) endemics of the Socotra Island; (2) native, non-endemic species (Miller and Morris, 2004); and (3) introduced (alien) species. Data obtained are represented in a tabular form for making a comparison of the effect of each species on the ecosystem and its conservation importance (Table 2).

Based on the information collected from SCDP and field survey, environmental and geographical characteristics of each sampling sites like Lat.(°N), Long.(°E), Alt.(m), Slope °, Habitat, Micro-environmental, Socotra–zoning-region, area importance were reordered (Table 1).

The statistical methodology used had to satisfy two objectives. The first was to clearly present an inventory of species present at different sites based on different distribution characteristics. The other was to relate the different sites to each other and assess their diversity based on the presence, absence and characteristics of the present target species.

Basic statistical methods followed were implemented using the PRIMER 5 (Plymouth Routines in Multivariate Ecological Research) statistical package (2001), and Graph Pad Prism Version 3.02 (2000).

Diversity indices were used to know the homogeneity or heterogeneity of the ecosystem. Higher the diversity index higher will be heterogeneity. A community that contains a few individuals of many species will have a higher diversity than will a community containing the same number of individuals but with most of the individuals confined to a few species.

To compare the different sites and assess the overall level of diversity and the impacts of invasive species in all targets areas, statistical analysis was carried out to obtain biodiversity indices like richness, Pielou's evenness index, Simpson index and Shannon-Wiener diversity index.

The data were analyzed for diversity indices using the following formula:

Total species: S - the number of species in each sample. i.e. species with non zero counts.

Total individuals: **N** - The number of individuals in each sample.

Species richness: Margalef's index (d): $d = (S-1)/\text{Log}(N)$

Margalef's species richness. It is a measure of the number of species present, making some allowance for the number of individuals.

Species richness (S) is the total number of species found in an environment/sample.

Pielou's evenness index: $J' = H'(\text{observed})/ H'_{max}$

Where: H'_{max} is the maximum possible diversity which would be achieved if all species were equally abundant (=log S)

Simpson index: λ = SUM (P_i ^ 2)

Where: Pi =the proportion of the total arising from the ith species.

Simpson's index (λ) is the probability that two randomly selected individuals belongs to two different species/categories.

Shannon-Wiener diversity index: $H' = -\sum_i P_i (\text{Log } P_i)$

Where: P_i = the proportion of the total arising from the ith species.

RESULTS AND DISSCUSSION :

A total of 42 plant taxa were found on sampling sites belonging to 36 genera and 24 families (Table 2). The recorded species constituted about 4.9% of the total flora of Socotra. The Papilionoideae accounted for 4 genera and 5 species, Asclepiadaceae for 3 genera and 3 species, Solanaceae for 3 genera and 3 species and Vitaceae for 1 genus and 3 species. The botanical survey of the reserve indicated 52 % endemic, 38 % native and 10 % exotic species.

The most abundant species were *Argemone mexicana, Grass spp, Tephrosia apollinea, Pulicaria stephanocarpa, Senna holosericea, Tephrosia odorata, Medicago laciniata, Aerva lantana and Calotropis procera* respectively, while the least abundant were *Withania adunensis, Trigonella* *fulcata, Teucrium balfourii, Tamrindus indica, Ochradenus socotranus, Indigofera nephrocarpa, Glossonema revoili, Ficus vasta, Ficus cordata, Exacum affine, Dendrosicyos socotrana, Cucumis dipsaceus, Cordia obovata, Cissus subaphylla, Azadirchta indica*. The invasive *Argemone mexicana* was the most abundant species introduced more than 50 years ago according to the elderly local Socotran people and now it has become a serious pest of native ecosystems. It is a very strong competitor, displaces native species while growing in the same habitat and colonizes quickly and has the ability to prohibit seed germination of other species. Now *Argemone mexicana* has spread in the near settlements, water streams, barren land and road sides. Based on the survey the following species are considered as bio-indicators of land degradation; *Tephrosia apollinea, Pulicaria stephanocarpa, Senna holosericea, Tephrosia odorata* associated with Argemone mexicana.

Species with conservation important status according to IUCN classification are Aloe *perryi* as (NT) near threatened species, *Dendrosicyos socotrana, Dracaena cinnabari* and *Pulicaria vieraeoides* as (VU) vulnerable species. Whereas *Trigonella fulcata*, *Ballochia amoena* as (DD) data deficient and 16 endemic species as (LC) least concern.

In the randomly selected sites, the habitats showed 32% Low croton - *Jatropha* shrub land; 13% High shrub land *with* succulents; 13% Date palm plantation; 13% Wadi, 10% Urban;3% Frankincense woodland and 1.2% Sparse dwarf shrub land (Fig. 6). The Frankincense woodland is one of the most important areas supporting endemic species like Boswellia species which considered as one of the most important species on the island (Fig. 7).

Biodiversity assessment

The study recorded 3389 individuals belonging to 42 species (Table. 2). The EcoQ is quantified as High $H' > 4$, Good $3 < H' \leq 4$, Moderate $2 < H' \leq 3$, Poor $1 < H' \leq 2$ and Bad $H' \leq 1$ using Shannon index (H'). The S-W

Index values (H) can range from 0 to ~4.6, a value near 0 would indicate that every species in the sample is the same. Conversely, a value near 4.6 would indicate that the number of individuals is evenly distributed between the 42 species. Overall 78% of study sites were indicated low community complexity and 22% indicated moderate complexity (Fig. 5); this decrease in biodiversity is attributed to the spread of wild invasive *Argemone mexicana.*

The values for evenness range from 0 to 1 where a sample of equal number of individuals of the same species has a value of 1. As species richness and evenness increase diversity increases (Fig. 3).

Simpson's Diversity Index is a measure of diversity which takes into accounts both richness and evenness. Simpson's Index (**λ**) measures the probability that two individuals randomly selected from a sample belong to the same species (or some category other than species). With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of **λ**, the lower the diversity (Fig. 4). A summarizing of biodiversity indices is shown in table 3.

IUCN recommends that a Quarantine System be developed to assist with more effective management of invasive species on Socotra in 1996. Such a system should be coupled with monitoring and eradication programmers across the islands to prevent the establishment of invasive species. Species introduced for amenity horticulture and agriculture are likely to become an increasingly important problem and this should be addressed as part of overall invasive species control plans.

Table 1: Geographical characteristics of study sites

No.	Lat. (°N)	Long. (°E)	Alt. (m)	Slope °	Habitat	Mic.env.	Socotra -Z- egion	Area importance
1	12.5884	54.3008	343	85.02°	Sparse dwarf shrub land	Undulating	National Park	W1, S1, P1, B1

No.	Lat. (°N)	Long. (°E)	Alt. (m)	Slope °	Habitat	Mic.env.	Socotra -Z- egion	Area importance
2	12.5869	54.30629	350	86.33°	Sparse dwarf shrub land	Undulating	National Park	W1, S1, P1, B1
3	12.5804	54.30714	361	86.33°	High shrub land with succulents	Undulating	National Park	W1, S2, P1, B2
4	12.5712	54.30866	404	85.27°	Frankincense woodland	Mountain	General Use Zone	W2, S2, P2, B3
5	12.6439	54.02125	19	0°	Low croton - Jatropha shrub land	Urban	General Use Zone	W1, S1, P1, B1
6	12.645	54.02157	22	0°	Urban	Urban	General Use Zone	W1, S1, P1, B1
7	12.6451	54.01651	25	0°	Low croton - Jatropha shrub land	Urban	General Use Zone	W1, S1, P1, B1
8	12.6443	54.01678	23	0°	Low croton - Jatropha shrub land	Urban	General Use Zone	W1, S1, P1, B1
9	12.6453	54.01562	22	0°	Low croton - Jatropha shrub land	Urban	General Use Zone	W1, S1, P1, B1
10	12.6837	53.49225	17	0°	Wadi	Wadi	General Use Zone	W3, S1, P1, B1
11	12.6071	53.76568	16	0°	Sparse dwarf shrub land	Wadi	National Park	W1, S1, P1, B1
12	12.6073	53.76537	17	0°	Sparse dwarf shrub land	Wadi	National Park	W1, S1, P1, B1
13	12.607	53.76502	13	0°	Sparse dwarf shrub land	Wadi	National Park	W1, S1, P1, B1
14	12.6067	53.76522	16	0°	Sparse dwarf shrub land	Wadi	National Park	W1, S1, P1, B1
15	12.6465	54.00742	56	0°	Low croton - Jatropha shrub land	Coastal	General Use Zone	W1, S1, P1, B1
16	12.6538	54.02355	13	0°	Date palm plantation	Wadi	General Use Zone	W1, S1, P3, B1

No.	Lat. (°N)	Long. (°E)	Alt. (m)	Slope °	Habitat	Mic.env.	Socotra -Z- egion	Area importance
17	12.6544	54.0239	13	0°	Date palm plantation	Coastal	General Use Zone	W1, S1, P3, B1
18	12.4731	53.67822	100	0°	Wadi	Wadi	Resource UseReserve	W3, S1, P1, B1
19	12.4009	53.74348	160	0°	Low croton - Jatropha shrub land	Undulating	Resource Use Reserve	W1, S1, P1, B1
20	12.4485	53.76572	133	0°	Low croton - Jatropha shrub land	Wadi	Resource Use Reserve	W1, S1, P1, B1
21	12.4625	53.74517	128	0°	Low croton - Jatropha shrub land	Wadi	Resource Use Reserve	W1, S1, P1, B1
22	12.4734	53.67948	82	0°	Wadi	Wadi	Resource Use Reserve	W3, S1, P1, B1
23	12.5036	53.69056	63	0°	Wadi	Wadi	Resource Use Reserve	W3, S1, P1, B1
24	12.5548	53.73453	45	85.89°	Wadi	Wadi	Resource Use Reserve	W3, S1, P1, B1
25	12.6421	53.97345	42	0°	High shrub land with succulents	Coastal	National Park	W1, S2, P1, B2
26	12.6421	53.97345	35	0°	High shrub land with succulents	Coastal	National Park	W1, S2, P1, B2
27	12.6598	54.11844	48	88.21°	Date palm plantation	Undulating	Resource Use Reserve	W1, S1, P3, B1
28	12.5336	54.0779	232	0°	Low croton - Jatropha shrub land	Mountain	National Park	W1, S1, P1, B1
29	12.5235	54.05568	472	89.99°	Low croton - Jatropha shrub land	Mountain	National Park	W1, S1, P1, B1
30	12.5034	54.05579	463	62.27°	High shrub land with succulents	Mountain	National Park	W1, S2, P1, B2

No.	Lat. (°N)	Long. (°E)	Alt. (m)	Slope °	Habitat	Mic.env.	Socotra -Z- egion	Area importance
31	12.6479	54.00558	22	0°	Urban	Coastal	General Use Zone	W1, S1, P1, B1
32	12.6479	54.00558	21	0°	Urban	Coastal	General Use Zone	W1, S1, P1, B1

Explanatory notes	1 ... low
W ... water-management importance	2 ... medium
S ... erosion control importance	3 ... high
P ... production importance	
B ... biodiversity importance	

Table 2: characteristics of recorded species

Scientific name	Family	Socotran name	Use	Gr. form	Status	IUCN St.
Adenium obescum	Apocynaceae	terimo	orn	sh	e	LC least concern
Aerva lantana	Amaranthaceae	faa	gra	h	n	....
Aerva microphylla	Amaranthaceae	faa	gra	ssh	e	LC least concern
Aloe perryi	Liliaceae	tayf	med	suc	e	NT near threatened
Argemone mexicana	Papaveraceae	miranniha	med	h	i	....
Azadirchta indica	Meliaceae	Neem tree	orn	t	i	.....
Ballochia amoena	Acanthaceae	miyszez	f gra	sh	e	DD data deficient
Calotropis procera	Asclepiadaceae	giniginoh	med	sh	i	.....
Caralluma socotrana	Asclepiadaceae	mish'hahir	gra	h	n	....
Cissus hamaderohensis	Vitaceae	atirheh	med	v	e	LC least concern
Cissus paniculata	Vitaceae	aterhe	med	v	e	LC least concern
Cissus subaphylla	Vitaceae	atirheh	med	v	e	LC least concern
Cometes abyssinica	Caryophyllaceae	qalqihal	gra	h	n	......
Cordia obovata	Boraginaceae	shezizhiyo	f gra	sh	n	.....
Croton socotranus	Euphorbiaceae	mitrer	f gra	sh	e	LC least concern
Cucumis dipsaceus	Cucurbitaceae	di ah'shawih	med	h	n	.....
Dendrosicyos socotrana	Cucurbitaceae	qamhiyn	gra	t	e	VU vulnerable
Dracaena cinnabari	Dracaenaceae	a'arhiyib	med	t	e	VU vulnerable
Exacum affine	Gentianaceae	di heyhi	med	h	e	LC least concern
Ficus cordata	Moraceae	ithip	f	sh	n	....
Ficus vasta	Moraceae	tiq	f	t	n	....

Scientific name	Family	Socotran name	Use	Gr. form	Status	IUCN St.
Glossonema revoili	Asclepiadaceae	fiqali	cult	h	n	.....
Grass	Poaceae	.....	gra	h	...	.....
Indigofera nephrocarpa	Papilionoideae	qownuh	gra	ssh	n	.....
Jatropha unicostata	Euphorbiaceae	seborihi	f med	sh	e	LC least concern
Lycium sokotranum	Solanaceae	suhur	med	sh	e	LC least concern
Medicago laciniata	Papilionoideae	sherishiroh	cult	h	n	.....
Ochradenus socotranus	Resedaceae	gershiyih	f	sh	e	LC least concern
Oldenlandia balfourii	Rubiacea	tamhur	gra	h	e	LC least concern
Phoenix dactylifera	Palmae	timirirh	cult	t	n	....
Psidium guajava	Myraceae	guava	cult	t	i	....
Pulicaria stephanocarpa	Compositae	diyrbeb	med	ssh	e	LC least concern
Pulicaria vieraeoides	Compositae	de mahahon	gra	h	e	VU vulnerable
Senna holosericea	Caesalpinioideae	feriro	med	h	n	....
Senna socotrana	Caesalpinioideae	di qerihan	med	ssh	e	LC least concern
Solanum incanum	Solanaceae	harjiym	med	sh	n	.....
Tamrindus indica	Caesalpinioideae	zubihur	cult	t	n	.....
Tephrosia apollinea	Papilionoideae	tifher	f	h	n	.....
Tephrosia odorata	Papilionoideae	di habalino	f	h	e	LC least concern
Teucrium balfourii	Labiatae	giyrbeb	med	h	e	LC least concern
Trigonella fulcata	Papilionoideae	ru'ud	med	h	e	DD data deficient
Withania adunensis	Solanaceae	ubab	med	sh	e	LC least concern

Table 3: Biodiversity indices

sampling sites	total species: S	Total individuals: N	Species richness (Margalef): d	Pielour's evenness: J'	Simpson: ⍰=SUM (Pî^2)	Shannon: H'
S 1	8	49	1.79	0.54	0.45	1.13
S 2	8	58	1.72	0.59	0.38	1.23
S 3	9	36	2.23	0.52	0.53	1.14
S 4	13	44	3.17	0.78	0.19	2.01
S 5	6	43	1.32	0.98	0.18	1.75
S 6	4	135	0.61	0.65	0.47	0.91
S 7	5	165	0.78	0.64	0.42	1.03
S 8	3	193	0.38	0.77	0.48	0.84

sampling sites	total species: S	Total individuals: N	Species richness (Margalef): d	Pielour's evenness: J'	Simpson: □=SUM (Pî^2)	Shannon: H'
S 9	4	151	0.59	0.43	0.64	0.60
S 10	5	66	0.95	0.67	0.41	1.09
S 11	5	136	0.81	0.60	0.46	0.97
S 12	5	300	0.70	0.21	0.85	0.34
S 13	4	346	0.51	0.14	0.92	0.20
S 14	6	249	0.90	0.49	0.56	0.88
S 15	5	224	0.74	0.59	0.46	0.95
S 16	5	238	0.73	0.79	0.33	1.27
S 17	5	169	0.78	0.59	0.54	0.95
S 18	5	78	0.92	0.91	0.24	1.46
S 19	4	67	0.71	0.29	0.83	0.40
S 20	3	37	0.55	0.87	0.42	0.95
S 21	4	55	0.75	0.66	0.50	0.91
S 22	3	76	0.46	0.75	0.47	0.82
S 23	6	109	1.07	0.61	0.41	1.09
S 24	5	49	1.03	0.83	0.29	1.33
S 25	6	36	1.40	0.72	0.37	1.30
S 26	9	53	2.01	0.82	0.21	1.81
S 27	4	22	0.97	0.79	0.39	1.10
S 28	11	57	2.47	0.69	0.31	1.65
S 29	7	22	1.94	0.89	0.21	1.73
S 30	5	16	1.44	0.70	0.44	1.13
S 31	6	72	1.17	0.82	0.28	1.46
S 32	7	38	1.65	0.63	0.41	1.24

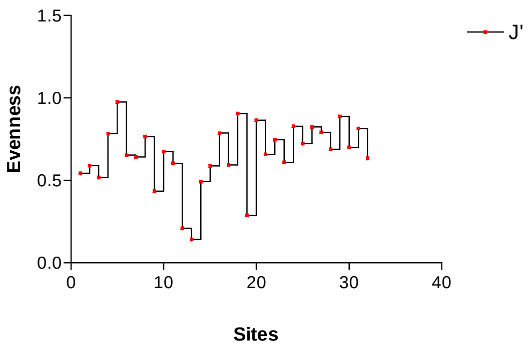

Fig. 3: Relation between Evenness at study sites

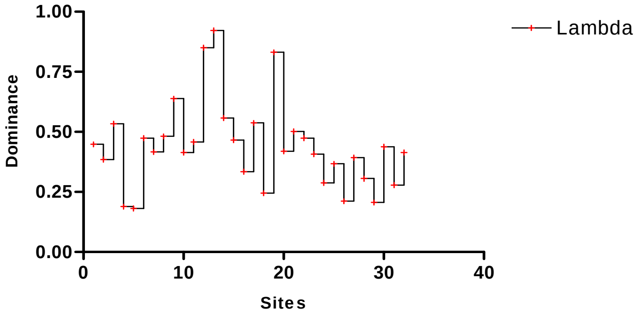

Fig. 4: Relation between Dominance at study sites

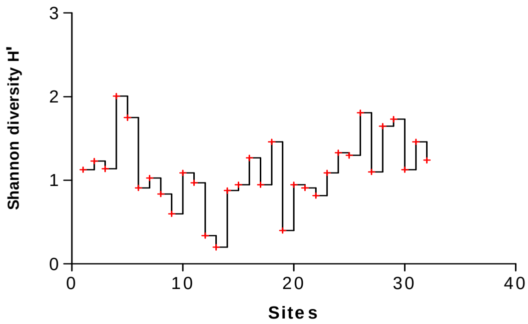

Fig. 5: Relation between Shannon indexes at study sites

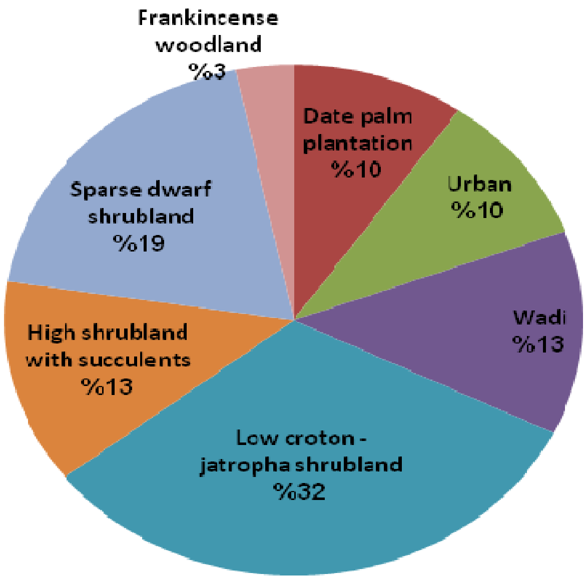

Fig. 6: Spectral pattern of habitats

Fig. 7: Argemone mexicana in Boswellia forest (Homhel, 2008)

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