

RUELLIA LINEARIBRACTEOLATA: CONSERVATION ASSESSMENT AND STRATEGIES TO AVOID EXTIRPATION

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Abstract

The conservation status of *Ruellia linearibracteolata* Lindau (Acanthaceae), originally considered as endemic to Pakistan, was assessed after four years (2005-2008) of extensive field studies strictly following IUCN categories and criteria 2001. Information was collected and analysed in connection with the distribution range, nature of habitat, population size, mode of reproduction and anthropogenic activities. On these parameters, the conservation status of *Ruellia linearibracteolata* has been classified as rare and endangered (EN) species in Pakistan. Conservation strategies have also been suggested avoiding its extirpation.

Introduction

Plants that makes possible for life to exist on earth are facing as diverse threats as diverse they are. According to USDA Forest Service (1993) extinction of even a single plant species may result in the disappearance of up to 30 other species of plants and wildlife. The plant diversity bolsters resilience-an ecosystem's ability to respond to pressures-offering "insurance" against climate change, drought, and other stresses (Anon., 1992). However, the scenario is quite complicated and leading towards disappearance even before proper recognition and utilization of these valuable plant germplasm.

In the current wave of multiple threats, humans are unable to predict the impact and consequences of plant extinctions. Arroyo *et al.*, (1992) reported that approximately 20% of world biodiversity would be extinct in the next 30 years due to anthropogenic disturbances. The statistics published more than a decade ago reported that "12.5% flora is threatened on the global scale (IUCN, 1998), although it was incomplete information. Later on Pitman & Jorgensen (2002) suggested that around half of the world's flora may be threatened by extinction if assessed according to the IUCN categories and criteria. Moreover, according to Bramwell (2002) that around the year 2050, current rate of extinction will be resulted in the loss of 60,000-100,000 plant species.

In the presence of all these facts, Matthies (1998) described that at global level, attempts to conserve and create populations of endangered plants have received far less attention than the reintroduction of, for instance, large birds or mammals. Unfortunately, very little work has been done on threatened plant germplasm of Pakistan and extremely limited information is available on this subject (Alam & Ali, 2009).

As we are not isolated from the rest of the world, Pakistan's scenario is not different. Due to exploding population, expanding urbanization, increasing deforestation and over-exploitation of natural resources, plant biodiversity is under enormous pressure (Anon., 2000; Ahmad *et al.*, 2005).

The flora of Pakistan is represented by 5521 species distributed in 1572 genera and it is estimated that 7.6% flora of Pakistan is endemic and majority of them are confined to northern Pakistan (Ali & Qaiser, 1986). In 1991, Nasir reported that 580-650 flowering plant species (i.e. 12%) are expected to be threatened. It has been further endorsed by the observations of Chaudhri & Qureshi (1991), who reported 709 taxa as threatened plants from Pakistan. However, both of these conclusions were purely based on literature, without any authentic support of field observations and quantitative data. In

contrast, the recent red data book of IUCN (Anon., 2009) listed only 19 flowering plant species from Pakistan. Of these 2 are vulnerable, 11 least concern, 3 near threatened and remaining 3 were classified as data deficient.

All reports published locally or internationally are revolved around previous work, which was concluded through literature or herbarium specimen, rather than following IUCN red list categories & criteria. Recently, 22 flowering taxa have been evaluated according to the criteria 2001 (Alam & Ali, 2009, 2010; Abbas *et al.*, 2010, 2011; Ali & Qaiser, 2010 a & b). Of these, one taxon is said to be extinct, 2 are regionally extinct, 8 possibly extinct, 8 critically endangered (CR), 1 endangered and 2 taxa are vulnerable. This figure hardly makes 0.4% of the total known flowering plant species of Pakistan.

The precise evaluation of the conservation status of concerned species is considered to be the major step towards avoiding complete disappearance of the species (Vischi *et al.*, 2004). Flora of Pakistan is not protected under any insurance policy and there is a dire need to protect it from disappearance. Genus *Ruellia* L., commonly known as ruellias or wild petunias comprises of c. 250 species in, distributed in tropical and temperate regions of both the hemispheres. The genus is represented in Pakistan by 5 species, of which 3 are native (Malik & Ghafoor, 1988).

Previous workers Ghafoor & Heine (1986) and Malik & Ghafoor (1988) reported *Ruellia linearibracteolata* as *R. sindica* in Flora of Pakistan and classified it as an endemic to this region. However, Kilian *et al.*, (2004) and Thulin (2006) it is also reported from other regions (Fig. 1). Present study was under taken in order to determine the conservation status of the *Ruellia linearibracteolata* in Pakistan.

Materials and Methods

For the assessment of conservation status of *Ruellia linearibracteolata*, comprehensive field studies were planned and conducted for continuously four years (2005-2008) at regular intervals. Habit, habitat, population size, distribution range, impacts of multiple threats like habitat destruction, erosion, fuel wood cutting, grazing, poultry farms and invasive species have been studied.

- Position of sites was noted with the help of global positioning system (GPS, Lowrance, iFinder).
- Distribution range of the taxon was worked out by plotting relevant GPS readings on the map. ArcGIS 9.2 version was used for this purpose.
- Previously known localities and surrounding regions were thoroughly surveyed to determine the exact area of occurrence and range of distribution of *Ruellia linearibracteolata*.

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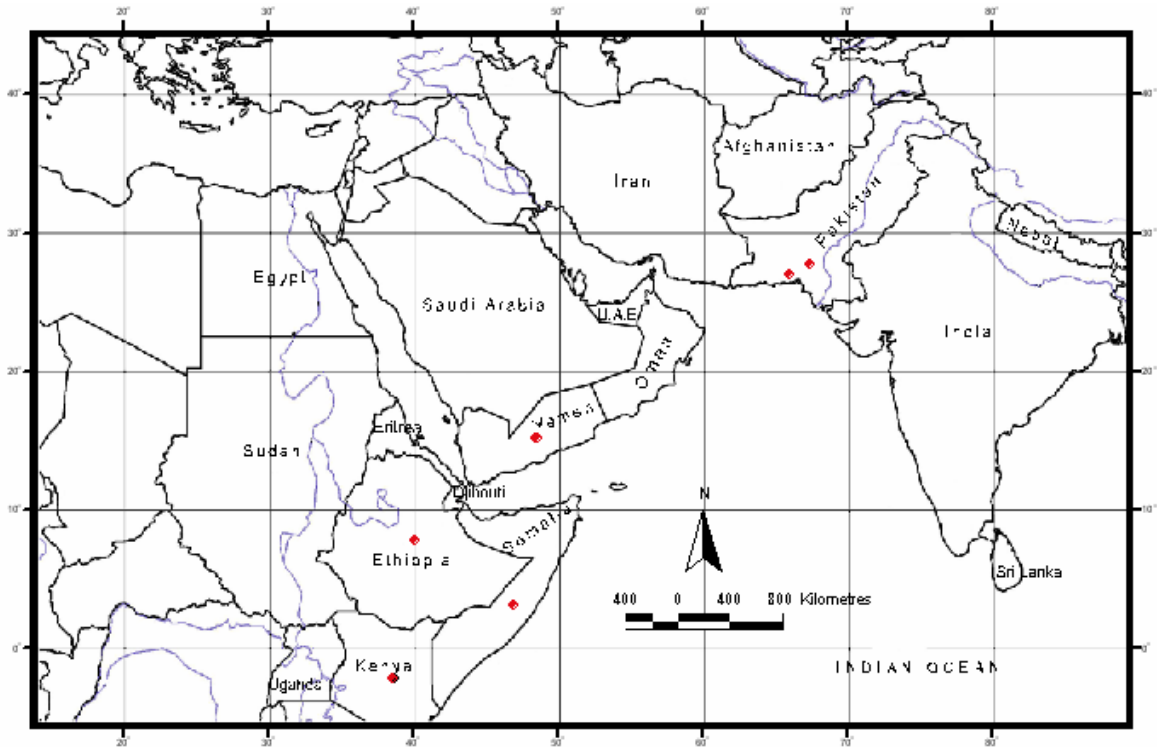


Fig. 1. Global distribution of *Ruellia linearibracteolata*.

(Source of international boundaries: ESRI, 2006)

- The population size was determined by counting the mature individuals. The seedlings were also counted separately.
- Impact of anthropogenic activities, agricultural land utilization, grazing, soil erosion and invasive species in the habitat was observed.
- Habit and life form of all associated species in the habitat was also recorded and classified according to Raunkier's System of Classification (Raunkiaer, 1934).

Information has also been collected from native people regarding the ethno-botanical usage. Collected data were thoroughly analyzed strictly following IUCN Red List Categories and Criteria (Anon., 2001).

Results

Habit, habitat and associated species: *Ruellia linearibracteolata* Lindau is much branched perennial herb, up to 80 cm tall with bluish purple flowers (Fig. 2), mostly found around the edges of calcareous rocky hills, cliffs, slopes and canyons (Fig. 3). *Fagonia brugueiri* DC., *Glossonema varians* (Stocks) Hook.f., *Grewia tenax* (Forssk.) Fiori, *Acacia senegal* (L.) Willd. and *Capparis decidua* (Forssk.) Edgew were found dominant species in the habitat (Fig. 4). In total 37 species were observed as associates in the habitat (Table 1). This included 16 shrubs, 11 herbs, 4 annual herbs and 3 trees. Phanerophytes was a dominant life form (16 species) followed by hemicryptophytes (8 species), chamaephytes (7 species) and therophytes (4 species).

Geographic Range: *Ruellia linearibracteolata* is reported from Pakistan (Ghafoor & Heine, 1986; Malik & Ghafoor, 1988), Yemen (Kilian *et al.*, 2004; Thulin, 2006) and Somalia, Ethiopia and Kenya (Thulin, 2006). Previously, *Ruellia linearibracteolata* was only reported from the surroundings of Sind Industrial Trading Estate Area (S.I.T.E.), Karachi and behind Cereal Disease Research Center (C.D.R.C.), at the campus of University of Karachi (Ghafoor & Heine, 1986; Malik & Ghafoor, 1988). Frequent and detailed field surveys confirm the findings of the earlier workers that the species still grows on the Campus of University of Karachi but due to developmental activities in the industrial area, habitat has been lost. Potential habitats in the areas like Khirthar National Park, Cape-Monze, Dugh/Sujalo at the boarder of Dadu/Thatta Districts and adjoining areas were also thoroughly surveyed in order to determine its distribution in the area. Small and extremely fragile population (i.e. 15 individuals) of the species was found at Cape-Monze (c. 55 km from Karachi City), on the other hand a large but scattered and fragmented population was recorded within and around Khirthar National Park (c. 97 km from Karachi City). Observed Global Positioning System (GPS) coordinates suggested that these localities collectively occupied an area of 1988.88 Km² (Fig. 5).

Area of occupancy: In these localities it was observed that *Ruellia linearibracteolata* grew exclusively around the edges of calcareous rocky hills, cliffs, slopes and within canyons while, no seedlings or mature plants were observed at the base (plains) of the same rocky slopes. In the distribution area, rocky slopes and canyons occupied lesser area as compared to plains.



Fig. 2. *Ruellia linearibracteolata*: A, habit; B, flower; C, fruits.



Fig. 3. A general view of canyon and rocky slope, a typical habitat of *Ruellia linearibracteolata* (A), B, close up.

Population size and mode of reproduction in the wild: Observed population size during study period (i.e. 2005 – 2008) is shown in Table 2. Considering site-wise population size, highest number of individuals was found at site “B” (Doddh /Parimom, 121 km from Karachi while going towards Thana Bola Khan), while at site “A” (Loach/Sari, 97 km from Karachi while going towards Khirthar National Park), 240 individuals were recorded. The highest number of mature individuals was

Habitat degradation: Habitat loss is one of the major threats for this species. The habitat destruction is because of stone excavation and developmental activities in the habitat. Local residents use these stone for making their homes and also supply the stones to the other areas (Figs. 7 B&C).

Agricultural activity: Cultivation of onion (*Allium cepa*) and maize (*Zea mays*) is fairly common in the

found in 2006 i.e. 495 followed by 490, 470 and 470 individuals in 2008, 2007 and 2005 respectively. During the four years studies, seedlings were also observed. The highest number of immature individuals was recorded in 2006 i.e. 39 followed by 33, 30 and 22 individuals in 2005, 2007 and 2008, respectively

Anthropogenic activities: During extensive field surveys following human impacts were observed in the habitat:

Grazing: It is found as one of the major threats, to *Ruellia linearibracteolata*. Habitat is under massive grazing activities of livestock (i.e. goats and camels). Due to demand of milk in Karachi, a cosmopolitan city, the distributors collect milk on daily bases and give handsome amount, which is a motivating factor in maintaining the livestock in the area. Demand of livestock during Eid-ul-Azha, is another reason, to keep the huge number of desired animals. All these livestock depends on the natural vegetation (Fig. 6).

Soil erosion: During the study, many mature and immature individuals were found eroded during heavy rains and thunder storms, because the mostly species grows on the edges of the hills and slopes (Fig. 7A).

Over exploitation for a medicinal purpose: During field surveys and interviews with the local residents, revealed that some of the local indigenous healers (Hakeems) use this plant for curing fever in infants (Local informant).

study area. These agricultural activities though uplift the economic conditions of the locals on one hand, but create negative impact on local vegetation due to habitat loss.

Invasive species: *Prosopis juliflora*, an invasive species, has been observed in the core habitat of *Ruellia linearibracteolata*. During study period, its population has been found gradually increasing, as compared to previous years.

Table 1. Associate species of *Ruellia linearibracteolata* s from 2005 to 2008 along with their habit and life form.

#	Family	Species	Habit	Life form
1.	Acanthaceae	<i>Barleria acanthoides</i> Vahl	Shrub	Chaemaphyte
2.	Acanthaceae	<i>Justicia vahlii</i> Roth	Annual herb	Therophyte
3.	Acanthaceae	<i>Blepharis indica</i> Stocks ex T. Anders.	Annual herb	Therophyte
4.	Amaranthaceae	<i>Aerva javanica</i> (Burm.f.) Juss ex Schultes	Perennial herb	Chaemaphyte
5.	Apocynaceae	<i>Rhazya stricta</i> Decne.	Shrub	Phanerophyte
6.	Asclepiadaceae	<i>Glossonema varians</i> (Stocks) Hook. f.	Perennial herb	Phanerophyte
7.	Asclepiadaceae	<i>Periploca aphylla</i> Decne.	Shrub	Phanerophyte
8.	Asclepiadaceae	<i>Leptadenia pyrotechnica</i> (Forssk.) Dcne.	Shrub	Phanerophyte
9.	Asclepiadaceae	<i>Pentatropis nivalis</i> (Gmel.) Field & Wood	Climber	Phanerophyte
10.	Asclepiadaceae	<i>Calotropis procera</i> (Ait.) Ait.f. subsp. <i>hamiltonii</i> (Wight) Ali	Shrub	Phanerophyte
11.	Asteraceae	<i>Pluchea arguta</i> Boiss.	Shrub	Phanerophyte
12.	Boraginaceae	<i>Heliotropium ophioglossum</i> Stocks ex Boiss.	Perennial herb	Chaemaphyte
13.	Bursereae	<i>Commiphora wightii</i> (Arn.) Bhandari	Shrub	Phanerophyte
14.	Caesalpinaceae	<i>Senna holosericea</i> (Fresen.) Greuter	Shrub	Chaemaphyte
15.	Capparaceae	<i>Capparis decidua</i> (Forssk.) Edgew.	Shrub	Phanerophyte
16.	Capparaceae	<i>Cleome brachycarpa</i> Vahl ex DC.	Annual herb	Therophytes
17.	Chenopodiaceae	<i>Haloxylon stocksii</i> (Boiss.) Benth. & Hook.	Shrub	Chaemaphyte
18.	Convolvulaceae	<i>Seddera latifolia</i> Hochst. & Steud.	Shrub	Chaemaphyte
19.	Convolvulaceae	<i>Convolvulus glomeratus</i> Choisy	Perennial Herb	Hemicryptophyte
20.	Convolvulaceae	<i>Convolvulus scindicus</i> Stocks	Perennial Herb	Hemicryptophyte
21.	Labiatae	<i>Ocimum basilicum</i> L.	Perennial Herb	Phanerophyte
22.	Labiatae	<i>Salvia santolinifolia</i> Boiss.	Perennial Herb	Chaemaphyte
23.	Malvaceae	<i>Pavonia arabica</i> Hochst. & Steud. ex Boiss.	Perennial Herb	Chaemaphyte
24.	Malvaceae	<i>Sida alii</i> S. Abedin	Under Shrub	Chaemaphyte
25.	Malvaceae	<i>Abutilon fruticosum</i> Guill. & Perr.	Perennial Herb	Chaemaphyte
26.	Mimosoideae	<i>Acacia senegal</i> (L.) Willd.	Tree	Phanerophyte
27.	Mimosoideae	<i>Prosopis juliflora</i> (Swartz) DC.	Shrub – Tree	Phanerophyte
28.	Papilionoidae	<i>Tephrosia purpurea</i> (L.) Pres.	Perennial Herb	Hemicryptophyte
29.	Poaceae	<i>Cymbopogon jwarancusa</i> (Jones) Schult.	Perennial Herb	Hemicryptophyte
30.	Poaceae	<i>Paspalidium geminatum</i> (Forssk.) Stapf	Perennial Herb	Hemicryptophyte
31.	Resedaceae	<i>Reseda aucheri</i> Boiss.	Perennial Herb	Hemicryptophyte
32.	Salvadoraceae	<i>Salvadora oleoides</i> Decne.	Tree	Phanerophytes
33.	Scrophulariaceae	<i>Kickxia ramosissima</i> (Wall.) Janchen	Perennial Herb	Hemicryptophyte
34.	Solanaceae	<i>Solanum surattense</i> Burm. f.	Perennial Herb	Hemicryptophyte
35.	Tiliaceae	<i>Grewia tenax</i> (Forssk.) Fiori	Shrub	Phanerophyte
36.	Zygophyllaceae	<i>Fagonia bruguieri</i> DC.	Perennial Herb	Chaemaphyte
37.	Zygophyllaceae	<i>Tribulus terrestris</i> L.	Annual	Therophyte

Discussion and Conclusion

According to various workers in the distribution of *Ruellia linearibracteolata*, is mostly found at the edges of calcareous rocky hills (Ghafoor & Heine, 1986; Malik & Ghafoor, 1988), on silty or gypseous soil or on limestone (Thulin, 2006), while Kilian *et al.*, (2004) reported it on rocky slopes of coastal mountains above the wadi bed. Here in the study area, all possible means were utilized to locate the species in the previously known localities and also in the other adjoining areas for the possibility of new localities.

During field survey, it was mostly observed around the edges of calcareous rocky hills, cliffs, slopes and specifically growing in canyons, and occasionally species was found on silty or gypseous soils. It is interesting to note that during the study period species could not be located in sandy plain area. It mostly grows around the edges of calcareous hills, cliffs, slopes and also in canyons. Hence, it is concluded that, *Ruellia linearibracteolata*, is a habitat specific.

Rarity in a taxon is determined based on its small population, narrow geographic range, or habitat specificity

or a combination of these parameters (Rabinowitz, 1981). Reports from Somalia (Thulin, 2006), suggest that the *R. linearibracteolata* is found on gypseous soil or on lime stone, While in Yemen it was reported from coastal mountains (Kilian *et al.*, 2004). Our results are in agreement with Thulin (2006) as it was mostly observed on the edges of calcareous hills (lime stones) and canyons. It is interesting to note that calcareous hills, cliffs, rocky slopes and canyons in the habitat occupied comparatively less area as compared to plains. Furthermore, the extent of occurrence is quite larger than the occupied area of the taxon due to specific habitat. Hence, presence of majority of individuals in and around specific habitat clearly indicates that this is a rare taxon.

In the present studies *Fagonia bruguieri* DC., was observed as the most prominent associate of the taxon, which was present in almost all the populations. Sometimes *R. linearibracteolata* was located, after observing the populations of *F. bruguieri*, other common associates found in the habitat, included *Grewia tenax*, *Pavonia arabica* and *Glossonema varians*.

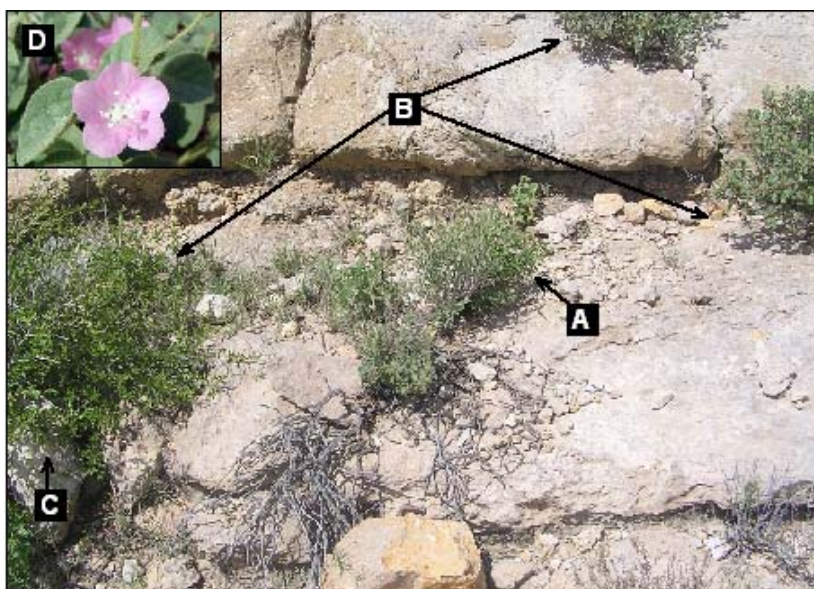


Fig. 4. *Ruellia linearibracteolata* (A), in association with; B, *Grewia tenax*; C, *Commiphora wightii*; D, *Pavonia arabica*.

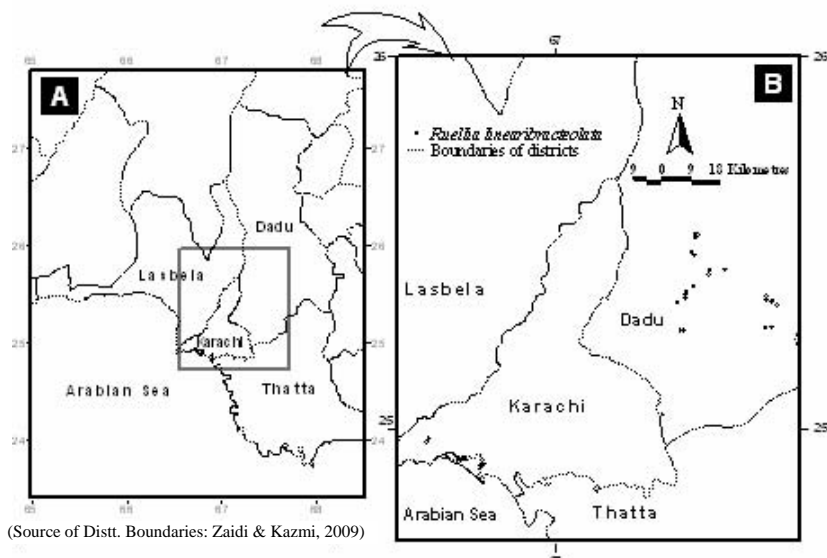


Fig. 5. *Ruellia linearibracteolata* A, study area; B, distribution in Pakistan

As motioned earlier that, grazing on large scale, in the core habitat of the taxon, is playing a vital role in the reduction of its population. Agriculture activities, in the area bring more human inhabitants as labour and number of livestock is rising. Therefore the situation is quite alarming, because these livestock are feeding on the herbaceous flora. Fully grazed plants of the species were observed in the entire area (Fig. 6C). Stone excavation in the habitat is another threat (Fig. 7B). Local indigenous healers are collecting this species for

According to hierarchical alphanumeric numbering system of the criteria (IUCN, 2001), *Ruellia linearibracteolata* can be evaluated for the conservation status. Evaluation can be summarised as follows:

ENB1ab (ii,iii,v); C2a (i).

EN, Endangered; B, Geographic range; 1, Area of Occupancy; a, severely fragmented or known to exist at

making medicines. Invasion of invasive species (i.e. *Prosopis juliflora*) in the study area, is not very severe due to its low population, but its presence, predicts that it will cause problems for local flora in coming years after it is fully established. Isolated, fragmented and habitat specify populations, habitat loss, massive grazing activity in the habitat, erosion of immature individuals and recent establishment of *Prosopis juliflora* in the habitat, are multiple threats, putting tremendous pressure on this rare species.

At the end of study period (2008) conservation status of *Ruellia linearibracteolata* at country level was determined, using IUCN red list categories and criteria (IUCN, 2001). The last observed individuals of the species were 490 mature individuals, as compared to 470, counted in 2005. This figure (490) falls under the criterion "C" of the endangered category. In the case of its partial area of occupancy (for Pakistan) the taxon (1988.88 Km²) is placed under the criterion "B1" of endangered category (i.e. area of occupancy less than 5000 Km²). A continuous degradation of the habitat due to grazing activities, agriculture practices, stone excavation, erosion of immature individuals, invasion of invasive species, habitat specificity and isolated, scattered and fragmented population in the country provide sufficient information to place the taxon under Endangered category (EN).

no more than five location; b, continuing decline, observed, inferred or projected; ii, area of occupancy; iii, area, extent and/or quality of habitat; v, number of mature individuals; C, Population size estimated to number fewer than 2500 mature individuals; 2, continuing decline, observed, projected or inferred, in numbers of mature individuals; a, population structure; i, no sub-population contained more than 250 mature individuals.

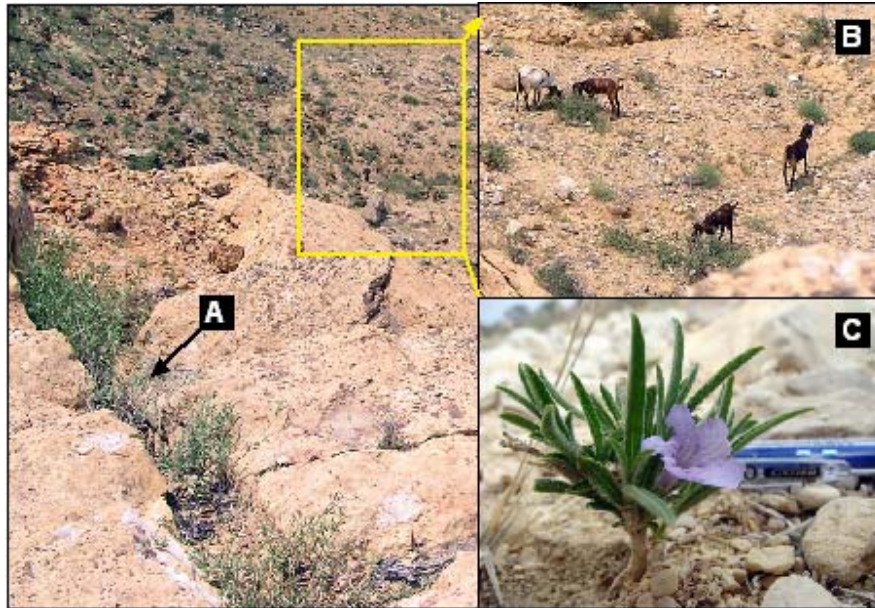


Fig. 6. *Ruellia linearibracteolata* (A); B, close up of the grazing activity in the habitat; C, showing the stunted growth due to over-grazing.

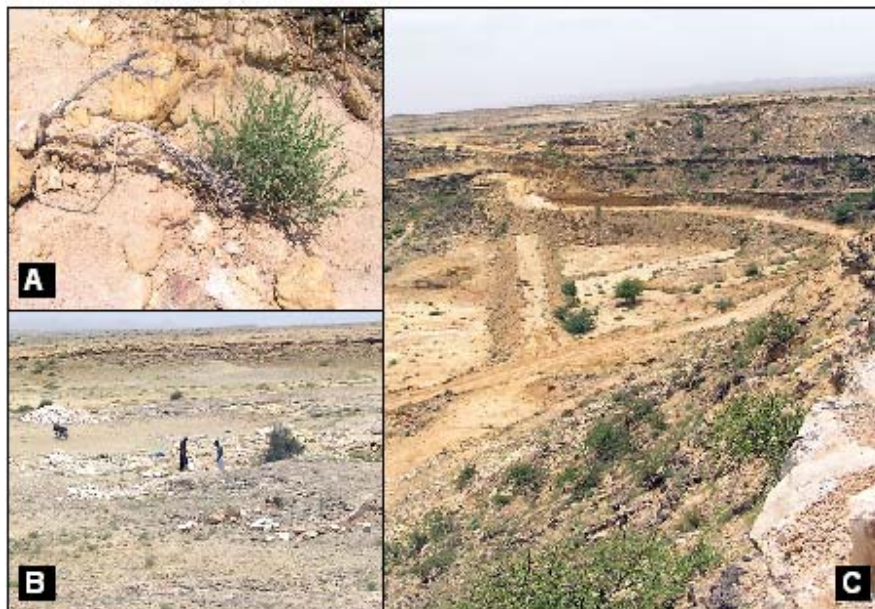


Fig. 7. Threats in the core habitat: A, erosion; B, stone excavation; C, road construction, leading towards habitat loss.

The significance of a rare taxon is not restricted to specific region but its importance and role can be viewed in global perspective. Hence, urgent and practical conservation measures should be adopted to stop further decline in the population of the taxon and possible extirpation.

The significance of a rare taxon is not restricted to specific region but its importance and role can be viewed in global perspective. Hence, following necessary conservation measures should be adopted to avoid its extirpation from Pakistan:

- ✓ *Ruellia linearibracteolata* should be included in the Red Data list of threatened species for Pakistan.
- ✓ Conservation status assessment of the *Ruellia linearibracteolata* should also be initiated in Ethiopia,

Kenya, Somalia and Yemen to assign the category in an international perspective.

- ✓ Efforts should be made to protect the taxon by minimizing the anthropogenic activities in the habitat (i.e. grazing, stone excavation, fuel wood cutting and poultry business).
- ✓ 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.
- ✓ It should be introduced in botanic gardens for public display.
- ✓ It can also be introduced in the horticulture industry as an ornamental plant.

- ✓ The complete biology of the species should be investigated.
- ✓ 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.
- ✓ Permanent monitoring programme should be developed.

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