Interactions between non-native plants and native insects: research gaps

Global climate change, habitat fragmentation and rise in non-native plant species have altered traditional native plant–insect interactions (Figure 1). Dominance of non-native plants has resulted in the decline of native plant species. As a result, native insects that use native plants as substrate for food and reproduction are affected leading to decline in native insect population[1]. Conversely, some native insects may find abundant non-native plants as a better source of diet, and prefer and reproductively perform well[1]. Such native insects, with time, choose a new host in the form of non-native plant species and continue to increase their progeny, thus increasing the overall native insect population.

Various hypotheses have emphasized the role of native insects in the regulation or proliferation of non-native plant populations[2,3]. The absence of native insects in the form of herbivores could increase the invasive success of non-native plants, as plants could then allocate more resources in development and growth rather than defence. The spread of the non-native plants could also be facilitated by the presence of native insects in the form of pollinators, referred to as faunal interactions by Sharma et al.[4].

Empirical studies of altered interactions of herbivory and pollination in complimentarity are essential for validating the invasion success of non-native plants. Studies worldwide have conflicting views on the role of insect herbivores on non-native plants towards successful invasions[1]. To understand the current scenario regarding such interactions from a tropical country like India, a bibliometric analysis of interactions of non-native plants and native insects was conducted. Information was assimilated using Web of Science (WoS) database in October 2016, using the search string (Inva* plant OR exotic plant OR alien plant OR Introduced plant OR Non-native plant) AND (insect* OR Herbivor* OR Pollinat*). Subject area was refined to biodiversity conservation, environmental sciences, environmental studies, ecology, entomology and plant sciences. Studies in WoS returned 44,740 hits worldwide and when limited to country India resulted in 707 hits. Content analysis was performed for all the 707 hits retrieved from WoS, and hits that did not address interaction of non-native plants and native insects in India were excluded. We were left with only eight studies which addressed native insects as herbivores and/or pollinators with the non-native plants. The analysis revealed that very few studies (eight) address the interactions of non-native plants and native insects from India. These articles were grouped into two categories, viz. (i) check and facilitation – check and facilitation of non-native plants invasion by native insects through herbivory and pollination, and (ii) preference and performance – 'preference', i.e. the ability of an insect to choose a plant for food or oviposition, while 'Performance' is the total number of offspring and its larval growth[1] (see Table 1 for description). We understand that despite the growing problems caused by non-native invasive plants in Indian ecosystems, limited information is available on altered native insects and non-native plants interactions.

Pandey and Sharma[5] suggested that research in India on non-native plant invasions has mainly focused on the processes such as spread, establishment, impact and control of the non-native plant species, but empirical studies of non-native plants on native insects and their interactions in the form of herbivory and pollination are lacking. Bibliometric analysis highlights that a considerable gap exists in our understanding of

Figure 1. Ecological interactions in a changing world. Native herbivore (*Oecanthus indicus*) (*a*) and native pollinator (*Belenois aurota*) (*b*) on a non-native invasive plant *Lantana camara* (Photo credit: A.S.).

Table 1. Summary of non-native plants and native insects interaction studies from India

Category	Description
Check and facilitation	Review:
	Studies focusing on the use of insects as biocontrol for check of plant invasion[6,7].
	Pollinator responses and outcomes on facilitation of non-native plant species[8].
	Role of herbivory and allelochemicals to understand the facilitation of non-native plants in native and introduced ranges[9].
	Role of native insects in check and facilitation of non-native plants[1].
	Empirical:
	Invasiveness of Mayweed Chamomile (*Anthemis cotula* L.) is facilitated by aphid herbivory in Kashmir, India[10].
Preference and performance	Native butterfly prefer using non-native plant species as hosts in Nagpur, India[11].
	Phenolics in non-native castor (*Ricinus communis* L.) on the performance of herbivores, viz. *Achaea janata* L. and *Spodoptera litura* F. in Hyderabad, India[12].

non-native plants and native insects interactions, as we do not have many empirical studies. The role of native insects, as herbivores and pollinators, in the control and spread of non-native plants on a regional scale is essential to understand and decipher how this interaction affects plant communities in the Indian subcontinent. Changes in insect communities on native and non-native plants could act as a tool in predicting invasiveness of non-natives and have implications for conservation of native biodiversity. It also emphasizes to integrate the role of non-native plants and native insects in understanding complexities of ecosystem functioning and dynamics. Trophic guilds comparisons, and identification of specialist insects on non-native plant species may help in understanding non-native plant invasiveness, and also for initiating control measures against potent invaders. The analysis advocates future studies and fund allocation towards research which focuses on insects and non-native plants interactions in a community.

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Time reduction for determination of infective propagule numbers of arbuscular mycorrhizal fungi by most probable number assay

It is now well documented that arbuscular mycorrhizal fungi (AMF) improve fitness and growth of plants which are important in agriculture, horticulture and forestry[1]. An important task in most AM studies is to determine accurately the number of infective propagules (IP) of AMF in soil, substrate, or inoculum. The most probable number (MPN) technique (or method of ultimate dilution)[2] for enumerating viable microorganisms, is a possible solution to the problems faced when using the usual methods of counting AMF endophyte propagules. Early microbiology frequently estimated population sizes on the basis of the highest dilution at which growth could be obtained. Thus, if growth was observed in a 10^{-4} but not in a 10^{-5} dilution, the number of viable cells was estimated to be between 10^4 and 10^5. It soon became evident that the testing of several aliquots from each of several successive dilutions, together with mathematical calculation, or interpolation, fostered much more precise estimations. The MPN technique is based on a determination of the presence or absence of microorganisms in several individual aliquots of each of several consecutive dilutions of soil or other material. A prerequisite of the method is that the AMF population to be determined must be easily recognized in the substrate. It is based on a series of soil dilutions where presence or absence of mycorrhizal colonization is recorded and the results given as a probability of the number of infective propagules based on a statistical table. Thus, the MPN method is recommended as most reliable to estimate the number of infective propagules of AMF in soil, substrate or inoculum. The number calculated has a 95% confidence level[2], but one of the disadvantages is that the set-up of the assay is time-consuming. Plants have to be grown for 45 days and then the roots collected for staining. This is because of larger containers of 7.5 cm diameter holding 300 g soil per pot and distributed in 5 replications for each dilution ranging from 10^{-1} to 10^{-4} or 10^{-5} as suggested by Porter[2]. Hence it was hypothesized that the period of 45 days of plant growth may be reduced by containing the substrate in smaller receptacles holding lesser quantity of soil/substrate.

PVC tubes 15 cm long with 3 different diameters (3.2, 2.5 and 1.9 cm) were used in the study. The substrate used was vermiculite (80%) mixed with 20% sterilized soil. Three different AMF species, viz. *Rhizophagus fasciculatus* (=*Glomus fasciculatum*), *Funneliformis mosseae* (=*Glomus mosseae*) and *Ambispora leptoticha* (=*Glomus leptotichum*) were maintained as pot cultures at Centre for Natural Biological Resources and Community Development, Bengaluru using Rhodes grass (*Chloris gayana*) as the host and vermiculite, perlite and soilrite in the ratio 1 : 1 : 1 (v/v/v) as the substrate. Each mycorrhizal inoculum (25 g) was removed to a plastic bag, 225 g of diluent (vermiculite 80% + sterilized soil 20%) added, and thoroughly shaken to obtain a dilution of 10^{-1}. Similarly, dilutions up to 10^{-4} were prepared. The