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Research Article

Assessment and impact of alien species - *Mimosa invisa* L. on the biodiversity and pattern of vegetation at Dhoni hills, Western Ghats of Palakkad, Kerala-A case study

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Abstract

Mimosa invisa is a widely adapted weed from tropical America that has invaded the Dhoni hills of Palakkad District, Kerala. They were established as monocultures in grasslands, agricultural fields, plantations and forest areas of Palakkad, causing threats to other species. In this juncture, the present study was conducted to evaluate the impact of *Mimosa invisa* on the natural biodiversity and floristic compositions of native species of Dhoni hills, Palakkad. Vegetation analysis was carried out using random-systematic design and gradient methods, including the importance value index, species richness, dominance index, diversity, similarity and dissimilarity index, using standard protocols, followed by soil parameters such as pH and nutrient content and phenols in the invaded and uninvaded areas. It was noticed that in the *Mimosa* invaded area, the mean species number and the α diversity declined by 32.10% and 41.21%, respectively. Similarly, fresh and dry plant weight displayed remarkable variation (decreased by 35.9 and 49.9%, respectively) in the intruded zones. Out of 135 species recorded, 63 species were common in the control and intruded zones. Eleven species were growing exclusively in the invaded areas. The total phenolic content was 45%, the ion conductivity was 32%, the % of organic carbon and organic matter was 51%, the nitrogen content was 55.7%, and the phosphorus, potassium and sodium contents were 48, 38.5 and 24.4%, respectively, in the invaded soil compared to the control. Similarly, the calcium, magnesium and chloride contents were increased by 38.4, 30.6 and 33.5% respectively. Hence, it could be concluded that the invasion of *M. invisa* drastically affected the productivity and diversity of the invaded areas in the Dhoni hills of Palakkad.

Keywords: Biomass, Biodiversity, Dhoni Hill, Invasive species, *Mimosa invisa*

INTRODUCTION

Biological invasion threatens biodiversity, ecosystem dynamics, resource availability, the national economy and human health worldwide (Ricciardi *et al.,* 2000). It is a pervasive and costly environmental problem. Over the last half of the last century, it has become the focus of intense management and research activities worldwide. Invasion of native communities by exotic species has become the most intractable ecological problem in recent years (Sharma *et al.,* 2005). Invasion of exotic species is a global-scale problem experienced by natural ecosystems and is considered the second largest threat to biodiversity globally (Global Invasive Species Programme, 2005). In India, especially in the dry deciduous forest region, no information is available on demographic instability caused by the exotic species *Mimosa invisa*. *Mimosa* is ranked at the top of the highest impacting invasive species and is considered one of the world's 100 worst invasive alien species (Geographic Information System in of plant (GISP) taxonomy, 2005). According to Sharma *et al.* (2005), the invasive species have spread in almost all areas of dry deciduous regions. In India, tropical forests account for approximately 86% of the total forest land (Mahato *et al.,* 2021), while dry forests account for 38.2% of the total forest cover (Padmakumar *et al.,* 2018). Natural forests are under immense pressure due to various human-induced activities. In Dhoni hills, the establishment of cement factories, quarrying for limestone and thermal power stations have resulted in a rapid population increase, which has caused deforestation and the conversion of natural forests into marginal croplands. *Mimosa* has strong allelopathic properties, and they interrupt the regeneration of other plant species in their invaded area by decreasing seed germination, reducing early growth rates and selectively increasing the mortality of other plant species, which ultimately results in the reduction of species diversity and decline of species (Uko *et al*., 2020).

Mimosa invisa is a shrubby sprawling annual plant that behaves as a perennial vine in certain years. The stem is bunching, often scrambling over other plants, four-angled and the angles with a line of sharp, hooked prickles. *M. invisa* scrambles vigorously over other plants, forming dense tangled thickets up to 2 m high (Wang *et al.,* 2019). They are nitrogen fixers and rapidly growing species. Their sharp, recurved thorns make stock reluctant to graze on them, as it is difficult to penetrate the stands. It is difficult to harvest crops infested with *M. invisa* because of their thorns. They are commonly seen along roadsides and in moist waste places. They cause major problems in plantations of coconut, tea, rubber, sugarcane, pineapple, and other croplands and pastures. In this scenario, the present study aimed to compare the impact of *M. invisa* invaded and non invaded areas on the flora and soil parameters of Dhoni hills, Palakkad, and Kerala.

MATERIALS AND METHODS

Study area

. The western Ghats mountain range covers 160,000 km² in a stretch of 1,600 km parallel to the western coast of the Indian Peninsula, traversing the states of Karnataka, Goa, Maharashtra, Gujarat, Kerala, and Tamil Nadu. The western ghats are interrupted by the Palakkad gap, approximately 30 km wide. They reappear abruptly as the Annamalai Palani block, whose high plateau attains a height of 2695 m, the highest point in South India, the Anamudi peak. Dhoni hills is one of the fast-changing areas of the Palakkad district situated between 76°21' to 77° east longitude and 10° 15' to 11°15' north latitude. It is situated at the foot of the Western Ghats and on the Palakkad gap. The altitude ranges from 90 m to 1525 m above mean sea level. The climate in the area is subtropical. The average rainfall in this area is approximately 1800 to 3510 mm. The minimum temperature in the hills is 10°C in winter, and the maximum is40°C in summer. Dhoni Hills was the study area. Tropical thorn forests, tropical dry forests, subtropical broad-leaved forests and tropical evergreen forests are the potential vegetation of this area.

Methodology

Vegetational analysis

The vegetation analysis study was performed using the random-systematic design and gradient methods of Barbour *et al.* (1999). To study the impact of *M. invisa* on other plant species, a vegetational analysis was performed from October 2009 to March 2010. Three-invaded sites of *M. invisa* were selected randomly from Dhoni hills. A noninvaded area with *Mimosa* was also selected as a control to compare the diversity, species richness and composition of vegetation in the intruded and nonintruded zones. A 200 m^2 study spot with 20 quadrats of 2 m^2 size was constructed in random mode for the present evaluation. Entire species in the intruded and nonintruding zones were screened to quantify their importance value index (IVI) (Mishra, 1968). In addition, species richness, dominance index, diversity, similarity and dissimilarity index were analysed. The evenness of the intruded and non intruded zones was also quantified and matched to pinpoint species loss due to the *M. invisa* invasion. To avoid conceptual and technical problems and to obtain precision, only a few indices, such as Margalef's richness, Hill's evenness, Shannon's diversity, and Simpson's index of dominance, were used in the study (Ludwig and Reynolds, , 1998). The vegetation other than invasive species in the study area was uprooted, and their fresh and dry biomass (after oven drying) was measured (Noumi, 2015).

Soil analysis

Parameters such as pH variation, soil electric conductivity, phenolic content, organic carbon and related matter, and available minerals such as N, P, K, Na, Ca, Mg and Cl were analysed between the *M. invisa* intruded and non intruded zones. The soils were gathered after eliminating litter of the top layer (3.5 – 5.5 cm) from each zone. The soil samples were filtered, dried in the shade and kept until further studies. The soil pH and electrical conductivity were recorded after placing the soil extract in a 1:2 ratio (soil: water w/v) by applying a digital pH-sensitive meter and an EcoScan Con 5 digital conductivity meter. The soil phenolics were quantified following the Buondonno *et al.* (2014) protocol. Organic carbon and organic matter were estimated by the rapid titration method of Walkey and Black (1934). Available N was estimated using the alkaline potassium permanganate method of Castro *et al.* (2008). Available phosphorus was determined by the method of Koralage *et al.* (2015), Na^+ and K^+ were estimated as per the method of Fardous *et al.* (2010), and available Ca^{2+}, $Mg^{2+}$and Cl^- were determined by the method of Black (1973).

Statistics analysis

SPSS ver. 10.0 Origin 6 and Micorstat were used for statistical analysis of each experiment. The significance of paired treatment was determined using Student's 2 sample *t*-test. The significance ($P < 0.05$ or $P < 0.01$) of the variation in the soil characteristics of the control and *Mimosa* intrusion zones was evaluated using a *t*-test.

RESULTS

Influence of *Mimosa invisa* on the diversity of species

The intrusion of *M. invisa* significantly (0.01%) affected Dhoni hills' diversity and vegetation composition, Palakkad. The present study revealed 123 plant species in the *Mimosa* uninvaded area. In contrast, 74 in the intruded zone (Table 1), i.e., the species number, declined by 38.8%in the intruded area compared to the control plot. Margalef's index of species richness, α-species diversity and evenness index were determined to be 48.6, 41.3 and 20.9%, respectively, in the *M. invisa* intrusion zones. Similarly, the number of abundant species (A1 & A2) was recorded in the *M. invisa* intrusion zones. The index of dominance has maximal values in the intruded zones, which suggests that communities were homogenous, with one species dominant compared to more heterogeneity in the uninvaded areas. The similarity index of communities in the invaded and noninvaded areas was only 51.4%, clearly indicating diversity loss due to the invasion of the exotic species *M. invisa*. Comparison of fresh and dry plant weight from the intruded and nonintruded zones also displayed remarkable variation (decreased by 35.9 and 49.9%, respectively) in the intruded zones.

Influence of *M. invisa* intrusion on the composition of flora

The composition of flora narrates the distribution pattern of species in aspecific habitat.In the current study, the flora compositions of the *M. invisa*-intruding and non intruded zones were compared. A total of 135 plant species of 51 flowering families were noticed during the current study. Thirty-eight families were noticed in the control zone compared to 23 in the *M. invisa*-intruding zones. Out of 135 species recorded, 63 species were uniform in control and intruded zones (Table 2). Eleven species were growing exclusively in the *M. invisa* invaded areas. *M. invisa* was found to be a major plant species in the invaded area in addition to *Cynodon-dactylon*, *Eclipta alba*, *Tribulus terrestris*, *Barleria cristata*, *Holarrhena antidysenterica* and *C. carandas*, while *Adhatoda vasica* was a well-established plant species in the control areas along with *C. dactylon*, *E. alba, B. cristata, C. carandas, Andrographis paniculata*, *Aspargus aspera,* and *Phyllanthus amarus*. In both study areas, the number of herbal species was quite high when compared to other life forms. Even though the number of herbal species was lower than that of other species habits in the intruded zones, it is plausible to suggest that herbs were affected more than other habits of species (Table 2). The sequence of species in both zones of the study was in the declining order of their IVI values, and it revealed that the species became less consistent in the *M. invisa* intruded zones (Fig. 1). Significant medicianal herbals were noticed in the control zones, such as *Vitex altissima, E. alba, A. paniculata, C. dactylon, A. aspera, A. vasica* and *C. carandas* (Fig. 2). The invasion of *M. invisa* mostly affected medicinal plants such as *Vitex altissimia, E. alba, A. paniculata, C. dactylon, A. aspera, A. vasica* and *C. carandas*. The IVI values of medicinal herbals seemed to be marginal in the intruded zones compared to the nonintruded zones. The IVIs of *A. vasica* and *V. altissimia* in the control zone were 8.6 and 5.6%, respectively, but both were not noticed in

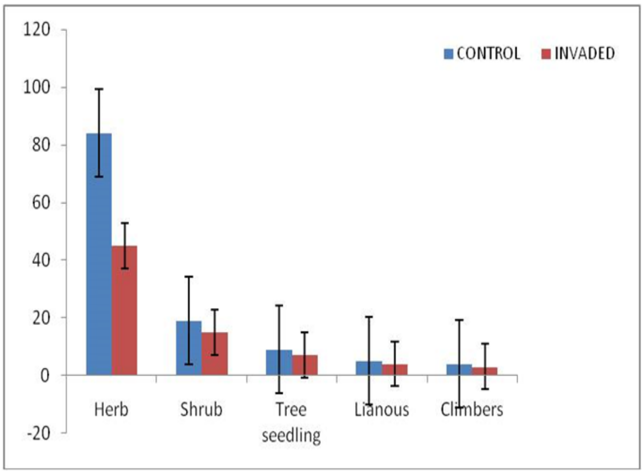

Fig. 1. *Comparison of different forms of plants in control and Mimosa invisa-invaded areas*

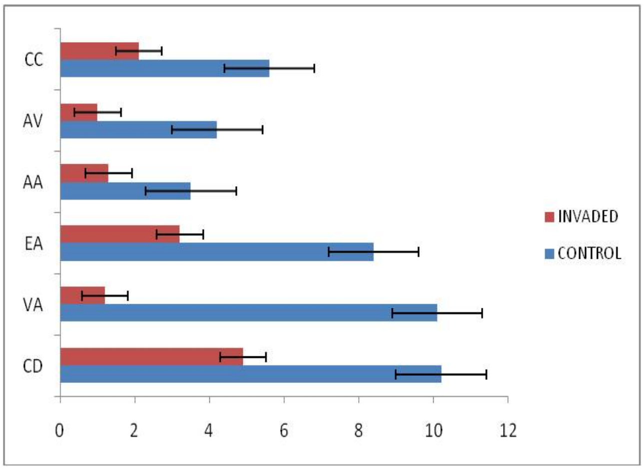

Fig. 2. *Impact of Mimosa invisa on the IVI (%) of some medicinal plant species. All values are significant at the 5% significance level after applying two population tests*

Table 1. Impact of *M. invisa* invasion on plant diversity and biomass.

Sl No.	Parameters	Control	Invaded	% decrease over control
1	Total Species	121	74	(-) 38.8
2	Average Fresh Biomass (g/m^2)	919.6	589.2	(-) 35.9
3	Average Dry Biomass (g/m2)	671.1	335.96	(-) 49.9
4	Margalef Index of Richness (R1)	7.2	3.7	(-) 48.6
5	Simpson's Index of Dominance (λ)	0.05	0.14	(+) 64.3
6	Shannon's Index of Diversity (H')	4.1	2.2	(-) 46.3
7	Diversity Number (N1)	21.5	10.4	(-) 51.6
8	Diversity Number (N2)	15.2	5.9	(-)61.2
9	Index of Evenness (Es)	0.91	0.72	(-) 20.9
10	Similarity Index (51.4)			
11	Dissimilarity Index (48.6)			

All values are significant at the 5% significance level after applying a two-population t test; (−) shows a lower value, and (+) shows a high value at the invaded site.

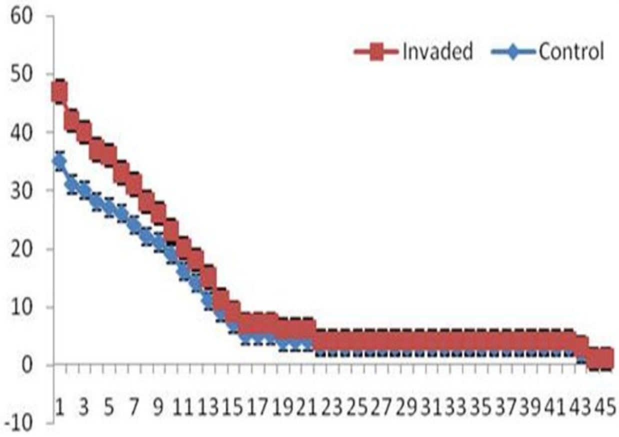

Fig. 3. *Distribution of common species in the control and Mimosa-invaded sites (decreasing order of importance value index).*

the top 10 species in the intruded zones. The IVI of *C. dactylon* in the invaded area was reduced by 44%, *E. alba* and *C. carandas* by 60.7 and 62.8%, and *A. aspera* by 52%. In addition, the sequence of species commonly noticed in both zones was represented in the declining order of their IVI values, and it displayed that the species become less consistent in the *M. invisa* intruded zones (Fig. 3).

Changes in soil nutrients

The total phenolic content in the *M. invisa*- intruding soil zone was 45% higher than in the control zone (Table 3). The soil pH of the control and intruded soil was almost 7; it was marginally lower in the control zone, while in the *M. invisa* intruded zone, it was 7.8. The ion conductivity was 32% higher in the *M. invisa* intrusion zone than in the control zone. % of organic carbon and organic matter inclined in the intruded zone by nearly 51%. The increase in the available nitrogen content was the highest among all other nutrients. It increased by 55.7% in the invaded area. The amounts of available phosphorus, potassium and sodium were 48, 38.5 and 24.4% higher, respectively, in the *M. invisa*-invaded soil than in the control soil. Similarly, the available calcium, magnesium and chloride also increased in the *M. invisa* -invaded soils; the increase was 38.4, 30.6 and 33.5%, respectively, in the invaded soil compared to the control soil (level of significance 0.01%).

DISCUSSION

Plants are the primary producers of the ecosystem, so it is important to protect them from various threats to sustaining all other biotas. Significant loss of the native medicinal plants in the invaded areas in the present study showed that they became less productive than the plants in the control area (Fig. 1,2 & 3). Biomass is directly related to the productivity of the plants (Table 1). The influence of the invaded species in the intruded zones of the Dhoni hills altered the physiological nature of the biological species and decreased the species diversity and dependent animals (Table 2). Dogra *et al.* (2009) also noticed a similar trend of the impact of three invasive species in the Shivalik hills, Himachal Pradesh. Uko *et al.* (2020) also recorded that *M. invisa* caused severe losses of yield reductions in cassava, maize, plantations and other arable crops (60-90%) in Nigeria and caused fire hazards during the dry season in infested fields. It formed large swathes of impenetrable prickly thickets that are difficult to irradicate.

It is time to record the impact of intrusion of alien species in terms of quantitative data of invasion influence on the diversity needed (Franz Essl *et al.,* 2020). In the present study, *M. invisa* seems to be a dominant alien species on the Dhoni hills and near plantations in Palakkad. They have increased density and abundance in the invaded habitats, resulting in the extinction of many

Table 2. Floristic composition of the vegetation in the control and *A. conyzoides*-invaded areas (alphabetical order). Total species = 135; Total species in control site = 121.Total species in invaded site = 74; Common species = 42

Sl. No	Name of the species	Family	Control	Invaded
1	*Abrus precatorius* L.	Fabaceae	+	-
2	*Acacia auriculiformis.*	Mimosaceae	+	+
3	*Acalypha indica* L.	Euphorbiaceae	+	+
4	*Acalypha wilkesiana* M.Arg.	Euphorbiaceae	+	-
5	*Acanthus ilicifolius* L.	Acanthaceae	+	-
6	*Achyranthes aspera* L.	Amaranthaceae	+	+
7	*Acorus calamus* L.	Araceae	+	-
8	*Adenanthera pavonina* L.	Mimosaceae	+	+
9	*Adhathoda beddomei* Clark.	Acanthaceae	+	-
10	*Adhathoda vasica* Nees.	Acanthaceae	+	-
11	*Aerva lanata* Juss.	Amaranthaceae	+	+
12	*Alpinia calcarata* Rosc.	Zingiberaceae	+	+
13	*Alstonia scholaris* R.Br.	Apocynaceae	+	+
14	*Amaranthus caturus* Heyne.	Amaranthaceae	-	+
15	*Amaranthus caudatus* L.	Amaranthaceae	+	-
16	*Amaranthus gangeticus* L.	Amaranthaceae	+	-
17	*Amaranthus spinosus* L.	Amaranthaceae	+	+
18	*Amaranthus viridis* L.	Amaranthaceae	+	-
19	*Andrographis paniculata* Nees.	Acanthaceae	+	-
20	*Antidesma menasu* Miq.	Euphorbiaceae	-	+
21	*Aristolochia indica* L.	Aristolochiaceae	+	+
22	*Asparagus racemosus* Willd.	Liliaceae	+	-
23	*Bacopa monnieri* (L)pennel.	Scrophulariaceae	+	-
24	*Barleria cristata* L.	Acanthaceae	+	+
25	*Barleria montana* Nees.	Acanthaceae	+	-
26	*Begonia sps.*	Begoniaceae	+	-
27	*Biophytum sensitivum* (L)DC.	Geraniaceae	+	+
28	*Boerhaavia diffusa* L.	Nyctaginaceae	+	+
29	*Calotropis gigantea* R.Br.	Asclepiadaceae	-	+
30	*Capsicum anum* L.	Solanaceae	+	+
31	*Capsicum frutescens* L.	Solanaceae	+	-
32	*Cardiospermum halicacabum* L.	Sapindaceae	+	+
33	*Carrisa carandas*	Apocynaceae	+	+
34	*Cassia siamea* Lam.	Caesalpiniaceae	+	+
35	*Cassia tora* L.	Caesalpiniaceae	+	+
36	*Cayratia pedata* Juss.	Vitaceae	+	+
37	*Centella asiatica* (L)Urban.	Apiaceae	+	-
38	*Cissus quadrangularis* L.	Vitaceae	+	+
39	*Cissampelos perera*	Menispermaceae	+	_
40	*Cleome viscosa* L.	Capparidaceae	+	+
41	*Clerodendron inermae* Gaertn.	Verbenaceae	+	+
42	*Clerodendron infortunatum* L.	Verbenaceae	+	+
43	*Clerodendron serratum* (L)Moon.	Verbenaceae	+	-
44	*Coccinia indica* W&A.	Cucurbitaceae	+	+
45	*Costus speciosus* S.M.	Zingiberaceae	+	-
46	*Crotalaria sps.*	Papilionaceae	+	+
47	*Croton tiglium* L.	Euphorbiaceae	-	+
48	*Curculigo orchioides* Gaertn.	Amaryllidaceae	+	-
49	*Curcuma canannoorensis.*	Zingiberaceae	+	-
50	*Cuscuta reflexa* Roxb.	Convolvulaceae	+	+
51	*Cyathula prostrata* Bl.	Amaranthaceae	+	+
52	*Cyclea peltata* Hf&T.	Menispermaceae	+	+
53	*Cymbopogon citratus*(DC)Stapf.	Poaceae	+	-
54	*Cynodon dactylon* (L)Pers.	Poaceae	+	-
55	*Cyperus rotundus* L.	Cyperaceae	+	+
56	*Datura stramonium* L.	Solanaceae	+	+
57	*Derris trifoliata* Lour.	Fabaceae	-	+
58	*Desmodium gangeticum* DC.	Fabaceae	+	-
59	*Dioscorea pentaphylla* L.	Dioscoreaceae	+	-
60	*Eclipta alba* Hassk.	Asteraceae	+	-

Contd…...

Table 2. Contd……

61	*Elephantopus scaber* L.	Asteraceae	+	-
62	*Emilia sonchifolia* DC.	Asteraceae	+	+
63	*Euphorbia hirta* L.	Euphorbiaceae	+	+
64	*Euphorbia pulcherima* Willd.	Euphorbiaceae	-	+
65	*Euphorbia splendens* Boj.	Euphorbiaceae	-	+
66	*Evodia roxburgiana* Benth.	Rutaceae	+	-
67	*Gloriosa superba* L.	Liliaceae	+	+
68	*Glycosmis pentaphylla* Corr.	Rutaceae	+	+
69	*Gmelina arborea* Roxb.	Verbenaceae	+	+
70	*Grewia microcos* L.	Teliaceae	+	+
71	*Grewia tiliaefolia* L.	Teliaceae	+	+
72	*Helicteres isora* L.	Sterculiaceae	+	+
73	*Hemidesmus indicus* R.Br.	Asclepiadaceae	+	+
74	*Holarrhena antidysenterica* Wall.	Apocynaceae	+	-
75	*Hydrocotyl asiatica* R.Br.	Apiaceae	+	-
76	*Indigofera prostrata* Willd.	Fabaceae	+	+
77	*Indigofera tinctoria* L.	Fabaceae	+	+
78	*Impatiens concinna* L.	Rubiaceae	+	-
79	*Ipomaea companulata* L.	Convolvulaceae	+	-
80	*Ipomaea hederacea* (L)Jacq.	Convolvulaceae	+	-
81	*Ixora coccinea* L.	Rubiaceae	+	+
82	*Ixora brachiata* Roxb.	Rubiaceae	+	-
83	*Jacquemontia caerulea* Choisy.	Convolvulaceae	-	+
84	*Jasminum malabaricum* L.	Oleaceae	+	-
85	*Jatropa curcas* L.	Euphorbiaceae	+	+
86	*Jussieua* sps.	Onagraceae	+	-
87	*Kaempferia galanga* L.	Zingiberaceae	+	-
88	*Leucas aspera* Spr.	Lamiaceae	+	-
89	*Maranta arundinacea* L.	Marantaceae	+	-
90	*Melastoma malabathricum* L.	Melastomaceae	+	+
91	*Melochia corchorifolia* L.	Sterculiaceae	+	-
92	*Mimosa pudica* L.	Mimosaceae	+	-
93	*Mucuna pruriens* Baker.	Fabaceae	+	+
94	*Murraya Koenigii* Spreng.	Rutaceae	+	-
95	*Mussaenda frondosa* L.	Rubiaceae	+	-
96	*Naravelia zeylanica* DC.	Rananculaceae	+	+
97	*Naregamia alata* W&A.	Meliaceae	+	-
98	*Ocimum basilicum* L.	Lamiaceae	+	-
99	*Ocimum gratissimum* L.	Lamiaceae	+	-
100	*Oldenlandia corymbosa* L.	Rubiaceae	+	-
101	*Oldenlandia umbellata* L.	Rubiaceae	+	-
102	*Olea dioica* Roxb.	Oleaceae	+	+
103	*Oxalis corniculata* L.	Oxalidaceae	+	-
104	*Passiflora foetida* L.	Passifloraceae	+	+
105	*Paveta indica* L.	Rubiaceae	+	+
106	*Pergularia extensa* N.E.Br.	Asclepiadaceae	+	+
107	*Phyllanthus amarusi* L.	Euphorbiaceae	+	-
108	*Piper betle* L.	Piperaceae	+	+
109	*Piper longum* L.	Piperaceae	+	-
110	*Piper nigrum* L.	Piperaceae	+	-
111	*Plumbago rosea* L.	Plumbaginaceae	+	-
112	*Plumbago zeylanica* L.	Plumbaginaceae	+	-
113	*Pothos scandens* L.	Araceae	+	+
114	*Premna latifolia* Roxb.	Verbenaceae	-	+
115	*Prunus avium* L.	Rosaceae	-	+
116	*Pseudarthria viscida* W&A.	Fabaceae	+	+
117	*Quamoclit pinnata* Boj.	Convolvulaceae	+	+
118	*Rauwolfia serpentina* Benth&Kurz.	Apocynaceae	+	-
119	*Sida cordifolia* L.	Malvaceae	+	+
120	*Sida retusa.*	Malvaceae	+	+

Contd……

Table 2. Contd…...

121	*Sida spinosa* L.	Malvaceae	+	+
122	*Solanum melongena* L.	Solanaceae	+	-
123	*Smilax zeylanica* L.	Liliaceae	+	-
124	*Sphaeranthus indicus* L.	Asteraceae	-	+
125	*Spilanthus calva* W.	Asteraceae	+	+
126	*Tabernae montana divericata.*	Apocynaceae	+	+
127	*Thunbergia grandiflora* Roxb.	Acanthaceae	+	+
128	*Tinospora cordifolia* (Willd)Miers.	Menispermaceae	+	+
129	*Tinospora malabaricum.*	Merispermaceae	+	+
130	*Tribulus terrestris* L.	Zygophyllaceae	+	+
131	*Trichosanthes anguina* L.	Cucurbitaceae	+	-
132	*Triumfetta rhomboidea* Jacq.	Tiliaceae	+	-
133	*Turnera ulmifolia* L.	Turneraceae	+	-
134	*Tylophora asthmatica* W&A.	Asclepiadaceae	+	+
135	*Urena lobata* L.	Malvaceae	+	-

Table 3. Comparison of selected physico-chemical properties of soil collected from areas invaded by *Mimosa* and free from it (control)

Sl. No	Parameters	Control	Invaded
1	Phenolics (ìg/100 g soil)	12.4 ± 1.05	21.8 ± 0.98**
2	pH	6.8 ± 0.01	7.5 ± 0.02**
3	EC (iS)	130.4 ± 1.8	190.6 ± 4.05**
4	Organic Carbon (%)	0.5 ± 0.03	0.97 ± 0.08**
5	Organic Matter (%)	0.85 ± 0.02	1.7 ± 0.1**
6	N (kg/ha)	91.79 ± 2.5	214 ± 7.6**
7	P (ppm)	65.53 ± 2.8	123 ± 1**
8	K (ppm)	88.39 ± 4.08	143 ± 2.79**
9	Na (ppm)	40 ± 4.21	53.05 ± 3**
10	Ca (g/100 g)	4.17± 0.28	6.7 ± 0.3**
11	Mg (g/100 g)	2.2 ± 0.3	3.2 ± 0.8**
12	Cl (g/100 g)	3.5 ± 0.18	5.1 ± 0.34**

native species. Dai *et al.* (2020) recorded the synergistic effect of alien plant invasion processes in native species. They also prepared a road map for future conservation of the crop species. Demertzis and Iliadis (2018) predicted the plausible impact of climate change on biodiversity in the ecological consequences of invasive species in Greece. Manoharan *et al.* (2019) proved that gene expression profiling enhanced the defense responses of invasive weeds compared to their native congener during pathogenesis. Rutherford *et al.* (2021) analysed the speciation dynamics of codistributed *Angophora* species in a varying landscape versus alien species. Sun *et al*. (2021) established the plant-soil feedback during biological invasions: effect of litter decomposition from an invasive *Sphagneticola trilobata* on its native congener (*S. calendulacea*). Xie *et al.* (2020) proved that hybridization with natives augments the threats of introduced species in *Sonneratia* mangroves. Zhang *et al.* (2021) analysed the transcriptome profiling of *Arabidopsis thaliana* roots in response to the allelopathic effects of *Conyza Canadensis.* Zhu *et al.* (2018) reviewed the invasive *Hydrocharis morsus-ranae* vs the native species in North America. Dai *et al.* (2022) documented global changes and plant invasions in different eco-climatic zones. All these findings substantiate the present data of the invasion of *M.invisa* at Dhoni hills.

According to Semwal *et al.* (2007), the increasing abundance of invaders decreases species diversity. Much effort has been put into identifying determinants constraining broad-scale variability in species richness. It is apparent that the factors influencing the patterns of species richness vary with the geographical extent and sample resolution (Shukla, 2009). Therefore, only by multiple analysis scales for different locations and at various spatial scales can general explanations of broad-scale species richness, diversity, and distribution patterns be provided (Semwal *et al.,* 2007).

M. invisa is a strong invader; its abundance, cover, and density threaten natural biodiversity. The decrease in plant mass and allied indices of the ecosystem features, such as α-diversity, abundant species, and Margalef's index, in the intruded habitats reflect that these zones were less productive and stable than the non-intruded zones. Certain species in the intruded areas were lost. Meanwhile, some are competing to survive. The lack of seedlings of trees in the intruded zones revealed that *M. invisa* allelopathically prevented their establishment. Thus, *M. invisa* inhibits the growth of other plant species directly by creating its own niches. The intrusion of *M. invisa* also changed the soil physico -chemical features, i.e., the soils in the intruded zones had a high nutrient content to facilitate the growth of the intruded species. The data revealed that the values of most soil nutrients seemed to be better in the *M. invisa*-intruding zones than in the control. pH showed a minimal change compared to other features. Similarly, the total phenolics of a proven allelochemical seemed to be higher in weed-intruded soil when compared to the control. Phenolics leached from the herbals as volatile molecules from the aerial parts and roots, volatilization or microbial degradation. These allelochemicals prove the allelopathic property of plants and regulate the biotic communities of soil (Shukla, 2009). Many studies suggest that allelopathy may contribute to the ability of particular alien species to become dominant in native plant communities (Abd El-Wahab *et al.,* 2008). Several aggressive weeds, such as *Eichhornia crassipes, Centaurea stoebe* ssp.*Micranthos*, *Alliaria petiolata,* exhibit the phenomenon of allelopathy as a mechanism of interference that provides them with a competitive advantage over other plants (Mahato *et al.,* 2021).

The present study revealed more availability of minerals and other nutrients in the *M.invisa*-intruded soils than in the nonintruded zones (Table 3). These higher values established the concept that more availability of minerals and other nutrients enhanced the susceptibility to the invasion of other communities. As reported by Padalia *et al.* (2010), the factors other than allelopathy might be operating in nature, which favours the rapid establishment and persistence of dense stands of invasive alien species such as *Chromolaena odorata, Fallopia japonica*, *Conyza bonariensis, Lantana camara, Acacia nilotica* sp. *indica, Parthenium hysterophorus, Opuntia stricta* and *Trianthema portulacastrum*. Furthermore, the absorption of phenolics and allelopathic compounds by soil particles and their microbial breakdown may account for the outcome of the present observations (Gupta *et al*., 2006), which are further affected by different soil factors, such as soil texture, organic carbon and organic matter. (Kobayashi, 2004).

Conclusion

The invaded dominance of *M. invisa* at Dhoni hills, Palakkad altered the structural types of vegetation into a homogeneous land, reducing the diversity of flora, most likely including many medicinal species. It altered the soil regimes, such as pH, organic matter, mineral content and phenols, and often encroached on water bodies. Globalization has increased by introducing alien species to new areas with deleterious effects on ecosystems and displaced native plants, degraded ecosystems, and negatively impacted human health. Plant invasions may result in the homogenization of biological systems worldwide and global biodiversity loss. Similarly, allelochemicals such as phenols leached from the alien may regulate the growth of native species but can have potential value in agriculture. Future research should use multiple environmental stressors to address their impacts on environment/ecosystem services and socioeconomic and human health.

Conflict of interest

The authors declare that they have no conflict of interest.

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