Pak. J. Bot., 42(1): 35-46, 2010.

CONSERVATION STATUS OF *CADABA HETEROTRICHA* STOCKS (CAPPARACEAE): AN ENDANGERED SPECIES IN PAKISTAN

HAIDER ABBAS[1*], MUHAMMAD QAISER[2] AND JAN ALAM[3]

[1]Karachi Institute of Biotechnology and Genetic Engineering (KIBGE), University of Karachi, Karachi-75270, Pakistan,
[2]Federal Urdu University of Arts, Science and Technology, Karachi -75300, Pakistan,
[3]Karachi University Herbarium (KUH), Center for Plant Conservation (CPC), University of Karachi, Karachi -75270, Pakistan
[*]Corresponding author: invitro.life@gmail.com

Abstract

The conservation status of *Cadaba heterotricha* Stocks in Pakistan was determined according to IUCN 2001, Red Data List Categories and Criteria. Based on four years extensive field studies including population size, geographic range and habitat. *Cadaba heterotricha* is classified as Endangered (EN) species in Pakistan.

Introduction

It is estimated that some 270,000-425,000 vascular plant species are already known (Govaerts, 2001) with perhaps a further 10-20% still to be discovered and described (Hawksworth & Kalin-Arroyo, 1995). Native plants are key components of the global biological diversity, these plants are an integral part of our ecosystem in which they are facing multiple threats i.e. habitat loss and degradation, introduction of alien species, pollution and diseases, over-exploitation and climate change (McNeely *et al*., 1995; Wilcove *et al*., 1998; Sala *et al*., 2000; Alonso *et al.*, 2001; Barbosa & Marquet, 2002; Sudhersan *et al.*, 2003).

Pakistan's scenario is not different from the rest of the world. Plant biodiversity is also under tremendous pressure due to its population explosion, unplanned urbanization, deforestation and over-exploitation of natural resources (Anon., 2000; Ahmad *et al*., 2005). Unfortunately, very little work has been done on threatened plants of Pakistan and extremely limited information is available on this subject (Alam & Ali, 2009). According to Nasir (1991) 580-650 flowering plant species (i.e. 12%) are expected to be threatened. Chaudhri & Qureshi (1991) reported 709 taxa as threatened plants from Pakistan. However, both these studies are manly based on field observation and literature, without any support of quantitative data. In contrast, the recent red list of IUCN (Anon., 2008) only 19 flowering plants species have been listed from Pakistan. Regarding Pakistan, previous workers have classified the plant species as threatened or rare on the basis of literature or herbarium specimen. No work has been done according to IUCN red list categories or criteria (Anon., 2001) except Alam & Ali (2009), who classified *Astragalus gilgitensis* Ali as a Critically Endangered (CR).

Cadaba heterotricha Stocks is a shrub and a member of the family Capparaceae. It is localized in the rocky slopes of Coastal belt of Karachi from Cape-Monze to Sona Pass. It is also reported from Kenya, Ethiopia, Somalia, Yemen, Oman and Pakistan (Fig. 1). Number of workers have reported it as a rare taxon in its geographic range (Table 1). Jafri (1958 & 1974) considered it as a rare species due to its narrow distribution in Pakistan. While, Nasir (1991) classified it as an endangered species for Pakistan. The conclusion of Nasir, was purely based on literature, rather then field based observations.

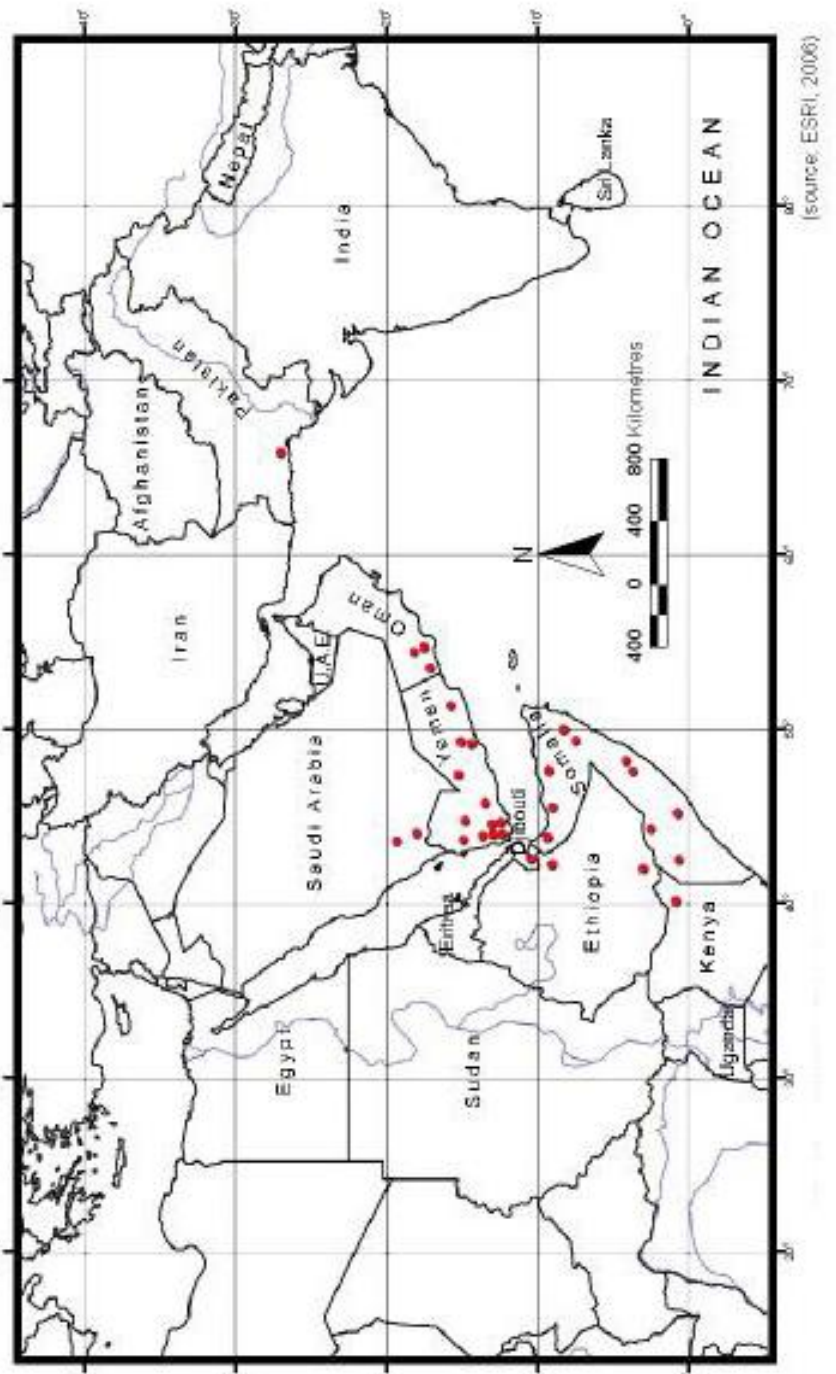

Fig. 1. Global distribution map of *Cadaba heterotricha*.

In order to determine the conservation status of the *Cadaba heterotricha* in Pakistan, present study was under taken.

Materials and Methods

Twenty one field surveys were conducted from 2005 to 2008 at a regular interval. Habit, habitat, altitudinal range, population size, distribution range, impacts of multiple threats like habitat destruction, erosion, fuel wood cutting, grazing, poultry farms and invasive species have been studied for four years in the habitat.

- Distribution area of the taxon was calculated by plotting relevant GPS values on the map. ArcGIS 9.2 version was used for this purpose.
- Previously known localities and their adjoining areas were thoroughly surveyed to determine the exact area of occurrence and nature of distribution of *Cadaba heterotricha*.
- Locations were recorded with the help of global positioning system (GPS).
- The population size was determined by counting the mature individuals. The seedlings were also counted separately.
- Nature of habitat was analysed by soil erosion, invasive species and impacts of anthropogenic activities.
- Habit and life form of every associated species in the habitat was also recorded and classified according to Raunkier's System of Classification.
- Information has also been collected from native people regarding the ethno-botanical usage.

Results

Habit, habitat and associated species: *Cadaba heterotricha* is a medium size shrub (Fig. 2) and grows on slopes and cliffs of calcareous rocks up-till an altitude of 150m. However, few individuals were also recorded in plains near rocky slopes. However, individuals in the plains concentrated along stream beds. *Euphorbia caducifolia* Haines, *Acacia senegal* (L.) Willd., and *Commiphora wightii (*Arn.) Bhandari were found as dominant species in the habitat. In total of 29 associated species (Table 2) were observed in the habitat. Amongst these, 18 shrubs, 3 trees, 7 biennial or perennial herbs, and 1 annual herb were recorded. The dominant life form was phanerophytes (14 species) followed by chemophytes (9 species), hemicryptophytes (4 species) and therophytes (1 species).

Area of distribution in Pakistan: In Pakistan, *Cadaba heterotricha* occupies an area of 76.96 Km^2 in the coastal belt of Karachi between Cape-Monze to Sona Pass. However, in the distribution area, rocky slopes occupy less area as compared to plains (Fig. 3).

Population size and mode of reproduction in the wild: The population size during 2005-2008 is given in Table 3. Maximum mature plants were found in 2005 i.e., 260 followed by 257, 254 and 251 in 2006, 2007 and 2008 respectively. During the study, no seedlings were observed on rocky slopes or cliff, however, some immature plant individuals growing of the suckers from the parent plants were found on eroded gravel plains. Initially, during two years (2005 & 2006) we could not find any young plant, while, during 2007 and 2008, 20 and 18 young plants were recorded, respectively.

Fig. 2. *Cadaba heterotricha*: A, Habit; B, Flower; C, Fruits.

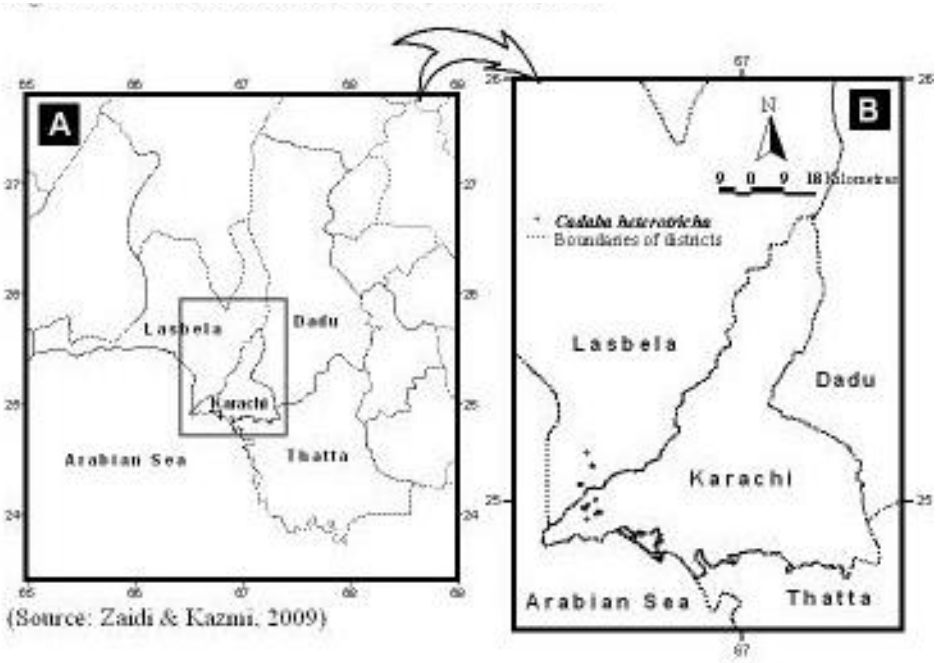

Fig. 3. *Cadaba heterotricha*: A, Study area; B, distribution in Pakistan.

Table 2. Species found in association with *Cadaba heterotricha* from 2005 to 2008 along with their habit and life form.

#	Family	Species	Habit	Life form
1.	Acanthaceae	*Barleria acanthoides* Vahl	Perennial Herb	Chaemaphyte
2.	Amaranthaceae	*Aerva javanica* (Burm.f.)Juss ex Schultes	Perennial Herb	Chaemaphyte
3.	Asparagaceae	*Asparagus dumosus* Baker	Shrub	Phanerophyte
4.	Asteraceae	*Pluchea arguta* Boiss.	Shrub	Phanerophyte
5.	Asteraceae	*Echinops echinatus* Roxb.	Annual	Therophyte
6.	Asteraceae	*Pulicaria boissieri* Hook.f.	Shrub	Chaemaphyte
7.	Boraginaceae	*Cordia sinensis* Lam.	Shrub	Phanerophyte
8.	Burseraceae	*Commiphora wightii* (Arn.) Bhandari	Shrub	Phanerophyte
9.	Caesalpiniaceae	*Senna holosericea* (Fresen.) Greuter	Shrub	Chaemaphyte
10.	Capparaceae	*Capparis cartilaginea* Decne.	Shrub	Phanerophyte
11.	Capparaceae	*Capparis deciduas* (Forssk.) Edgew.	Shrub	Phanerophyte
12.	Chenopodiacee	*Salsola imbricata* Forssk.	Perennial Herb	Chaemaphyte
13.	Chenopodiaceae	*Suaeda fruticosa* Forssk. ex J. F. Gmelin	Shrub	Phanerophyte
14.	Convolvulaceae	*Convolvulus glomeratus* Choisy	Perennial Herb	Hemicryptophyte
15.	Convolvulaceae	*Seddera latifolia* Hochst. & Steud.	Shrub	Chaemaphyte
16.	Euphorbiaceae	*Euphorbia caducifolia* Haines	Shrub	Phanerophyte
17.	Gentianaceae	*Enicostemma hyssopifollium* (Willd.) Verdoon	Perennial Herb	Hemicryptophyte
18.	Malvaceae	*Senra incana* Cav.	Shrub	Chaemaphyte
19.	Malvaceae	*Abutilon fruticosum* Guill. & Perr.	Perennial Herb	Chaemaphyte
20.	Mimosoideae	*Acacia senegal* (L.) Willd.	Tree	Phanerophyte
21.	Mimosoideae	*Prosopis juliflora* (Swartz) DC.	Shrub - Tree	Phanerophyte
22.	Mimosoideae	*Acacia nilotica* subsp. *hemispherica* Ali & Faruqi	Shrub to Tree	Phanerophyte
23.	Papilionaceae	*Indigofera articulata* Gouan	Shrub	Phanerophyte
24.	Poaceae	*Cymbopogon jwarancusa* (Jones) Schult.	Perennial Herb	Hemicryptophyte
25.	Poaceae	*Chrysopogon aucheri* (Boiss.) Stapf	Shrub	Phanerophyte
26.	Rhamnaceae	*Ziziphus nummularia* (Burm.f.) Wight & Arn.	Shrub	Phanerophyte
27.	Salvadoraceae	*Salvadora oleoides* Dcne.	Tree	Phanerophyte
28.	Scrophulariaceae	*Kickxia ramosissima* (Wall.) Janchen	Perennial Herb	Hemicryptophyte
29.	Tiliaceae	*Grewia tenax* (Forssk.) Fiori	Shrub	Phanerophyte
30.	Tiliaceae	*Grewia villosa* Willd.	Shrub	Phanerophyte
31.	Zygophyllaceae	*Fagonia indica* Burm. f.	Perennial Herb	Chaemaphyte

Habitat destruction and soil erosion: The habitat of *Cadaba heterotricha* has a good quality stone, suitable for the construction purposes which is being excavated by and transported with help of machines. This excavation activity is going on in the entire habitat. At an average from each excavation site three trucks are loaded each day if they are filled manually but if big machines are used, then they can easily send around 15-20 truck loads per day. The crushing and excavation of stones continues throughout the year, but it reaches at its maximum during the summer because of enormous increase in demand. Soil erosion during rainy season, is another threat in the habitat. Plant individuals of *Cadaba heterotricha* grows very well on the plains instead of rocky slopes, but they tend to grow on the edges of the eroded land and soil erosion is accelerated due to heavy rains, thus disturbing the already restricted and specific habitat (Fig. 4).

Fig. 4. *Cadaba heterotricha*: A, General view of the habitat degradation due to stone excavation; B, Stone excavation and transportation activities; C, Grazing activities.

Table 3. Summary of population size of *Cadaba heterotricha* from 2005-2008.

Population size	2005	2006	2007	2008
Mature plants	260	257	254	251
Immature plants	0	0	20	18

Fuel wood cutting and poultry sheds: Another threat for the small population of *Cadaba heterotricha*, is its over-exploitation for fuel wood purpose. Local residents of various goths (villages) i.e., Goth Haji Usman, Goth Ahmed and other, have no access to natural gas (sui-gas) and electricity. The population of 20,000 inhabitants and increasing number of poultry farms, need fuel wood on regular basis, for cooking and maintaining temperature during winter season in poultry farms.

Grazing impact: Inhabitant of the area tends to maintain a large number of livestock like goats, camel and cows, which exerts a tremendous pressure on the vegetation. Unfortunately, the situation further deteriorates before Eid-ul-Azha (A Muslim festival in which livestock are sacrificed), when local inhabitants purchase extra livestock for this upcoming event at least three to five months ahead. This seasonal increase in the number of livestock creates an immense pressure on the vegetation which is already under severe stress. More than 300 goats and 60-70 cows in the areas were counted during the field studies (Fig. 4C).

Invasive species: The whole area has been heavily infested by *Prosopis juliflora* but it grows more aggressively on the plains then on the stony slopes or gravel sites. During 2005, the first year of survey, *Prosopis juliflora* was not found growing as gregariously as in 2008 and one can imagine the scenario in the future.

Discussion and Conclusion

The specific features of restriction and isolation expose the species, prone to extinction, especially in the era of rapid habitat loss or degradation (Myers, 1988; Heywood & Watson, 1995; Sala *et al*., 2000). *Cadaba heterotricha* is mostly found on rocky slopes and sandy soils with limestone silt. Our observations are in agreement with the previous workers, which have reported the species from almost similar habitats from other parts of the world (Table 1). Hence, it is suggested that *Cadaba heterotricha* is habitat specific and confined to a narrow distribution range.

The prime cause of plant extinction around the globe is the fragmentation and disturbance of species habitat (Sala *et al*., 2000; Barbosa & Marquet, 2002). A large scale stone excavation and road construction activity is the major cause of disturbance and destruction in the habitat of *Cadaba heterotricha*. Gully erosion is causing a severe damage during rains, individuals of *Cadaba heterotricha* growing in sandy are found more prone to erosion than the plants found on rocky slopes and cliffs.

Invasion of invasive species is widely considered as second greatest cause of species endangerment and extinction after habitat loss around the globe (Huston, 1994; Wilcove *et al*., 1998; Primental *et al*., 2001; Levine *et al*., 2003). Millions of hectares of rangeland have already been invaded by *Prosopis juliflora*. The process is still occurring in South Africa, Australia and coastal Asia (Pasiecznik, 1999) and having serious consequences on ecological, economic and social systems (Primental *et al*., 2000). Due to devastating effects of *Prosopis juliflora*, it has been included in the IUCN's list of 100 world's worst invasive species (Pallewatta *et al*., 2003). According to El-Keblawy & Al-Rawai (2007) *Prosopis juliflora* is causing extirpation of the native flora, resulting in the reduction of species richness and diversity. Noor *et al*., (1995) reported that *Prosopis juliflora* is playing a vital role in Pakistan in the elimination of natural vegetation due to its allelopathic effects. *Prosopis juliflora* was also observed as aggressively growing invasive species in the habitat of *Cadaba heterotricha.* However, concentration of the population was mostly found on sandy areas rather than rocky slopes.

According to Pieper (1994) impact of grazing ranges from almost undetectable removal of plant material to severe depletion of vegetational resources and extensive erosion. Grazing activity was observed in the habitat, but its impact was quite prominent and devastating for *Cadaba heterotricha*. Uncontrolled and expanding grazing activities have a deep and long term impact on the local vegetation and it is disastrous for the local plant wealth which is already in stress.

Over-exploitation of plant species for fodder and fuel wood purpose by local communities and nomads is a complex problem and a major cause of plant extinction (Hirway & Goswami, 2007; Engler, 2008). Regarding impacts of unsustainable use of plant species, no accurate information has been published (Davis *et al*., 1995), but there is no doubt about its consequences. In case of *Cadaba heterotricha*, another major concern is that, local inhabitants and commercial scale poultry farms have no access to the natural

gas and electricity for maintaining their living. Fuel wood chopping exercise is quite prominent in the habitat of *Cadaba heterotricha*, thus badly affecting its population.

Rabinowitz (1981) suggests that those species which are found over a wide geographic range but are consistently rare throughout their distribution need immediate attention as they are more vulnerable from extinction point of view. *Cadaba heterotricha* is reported from Coast of Karachi to North Eastern Africa, a quite large distribution area. However, at the same time it is reported as a rare species throughout the region by previous workers (Baker, 1894; Gillett, 1944; Jafri, 1958, 1974; Miller & Moris, 1988; Tadesse, 1995; Wood. 1997; Ghazanfer, 2003; Raffaelli *et al*., 2003). It was first discovered by Stocks in 1852, from Sindh, Pakistan and even 157 years it is still considered as a rare species in the entire distribution range. In case of Pakistan, Jafri (1958, 1974) has clearly mentioned that it appears to be a rare species due to its narrow distribution range from Cape-Monze to Sona Pass area; moreover Nasir (1991) also considered this taxon as an endangered species for Pakistan. According to our observations, *Cadaba heterotricha* requires a specific habitat and grows from Cape-Monze to Sona Pass It is a rare taxon according to the criteria of Rabinowitz (1981) by having specific habitat, extremely narrow distribution and rare throughout its geographic range.

According to Baggs & Maschinski (2000) population size is often affected by dry periods during the growing season, when plants may not produce any viable seed and there will be no natural recruitment. No natural recruitment was observed in *Cadaba heterotricha* during field studies of 2005–2008. Hence, it is concluded that the population sizes of studied taxa are continuously reducing at an alarming rate, without having natural recruitment.

Many threatened plant species are predisposed to threat due to their small population sizes (Rabinowitz, 1981; Kruckeberg & Rabinowitz, 1985). The conservation status of a species is mainly based on the number of mature individuals of that taxon (Anon., 2001). The current study was conducted, according to the IUCN red list categories and criteria (Anon., 2001), which describes in detail that if population size is fewer than 250 mature individuals with a continuous decline in their number along with no sub-populations, making the taxon eligible to be placed under Critically Endangered (CR) category. *Cadaba heterotricha* with a population size of 251, is placed under Critically Endangered category and is under threat of extirpation. These findings suggest that low population size along with continuous decline in their numbers without having any subpopulations is critical for its survival.

Conservation status of a taxon is also based on the geographic range and number of localities/sub-populations (Anon., 2001). The categories and criteria clearly explain that if a taxon has less then 500 km^2 extent of occurrence with one locality or severely fragmented localities should be considered as Endangered (EN) in addition to other parameters. In case of *Cadaba heterotricha* the extent of occurrence is 76.96 km^2. From the point of view of number of localities the studied taxa is reported from single locality. Based on the small geographic range and single locality, *C. heterotricha*, is placed under Endangered Category. These findings according to IUCN criteria suggest that the restricted distribution range of concerned taxon in a single locality is critical for its survival.

On the basis of multiple threats i.e., habitat specificity, restricted distribution range, habitat loss through commercial scale stone excavation activities, invasion of invasive

species i.e., *Prosopis juliflora*, over exploitation in the form of grazing and fuel wood cutting and low population size along with negligible natural recruitment, the current study concluded that *Cadaba heterotricha* is highly prone to extirpation and eligible to be placed under Endangered (EN) category.

In context with global biodiversity, conservation of a rare species at national level is very important. Hence, urgent conservation steps should be taken as suggest below, to avoid its extirpation from Pakistan.

- ✓ The *Cadaba heterotricha* should be included in the Red Data list of threatened species for Pakistan.
- ✓ Conservation status assessment of the *C. heterotricha* in other countries should also be initiated to assign the category in international perspective.
- ✓ Efforts should be made to protect the taxon by minimizing the anthropogenic activities in the habitat (i.e. stone excavation, fuel wood cutting, grazing and poultry business).
- ✓ *Cadaba heterotricha* should be introduced in botanic gardens for public display.
- ✓ Seeds of the taxon should be preserved in local seed banks and also distributed to other regional conservation organizations, so that in case of any natural disaster it can be protected and recovered.
- ✓ Protocols for *in vitro* conservation as a backup support, should be designed, initiated and established on urgent basis to fulfill the *ex-situ* conservation strategy.
- ✓ Alternate environmentally friendly and sustainable jobs should be provided for the local inhabitants for maintaining their living properly.
- ✓ Alternate means of energy like electricity and natural gas should be provided in the area to reduce the wood cutting activities.

References

Alam, J. and S.L. Ali. 2009. Conservation status of *Astraglus gilgitensis* Ali (Fabaceae): a critically endangered species in Gilgit district, Pakistan. *Phyton (Horn, Austria)*, 48(2): 211-223.

Alonso, A., F. Dallmeier, E. Granek and P. Raven. 2001. *Biodiversity: connecting with the tapestry of life*. Smithsonian Institution/Monitoring and Assessment of Biodiversity Program and President's Committee of Advisors on Science and Technology, Washington, DC.

Anonymous. 2000. Biodiversity action plan for Pakistan: Framework for conserving our natural wealth, Rawalpindi Cantt., Pakistan.

Anonymous. 2001. *IUCN Red List Categories*: Version 3.1. Species Survival Commission. IUCN, Gland, Switzerland & Cambridge, UK.

Anonymous. 2008. IUCN Red List of threatened species, www.iucnredlist.org cited on December 27th 2009.

Chaudri, M.N. and R.A.Qureshi. 1991. Pakistan's Endangered Flora –II. *Pakistan Systematics* 5 (1-2):1-84.

Baggs, J.E. and J. Maschinski. 2000. Annual report on the long-term research on *Purshia subintegra* in the Verde Valley for 1999. Report to Arizona Department of Transportation, Phoenix, Arizona, USA.

Baker, J.G. 1894. Botany of the Hadramaut Expedition. *Bulletin of Miscellaneous Information Kew*, 328-343.

Barbosa, O. and P.A. Marquet. 2002. Effects of forest fragmentation on the beetle assemblage at the relict forest of Fray Jorge, Chile. *Oecologia*, 132: 296-306.

Brenan, J.P.M. 1958. "Notes on Mimosoideae: V". *Kew Bulletin*, 13(3): 407-408.

Davis, S.D., V.H. Heywood and A.C. Hamilton. 1995 *Centres of Plant Diversity: a guide and strategy for their conservation*, Vol. 2 (*Asia, Australasia and the Pacific*). Cambridge: IUCN.

Elfers, R.A., D.G. Grahama P. Dewolf. 1964. Capparidaceae. In: *Flora of Tropical East Africa*. (Eds.): C.E. Hubbard & E. Milne-Rehead. Crown Agents for Overseas Governments and Administration, London.

El-Keblawy, A. and A. Al-Rawai. 2007. Impacts of the invasive exotic *Prosopis juliflora* (Sw.) D.C. on the native flora and soils of the UAE. *Plant Ecology*, 190(1): 23-35.

Engler, M. 2008. The Value of International Trade. *Traffic Bulletin*, 22(1): 4-5.

ESRI. 2006. ESRI World Data, ArcGIS 9.2. ESRI: Redlands, CA.

Ghazanfar, S.A. 1994. *Handbook of Arabian Medicinal Plants.* CRC Press, Boca Raton.

Ghazanfar, S.A. 2003. *Flora of the Sultanate of Oman*, Piperaceae-Primulaceae. Scripta Botanica Belgica. Belgium: National Botanic Garden of Belgium, Meise; 1: 132 & 230.Gillett, 1944

Gillet, J.B. 1941. The plant formation of western British Somaliland and the Harar Province of Abyssinia. *Kew Bulletin*, 37: 199.

Gilliland, H. B. 1952. The vegetation of Eastern British Somaliland. *Journal of Ecology*, 40(1): 91-124.

Govaerts, R. 2001. How many species of seed plants are there? *Taxon*, 50(4): 1085-1090.

Hawksworth, D.L. and M.T. Kalin-Arroyo. 1995. Magnitude and distribution of biodiversity. In: *Global Biodiversity Assessment*. (Ed.): V.H. Heywood. Cambridge University Press**,** Cambridge, UK; 107-192.

Heywood, V.H. and R.T. Watson. 1995. *Global Biodiversity Assessment*. Cambridge University Press, New York.

Hirway, I. and S. Goswami. 2007. *Valuation of Coastland Resources. The Case of Mangroves in Gujrat*. Academic Foundation. India.

Hughes, R.H. and J.S. Hughes. 1992. *A Directory of African Wetlands.* Gland, Switzerland, Nairobi, Kenya, and Cambridge, UK: IUCN, UNEP and WCMC.

Huston, M.A. 1994. *Biological Diversity: The Coexistence of Species on Changing Landscape.* Cambridge University Press, Cambridge.

Jafri, S. M. H. 1958. A note on the taxonomy and distribution of some species of *Cadaba. Pakistan Journal of Forestry*, 8(2): 204-205.

Jafri, S.M.H. 1974. Capparidaceae. In: *Flora of Pakistan*. (Eds.): E. Nasir & S.I. Ali. 71: 1-42.

Kruckeberg, A.R. and D. Rabinowitz. 1985. Biological aspects of endemism in higher plants. *Annual Reviews of Ecological Systematics*, 16: 447-479.

Le Houérou, H.N. and M. Corra. 1983. *Some browse plants of Ethiopia*. In: *Browse in Africa; the current state of knowledge*. (Ed.): H.N. Le Houérou. International Livestock Centre for Africa, Addis Ababa; 109-114.

Levine, J.M., M. Vila, C.M. D'Antonio, J.S. Dukes, K. Grigulis and S. Lavorel. 2003. Mechanisms underlying the impacts of exotic plant invasions. *Proceedings of the Royal Society of London*, 270: 775-781.

McNeely, J.A., M. Gadgil, C. Leveque, C. Padoch and K. Redford. 1995. Human Influences on Biodiversity. In: *Global Biodiversity Assessment*. (Eds.). V.H. Heywood & R.T. Watson. Cambridge: Cambridge University Press and United Nations Environment Programme.

Miller A.G. and M. Morris. 1988. *Plants of Dhofar. The southern region of Oman.* Traditional, economic and medicinal uses. Muscat. The Office of the Advisor for Conservation of the Environment, Diwan of Royal Court Sultunate of Oman, Oman; 90: 307-8.

Miller, A.G. and T.A. Cope. 1996. *Flora of the Arabian Peninsula and Socotra*. Edinburgh: University Press; 376.

Myers, N. 1988. Threatened Biotas: "Hotspots" in tropical forests. *Environmentalist*, 8: 1-20.

Nasir, Y.J. 1991. Threatened plants of Pakistan. In: *Plant Life of South Asia*. (Eds.): S.I. Ali & A. Ghaffar. Shamim Press, Karachi; 229-234.

Noor, M., U. Salam and M.A. Khan. 1995. Allelopathic effects of *Prosopis juliflora* Swartz. *Journal of Arid Environments*, 31(1): 83-90.

Pallewatta, N., J.K. Reaser and A.T. Gutierrez. 2003. Invasive alien species in South-Southeast Asia: National Reports & Directory of Resources. Global Invasive Species Programme, Cape Town, South Africa.

Pasiecznik, N. 1999. *Prosopis* - pest or providence, weed or wonder tree? *European Tropical Forest Research Network Newsletter*, 28: 12-14.

Pieper, R.D. 1994. Ecological implications of livestock grazing. In: *Ecological Implications of Livestock Herbivory in the West*. (Eds.): M. Vavra, W.A. Laycock and R.D. Pieper. Society for Range Management, Denver, CO; 177-211.

Primental, D., L. Lach, R. Zuniga and D. Morrison. 2000. Environmental and economic costs of non-indigenous species in the United States. *Bioscience*, 50: 53-65.

Rabinowitz, D. 1981. Seven forms of rarity. In: *The Biological Aspects of Rare Plant Conservation*. (Ed.): H. Synge. Wiley & Sons Ltd.; 205-217.

Radcliffe-Smith, A. 1973. An account of the genus *Cephalocroton* Hochst. (Euphorbiaceae). *Kew Bulletin*, 28(1): 123-132.

Raffaelli, M., S. Mosti and M. Tardelli. 2003. The Frankincense Tree (*Boswellia sacra* Flueck.) Dhofar, southern Oman: field-investigations on the natural populations. *Webbia*, 58(1): 153-149.

Sala, O.E., F.S. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker and D.H. Wall. 2000. Global Biodiversity Scenarios for the Year 2100. *Science*, 287(5459): 1770-74.

Sudhersan, C., M. Abo El-Nil and J. Hussain. 2003. Tissue culture technology for the conservation and propagation of certain native plants. *Journal of Arid Environments*, 54: 133-147.

Tadesse, M. 1995 New Species of *Iphiona* and *Pentanema* (Compositae: *Inuleae*) from Somalia with a note on *P. indicum* (L.) Ling in Africa. *Kew Bulletin*, 50(2): 401-408.

Thulin, M. 1993. Capparaceae: Cadaba. *Flora of Somalia*, Royal Botanic Gardens, Kew; 1: 48.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips and E. Losos. 1998. Quantifying threats to imperiled species in the United States. *Bioscience*, 48: 607-615.

Wood, J. R. I. 1997. *A Handbook of the Yemen Flora*. (Ed.): J.M. Lock. Royal Botanic Gardens, Kew; 121-122.

Zaidi, I. H. and J. H. Kazmi, 2009. Resurgence of Malaria in Pakistan: A Geographical Evaluation, In: Akhtar, R., Dutt, A., Wadhwa, V. (Ed.) *Malaria in Asia: Eradication, Resurgence and Diffusion. During the Second Half of the Twentieth Century*, Springer-Verlag: New York; 170-190.

(Received for publication 25 May 2009)