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Environmental Impact of Invasive Alien Plant *Senna tora (L.)*Roxb

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Abstract: Invasive alien species considerably affect biodiversity by inducing various environmental effects that cause serious socio-economic damages, changes in the species composition, biotic interactions and decrease in ecosystem services. The main challenge in invasion biology is to find out which invasive species will be a threat to biodiversity. Various approaches has been developed nowadays to assess the environmental impact of alien species. *Senna tora* (L.) Roxb. is one of the alien species from Central America. It is non-native to Gangaikondan Spotted Deer Sanctuary, Reserve Forest in Tirunelveli Forest Division, Tamil Nadu. *S. tora* grows vigorously in this region either by deliberate anthropogenic activity or accidental. The impact of this species caused various negative effects on the local ecosystem and has established beyond the place of introduction. Seed germination test of *S. tora* revealed that 98% of the seeds are germinated in earthen pot having garden soil which is kept under greenhouse conditions. Soil test also confirmed that natural condition would favour vigorous growth of *S. tora* that would competitively displace many other native species from this region. Hence, there is an urgent need for another revolution in conservation programme to protect the native species and eradication of *S. tora* in this region.

Keywords: *Senna Tora,* Alien species, Conservation, Ecosystem.

1. Introduction

Invasive alien species (IAS) or non-native species are plants that are introduced by humans from outside of their natural habitats. According to the IUCN Red List of Threatened Species, alien species are one of the main causes of species extinction and loss of global biodiversity. It is a serious threat to livelihood, food security, human health and well-being. It has devastating impacts on native ecosystem causing decline of native species. They reproduce rapidly, out-compete native species for food, water and space (IUCN, 2005).If the genes of invasive species are introduced into habitats with closely related species, they interbreed with native species resulting in changes to the genetic makeup of the species (Secretariat of the Convention on Biological Diversity, 2003). The possible negative consequences of such alterations include reduction in the survival of species or creation of hybrids that could be more susceptible to certain pests and pathogens.

Invasive species can influence species diversity, richness, composition and abundance. At the species level, direct effects of invasive species occur through various processes finally leads to decline in population and species extinctions (Loehle, 2003). Alien species are responsible for placing 762 forest species at risk through direct impacts on species or through alterations of their habitats (IUCN, 2005). Conservation biology is the study of management of nature and status of earth's biodiversity. Its aim is to protect species, their habitats and ecosystems from threatening to extinction. The Ministry of Environment, Forests & Climate Change, Government of India implemented various policies and programmes to conserve the natural resources of our nation. *Parthenium hysterophorus* invades disturbed land and this species has promoted famine in the country. Hence, the Government of India has announced the removal of this species from natural environmental conditions. Tamil Nadu government announced the plan of action to root out *Parthenium* and to create awareness on eradication of *Parthenium* weed in 2011 (The Hindu, 2011).

Senna tora (L.) Roxb. is a rapidly invaded species which occupied more land in Gangaikondan Spotted Deer Sanctuary, Reserve Forest in Tirunelveli Forest Division, Tamil Nadu. This alien species leads to destroy of native species. *S. tora* belongs to the family Fabaceae. It is an economically and ecologically important species with sources of insecticides, gums, oils, timber, dyes, fibre, fuel, medicinal and pulses (Wojciechowski *etal.*, 2004).The useful parts of *S. tora* are leaves, seeds and roots. Seeds contain gum of commercial interest which is used for weight loss and diabetes (Brown and Livesey, 1994). Seed gum can also be used in food, feed, paper, textile, petroleum recovery and pharmaceutical industries.

The leaves contain the major elements needed by human body. The leaves are used as vegetables and medicines for skin diseases and leprosy in India (Jalil and Dixit, 1995).

The roots of *S. tora* showed the presence of 1,3,5-trihydroxy-6-7-dimethoxy-2-methyl anthraquinone and α-sitosterol. Seeds contain naptho-a-pyronetoralactune, chrysophanol, physcion, emodin, rubrofusarin, chrysophonic acid-9-anthrone. The leaves are rich in emodin, tricontan-1-ol, stigmasterol, beta-sitosteral-beta-D-glucoside, palmitic, stearic, succinic and d-tartaric acids, uridine, quercetin and iso-quercetin (Mukherjee, 2002; Soumyanath, 2005).

The flowers are reported to contain kaempferol and leucopelargonidin (Anonymous, 1999). Eventhough *S. tora* possess useful medicinal properties, it is also a threat to native species. With this background, the present study assessed the environmental impact of *S. tora* causingthreat to native species in the Gangaikondan Spotted Deer Reserve Forest. *S. tora* occupied more places and grown rapidly in the present study area. The growth of this plant must be checked properly to conserve spotted deer in the reserved forest.

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2. Materials and Methods

Study Area

Gangaikondan Spotted Deer Reserve Forest is located in Gangaikondan Panchayat, Tirunelveli Taluk, Tirunelveli District, Tamil Nadu covering an area of 288.40 hectares. It is the southernmost habitat for Spotted Deer in India. The Department of Forest, Government of Tamil Nadu has decided to convert it into a full-fledged Spotted Deer park and an extended area of about 441.16 hectares between Gangaikondan and Thazhaiyuthu has been declared as protected areas to protect deer which is facing serious threat from poachers. They are also being hit by speeding vehicles on the adjacent Tirunelveli-Madurai four lane National Highway when they move out of their habitat in search of food and water. The topography of the present study area consists mainly of rocky surfaces and hilly terrain. Since predator population is completely absent in this area, it has resulted in significant increase in spotted deer population, but has triggered scarcity with regard to food and water. Despite scaling the compound wall on the western side of the habitat and laying of wire fence on the other three sides, the spotted deer are now migrating to the surrounding areas upto Abhishekapatti where they face serious threat from poachers and street dogs. Due to the present situation, the Department of Forest has drawn up a new plan for establishing a deer park at Gangaikondan habitat housing around 450 spotted Deer.

Impact of Senna Tora

The population of invasive alien species *S. tora* has increased in and around areas of Spotted Deer Park. The impact of this species will destroy other native plants present in the study area. Hence, an environmental assessment approach has been used to study the soil profile, seed germination, pollen morphology, cytology of *S. tora.* The native species in the Gangaikondan Spotted Deer Reserve Forest which is affected by *S. tora* are also studied at 10x10 squarer fit areas by three quadrats based on random sampling method.

3. Results and Discussion

The physico-chemical properties like soil colour, lime status, soil pH, exchangeable bases and macronutrients present in the soil are studied and tabulated in Table 1.

Table 1: Soil analysis in *S. tora* habitat

Soil colour	Lime Status	pH	Exchangeable bases (m.mhos/c.ml)				Macronutrients (Kg/acre)		
			Ca	Mg	Na	Mn	N	P	K
Red	Medium	7.5	11.0	1.5	0.9784	0.5482	125	25	425

Electrical Conductivity (EC) is a measure of amount of salinity in soil. Cation exchange capacity (CEC) is a measure of the total negative charges within the soil that adsorb plant nutrient cations such as calcium (Ca^{2+}) and magnesium (Mg^{2+}). CEC is a property of a soil that supplies nutrient cations to the soil solution for plant uptake. Addition of fertilizer to soil causes an initial increase in nutrient concentration in the soil solution, which results in nutrients moving toward clay particles.Soil Base Saturation Percentage (BSP) plays an important role in the assessment of soil taxonomic classification and soil fertility. The presence of excessive amounts of exchangeable sodium (ESP) reverses the process of aggregation and causes soil aggregates to disperse into their constituent individual soil particles. Table 2 showed the values of EC, CEC, BSP, ESP, percentage of soil texture and organic matter content present in the soil.

Table 2: Different parameters studied in the soil of *S. tora*

EC dsm^{-1}	CEC (m.mhos/cm)	BSP	ESP	Ca:Mg ratio	Soil texture (%)			Organic matter content (%)	
					Sand	Clay	Slit	Carbon	Organic matter
0.09	15.6	84.51	5.56	3.1:1	58.2	36.7	5.1	0.6703	1.1556

EC - Electrical Conductivity; CEC - Cation Exchange Capacity

BSP - Basal Soil Particle; ESP - Exchangeable sodium Percentage

The results of various parameters studied in the soil test revealed that natural condition is favourablefor vigorous growth of *S. tora* that would competitively displace many other native species from the present study region. Seed germination test of *S. tora*alsorevealed that 98% of the seeds are germinated in earthen pot having garden soil which is kept under greenhouse conditions (Table 3).

Table 3: Effect of PGR treatment on seed germination of *S. tora* (after 3rd day)

Type of treatment	No. of seeds tested	Duration of the treatment	% of germination	Length of Shoot (cm)	Length of Root (cm)
Control	20	24 hours	98	2.0	1.7
BAP (0.1 mg / 100 ml)	20	24 hours	40	2.5	1.0
2,4-D (0.1 mg / 100 ml)	20	24 hours	-	-	-

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The cytological studies also confirmed that the percentage of fertile pollen grains is 93.60 and under the right conditions, the pollen can double in number. The size of the pollen grain is 104.40 µm. The haploid (gametophyte) chromosome number is 28 and the diploid (sporophyte) number is 56. Due to the aggressive growth of *S. tora* in the present study area, the native species belonging to different families face a serious threat to survive. The spotted deer present in the forest survive in this region only with the help of native species and is now unable to forage for food. Totally, 58 native species were affected by *S. tora* and their IUCN status is tabulated in Table 4 and Plate 1.

Table 4: List of native species affected by *S. tora*

S.No	Botanical Name	Family	IUCN status
1.	*Abrus precatorius* L.	Papilionaceae	Common
2.	*Ageratum conyzoides* L.	Asteraceae	Least Concern
3.	*Alysicarpus vaginalis* DC.	Papilionaceae	Common
4.	*Andropogon pumilis* Roxb.	Poaceae	Common
5.	*Anisomeles malabarica* R.Br.	Lamiaceae	Common
6.	*Apluda mutica* L.	Poaceae	Common
7.	*Aristida adscensionis* L.	Poaceae	Common
8.	*Aristida setecea* Trin.	Poaceae	Common
9.	*Asparagus racemosus* Willd.	Liliaceae	Least Concern
10.	*Barleria cristata* L.	Acanthaceae	Common
11.	*Biophytum sensitivum* DC.	Oxalidaceae	Common
12.	*Boerhavia diffusa* L.	Nyctaginaceae	Common
13.	*Brachiaria ramosa* (L.) Stapf.	Poaceae	Common
14.	*Bulbostlis barbata* C.B.Clarke.	Poaceae	Common
15.	*Calotropis gigantea* R.Br.	Asclepiadaceae	Common
16.	*Canthium parviflorum* Lam.	Rubiaceae	Common
17.	*Capparis spinosa* L.	Capparaceae	Threatened
18.	*Cardiospermum halicacabum* L.	Sapindaceae	Common
19.	*Carissa carandas* L.	Apocynaceae	Common
20.	*Cleome viscosa* L.	Capparaceae	Common
21.	*Commelina benghalensis* L.	Commelinaceae	Common
22.	*Corchorus aestuans* L.	Tiliaceae	Common
23.	*Crotalaria angulata* Mill.	Papilionaceae	Common
24.	*Ctenolepis garcinii* (Burm. f.) Naud.	Cucurbitaceae	Common
25.	*Curculigo orchiodes* Gaertn.	Hypoxidaceae	Threatened
26.	*Cyanotis axillaris* (L.) D. Don	Commelinaceae	Common
27.	*Cyperus rotundus* L.	Cyperaceae	Common
28.	*Datura metel* L.	Solanaceae	Common
29.	*Digitaria bicornis* Roem. & Schutt.	Poaceae	Common
30.	*Eragrostis tenella* P.Beauv.ex M.Roemer	Poaceae	Common
31.	*Evolvulus alsinoides* L.	Convolvulaceae	Common
32.	*Gloriosa superba* L.	Liliaceae	Least Concern
33.	*Hemidesmus indicus* (L.) R.Br.	Asclepiadaceae	Common
34.	*Indigofera tinctoria* L.	Papilionaceae	Common
35.	*Justicia procumbens* L.	Acanthaceae	Common
36.	*Kyllinga brevifolia* Rottb.	Cyperaceae	Common
37.	*Lepidogathis pungens* Wall ex. Wight	Acanthaceae	Common
38.	*Leucus aspera* Lam.	Lamiaceae	Common
39.	*Leucus biflora* (Vahl.) Sm.	Lamiaceae	Common
40.	*Merremia tridentata* (L.) Hall.f.	Convolvulaceae	Common
41.	*Mollugo cerviana* Ser.	Aizoaceae	Common
42.	*Mollugo nudicaulis* Lam.	Aizoaceae	Common
43.	*Ocimum americanum* L	Lamiaceae	Common
44.	*Ocimum tenuiflorum* L.	Lamiaceae	Common
45.	*Orthosiphon thymiflorus* Sleensen	Lamiaceae	Common
46.	*Pavonia odorata* Willd	Malvaceae	Common
47.	*Phyllanthus amarus* L.	Papilionaceae	Common
48.	*Phyllanthus maderaspatensis* L.	Papilionaceae	Common
49.	*Rivea hypocrateriformis* Choisy	Convolvulaceae	Common
50.	*Scleria lithosperma* (L.)Sw.	Cyperaceae	Common
51.	*Sida acuta* Burm.f.	Malvaceae	Common
52.	*Sida cordifolia* L.	Malvaceae	Common
53.	*Solanum surattense* Burm.f.	Solanaceae	Common
54.	*Spermacoce hispida* L.	Rubiaceae	Common
55.	*Tephrosia purpurea* Pers	Papilionaceae	Common
56.	*Toddalia asiatica* Lam.	Rutaceae	Common
57.	*Vernonia cinerea* (L.) Less.	Asteraceae	Common
58.	*Xanthium indicum* Roxb.	Asteraceae	Common

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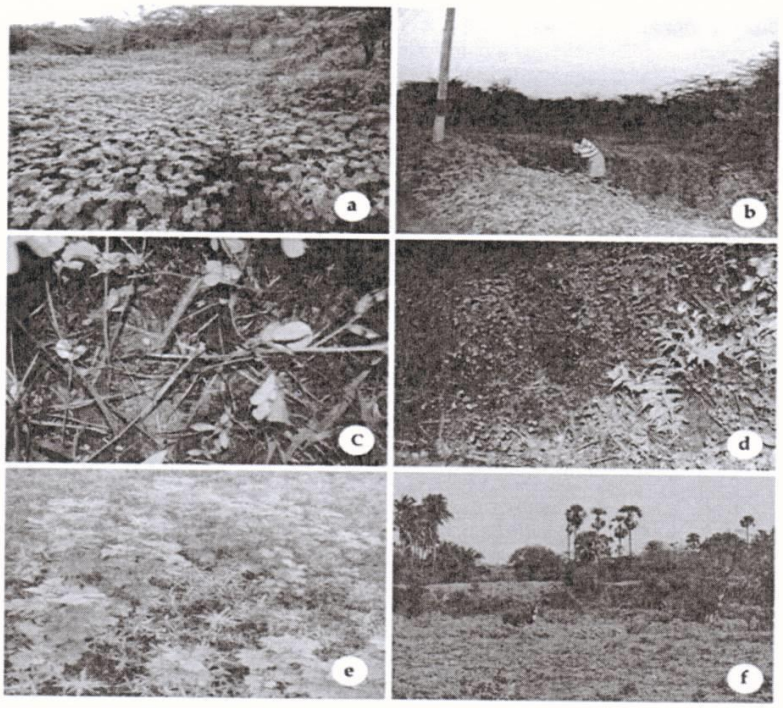
Plate 1: Environmental Impact of Invasive Alien Plant Senna Tora (L.) Roxb



a) Vigorous Growth of Alien Plant S. Tora; b) Removal of Alien Species; C-E) Native Species Present in the Study Area; f)Spoted Deer Foraging for Food

Invasive species are serious threats to the forest department in many aspects.The impact of alien invasive species will continue in forests not only at the biological level but also at policy level by the Government. The forest sector has long been considered as a victim due to invasive species and there is growing evidence. The solution to this vigorous growth of alien invasive species will come from local and national actions with regard to early warning systems, eradication and control attempts as well as increased awareness and political pressure (Mooney and Hobbs, 2000). The other part of the solution requires bilateral, regional and international efforts, since the issue of alien invasive species is global in scope. Numerous international and regional programmes have been developed to address the problem of alien invasive species.

In order to prevent and reduce the harmful effects of invasive alien species, an interdisciplinary approach is required that incorporates biological, ecological and social sciences, economics, policy analysis, decision sciences, informatics and engineering (FAO, 2003). It is also clear that introduced species have many positive impacts leading to sustainable development and negative impacts in loss of native species. Such conflicts of interest require a balanced analysis of the costs and benefits of the introduction of alien species which will help strengthen policy and management decisions (Chornesky *et al.*, 2005). The present study results suggest that these kind of invasive species cause serious threats to natural ecosystem and food chain. This must be properly integrated into existing sustainable forestry to reduce the impacts of alien invasive species.

4. Conclusion

The native species mentioned in the present study is used as fodder for deer in the study area. Hence, there is an urgent need for another revolution in conservation programme to protect the native species in this region and also proper eradication of *S. tora* is essential to conserve these species. The following findings were recommended to Tirunelveli forest division to conserve native speciesin Gangaikondan Spotted Deer Reserve Forest.

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