

Emerging Pattern of Arthropod Assemblages, Biomass and Damage on Native and Non-Native Plant Species

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ABSTRACT

Assemblages of arthropod on non-native plants are thought to be an important factor contributing to the success of non-native plants. It is hypothesized that there is a difference in the arthropod abundance, biomass and damage between native and non-native plant species. The study investigates arthropod abundance, richness, trophic guilds, arthropod biomass and damage on naturally occurring dominant monocultures of taxonomically close related native (*Plectranthus mollis* - Lamiaceae) and non-native (*Hyptis suaveolens* - Lamiaceae) plant species and taxonomically distant native (*Justicia adhatoda* - Acanthaceae) and non-native (*Lantana camara* - Verbenaceae) plant species across five sites in India.

A total of 2,697 arthropods were estimated belonging to 14 taxonomic orders. It was interesting to observe that average arthropod abundance per plant among native and non-native plant species did not differ. Principal component analysis exhibited that insect orders separate out according to their presence and abundance on plant species. Arthropod biomass and damage caused by herbivores on selected native and non-natives plant species was also not significantly different. Predator abundance was high on non-native *H. suaveolens* than native *P. mollis* indicating the potential attribute of plant relatedness and role of arthropod trophic guilds assemblages on native and non-native studies. Plant relatedness and arthropod trophic guilds emerged as a key component determining arthropod assemblages on native and non-native plant species. The emerging pattern of arthropod in non-native dominated environments will narrow the gap for habitat restoration.

Key words: arthropod diversity, herbivory load, non-native plants, trophic guilds, plant relatedness.

INTRODUCTION

Assemblages of arthropod on non-native plants are seen as an important factor that contributes towards the success of non-native plants (Keane and Crawley 2002). The impact of changing arthropod community is multidimensional which results in altered nutrient cycling, functional guilds and outcompetes the native arthropods (Houghton et al. 2019). Abundant non-native plants outcompete native plants for resources resulting in decline of native plants (Vil'a et al. 2011, Litt et al. 2014). Non-native plants abundance acts as a driver for the decline or even extinction of many insect species (Strong et al. 1984, Tallamy 2004, Bellard et al. 2016). Reducing the spread of non-native plants is suggested as a way to reduce decline in insects (Tallamy et al. 2020). Although, certain generalist insects prefer to use and perform fairly well on abundant non-native plants (Herrera et al. 2011). Sunny et al. (2015) suggest increase or decline of insects may be associated with check/facilitation of

non-native plants through herbivory and pollination respectively. It is also reported that native and non-native plant species richness is considered as a strong predictor of insect abundance (Liebhold et al. 2018). Recent review by Harvey et al (2020) and Samways (2020) suggest that little attention has been paid to the insect decline in the past and have suggested that insect decline are indirect impacts of non-native vegetation.

Although many studies have reported variable results e.g., no difference, in herbivore abundance among non-native and native plant species in Switzerland (Dawson et al. 2014), lesser biomass of herbivores on non-native than native plant in USA (Ballard et al. 2013) and a greater herbivore abundance on non-native, *Senecio madagascariensis* than native, *Senecio pinnatifoliush* plants in Australia (Harvey et al. 2013). Variability in interactions can make alterations in community assemblage. Such alterations can be understood through arthropod assemblages/load which is quantified as the total

number of arthropods present on non-native plants (abundance, richness and biomass) and damage is quantified as the total amount of leaf surface area removed by herbivores on native and non-native plants (Engelkes et al. 2012, Carpenter and Cappuccino 2005). Information generated through such pattern studies would be useful to understand community assemblages in dynamic communities.

Plant species relatedness could be one of the attributes that could affect arthropod assemblages and thereby alter the plant species communities (in terms of native and non-native) drastically. Plant species relatedness and the way arthropod communities assemble on native and non-native plant could explain the pattern of community dynamics (Strong et al. 1984, Engelkes et al. 2012). Plant species relatedness here implies the taxonomic similarity based on phylogenetic distance among the plant species. If the phylogenetic distance of the plant species are closer, the plants are more closely related and vice versa (Burns and Strauss 2011). There have been studies suggesting that arthropod assemblages tend to exist on more closely related plant species than distant related plant species (Strong et al. 1984, Ødegaard et al. 2005). Abundance of insects on taxonomically distant and close related native and non-native plant species will provide insights on the drivers of non-native plant species abundance.

Increase or decrease of arthropod load and herbivory on non-native plants can potentially check non-native plant invasion (Maron and Vila 2001). As increase in arthropod load on non-natives may result in impeded growth of non-natives due to increased herbivory. Non-native plants resource will be invested more in defense rather than propagation and range expansion. On the other hand, lesser assemblages of arthropods on non-native plants species may help in its successful establishment, colonization, and naturalization (Keane and Crawley 2002). It is hypothesized that there is a difference in the arthropod abundance, biomass and damage between native and non-native plants species. The study intends to investigate the role of increase and decrease of arthropod load and herbivory on non-native plant species. Arthropod biomass, arthropod abundance and leaf damage together may draw more concise conclusions towards invasiveness of non-native plant species. Such studies from developing nations are scarce especially from India.

The objectives of the study were thus to 1) estimate the abundance and richness of arthropod communities on native and non-native plant species, 2) compare the arthropod assemblage on taxonomically distant and close (plant relatedness) native and non-native plant families, 3) quantify arthropod trophic guilds (herbivores, predators and detritivores) on native and non-native plant species. The study also compared arthropod biomass, and damage caused by herbivores on a selected native and non-native plant species. Pattern of arthropod community will be a key indicator of the environmental change and will potentially narrow the knowledge gap for habitat restoration.

MATERIALS AND METHODS

Study sites

Arthropod assemblages study was conducted across five sites in India viz. Amarkantak (22°36' to 22°47' N and 81°43' to 81°46' E); Bilaspur (22°36' to 22°43' N and 81°45' to 81°46' E); Dehradun (30°10' to 30°19' N and 78°06' to 78°14' E); Delhi (28°32' to 28°41' N and 77°10' to 77°12' E) and Goa (15°19' to 15°24' N and 74°01' to 74°12' E) in peak growing period of plant species during 2015 and 2016. Sampling was done within tropical deciduous region and within the region the climatic condition remains the same (Bullock et al 1995, Singh and Chaturvedi 2017). Since insect community dynamics is also dependent on spatial distribution of native and non-native species (Clem and Held 2018), site selection was based on identification of dominant stands of native- *Justicia adhatoda* (Family: Acanthaceae) and *Plectranthus mollis* (Lamiaceae) plant species and non-native- *Hyptis suaveolens* (Lamiaceae) and *Lantana camara* (Verbenaceae). Arthropod biomass and herbivore damage estimates were narrowed down within Delhi's green spaces.

Study system

We chose native *Justicia adhatoda* (Acanthaceae) and non-native *Lantana camara* (Verbenaceae) as taxonomically distant species for comparisons in our study. While, native *Plectranthus mollis* and non-native *Hyptis suaveolens* belonged to the same family i.e., Lamiaceae were taken as taxonomically close related plant species. The species were selected on the basis of abundance and plant relatedness, such

that two taxonomically distant (*J. adhatoda* and *L. camara*) and two taxonomically close (*P. mollis* and *H. suaveolens*) native and non-native plant species are synchronous in presence of the above species at all the sites. Although it is difficult to encounter non-native and native taxonomically related plant species within the same vicinity, sampling was conducted keeping in mind that these species lie within close vicinity so that insect interaction could be understood in same light.

Co-occurring non-native plant species *Lantana camara* (Family: Verbenaceae) and native plant species *Justicia adhatoda* (Family: Acanthaceae) were selected for investigating arthropod biomass and herbivore damage. *L. camara* is regarded as one of the world's as well as India's worst plant invader (Sharma et al. 2005). While, *J. adhatoda* is native to India and spread throughout the tropical regions of Southeast Asia (Claeson et al. 2000).

Arthropod assemblages

Plants were sampled for arthropod assemblages as described by Yela and Herrera (1993) and for estimation of invertebrates, i.e., by beating the foliage (Yela and Lawton 1997). A total of 520 plant individuals were sampled across the 5 sites with an average of ~100 plants per site (native and non-native plants). Plants that were nearly similar in height i.e. (1m average) were selected for beating method. Each plant was thoroughly observed to see if any flying insect was sitting on it. The numbers of insects were recorded and pictures of invertebrates were taken using a high-resolution cell phone camera (Samsung GT-I9500). Each invertebrate representing a particular insect order group was collected and preserved for identification. The invertebrates were identified up to order level using taxonomic keys under stereo-zoom microscope (Olympus SZX7). Arthropods were identified till order level as utilitarian arthropod richness is higher at the level of order as compared to species level which is often repetitive (Tang et al. 2012).

Plant relatedness and trophic guilds

The collected arthropod individuals were classified plant wise according to their respective orders, number of individuals and trophic guilds. The impact of invertebrates on plant species based on herbivores level can be estimated by the trophic guild studies

that may further highlight interesting inference. Arthropods were classified in respective trophic guilds based on their mouth parts and were divided into three trophic guilds i.e., herbivores, predators and detritivores. Herbivores included three feeding guilds i.e., chewers, sap feeders and miners. Predators included all carnivore insects including the parasitoids, while detritivores trophic groups included arthropods feeding on dead and decay materials found on plant species.

Arthropod biomass

Arthropod biomass was estimated following Engelkes et al. (2012). A total of 120 plants were sampled which included 60 non-native *L. camara* and 60 native *J. adhatoda* plants during February-April months. Sampling was carried out in the early morning between 8 am to 11 am as least activity of arthropods was observed in this time and maximum number of insects could be captured. Plants with an average height of 1 m were collected from all three sites. A plastic bag which was placed on the selected plant and the base of the plant was cut using secateurs (minimum 2 cm above the ground) and then cotton balls soaked in ethyl acetate was placed in the bag and the bag was tied closely. Bags were then returned to the lab where arthropods were removed from the bag and placed in 70% ethanol until their further identification. The total number of arthropods on each of native and non-native plant was counted and recorded. Further, all plants were then oven dried at 80°C for 3 days, while the arthropods were dried for 50°C for 1 day and both were weighed using analytical weighing balance (Denver instruments, Min-0.1mg). Arthropod biomass load was calculated by using arthropods dry weight per 100gm of plant's dry mass of native *J. adhatoda* and non-native *L. camara* plants. Similarly, arthropods abundance was calculated as arthropods on 100 gms of plant biomass and plant biomass as average dry weight (g) of native and non-natives.

Herbivore damage

Measurement of insect leaf damage was carried out by selecting co-occurring plant pairs of *L. camara* and *J. adhatoda* during April-July. A total of 327 leaves were sampled that included non-native species and native species. The leaves were pressed and brought to the lab. Leaves were scanned on the same

day of sampling using scanner HP M1136 and area analyses was done using by ImageJ software (Version 1.47t; U.S. National Institutes of Health, 2014) to determine the area of leaf removed or damaged. The damaged leaf was extrapolated to calculate the percentage of total herbivore damage per leaf in native and non-native plant species. Percentage herbivory damage was estimated as total damaged leaf area by total leaf area $\times 100$.

Data analyses

A matrix was generated which comprised of arthropod abundance, richness and trophic guild per plant. The matrix was further used to calculate average arthropod abundance and richness per plant, abundance and richness of arthropod trophic guilds, as well as to plot the rarefaction curve between number of individuals of plants sampled and arthropod order assemblages (Fig. S1). Non-parametric Mann-Whitney U-test assuming unequal variances was conducted for comparison of average arthropod abundance and richness on native and non-native plant species. Percentage of arthropods sampled on distant and close related plant species was calculated by taking the proportion from overall arthropod assemblage on the total plants. Trophic guilds comparison on selected plants was carried out w.r.t predator, herbivores and detritivore trophic guilds. Principal component analysis was performed using XLSTAT (Addinsoft 2017) to understand the assemblage of arthropod order richness and abundance on four different plant species and to understand the role of plant relatedness and arthropod taxa richness. Each point in PCA represented arthropod taxa based on their abundance found on different plants i.e., *L. camara*, *J. adhatoda*, *H. suaveolens* and *P. mollis*.

Data of arthropod abundance (arthropod abundance per 100g plant biomass) and plant biomass were transformed. The transformed data of abundance and plant biomass was analyzed using unpaired t-tests. Comparison of total arthropod biomasses (arthropod biomass per 100g plant biomass) and herbivory leaf damage on native and non-natives were carried out using non-parametric Mann Whitney U test as the data was not normally distributed even after transformations. Analyses were performed with the data analysis software Statistica, version 12 (StatSoft, Inc.).

RESULTS

Arthropod assemblage

A total of 2,697 arthropods belonging to 14 taxonomic orders were estimated on the selected plant species i.e. (*L. camara*, *J. adhatoda*, *H. suaveolens* and *P. mollis*). The average (\pm standard error) arthropod abundance per plant among native and non-native plant species was found to be (4.51 ± 0.20) and (5.72 ± 0.40) respectively and did not differ significantly (Fig. 1a; Mann-Whitney U = 31847, $Z = -0.89$, $p = 0.37$). However, average order richness per plant was greater on native plants (2.37 ± 0.07) than non-native (2.09 ± 0.05) and varied significantly (Fig. 1b; Mann-Whitney U = 29370.50, $Z = -2.45$, $p = 0.01$). Table 1 shows the abundant insect orders based on trophic guilds across the various sampled plant species. Orders such as Araneae, Coleoptera, Hemiptera, Hymenoptera, Lepidoptera and Orthoptera had the largest arthropod abundance as compared to the detritivore orders.

Effect of plant relatedness on arthropod assemblage

Arthropod abundance on distant native *J. adhatoda* (4.8 ± 0.24) and non-native plant *L. camara* (6.38 ± 0.63) was not significantly different (Fig. 1c; Mann-Whitney U = 14354, $Z = -0.107$, $p = 0.92$). However, arthropod abundance for close related native *P. mollis* and non-native *H. suaveolens* was recorded as 3.50 ± 0.30 and 4.78 ± 0.33 respectively. The abundance was observed to be significantly higher on non-native *H. suaveolens* (Fig. 1c; Mann-Whitney U = 2783, $Z = -2.5$, $p = 0.01$). In contrast, arthropod order richness on close related plant species *P. mollis* and *H. suaveolens* was recorded as 2.05 ± 0.13 and 2.10 ± 0.07 respectively and no significant difference were observed (Fig. 1d; Mann-Whitney U = 3338, $Z = -0.84$, $p = 0.39$). Order richness among distant plant families *J. adhatoda* and non-native *L. camara* was recorded as 2.48 ± 0.08 and 2.10 ± 0.07 respectively and were significantly higher on native *J. adhatoda* (Fig. 1d; Mann-Whitney U = 11771, $Z = -3.08$, $p < 0.01$).

Trophic guild and plant relatedness

Out of a total of 2,697 invertebrates, 40.82 % comprised of herbivores, 53.61 % predators and 5.56 % of detritivore trophic guilds (Table 1). Average

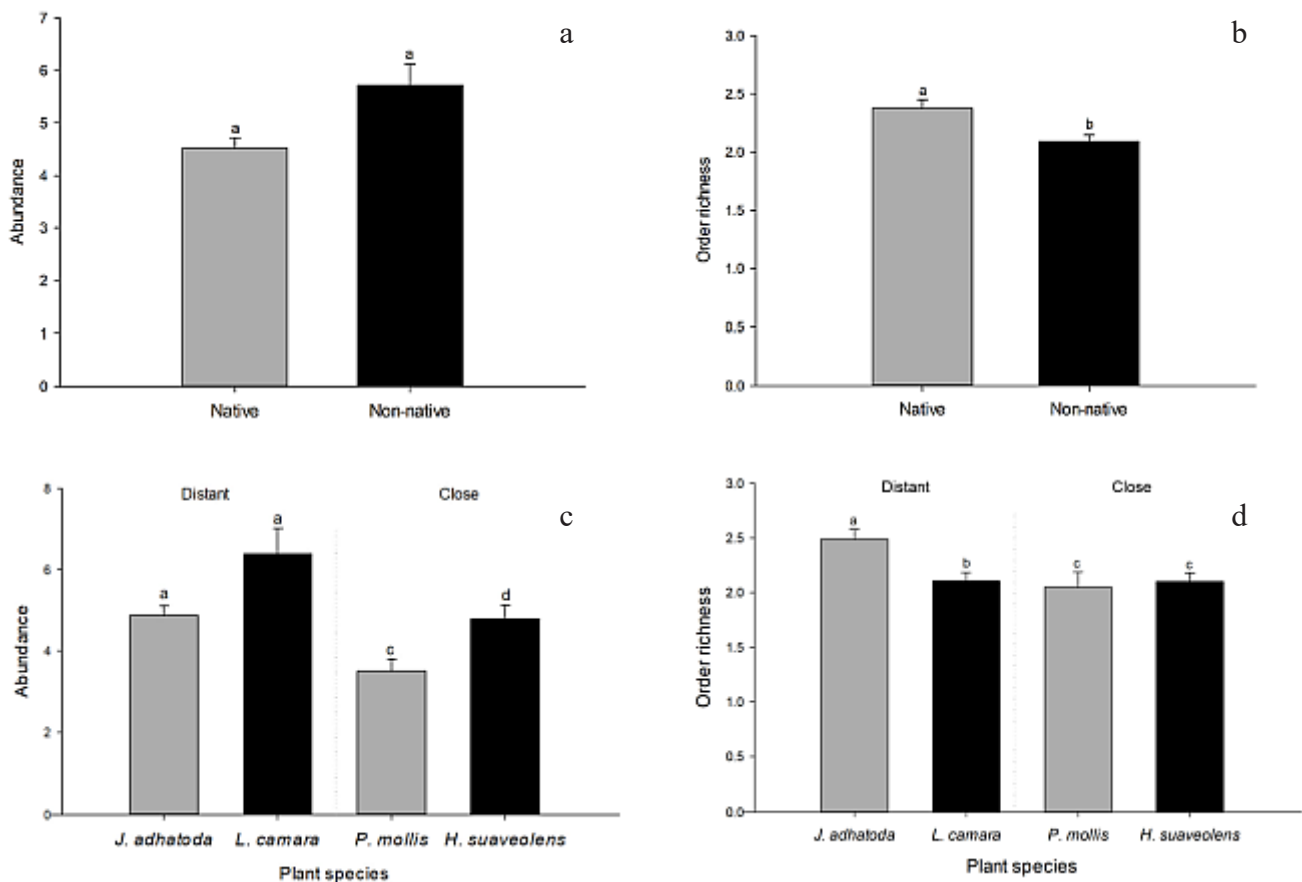


Figure 1. (a) Arthropod abundance on native and non-native plant species (b) arthropod order richness native and non-native plant species. (c) Arthropod abundance on different plant species. (d) Arthropod order richness on different plant species. Dotted line separates distant and close related plant species. Native plant species - *Justicia adhatoda* and *Plectranthus mollis*; non-native plant species - *Lantana camara* and *Hyptis suaveolens*. Arthropod abundance and arthropod orders are represented as average numbers of arthropod abundance and orders per plant. Different small alphabets on the bars denote significant difference at $p < 0.05$.

predator abundance per plant on distant native *J. adhatoda* (2.83 ± 0.28) and non-native *L. camara* (3.06 ± 0.24) was not significantly different (Fig. 2a; Mann-Whitney $U = 14180.500$, $Z = -0.30$, $p = 0.76$). While predators on close related families *P. mollis* (1.73 ± 0.28) and *H. suaveolens* (2.82 ± 0.17) varied significantly and was observed to be high on non-native species (Fig. 2a; Mann-Whitney $U = 2432$, $Z = -3.61$, $p < 0.01$). Average herbivore abundance per plant on distant and close related plant species showed no significant difference, *P. mollis* (1.56 ± 0.19) and *H. suaveolens* (1.47 ± 0.15), (Fig. 2a; Mann-Whitney $U = 3522.500$, $Z = -0.24$, $p = 0.81$); *J. adhatoda* (1.76 ± 0.16) and *L. camara* (3.20

± 0.60) (Fig. 2a; Mann-Whitney $U = 14000$, $Z = -0.52$, $P = 0.60$). While, average detritivore abundance per plant on *J. adhatoda* (0.18 ± 0.06) and *L. camara* (0.11 ± 0.02) were significantly higher on *J. adhatoda* (Fig. 2a; Mann-Whitney $U = 11546.500$, $Z = -4.70$, $p < 0.01$) while, *P. mollis* (0.20 ± 0.07) and *H. suaveolens* (0.57 ± 0.08) were not significantly different in terms of accrual of arthropods belonging to detritivores (Fig. 2a; Mann-Whitney $U = 3402$, $Z = -1.10$, $p = 0.27$).

Average predator order richness per plant on both distant as well as close related plant species was not significantly different. *J. adhatoda* (1.35 ± 0.05) and *L. camara* (1.25 ± 0.05) (Fig. 2b; Mann-Whitney U

Table 1. Arthropods trophic guilds and percentage of the sampled arthropod orders. (Native - *Justicia adhatoda* and *Plectranthus mollis*; Non-native - *Lantana camara* and *Hyptis suaveolens*)

Trophic guild	Order	Distant plant species			Close related plant species		
		<i>L. camara</i>	<i>J. adhatoda</i>	<i>H. suaveolens</i>	<i>H. suaveolens</i>	<i>P. mollis</i>	
Herbivores	Coleoptera (Carabidae, Chrysomelidae, Curculionidae)	1.57	2.66	1.22	1.43		
	Lepidoptera larvae	1.66	2.42	2.44	1.90		
	Orthoptera	2.40	2.90	5.57	2.86		
	Hemiptera (Cantharidae, Pentatomidae, Ricaniidae)	42.03	12.56	27.70	38.10		
	Thysanoptera	0.55	0.85	-	-		
	Trombidiformes (Tetranychidae)	2.03	8.70	-	0.48		
	Diptera larvae (Agromyzidae)	-	0.12	-	-		
	Araneae	16.68	29.83	49.30	10.00		
	Coleoptera (Coccinellidae, Leiodeae, Meloidae, Staphylinidae)	1.01	0.60	0.35	4.29		
	Hemiptera (Anthocoridae, Reduviidae)	0.18	0.48	-	1.90		
Predators	Hymenoptera	30.05	27.17	9.41	32.86		
	Thysanoptera (Predatory thrips)	-	-	0.17	-		
	Mantodea	0.09	-	-	0.48		
	Blattodea	0.18	1.33	-	0.48		
	Diptera (Sepsidae)	1.47	1.45	0.52	4.76		
	Entomobryomorpha	-	3.02	3.31	0.48		
	Isopoda	0.09	-	-	-		
	Psocodea	-	5.92	-	-		

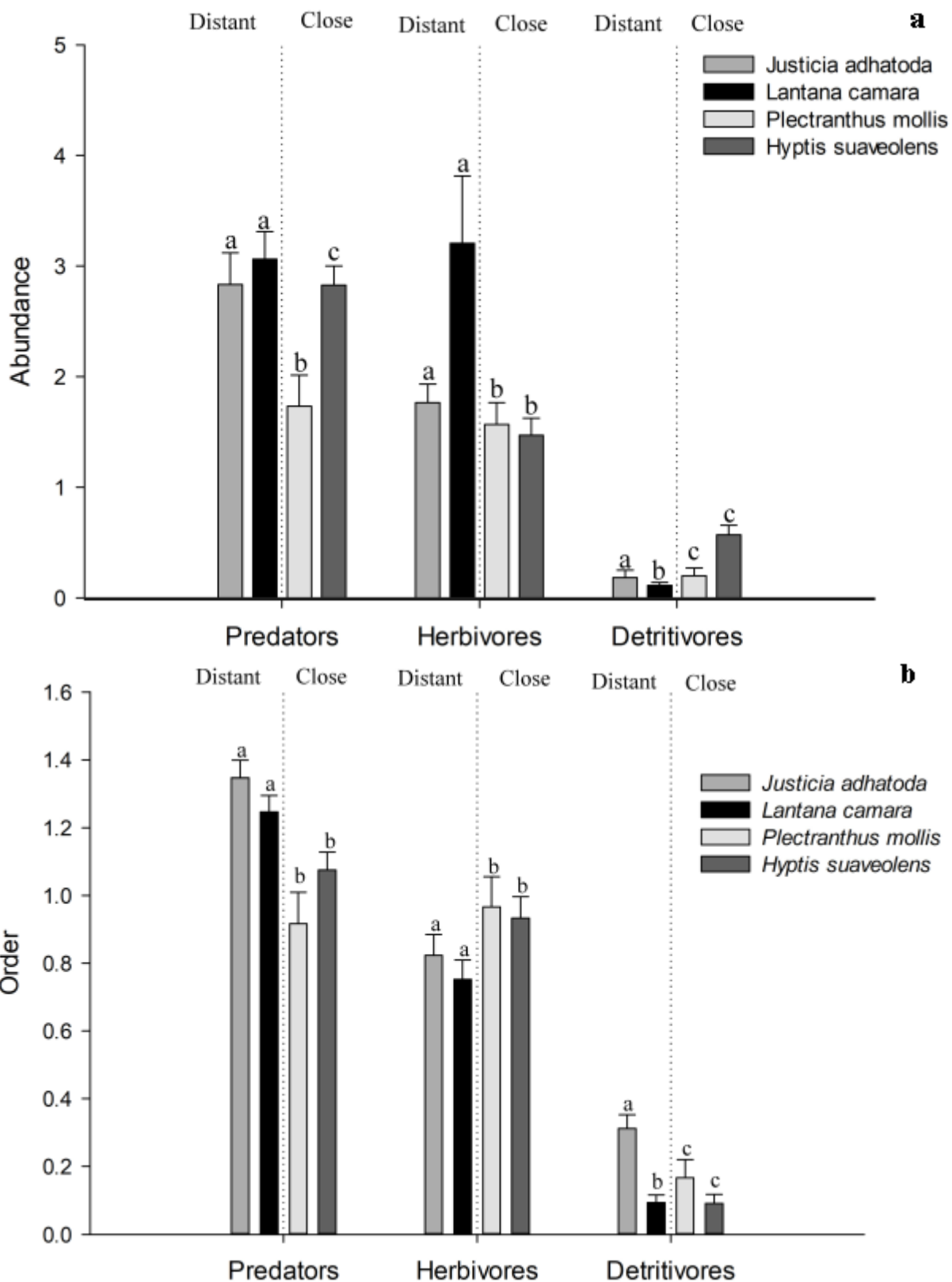


Figure 2. (a) Abundance of arthropod trophic guilds (b) Order of arthropod trophic guilds, among sampled native plant species- *Justicia adhatoda* and *Plectranthus mollis*; non-native plant species- *Lantana camara* and *Hyptis suaveolens* plant species, dotted line separates distant and close related plant species. Arthropod abundance and arthropod orders are represented as average numbers of arthropod abundance and orders per plant. Different small alphabets denote significantly different results ($p < 0.05$).

= 12981.50, $Z = -1.62$, $p = 0.10$), *P. mollis* (0.91 ± 0.09) and *H. suaveolens* (1.07 ± 0.05) (Fig. 2b; Mann-Whitney $U = 3119$, $Z = 1.46$, $p = 0.14$). Also, the average herbivore order richness per plant on both distant and close related plant species was not significantly different. *J. adhatoda* (0.82 ± 0.06) and *L. camara* (0.75 ± 0.06) (Fig. 2b; Mann-Whitney $U = 13888$, $Z = -0.62$, $p = 0.53$), *P. mollis* (0.97 ± 0.09) and *H. suaveolens* (0.93 ± 0.06) (Fig. 2b; Mann-Whitney $U = 3546$, $Z = -0.16$, $p = 0.87$). Detritivore order richness per plant was significantly higher on distant native *J. adhatoda* (0.31 ± 0.04) than invasive *L. camara* (0.09 ± 0.02) (Fig. 2b; Mann-Whitney $U = 11767$, $Z = -2.96$, $p < 0.01$). While, detritivore order richness on close related *P. mollis* (0.16 ± 0.05) and *H. suaveolens* (0.09 ± 0.03) was not significantly different (Fig. 2b; Mann-Whitney $U = 3384.500$, $Z = -0.65$, $p = 0.51$).

Principal component analysis showed that irrespective of plant types, insect orders separate out according to their presence and abundance on selected plant species (Fig. 3, Table 2). The first axis separated the insects orders associated with native (*J. adhatoda* and *P. mollis*) with the orders associated with non-native (*L. camara* and *H. suaveolens*) explaining 49.51% variation. Both axes of PCA

together explained 81.57% of variance. The analysis shows strong effect of native and non-native on arthropods presence. Higher order richness could be seen in close proximity to native plants *J. adhatoda* and *P. mollis* than non-native *L. camara* and *H. suaveolens*. Few orders could be seen specifically associated with selected species such as isopoda with *Lantana* sp., Diptera with *Justicia* sp. and Thysanoptera with *Hyptis* sp. (Table 1).

Arthropod biomass and damage

Arthropod abundance was more on non-native, *L. camara* (35.19 ± 5.06) than native, *J. adhatoda* (20.94 ± 2.69) and was found to be significant (Fig. 4a; *t*-test, $t(118) = 2.96$, $p < 0.01$). Native plant biomass (g) was higher on native (21.48 ± 1.27) than non-native (14.87 ± 1.10) and had significant

Table 2. Eigenvalues and proportions of variation explained by principal components

	F1	F2	F3
Eigenvalue	6.9319	4.4877	2.5804
Variability (%)	49.5134	32.0551	18.4314
Cumulative %	49.5134	81.5686	100.0000

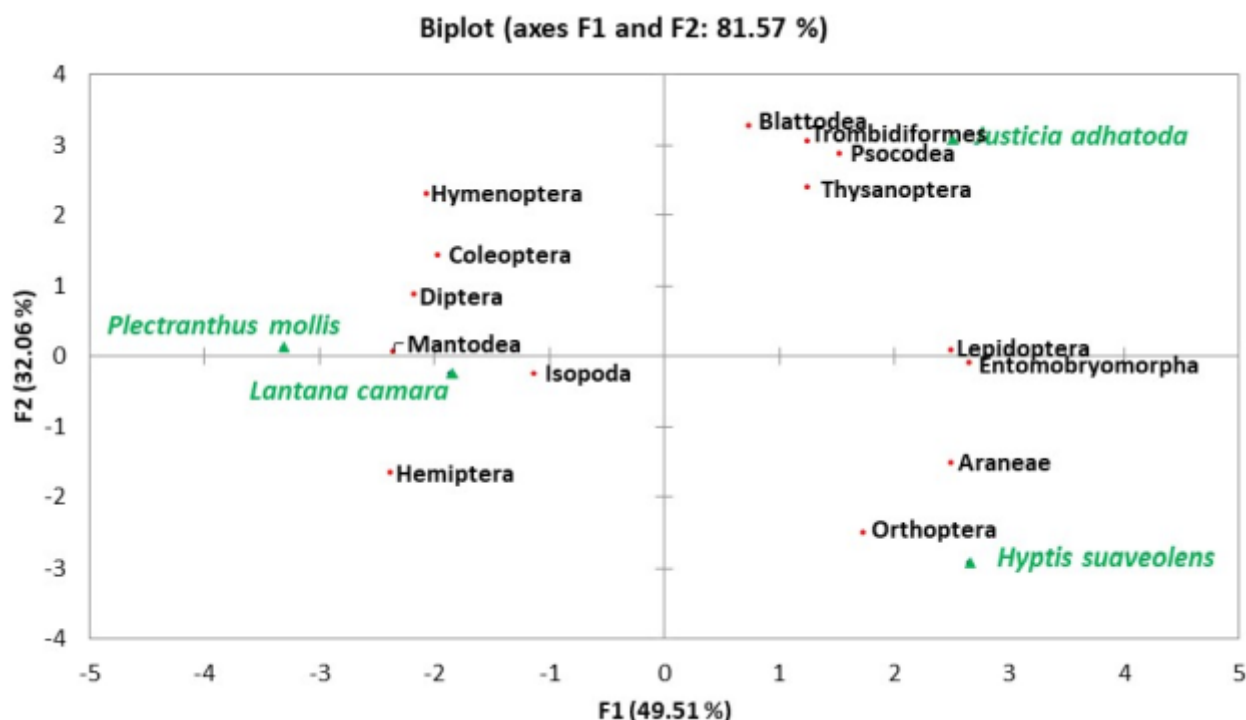


Figure 3. Principal component analysis of the arthropod taxa assemblages on four different plant species. Each point represents arthropod taxa based on their abundance found on different plant species.

difference (Fig. 4b; t -test, $t(238) = 2.38, p = 0.01$). While, arthropod biomass among native (0.017 ± 0.005) and non-native (0.026 ± 0.008) were not significantly different (Fig. 4c; Mann-Whitney $U = 1671.50, Z = 0.67, p = 0.50$). No significant difference were observed for percent damage caused by herbivores on native and non-native (10.74 ± 0.82 and 10.78 ± 0.49 ; Fig. 4d; Mann-Whitney $U = 11203, Z = -1.48, p = 0.14$).

DISCUSSION

Herbivore assemblages were found to be similar between native and non-native plants in the present study. Average arthropod abundance was similar on distant native *J. adhatoda* and non-native *L. camara* but was more on close non-native *H. suaveolens* than native *P. mollis*. Abundance based on trophic guilds

revealed that there was no difference in herbivores abundance and richness on close or distant related non-native sp. and native plant sp. Predator abundance was found to be more on non-native *H. suaveolens* than native *P. mollis* which are closely related. To the best of our knowledge the present study is the first to conducted sampling of arthropods associated with co-occurring native and non-native in India. Arthropod abundance was found to be more on non-native *L. camara* than native *J. adhatoda*, despite the presence of more native plant biomass. While, arthropod biomass and herbivore damage did not differ between native and non-native plant species.

Herbivore assemblages were found to be similar on native and non-native plants in our study, contrary to the general perception of decrease in herbivores on non-native plant species (Keane and Crawley

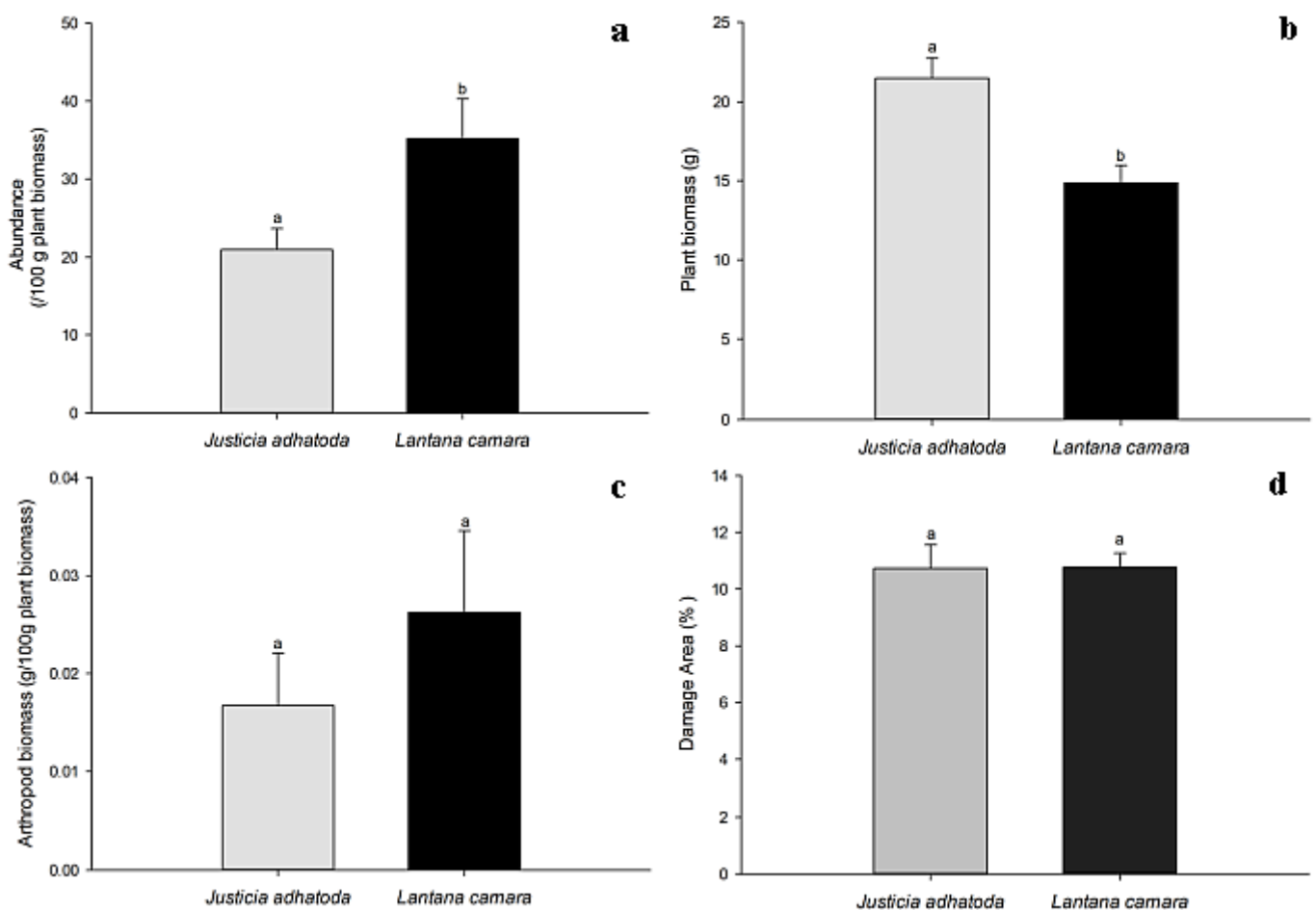


Figure 4. (a) Arthropod abundance (b) Plant biomass, (c) Arthropod biomass and (d) Herbivory leaf damage area on native *J. adhatoda* and non-native *L. camara*. Arthropod abundance is calculated as per 100g of each plant biomass. Arthropod biomass is calculated as per 100g of each plant biomass. Herbivory damage (%) was calculated as total damaged leaf area by total leaf area $\times 100$ for each leaf of native and non-native plants. Different alphabets on the bars denote significant difference at $p < 0.05$.

2002). Frenzel and Brandl (2003) also found no difference in richness and abundance of phytophagous insects on native and invasive cabbage plant species in Poland. Since the arthropod assemblages and load were studied on co-occurring native and non-native, a shift of arthropods on non-native plant species over a period of time could have resulted in similar or higher level of assemblages (Crous et al. 2017). Arthropods on native plant species shift more easily to non-native congener species than to unrelated species (Strauss et al. 2006). This could be due to more attractive nature or abundance of non-native plants in its surrounding but needs to be substantiated through experimental evidence (Bezemer et al 2014). Arthropods may choose non-native plants as a site of food or reproduction when native plant abundance decline which could be transitional host shifting (Sunny et al. 2015).

On the plant relatedness aspect, average arthropod abundance was similar on distant native *J. adhatoda* and non-native *L. camara* but was more on close non-native *H. suaveolens* than native *P. mollis*. Darwin (1859) in his naturalization hypothesis proposed that closely related native plant species in the vicinity of non-native plants may result in colonization of the native herbivores and so is less likely to establish self-sustaining population of non-natives. Strauss et al. (2006) supported the naturalization hypothesis and demonstrated that native and non-native relatedness is one of the useful measures for effectively managing non-native invasive abundance. Ducan and Williams (2002) analyzed non-natives with and without congeneric relatives in New Zealand and concluded that the non-native plant species with congeneric relatives are more likely to naturalize, contrary to the “naturalization hypothesis”. Brandle et al. (2008) highlighted the importance of residence time of non-native plant species in its introduced ranges and showed that species richness of herbivores on non-native hosts increases with time since its introduction. While, Carpenter and Cappuccino (2005) showed that there was no relationship between time since introduction and herbivory based on their field surveys of herbivory on native and non-natives in Ottawa, Canada. Hartley et al. (2010), reported accumulation of higher herbivore loads on non-native

tallow tree of Georgia (time since present: >230 years) than Texas (time since present: <100 years). In India, *Lantana sp.* and *Hyptis sp.* have been present for about more than ~100 years. Shift of arthropods on non-native plants could have resulted in higher biomass of arthropods on non-native plants in our study. However limited empirical evidence exists in this direction.

Abundance based on trophic guilds revealed that there was no difference in herbivores abundance and richness on close or distant native and non-native plant species. However, predator abundance was found to be more on close related non-native *H. suaveolens* resulting in overall higher arthropod abundance. A previous study has also reported that predator abundance was greater on the non-natives in California (Lau 2013). Increase in predators on close related non-native may help in regulating herbivores abundance on native plant species through top-down effect. (Smith and Schmitz 2015). Shift of predators on closely related non-native plants could be a result of similar morphology and chemistry than distant non-native, as well as the residence time of non-native (Spafford et al. 2013; Frenzel & Brandl 2001).

In our study, higher detritivores were found on native *J. adhatoda*. Principal component analysis showed that *J. adhatoda* is closely associated with arthropod orders Psocoptera, Entomobryomorpha, Diptera and Blattodea respectively belonging to detritivores. It has been suggested that detritivores may help in the increase of predator abundance on the plant species as they serve as food for predators (Engelkes et al. 2012). The current study reported that herbivore and predator abundance was same on distant native and non-native plant species. However, these preliminary patterns observed in the study needs further investigation through long term observational and experimental set ups to substantiate preference and performance of insects on non-native plants (Sunny et al 2015). Long term studies could reveal whether such patterns lead to host shift, ecological fitting and/or evolutionary trap (Sunny et al 2015).

J. adhatoda had larger average leaf area and size than *L. camara*. General assumption is that larger leaves are easier for insects to exploit than smaller leaves (Brown et al 1991; Cincotta et al. 2009).

However thickness of *J. adhatoda* was more than *L. camara* and may provide an alternate explanation as thickness may result in difficult in insects to digest (Cincotta et al. 2009). Therefore the larger area and thicker leaf can result in little and relatively no advantage of herbivore assemblages on *J. adhatoda*. Urbanization has also been studied as a factor for decrease of insect loads associated with urban native plants (McKinney 2008). Morrison and Mauck (2007) also found similar damage by arthropods in native *Acer saccharum* (sugar maple) and non-native *Acer platanoides* (Norway maple) in an experimental plot in USA. Amalgamation of long term field observations and lab experimentation can help to understand the dynamic nature of insects and plant community patterns.

CONCLUSIONS

The study recommends trophic guilds, preference and performance based studies to further substantiate arthropod assemblages on native and non-native plant species. Trophic guilds comparison on basis of native and non-native plant relatedness may help in understanding non-native plant abundance (invasiveness). This would open up an arena to identify specialized insects that could be exploited for control measures. The study indicated a possible role of predators in controlling herbivores through top-down effect of the food chain and regulation of herbivores abundance on native plant species. Shift of arthropod predators on closely related non-native plants could be a result of similar morphology and chemistry than distant non-natives plant species. The emerging paradigms suggest that extensive research on arthropods assemblage in a human modified local landscape may provide useful insights to this pattern. Long term studies of the dynamic alterations in abundance of native and non-native plant species and its subsequent effects on arthropod community are a need of hour. Such findings will assist to narrow down the knowledge gap for restoration of non-native dominated habitats.

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Supplementary Information

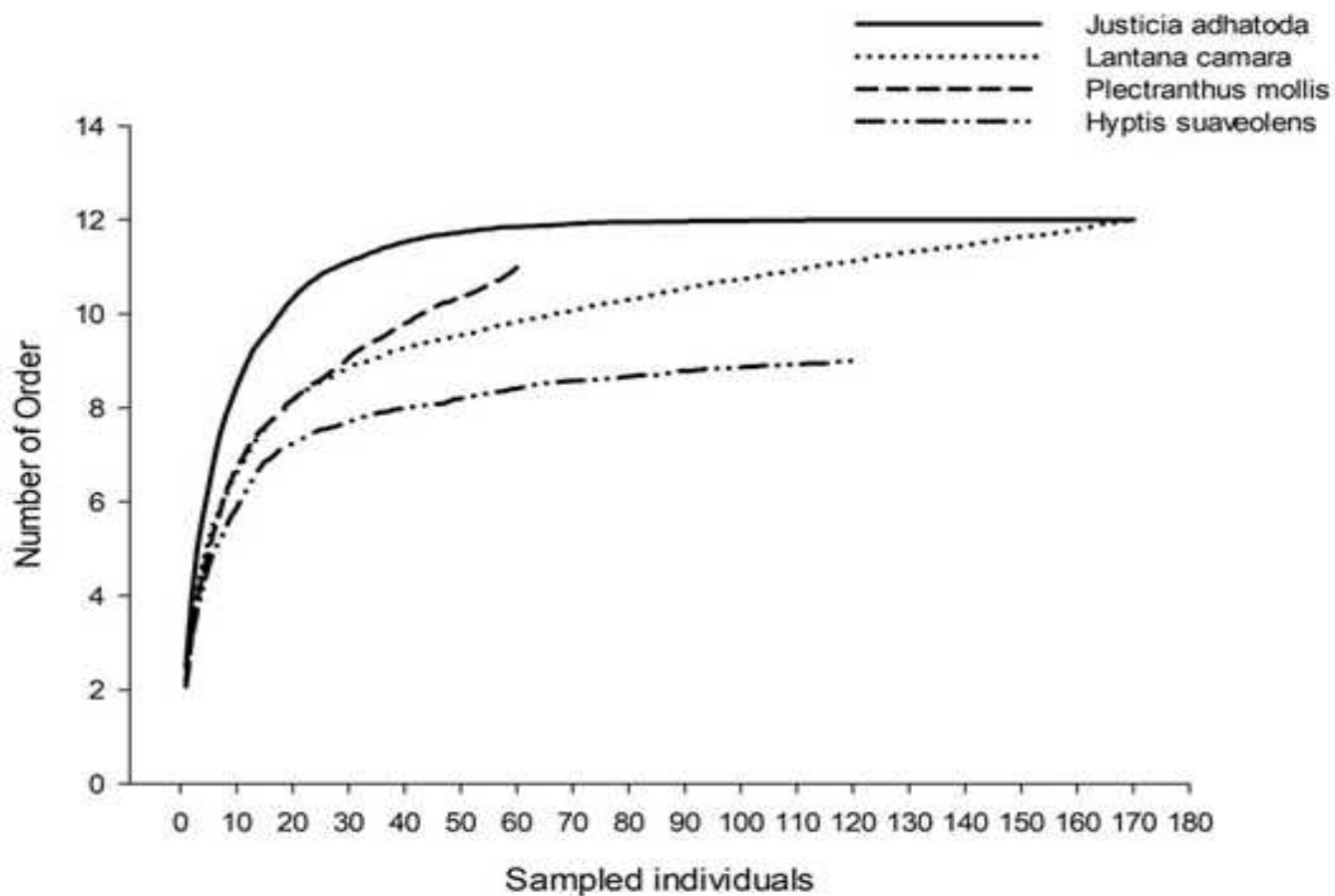


Figure S1. Rarefaction curve between number of individuals of plants sampled and arthropod order assemblages