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Impact of Invasive shrub species (*Cassia Spp.*) on Plant Diversity and Insect Abundance in Grasslands from Solapur region

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Abstract

Invasion of a species is termed as introduction of species to the foreign land or to the foreign community, either intentionally or unintentionally. *Cassia tora* and *Cassia uniflora* are native from tropical South America, invaded in India. The present study is an attempt to investigate the probable impact of the *Cassia spp.* on the overall plant diversity and insect abundance.

The results of current investigation represents that there was a strong negative correlationship in between overall plant diversity and *Cassia spp.* cover (Pearson correlation value: -0.991; p = 0.001). The strong negative correlationship was also found between the insect abundance and the *Cassia spp.* cover (Pearson correlation value: -0.986; p = 0.002). Which shows that there is strong positive correlationship between overall plant diversity and the insect abundance (Pearson correlation value: 0.966; p = 0.007); which was represented by the quadrates with higher plant diversity represented with higher insect abundance. Such species becomes a challenge for the policy makers in conservation as many native species are being affected by them hence more detailed studies required for interpreting the impact of invasive species on native community dynamics and controlling their growth and dispersal which is important for protected area management.

Keywords: Invasive Species, *Cassia Spp.*, Grassland, Solapur.

Introduction

Invasive alien species is one of the major challenges faced by wildlife managers; on many occasions reduced cover of native food plants because of increased cover of invasive species became one of the reasons for straying out of wild herbivores over long distances in search of food (Mathur *et al.* 2015). Biological invasion is becoming a pressing threat to native biodiversity, most of the successful alien species often spread over a new range in a very short time scale (Hengeveld, 1989; Weber, 1998). Mostly invasive species fail to survive or reproduce in foreign conditions but some of them flourishes by overcoming the challenges in foreign lands like climatic conditions, competitors due to their evolutionary traits that they bear (Kleunen *et al.* 2010, Davidson *et al.* 2011) like allelopathy, fire adaptation, phenotypic plasticity etc. Such Invasive Alien Species (IAS) has a potential to breed successfully and to colonize at the communities or places where they have invaded. These species can affect the native community dynamics by competing with native species for the resources at various trophic levels. Such species may become mostly dangerous to the endemic species with small biogeographic range. But their success does depends upon their adaptability to environmental conditions, phenotypic plasticity, niche breadth and interactions with competitors, predators etc.(Maron JL, Vil`a M., 2001). The species richness decreases with increase in the density of the alien species (Meiners *et al.*, 2001); the level of decrement in species richness is larger if there is an invasion of exotic species than the native one. Invasion of native species in case have less impact on the species richness, because of traits of native competitors that coevolved over time through various types of inter species interactions; most of them will disappear over time after invasion (Meiners *et al.,* 2001).

The interaction of insects with plants is mostly non-obligatory, as major insects rely on plant species for food but in some cases it is obligatory as they also pollinate plants; this reflects there should be a strong positive correlationship between diversity of plants and the diversity of insects. The abundance of herbivores increases with the increase of plant species richness, plant biomass, and predator and parasitoid abundance (Haddad et al., 2001). There is strong positive correlationship between plant biomass and the abundance of chewing insects, mostly generalist species like locusts and grasshoppers. Higher plant species richness may increase availability of resources, like more number of host plants within a functional group for herbivores as well as vegetative and floral resources or both to the insect species (Price et al., 1980; Powell W., 1986). The insects belonging trophic group of predators also shows a positive response to plant species richness (Haddad *et al.*, 2001). More the diversity in plants avails more structural complexity which may increase prey and predator populations by availing more niches (Root, 1973; Letourneau, 1990; Marino and Landis, 1996).

The present study was undertaken to investigate the impact of invasive shrub species *Cassia tora* and *Cassia uniflora* on overall plant diversity and insect population from the grasslands of Solapur region. Once which was home for the largest population of grassland obligatory species like critically endangered bird Great Indian Bustard (*Ardeotis nigriceps*) in Maharashtra State; now facing many threats because of habitat fragmentation and changes in land use pattern. *Cassia tora* and *Cassia uniflora* both are native to tropical South America introduced in India nearly in early 1960's (Singh, 1979; Raghavan, 1980; C. Sudhakar Reddy , 2008; Reddy *et al.* 2008). *Cassia Spp.* normally found to be distributed in clumps, in quarried areas, temporary water logged areas and along roads in grasslands of the study area. Mostly found mixed vegetation of both species *Cassia tora* and *Cassia uniflora*. The change in plant community over variation in *Cassia Spp.* cover along with its impact on insect abundance was studied during the one life cycle of *Cassia Spp.*, which generally starts on onset of monsoon to till December. Studies from the Solapur region were mainly focused on plant taxonomy, also recorded both invasive species (*Cassia Spp.*) from the area (Janakiraman J. and Jalal J.S. 2015, Garad *et al.*2015) but never investigated their ecological impacts on native species. Such data is very important to predict the possible impacts of invasive species on community structure and ecosystem functioning.

Methodology

Study Site: The study was conducted in grassland patches near Great Indian Bustard sanctuary (Latitude: N 17°44'00'', Longitude: E 75°50'00'') (Fig.1). The study area lies in Biogeographic Zone 6 (Deccan peninsula), Province 6B (Chhota Nagpur). The region has extensive patches of grassland with intervening bare grounds covered with exposed rocks and stones, soil types in this area are light Soil locally known as *Malraan* soils, medium black Soil and black cotton soil. The terrain is slightly undulating with hills having gentle slopes with average elevation of 470m. The rainfall in area majorly occurs in south-west monsoon June to September and some part in post monsoon or retreating monsoon season in October and November, the average rainfall in this region is between 600-650 mm, with humidity averaging at 60%. The average temperature varies between 11°C in winter to 44°C in summer. The vegetation of the area is classified as Type 6 -Tropical Thorn Forest, Subgroup 6A/C1 – Southern Tropical Thorn Forest as defined by Champion and Seth (1968).

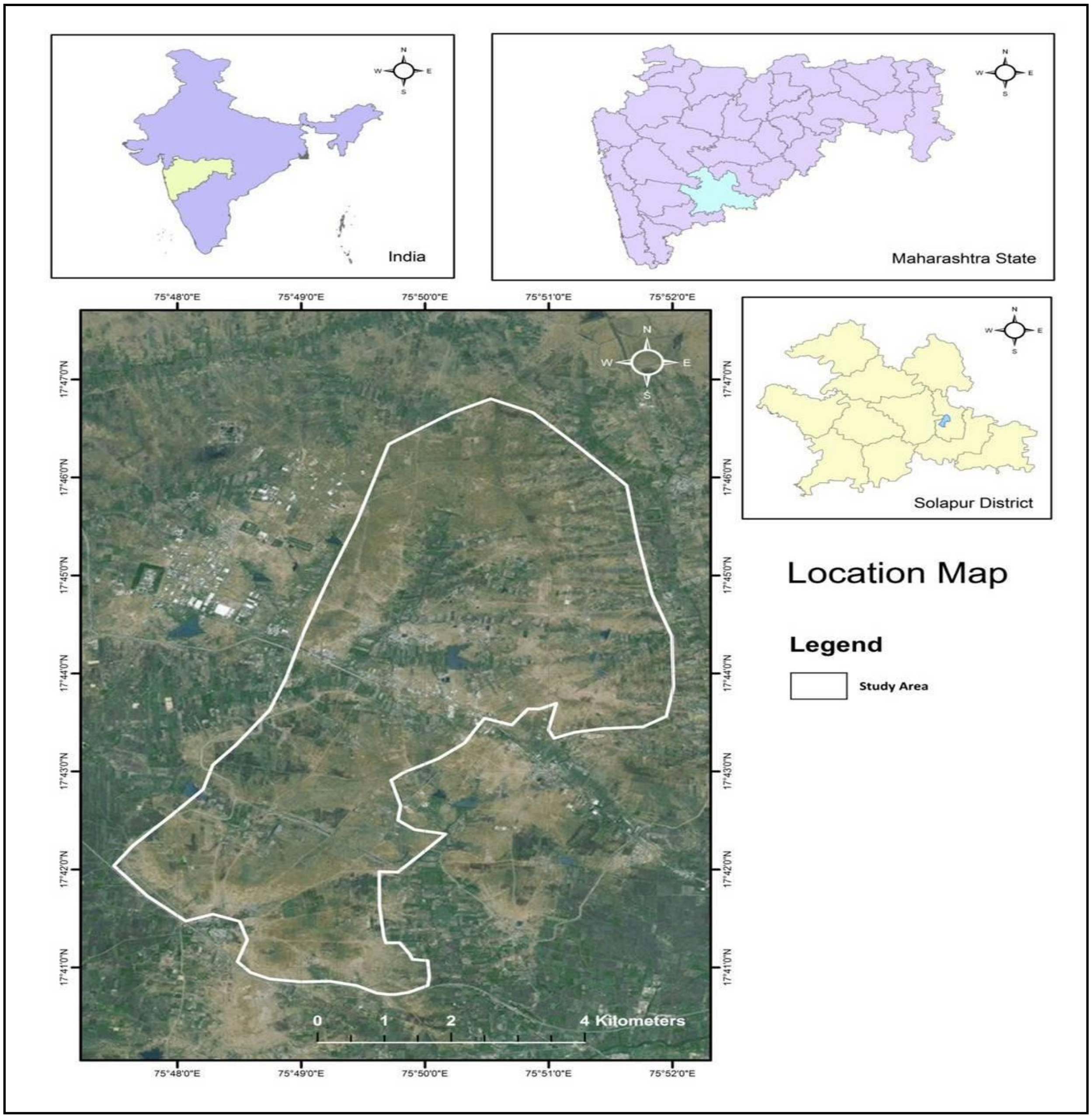

Figure 1: Study area – Great Indian Bustard Sanctuary

Data Collection: There are various methods to collect plants and insects (Sutherland, 1996). These methods are designed and developed for rapid and reliable sampling that will provide data to evaluate local species richness and abundance at given time (Coddington *et al*., 1991, 1996). The plants and insects were studied with quadrate method, further the insect abundance was estimated by employing the sweeping and active searching methods. To estimate possible impact of invasive plant species on insect abundance, the generalist insect orders like arthropods (grasshoppers and locusts), arachnids (Spiders) and Coleoptera (Beetles) were selected as there is positive correlationship between plant diversity and insect abundance (Haddad et al., 2001). The quadrates were classified in five categories with none or zero to increasing Invasive Alien Species (IAS) *Cassia Spp.* cover viz. 100% native plant covered quadrate (NAT) or 0% *Cassia Spp.* cover, 10-30 % *Cassia Spp.* cover, 30-50% *Cassia Spp.* cover, 50-70% *Cassia Spp.* cover and 70-90% *Cassia* covered quadrates. The study was commenced on onset of monsoon continued to till end of life cycle of *Cassia* species spanning six months ie. From July to December. Monthly three surveys were conducted to study the plant species composition and insect abundance throughout study area.

Sampling Design: The quadrates were selected randomly over the study area. The quadrate size for insect abundance data was selected 10×10 meters for sampling as after it insect abundance from the quadrate tend to reach asymptote; within the same quadrate, sample size of 1×1 meter was selected for estimation of plant diversity, 10 such samples taken from each quadrate. During each sample survey one quadrate per cover classification of *Cassia Spp.* was surveyed to produce data regarding the plant diversity and associated insect abundance data over time in the study area. The total of 90 quadrates were surveyed during study spanning six months included three surveys per month and one quadrate for each of five cover classification types per sample survey.

Data Analysis: A total of 90 quadrates were plotted and the species richness of plants and insect abundance was estimated by pooling all samples. Statistical analysis was carried out by using Past Statistical Software (Hammer, et al, 2001) and the correlation analysis was done with Minitab14 Software Package.

Result

Plant Diversity: A total of 84 species representing 24 families are recorded from the study area. Compared to total richness recorded in study area (Family: 24, Genus: 63 Species: 84) the community dominated with native vegetation shown highest diversity (Family: 23, Genus: 62 Species: 82). The diversity decreased gradually as increase in area covered by invasive *Cassia spp.* (Figure. 2).

The significant difference was found in overall plant diversity among study plots (P=0.0008) when tested with kruskal-Wallis test based on Mann-Whitney pair wise comparisons. Diversity measurements varied well between five types of study plots. (Table.1). The study plots without *Cassia spp.* recorded highest Shannon indices (4.407), while 70-90% *Cassia Spp.* covered study plots recorded lowest (3.045). The Simpson index too was highest at the study plots with *Cassia spp.* absent or 0% *Cassia* cover (0.9878) compared to 10-30% (0.9851), 30-50% (0.98), 50-70% (0.9667) and 70-90% (0.9524) *Cassia Spp.* covered study plots. The dominance was found to be highest at 70-90% *Cassia Spp.* covered study plots (0.04762) and lowest at study plots without *Cassia spp.* (0.0122).

When plant diversity was analyzed using cluster analysis across the five types of study plots (Figure. 3), the dendrogram shows that the 50-70% and 70-90% *Cassia Spp.* covered study plots are isolated from other three types of study plots and forms a separate clade. The study plots without *Cassia spp.* and 10-30%, 30-50% *Cassia spp.* covered study plots are clustered in a separate clade within this clade study plots without *Cassia spp.* and 10-30% *Cassia spp.* covered study plots formed a separate clade.

When analyzed with SIMPER an analysis of dissimilarity, overall dissimilarity based on plant diversity among the various types of study plots was found to be 34.5%, while study plots without *Cassia spp.* and 70-90% *Cassia Spp.* covered study plots shown highest dissimilarity of 63.11%. The lowest dissimilarity found to be 12.75% among study plots without *Cassia spp.* and 10-30% *Cassia Spp.* covered study plots. The significant negative correlationship (Pearson correlation value: -0.991; p = 0.001) was observed between plant diversity and *Cassia Spp.* cover.

Insect abundance: The insect abundance was gradually decreased with increase in cover of *Cassia spp.*(Figure. 2). The significant difference was found in insect abundance among study plots (P=0.04643) when tested with kruskal-Wallis test based on Mann-Whitney pair wise comparisons.

When insect abundance was examined using cluster analysis, across the five types of study plots (Figure. 4), the dendrogram shows that the 50-70% and 70-90% *Cassia Spp.* covered study plots are isolated from other three types of study plots and forms a separate clade. The study plots without *Cassia spp.* and 10-30%, 30-50% *Cassia Spp.* covered study plots are clustered in a separate clade within this clade study plots with 30-50% and 10-30% *Cassia Spp.* covered study plots formed a separate clade.

When analyzed with SIMPER an analysis of dissimilarity, overall dissimilarity based on insect abundance among the various types of study plots was found to be 29.85%, while study plots without *Cassia spp.* and 70-90% *Cassia Spp.* covered study plots shown highest dissimilarity of 51.10%. The lowest dissimilarity found to be 23.10% among study plots without *Cassia spp.* and 10-30% *Cassia Spp.* covered study plots. The significant negative correlationship (Pearson correlation value: -0.986; p = 0.002) was observed between insect abundance and *Cassia Spp.* cover.

The significant positive correlationship (Pearson correlation value: 0.966; p = 0.007) was observed between insect abundance and plant diversity, which was resulted in greater insect abundance with lesser *Cassia Spp.* cover.

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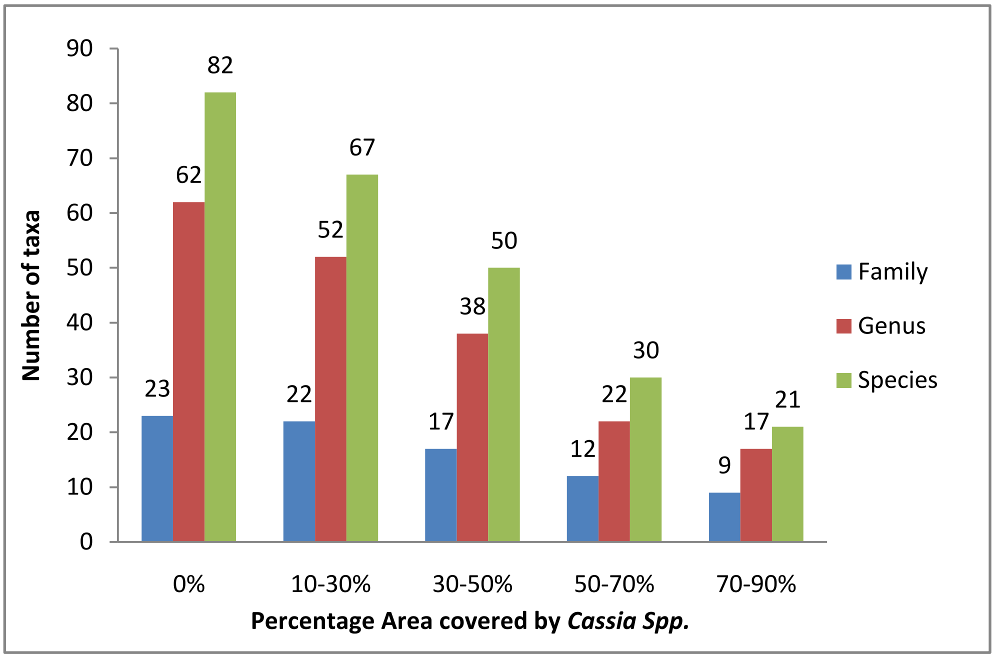

Figure 2: Plant diversity in various study plots

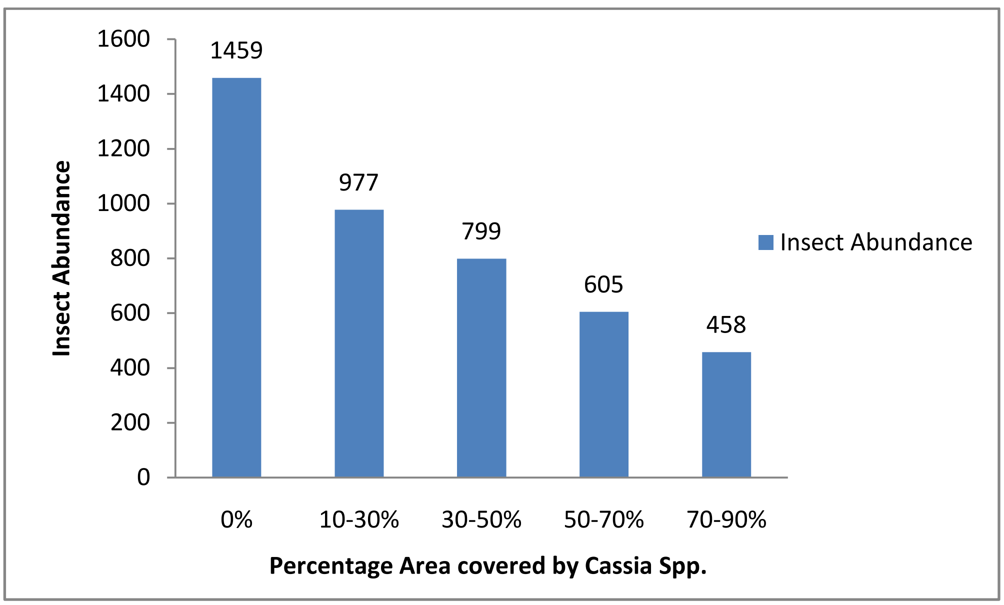

Figure 3: Insect abundance in various Study plots

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Table 1: Diversity Indices for plant diversity in various study plots

Percentage *Cassia* Cover	0%	10-30%	30-50%	50-70%	70-90%
No. of Taxa	82	67	50	30	21
Dominance_D	0.0122	0.01493	0.02	0.03333	0.04762
Shannon_H	4.407	4.205	3.912	3.401	3.045
Simpson_1-D	0.9878	0.9851	0.98	0.9667	0.9524
Margalef	18.38	15.7	12.53	8.526	6.569

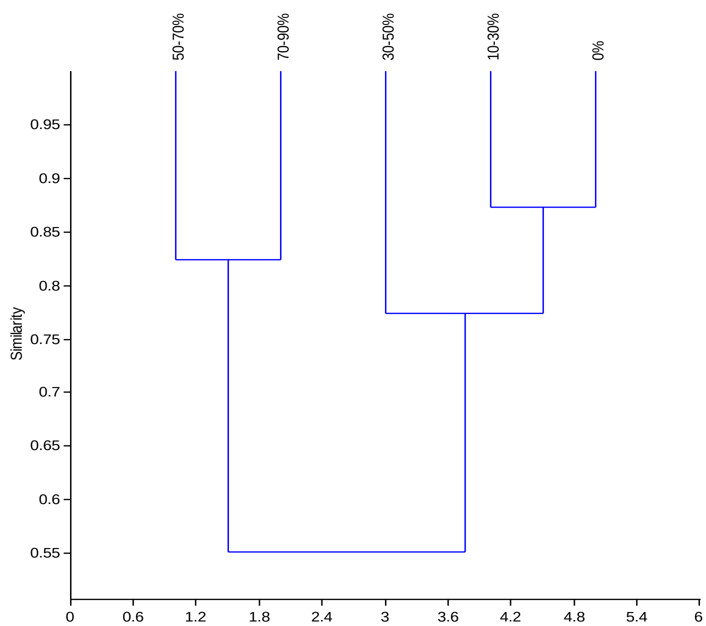

Figure 4: Cluster analysis based on plant diversity across study plots (Based on Brey-Curtis similarity indices).

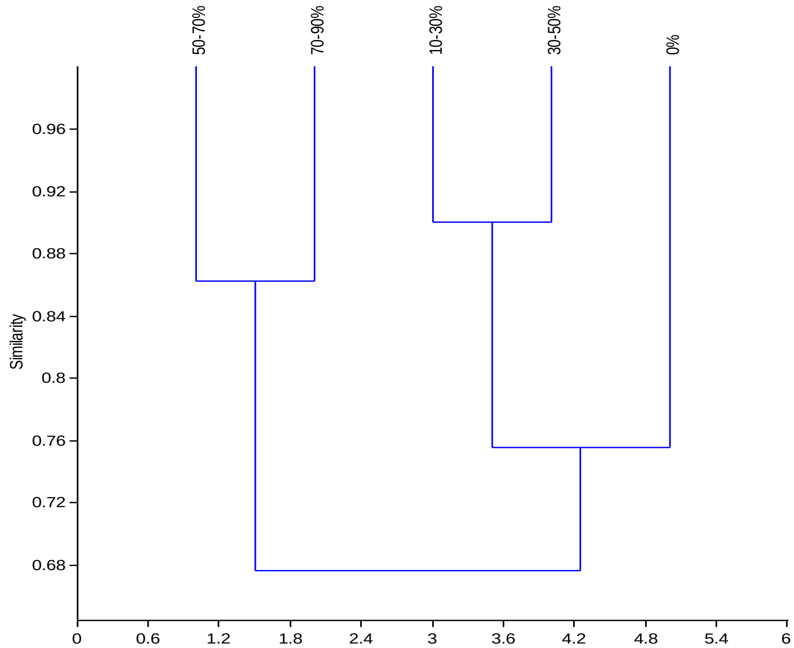

Figure 5: Cluster analysis based on insect abundance across study plots (Based on Brey-Curtis similarity indices).

Discussion

Invasive alien species may become unfavorable or favorable to the native species (Bezemer *et al.* 2014), it mostly depends upon inter species relationship where evolutionary traits of native species, their adaptability and interaction with invasive one matters a lot for their success or failure. The impacts of invasive species are often categorized in either positive or negative but the interpretation is relatively simple, with reduced number of species diversity and abundance there is negative impact while otherwise for positive vice versa. Even though the chances of successful breeding and colonization of invasive species are very less in foreign conditions if does happens, the climax community will be dominated by Invasive species in absence of strong resource competitor and predator species.

Alien species or invasive species all are negative for local native species is a part of scientific debate as many focuses on negative impacts and positive impacts of such species remains unnoticed. In an Indian scenario either the *Lantana camara* in forests of India, *Prosopis julifera* in Kevladeo Ghana National park, in Kutch or water hyacinth (*Eichhornia crassipes*) in aquatic ecosystems affected negatively the native species (Mathur *et al.* 2015, Munjpara *et al*. 2012, Mukherjee *et al*. 2017). *Cassia uniflora* bears allelopathic properties that may affect the seed germination and seedling growth (Joshi S., 1991) that may affect growth and development of plants surrounding it. It was observed that the plant diversity was gradually decreased with increase in *Cassia spp.* cover in study plots resulting in significant reductions in species richness (P=0.0008), causing the negative impact of *Cassia spp.* on plant diversity. The study plots with 0% and 70-90% of *Cassia spp.* cover have shown highest level of dissimilarity (63.11%) means these communities became well separated in species composition than others because of alterations caused by *Cassia spp*.

The changes in the chemical and structural complexity in native habitats caused by invasive alien plants can alter the foraging behavior and dispersal abilities of native insects (Bezemer *et al.* 2014), which reflected in the results as the insect abundance among the study plots was varied significantly. Higher species level diversity in plants resulted in higher structural diversity of habitat and vegetation are known to support diverse fauna (Greenstone 1984, Wise 1993) by providing more number of niches, finer microhabitats and more food resources (Nyffeler and Sunderland 2003, Langellotto and Deno 2004). This is represented in the strong positive correlationship between the plant diversity and the insect abundance in the study area (Pearson correlation value: 0.966; p = 0.007). Through the effects of association between plants and insects; the invasive plants can influence interactions between insects and native plants (Bezemer *et al.* 2014). The higher percentage cover of invasive *Cassia* species in *Cassia Spp.* dominated community affected negatively the plant diversity in community as the correlationship between the *Cassia Spp.* cover and plant diversity have shown strong negative correlationship (Pearson correlation value: -0.991; p = 0.001); it is also affected the insect abundance in the area as the correlationship between the *Cassia Spp.* cover and insect abundance have shown strong negative correlationship (Pearson correlation value: -0.986; p = 0.002).

Conclusion

On the basis of the results of present study we may conclude that the invasive plants *Cassia tora* and *Cassia uniflora* have negatively affected the local plant diversity and the insect abundance in the area by affecting the local community structure. Along with the habitat fragmentation and habitat loss because of increasing agricultural area, urban sprawl, internal roads, stone quarries, increasing industrialization; the invasive alien species is also becoming a pressing threat for the local biodiversity. The impacts of the invasive alien species not only represented serious hazard on community level but also represent a serious hazard on landscape scale (Hulme and Bremner 2006); hence to study their control measures and effective management is became important for sake of conservation of native species.

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