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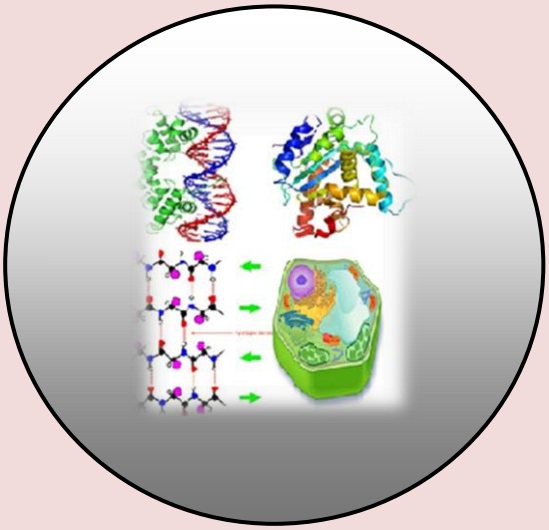

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RESEARCH PAPER
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Impacts of *Prosopis juliflora* on Vegetation of Aravalli Hills of Ajmer (Rajasthan)

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ABSTRACT

The Aravalli hills in Ajmer are located in the almost centre of the Rajasthan. The area studied has high endemic plant diversity which also includes some endangered species. The invasive alien species Prosopis juliflora commonly known as vilayti babool is causing enormous damage to biodiversity of Aravalli hills in general, and in Ajmer region in particular. The branching pattern of P. juliflora prevents sunlight to reach the under canopy vegetation thus hampering their growth. It is also lowering the water table due to excessive evaporation. Further, it harms the soil productivity by releasing various phytochemicals like flavonoids, steroids, tannins, phenolic compounds, hydrocarbons and alkaloids etc. These phytochemicals play an important role in plant defense mechanism of herbivory but may also have negative impact on the native plant species by affecting the germination and growth of other plant species. The results indicate that the P. juliflora has visible adverse impacts on native plant diversity.

Keywords: Aravalli Hills, Invasive Alien Species, Plant Biodiversity, Endemic and Phytochemicals.

INTRODUCTION

The Aravalli hills range runs diagonally across the state of Rajasthan extending from Champaner in Gujarat in the south-west to near Delhi in the north-west for a distance of about 692 km. Within Rajasthan, the range runs from Khed Brahma in the south west to Khetri in the north-east for a length of about 550 km. with the elevation of the Aravalli hill gradually rising in the south-west direction due to changes in climatic and edaphic factors, the vegetation pattern and floral composition also get altered. Ajmer district (Latitude is 26^0 27' 7.56" North and Longitude is 74^0 38' 19.21" East) is in the north-west of India and almost in the centre of the state of Rajasthan, India. The total geographical area of Ajmer district is 8481 Km^2. The western parts of the district, from South-west to North-west, are intersected by the Aravalli hills. To the northwest of Ajmer Naagpahar range of the Aravalli hills are situated, which protect it from desertification from the Thar Desert. The surface topography is rocky and broken with weakly developed granular to crumby structures.

It has mainly scrub vegetation which merges to some extent with the deciduous type due to this it has vast spectrum of flora (vegetation) and fauna, which make it a treasure of the unique biodiversity. Therefore, this region also provides an interesting case study because of its topographic complexity, edaphic conditions and variability in climate together with varied biodiversity.

The climate of this region varies from very hot summer to relatively moderate winter. The summer (March to June) is generally very hot with the temperature reaching up to 42°C. Monsoon (July to September) starts generally in the last week of June and intermittently continues up to September with the average annual rainfall of about 520 mm and average rainy days of 20 to 25; winter extends from November to February with the coldest month being January and the mean daily minimum temperature of around 8°C. The vegetation of this region of Aravalli falls under the category of Dry Deciduous Forests (ICAR-NRCSS, Ajmer). The *Prosopis juliflora* (Sw.) DC. commonly known as vilayti babool, vilayti kikar and honey mesquite etc. belongs to family Leguminoseae (Fabaceae), is a noxious invasive alien species that is native to Central and South America, Mexico and Caribbean (Orwa *et.al*., 2009). Currently, it occurs as invasive weed in many countries including India. It is an evergreen, medium sized (~10-12 m height and ~1m girth) thorny tree with a large spreading crown, deep taproot (~20m) and extensive lateral root system. In Northern India, *P. juliflora* was introduced in the arid and semi-arid tracts of Rajasthan to check desertification (Mwangi *et al*., 2008) but now it has become a noxious weed and occupying vast area of arid and semi-arid zones.

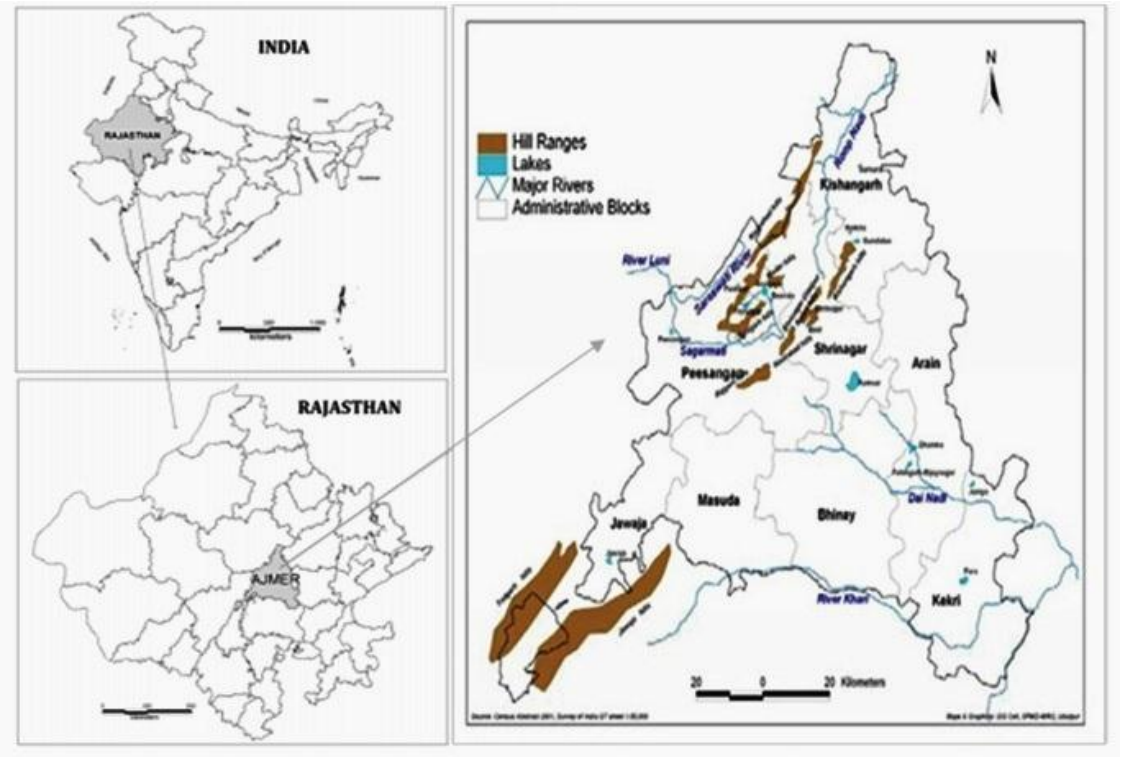

Figure 1. Location map of Aravalli hills in Ajmer district.

In 2004 *P. juliflora* was rated one of the world's top hundred least wanted species (Invasive Species Specialist Group of the IUCN, 2004). The spread of invasive alien species is recognized as one of the most important global scale problems experienced by the natural ecosystems. They are causing enormous threat to biodiversity of the natural ecosystems (Wakie *et al.,* 2016). Arrival of non-native species may occur either through accidental introduction or purposeful import for human utility and the successful invasion of alien species depends on characteristics of the invaded habitat as well as capability of invasive plant in question.

The aim of present research work is to assess the impact of *P. juliflora* on local plant community composition. The presence of invasive plant species *P. juliflora* affects local plant community composition and its diversity and ground vegetation cover due to increased competition for resources and by producing some photochemicals (Kumar S. *et al*., 2014). This could be investigated by comparing the composition, diversity and ground vegetation of area invaded by *P. juliflora* with that one which is not invaded by *P. juliflora*.

METHODOLOGY

The sampling was performed in 5 different sites namely Taragarh hills, Naagpahar, Goramji, Nasirabad hills and Nareli hills of Ajmer District and estimation of species content was made by observing the plant species at all the sample sites. Surveys were undertaken two to three times in a season. The studies of different sites were done with the help of different quadrats. At each site vegetation was sampled in Ten (each 10 x 10 m) quadrats. Numbers of individuals of each ligneous species were counted in these quadrats and the identification of flora was made with the help of "Flora of Rajasthan" (Sharma and Tiagi, 1979 and Shetty & Singh, 1987) and "Flora of Indian desert" (Bhandari, 1990).

The data so collected were analyzed for computing Importance Value Index (IVI). IVI helps to depict the sociological structure of a species in its community. As a function of relative density, relative frequency and relative abundance IVI was calculated to know dominance and association of species. (Cottom and Curtis, 1956)

IVI = Relative frequency + Relative density + Relative dominance

For the further study of the impact of *P. juliflora* on local phytodiversity, the phytochemical studies have also been undertaken. For this purpose, the plant materials were collected from the investigation sites of Aravalli hills in the Ajmer district.

Extract of each plant part of *P. juliflora* was made by soaking 20 grams of the powdered plant parts in 250ml of double distilled water and kept in orbital shaker for 24 hrs in a closed Erlenmeyer flask for continuous agitation. The extracts were then filtered by using Whatmann No.1 filter paper. The solvent from the extracts were removed by using rotary vacuum evaporator. The extracts obtained were labeled and stored at 5°C for further use.

The Qualitative Phytochemical screenings of extracts were done according to the standard methods of Harborne (1973), Trease and Evans (1989), Sofowara (1993), Tiwari *et al*. (2012) and Mariajancyrani (2014).

RESULTS AND DISCUSSIONS

The impact of *P. juliflora* on the vegetation of Aravalli hills of Ajmer district is shown in Table 1. It is observed that *P. juliflora* starts branching closer to the ground. This makes under canopy seedling establishment difficult as a result of a physical barrier created by lower branches. Even though the branching angle of *P. juliflora* is not greater, its branches stretch out sideways and intercept each other. This results preventing sunlight to reach to the under canopy vegetation, lowering the water table and by releasing various chemicals that may have negative effect on the native plant species.

In the present observations, a few species such as such as *Acacia leucophloea, Dichrostachys cinerea, Azadirachta indica, Grewia tenax, Anogeissus pendula* and *Boswellia serrata,* appeared to be associated with *P. juliflora* which represent elements of the degraded formation of dry deciduous forests. Similarly, at the other sites without *P. juliflora* had a presence of plants namely *Balanites aegyptiaca, Commiphora wightii, Capparis decidua, Diospyros melanoxylon*, *Cassia auriculata* and *Euphorbia caducifolia*, recognized as dominant associates.

In addition, the sites without *Prosopis juliflora* supported *Acacia senegal, Acacia jacquemontii, Butea monosperma, Cassia auriculata and Phoenix dactylifera,* all representing late successional stages, and all these species were in reduced number on the sites with *P. juliflora*. On the other hand, sites invaded with *P. juliflora* had other species such as *Salvadora persica*. It can therefore be, inferred that on the sites occupied with *P. juliflora*, the climax species and a higher order serial species slowly deteriorates and disappears leaving behind only unpalatable, thorny species as associates of *P. juliflora.* Further, impact of *P. juliflora* on endangered species *Commiphora wightii* revealed that as the density of *P. juliflora* increased, that of *C. wightii* declined. Such decline in density therefore, making it vulnerable to local extinction.

Figure 2. Photographs showing impact of *Prosopis juliflora* on vegetation of Aravalli hills.

The success of *P. juliflora* is largely attributed to the high number of seeds produced and their efficient dispersal mechanisms. It start flowering at three-four years of age and flowering and fruiting take place three times in a year: In February-March, August-September and November-December. In addition, it has fast growing ability, attractive and rewarding pods, dormancy period of seeds and seeds maintaining viability in the droppings of livestock and wild animals, resistance to browsing, incredible ability of re-sprouting and fast coppice growth are some of the main causes for the prolific spread of *P. juliflora*. The Phytochemical analysis of the water soluble extracts of root, stem, leaves, flower and pod of *P. juliflora* is shown in Table 2. The results show the presence of very high amount of phytochemicals like alkaloids, tannin, steroid, cardiac glycoside, flavonoids, terpenoids and phenolic compounds etc in *P.juliflora.* Different parts of plant have different consistency of these phytochemicals wherein the leaves and pod extracts exhibited greater phytotoxicity than the other plant parts. The detrimental effect of these phytochemicals is known as Allelopathy. These exudates produced by one living plant species known to have effect on the germination, growth or development of other plants sharing the same habitat.

As a result of this, the plant diversity including the number of individual plants of a species and the number of species around *P. juliflora* is affected by the allelochemicals. *P. juliflora* was invading all the habitat types observed in the area and visibly (Fig. 2) changing many of these into *P. juliflora* dominated shrub lands. Considering the harmful impacts of *P. juliflora*, government of Rajasthan recently has taken a policy decision to totally eradicate this invasive plant from the wildlife sanctuaries and such protective areas of the state.

Table 1. Relative Importance Value Index of some selected plants.

Plant	Invaded	Un-invaded
Acacia catechu	1.4	4.3
Acacia leucopholea	4.2	4.75
Acacia nilotica	9.5	11.3
Acacia senegal	32.5	38.75
Anogeissus pendula	38.3	47.2
Balanites aegyptiaca	7.4	13.3
Boswellia serrata	26.3	32.5
Bridelia retusa	3.4	9.56
Butea monosperma	3.3	3.8
Capparis deciduas	3.1	5.2
Cassia auriculata	16.8	23.1
Commiphora wightii	4.3	6.75
Cordia crenata	1.2	5.0
Dalbergia sissoo	5.9	8.2
Ehretia laevis	4.35	21.9
Euphorbia caducifolia	34.7	42.75
Ficus arnottiana	17.1	26
Grewia tenax	3.4	4.0
Lannea coromandeliana	2.8	6.7
Mallotus philippinensis	4.0	10.1
Salvadora persica	7.2	8.4
Securinega leucopyrus	8.8	12.3
Spermadictyon suaveolens	4.1	5.3
Ziziphus nummularia	12.2	16.8

Table 2. Phytochemical screening of various parts of *Prosopis juliflora.*

Plant parts / Phytochemicals	Root	Stem	Leave	Flower	Pod
Alkaloids	+	-	+++	++	+++
Cardiac Glycoside	-	-	+	-	+
Flavonoids	++	+	+++	+++	++
Pholbatannins	-	-	-	-	-
Steroids	+	+	+++	+	++
Tannin	++	-	+	-	+
Phenolics	++	+	+++	+++	+++
Terpenoids	++	+	+++	+	++

(+++ = high; ++ = moderate; + = low; - = absent)

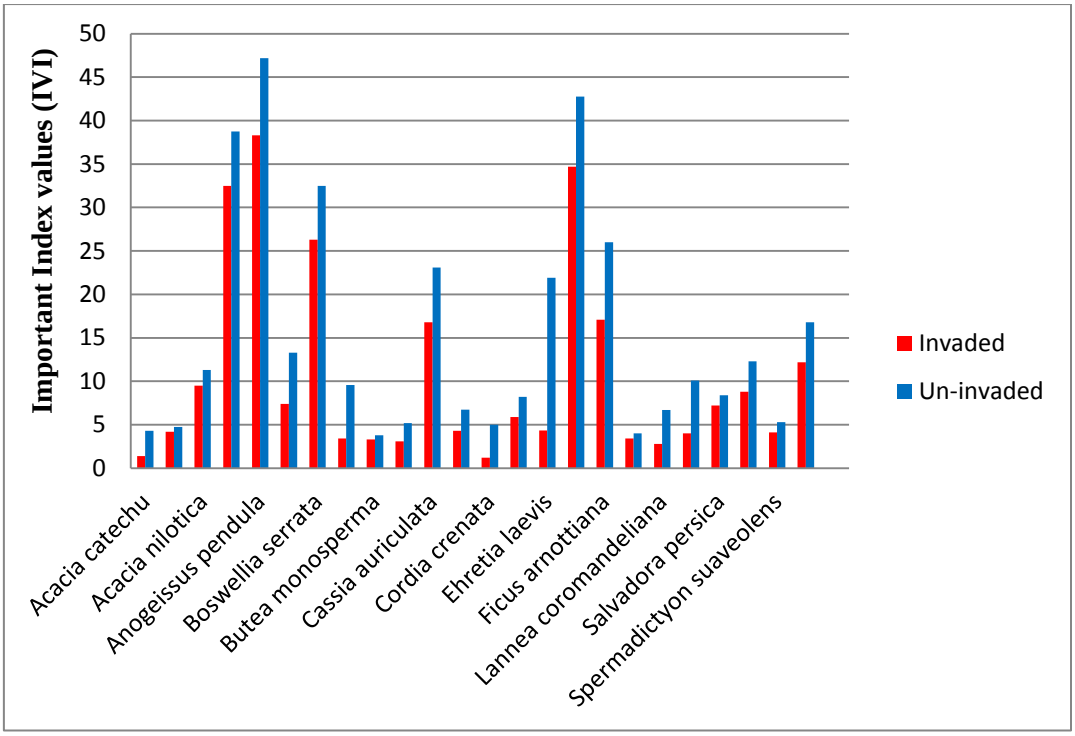

Figure 3. Showing IVI of some selected plant of the invaded and un-invaded areas by *Prosopis juliflora*.

CONCLUSION

From the available evidences it becomes clear that *P. juliflora* have both positive as well as negative impacts. This dual cost nature of *P. juliflora* creates conflict of interests among stakeholders. Therefore, during the management of *P. juliflora* a uniform management policy cannot be adopted. Aggressive invasion of *Prosopis juliflora* results in suppression of native bio-diversity and species richness of habitats such as pastures, woodlands and arable lands. It is proven that *P. juliflora* survives in a wide range of environments and is one of the most successful invasive species in the Aravalli hill ranges. It has high amount of allelochemicals which hinder the germination and growth of other plants. The plant parts of *P. juliflora* have various phytochemicals in variable amounts but the phytotoxcity of leaves are found to have highest impact due to the presences of very high amount of phytochemicals in them. This invasive plant has now well established in the local ecology in major parts of Ajmer and became a dominant species.

The invasion of *P. juliflora* has harmed native flora of Aravalli hills and it has proved dreadful to the native species. Currently, this invasive weed occupies vast areas of land and further continues to expand its establishment because of its high invasive potential. The control of this plant may help in protection and restoration of lost biodiversity. *P. juliflora* is among the most invasive species in hot semiarid and arid regions of the world, and our results indicate that this invader has substantially stronger impacts on native diversity of Aravalli hills of Ajmer. This may be one of the reasons for low plant diversity observed in the *P.juliflora* infested fields. It can be concluded that the species richness was approx 65% lower under *P. juliflora* canopy than in the open fields. The observations of present research will act as baseline data for Aravalli hills range in Ajmer to understand the patterns and impacts of *P. juliflora* on local flora.

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