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The impact of invasive *Hyptis suaveolens* on the floristic composition of the periurban ecosystems of Chandigarh, northwestern India

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ABSTRACT

We investigated the impact of invasive *Hyptis suaveolens* on the natural vegetation and soil of the periurban ecosystems of Chandigarh (Northwestern India), in terms of declines in species number, importance value index (IVI), richness, diversity, evenness, and changes in soil pH, conductivity and organic matter. The number of species declined by 46–52% in the areas massively invaded by *H. suaveolens*. The richness, diversity, dominance and evenness of species were severely reduced in the invaded areas compared to uninvaded areas. The reasons for this strong impact may be attributed to the vigorous growth of the weed in the invaded areas. Invaded areas were characterized by high cover of the exotic species. Several economically important species like *Justicia adhatoda, Anisomeles indica, Carissa carandas, Dioscorea deltoidea, Murraya koenigii* and *Paspalidium flavidum* were conspicuously absent in the invaded areas, though present in the uninvaded areas. Absence of these species in the areas invaded by *H. suaveolens* may pose socio-economic problems for the local people. Further, alterations were also noticed in the pH, conductivity, organic carbon and organic matter of the soil of invaded areas. Based on these observations, it was concluded that invasion of *H. suaveolens* has a marked influence on the vegetation of periurban ecosystems, and causes depletion of several economically important species. The present study calls for an immediate action for the management of this noxious alien weed.

1. Introduction

Biological invasion is the second largest threat to biodiversity after habitat destruction (Holzmueller and Jose, 2009). Invasive alien species decrease species diversity, alter ecosystem functioning, lead to homogenization of biota and have severe socio-economic implications (Cushman and Gaffney, 2010). Though not all introduced species are harmful, a few of them spread fast in the introduced areas, acquire invasive character and harm the native ecosystems (Pyšek et al., 2012). Several plants were introduced to different parts of the world for their economic and aesthetic value (Hulme et al., 2013). Notwithstanding, globalization, climate change and increasing anthropogenic activities have further contributed to their spread (Mack, 2000). Plant invasion has become a hot topic for ecological research in the past few decades (Nuñez and Pauchard, 2010). Depending upon the opportunities available, invasive plants invade a variety of ecosystems including forest, agriculture, urban and periurban areas. Owing to urban sprawling, periurban areas are fast becoming susceptible to the invasive alien plants due to human disturbance, habitat loss, and migration of invasive species from urban landscape, consequently resulting in reduced biodiversity and loss of ecosystem services provided by the native species (Duguay et al., 2007; Niinemets and Peñuelas, 2008; Dolan et al., 2015; Martin et al., 2016). Periurban areas, however, are important as these serve as green belts around human habitation, have habitat heterogeneity, possess high species richness of indigenous species and provide numerous ecosystem services (McKinney, 2008; Bernholt et al., 2009; Huang et al., 2011). Their protection from the invasive plants therefore is important, though not much has been done in this direction.

Hyptis suaveolens (L.) Poit. (pignut or bushmint; Lamiaceae; Fig. 1), a pantropical, aromatic herb with a tendency to be perennial, is a fast emerging invasive plant posing detrimental effects on the native biodiversity and replacing the vulnerable or threatened species (Padalia et al., 2014). In India, the weed has been reported

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Fig. 1. Pictures showing a) an area invaded by *H. suaveolens*, and b) a flowering shoot of the plant.

from Vindhyan region, North-East India, Deccan Peninsula and Andaman and Nicobar Islands (Anonymous, 1959) and Telangana region (Suthari et al., 2016). It grows luxuriantly during the months of July till November, and rail tracks, roadsides or foothills of open forests, forest clearings and wastelands are its typical habitats (Verma and Mishra, 1992; Mudgal et al., 1997). There is, however, hardly any systematic study showing the impact of *H. suaveolens* on the native/local vegetation of the invaded areas except that of Sharma et al. (2009) who reported significant alteration in the species diversity in the dry deciduous forests of Vindhyan region due to invasion of *H. suaveolens*. Nevertheless, the weed possesses immense potential to spread to other parts, especially to areas with warm and wet climate, as predicted by the species distribution models taking various climatic and non-climatic variables into consideration (Padalia et al., 2014). Chandigarh, a modern Indian city situated in the foothills of Shiwalik range of Northwestern Himalayas, possesses favourable climate for this species. It is a well-designed city marked by periurban areas with open green spaces. However, due to urban sprawl and expansion of satellite towns, these periurban areas around Chandigarh are degrading fast, thereby paving a way for invasive alien species like *H. suaveolens*. The weed can be seen forming monocultures at the expanse of local plants (Fig. 1). However, no study has been conducted to assess and quantify the ecological impact of *H. suaveolens* in periurban areas. In order to fulfill the knowledge gap, we conducted specific studies to determine the effect of *H. suaveolens* invasion on the natural vegetation, and on soil of the periurban ecosystems in terms of species number, richness, diversity, evenness, and also the pH, conductivity and soil organic matter.

2. Materials and methods

2.1. Study site

The present study was conducted in periurban areas on the outskirts of city Chandigarh (Site I: 30°45′32.62″ N; 76°44′51.01″E to 30°46′00.14′N; 76°49′08.47″E; Site II: 30°41′51.72″N; 76°49′02.77″E to 30°44′32.10″N; 76°51′01.99″E and altitude 321 m) in Northwestern India (Fig. 2). It is situated in the foothills of Shiwaliks and experiences cold dry winter, hot summer and sub-tropical monsoon (~1110 mm average annual precipitation) (Chandigarh Administration, 2017). The city is well-planned and has extensive greens mainly contributed by its tree cover. The open vacant areas around the city harbor vegetation composed of common local weeds, grasses and forbs. Besides these, it also serves as an important sink for extra water at the time of monsoon season. Expansion of urban areas or suburbs has disturbed these periurban areas that otherwise provided important ecosystem services such as fodder, food, medicine and habitat for various plants and animals beneficial to the local inhabitants. Unfortunately, due to unorganized development and anthropogenic pressure, these periurban areas have become home for invasive species like *H. suaveolens*. However, its impact on the local vegetation is yet to be ascertained. For this, two massively infested sites (with IVI of *H. suaveolens* >60%) referred to as site I and II were selected and each site was further divided into uninvaded (control) or *H. suaveolens* invaded areas (Fig. 2). The coordinates of the selected sites are: Site I: Uninvaded: 30°45′58.55″N; 76°46′57.29″E to 30°46′09.18″N; 76°49′13.63″E; Invaded: 30°45′34.91″N; 76°44′51.09″E to 30°46′25.31″N; 76°46′25.31″E; Site II: Uninvaded: 30°42′07.13′N; 76°49′25.35″E to 30°43′36.01″N; 76°51′33.56″E; Invaded: 30°43′10.14″N; 76°49′25.47″E to 30°44′41.21″N; 76°50′46.60″E.

2.2. Data collection

A quadrat-based study was conducted in the two selected study sites (Site I and Site II) during the post-rainy season (from September-November). At each study site, 10 quadrats of 1 m^2 were laid randomly in the uninvaded and invaded areas of site I and II making a total number of quadrat as 40, which was sufficient for vegetation analyses (Squiers and Wistendahl, 1976; Barbour et al., 1987). Collected data was fed in MS Excel sheet and plant samples were identified through Herbarium of the Department of Botany, Panjab University, Chandigarh, India. The voucher specimens were deposited, and voucher numbers of all the plants including *H. suaveolens* have been given in Table 1. The soil samples were also collected from the top 15 cm soil after removing litter or humus, from both the sites. Five replicates were taken for each sample. The soil samples were dried, sieved through 2 mm mesh after gentle grinding and were stored in polythene bags for further analysis (Batish et al., 2007). The above-ground biomass of *H. suaveolens* plants was determined by chopping the aboveground parts of the plants from both the study sites. The dry biomass was determined by oven drying the plant samples for 72 h at 65 °C (Kuruppuarachchi et al., 2016).

2.3. Data analysis

Different parameters like density, frequency and dominance of the vegetation of both the sites were calculated in MS Excel using various formulae as per Kent and Coker (1992). Importance value indices (IVIs) were calculated for each plant species using the formula:

$$\text{Importancevalueindex(IVI)} = \text{R.Den.} + \text{R.F.} + \text{R.D.(Philips, 1959).}$$