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Plant Invasion Ecology of an Indo-Burma Hot spot region along the Disturbance Gradient: A case study

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Abstract

Plant invasion is the priority threat to global biodiversity and hence deleterious to both ecology and economy of any nation. Invasive plants or weeds transmogrify the landscapes of urban forests and duly affect its phytosociology as well as diversity of native species in a complex intricate manner. Various hypotheses have been proposed to understand the basic mechanism of succession in order to device sustainable management strategy, however, no one describe it in its totality. Present case study was performed in urban forests of Aizawl, Mizoram, North East India falling under an Indo-Burma hot spot region of existing ecological relevance and pristine environment. Phytosociolology of invasive weeds and soil attributes (pH, soil moisture, soil respiration) or resources (organic matter, C, N, K) were analyzed along a disturbance gradient. Ageratum conizoides was the widest occurring invasive weed which was recorded at all the three sites along the disturbance gradient. Organic matter, soil carbon, soil moisture, soil respiration, soil nitrogen; soil pH was recorded highest at disturbed sites which may be responsible for highest diversity of weeds. Results concluded that high intensity of disturbance and plenty of soil resources may facilitate the site ripe for plant invasion.

Keywords: Plant invasion, biodiversity, human health, soil attributes, disturbance.

Introduction

Biodiversity is extremely precious resource issue in current civilization as it is inextricably linked with sustainable development. In recent Anthropocene era, biodiversity extends to humankind multifaceted direct economic benefits and direct essential services through natural ecosystems and plays a prominent role in ecosystem function and stability[1-7]. Biodiversity provides a vast array of products which are intimately linked with the human health[1-7]. Introduction of exotic invasive species are assumed to be the major threats to the global biodiversity[1,3]. In current scenario, plant invasion is generally considered to be one of the 'big five' environmental issues of public concern[1,8,9] and one of the six most serious environmental problems which may influence future economic and social development[1]. Although there are several definitions of alien invasive species, however, the one given by GISP (2003) seems to be most relevant in totality i.e.: 'Invasive alien species are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health'. Likewise, Convention on Biological Diversity held in 1992, defined invasive species as alien species whose introduction or spread threaten biological diversity. Thus, establishment and spread of these invasive species threatens landscape in terms of economy as well as environment[1,10-12].

Mizoram (literally-house of forest) is an important state of NE India (an Indo-Burma Hot spot) and the forests in Mizoram are classified as Tropical Wet Evergreen Forests, Tropical Semi-Evergreen Forests and Sub-Tropical Hill Forests[2,-4,13]. Therefore, there are varying forest types Mizoram harbouring great deal of biodiversity which are of immense values to its rural tribal people. Mizoram is the site of particular ecological relevance as it falls under an Indo-Burma hot spot region (figure-1). In Mizoram, land use change through shifting cultivation is very frequent which may exacerbate the problem of biological invasions[13]. In Aizawl, which is capital city of Mizoram, shifting cultivation transmogrify the landscapes of urban forests ripe for plant invasions. Land-use change is projected to have the largest global impact on biodiversity by the year 2100, followed by climate change, nitrogen deposition, species introductions and changing concentrations of atmospheric CO_2[1-3,8]. Land-use change is expected to be of particular importance in the tropics, climatic change is likely to be important at high latitudes, and a multitude of interacting causes will affect other biomes[1]. Various hypotheses have been proposed to understand the basic mechanism of succession, however, no one describe it in its totality[1].

However, one of the prime threats to biodiversity of indigenous/native diversity in Mizoram is plant invasion or introduction of exotic or alien plant species. Despite the large documented threats from invasive species to native biodiversity in several ecosystems of North East India, invasive species have rarely been considered as a significant threat to the diversity of tropical forests, and while invasions have been the subject of intensive ecological research during the last two decades, this research has largely ignored tropical forests[1] confined particularly to urban areas. Henceforth, present study is an initial attempt to identify the prime invasive plants of Aizawl,

Mizoram, North East India at sites of varying disturbance i.e. low (Vety Tlang), moderate (Kendriya Vidayalaya site located at Tanhril campus of Mizoram University) and high disturbance (Roadside site at Ramrikawn). Further, the present study investigated the selected soil characteristics at these three sites along a disturbance gradient. *Lantana camara, Mikania micrantha* and *Ageratum conizoides* were phyto-sociologically dominant invasive weeds at disturbed sites.

Material and Methods

The phyto-sociological studies were performed at three sites in Aizawl, Mizoram, North East India during the month of November to December, 2011 while the soil attributes as well as nutrients were analysed during the month of April, 2012. It is worth to mention that sites were selected in accordance with varying disturbance intensity. To perform phyto-sociological studies at different sites 5 quadrats of 10m×10m in size has been randomly used. Quantitative/phyto-sociological parameters such as % frequency, density, abundance and total basal cover of each species present in quadrats has been recorded and analysed as per the methods of Kershaw[14] and Misra[15]. Part of the moist soil samples is air-dried and sieved to obtain fine soil samples (<2 mm). Soil pH has been measured with soil water (1:5) slurry using a pH glass electrode. Organic carbon has been determined according to the Walkley and Black method and total nitrogen with Kjeldahl method. All other analyses are conducted as per the methodology described elsewhere[16].

Results and Discussion

Table 1-12 document the results obtained pertaining to diversity of invasive plants and soil attributes along a disturbance gradient. Maximum number of weeds[12] were recorded during the month of November and December, 2011 at site of high disturbance (Roadside site at Ramrikawn) followed by site of moderate disturbance (Kendriya Vidayalaya site of Tanhril campus of Mizoram University) and lowest[9] weeds were recorded during the month of December, 2011 at Vety Tlang site of low disturbance (table-1 to 6). The results revealed that number of weeds increased as the intensity of disturbance along the sites increased. *Lantana camara, Mikania micrantha* and *Ageratum conizoides* were phyto-sociologically dominant invasive weeds at disturbed sites (table-2 to 6).

Mikania micrantha is a many-branched perennial vine of the family Asteraceae that can reproduce easily through both sexual as well as vegetative reproduction[1]. Particularly, during the winter season, this invasive weed virtually covers the upper canopy of most of the angiosperm plants in Aizawl, producing the shade effect which may hamper the plant photosynthesis.

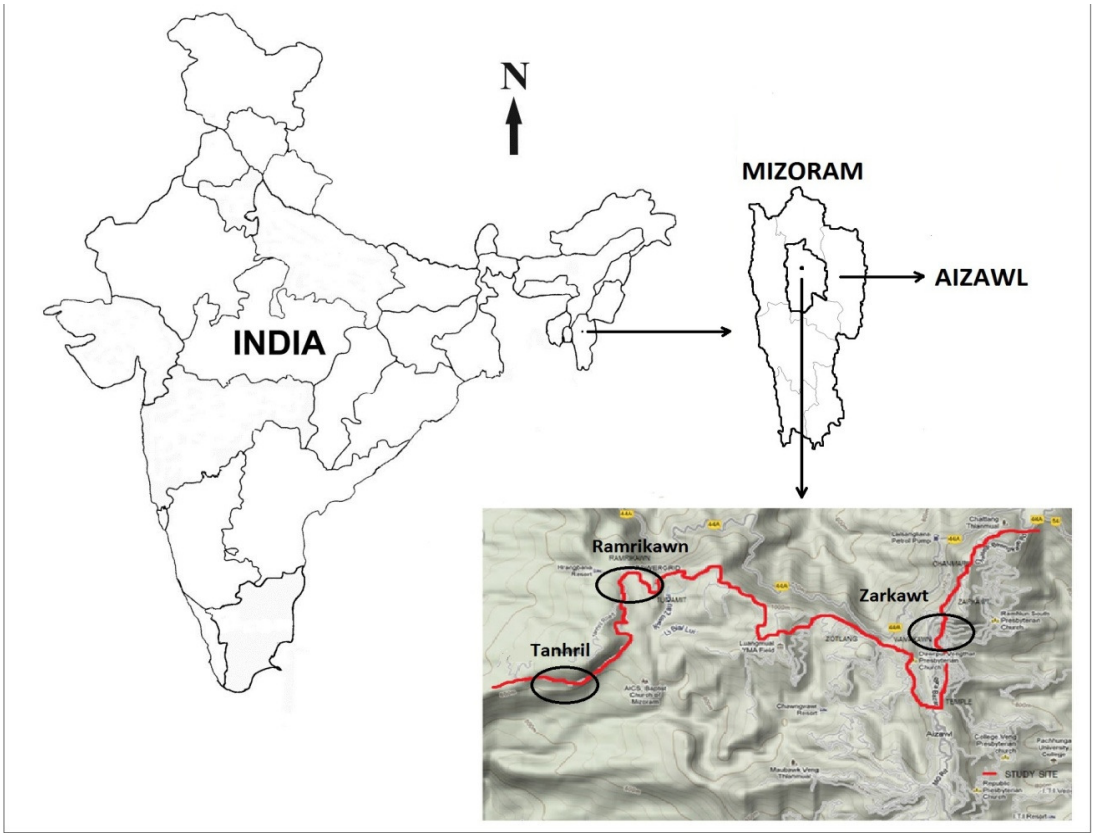

Figure-1
Map of the Study Area (Aizawl) Mizoram, North-East India (An Indo-Burma hot spot)

This vine can produce a large number of seeds[1]. *Lantana camara* is a member of the family Verbenaceae and is a pantropical invasive weed affecting urban forests, pastures and native forests in > 60 countries worldwide[1]. *Ageratum conizoides* was the widest occurring invasive weed which was recorded at all the three sites along the disturbance gradient (table-1 to 6). It is worth to mention that organic matter, soil carbon, soil moisture, soil respiration, soil nitrogen; soil pH was recorded highest at disturbed sites which may be responsible for highest diversity of weeds (table-7 to 12). Thus soil attributes and resources may alter the invasion success drastically. Generally, the soil with higher nutrients favored the invasive plants in present case study Only the potassium content of the soil was lowest at the disturbed site while higher values were recorded at the site of low disturbance (table-12).

Table-1
List of invasive weeds- Site 1: Vety Tlang (Low Disturbance site); November, 2011

Name of Species	Q1	Q2	Q3	Q4	Q5	No. of Individuals	Density	Freq.	Abundance	Basal Area	Basal Cover	Relative Density	Relative Frequency	Relative Abundance	IVI
Ageratum conizoides	+	+	+	+	+	140	28	100	28	7.06	197.68	35.80563	16.12903	56.48	108.4147
Spilanthes oleracea	+	+	+	+	+	90	18	100	18	3.14	56.52	23.0179	16.12903	16.14857	55.2955
Stellaria media	+	+	+	+	+	44	8.8	100	8.8	0.19	1.672	11.2532	16.12903	0.477714	27.85994
Galinsoga parviflora	-	+	-	+	+	31	6.2	60	10.3	3.14	19.468	7.928389	9.677419	5.562286	23.16809
Cyrtococcum accrescens	-	+	+	-	+	23	4.6	60	7.6	1.76	8.096	5.882353	9.677419	2.313143	17.87292
Comellina sikkimensis	-	-	+	-	+	8	1.6	40	4	0.78	1.248	2.046036	6.451613	0.356571	8.85422
Kyllingia brevifolia	-	-	+	+	+	30	6	60	10	0.78	4.68	7.672634	9.677419	1.337143	18.6872
Mikana micrantha	-	+	-	-	+	18	3.6	60	6	7.06	25.416	4.603581	9.677419	7.261714	21.54271
Dicrocephala latifolia	-	-	-	-	+	5	1	20	5	3.8	3.8	1.278772	3.225806	1.085714	5.590292
Clerodendron infortunatum	-	-	-	-	+	2	0.4	20	2	78.55	31.42	0.511509	3.225806	8.977143	12.71446

Table-2
List of invasive weeds Site 1: Vety Tlang (Low Disturbance site); December, 2011

Name of Species	Q1	Q2	Q3	Q4	Q5	No. of Individuals	Density	Freq.	Abundance	Basal Area	Basal Cover	Relative Density	Relative Frequency	Relative Abundance	IVI
Ageratum conizoides	+	+	+	+	+	114	22.8	100	22.8	7.06	160.968	28.00983	14.70588	50.29464	93.01035
Spilanthes oleracea	+	+	+	+	+	87	17.4	100	17.4	3.14	54.636	21.37592	14.70588	17.07108	53.15288
Stellaria media	+	+	+	+	+	61	12.2	100	12.2	0.19	2.318	14.98771	14.70588	0.724262	30.41785
Cyrtococcum accrescens	+	+	+	+	+	42	8.4	100	8.4	1.76	14.784	10.31941	14.70588	4.619278	29.64457
Kyllingia brevifolia	+	+	+	+	+	67	13.4	100	13.4	0.78	10.452	16.46192	14.70588	3.26574	34.43354
Mikania micrantha	-	+	+	-	+	21	4.2	60	7	7.06	29.652	5.159705	8.823529	9.264802	23.24804
Galinsoga parvviflora	-	-	+	+	+	10	2	60	3.3	3.14	6.28	2.457002	8.823529	1.962193	13.24272
Gynura bicolor	-	-	+	+	-	3	0.6	40	1.5	15.9	9.54	0.737101	5.882353	2.980784	9.600238
Clerodendron infortunatum	-	-	-	-	+	2	0.4	20	2	78.55	31.42	0.4914	2.941176	9.817216	13.24979

Table-3
List of invasive weeds; Site-2: Kendriya Vidayalaya site (moderately disturbed site), November 2011

Name of Species	Q1	Q2	Q3	Q4	Q5	No. of Individuals	Density	Freq.	Abundance	Basal Area	Basal Cover	Relative Density	Relative Frequency	Relative Abundance	IVI
Ageratum conizoides	+	+	+	+	+	59	11.8	100	11.8	7.06	83.308	11.21673	12.19512	10.69137	34.10322
Spilanthes oleracea	+	+	+	+	+	85	17	100	17	3.14	53.38	16.1597	12.19512	6.850546	35.20537
Mikania micrantha	+	+	+	+	+	74	14.8	100	14.8	7.06	104.488	11.59696	12.19512	13.40951	37.20159
Biden biternata	+	+	+	+	+	61	12.2	100	12.2	19.63	239.486	13.68821	12.19512	30.73454	56.61787
Stellaria media	+	+	+	+	+	72	14.4	100	14.4	0.19	2.736	20.15209	12.19512	0.351126	32.69834
Kyllingia brevifolia	+	+	+	+	+	106	21.2	100	21.2	0.78	16.536	7.794677	12.19512	2.122155	22.11195
Par yellow (local name)	+	+	+	+	+	41	8.2	100	8.2	3.14	25.748	3.231939	12.19512	3.304381	18.73144
Sida acuta	-	+	-	+	+	17	3.4	60	5.6	63.62	216.308	0.570342	7.317073	27.75998	35.6474
Merremia umbellatum	-	+	-	-	-	3	0.6	20	3	19.63	11.778	1.520913	2.439024	1.511535	5.471472
Gynura bicolor	-	-	-	+	+	8	1.6	40	4	15.9	25.44	14.06844	4.878049	3.264854	22.21134

Table-4
Invasive weeds Site-2 Kendriya Vidayalaya site (moderately disturbed site), December 2011

Name of Species	Q1	Q2	Q3	Q4	Q5	No. of Individuals	Density	Freq.	Abundance	Basal Area	Basal Cover	Relative Density	Relative Frequency	Relative Abundance	IVI
Ageratum conizoides	+	+	+	+	+	45	9	100	9	7.06	317.7	11.22195	13.88889	8.977822	34.08866
Spilanthes oleracea	+	+	+	+	+	51	10.2	100	10.2	3.14	160.14	12.7182	13.88889	4.525365	31.13246
Mikania micrantha	+	-	+	+	+	61	12.2	80	15.2	7.06	430.66	15.21197	11.11111	12.16994	38.49302
Biden biternata	+	+	+	+	+	58	11.6	100	11.6	19.63	1138.54	14.46384	13.88889	32.17378	60.52651
Stellaria media	+	+	+	-	-	44	8.8	60	14.6	0.19	8.36	10.97257	8.333333	0.236244	19.54215
Kyllingia brevifolia	+	+	+	+	+	79	15.8	100	15.8	0.78	61.62	19.70075	13.88889	1.741308	35.33095
Par yellow (local name)	+	-	+	-	+	33	6.6	60	11	3.14	103.62	8.229426	8.333333	2.928177	19.49094
Sida acuta	-	+	-	+	+	17	3.4	60	5.6	63.62	1081.54	4.239401	8.333333	30.56303	43.13576
Merremia umbellatum	-	-	-	+	+	8	1.6	40	4	19.63	157.04	1.995012	5.555556	4.437763	11.98833
Gynura bicolor	+	-	-	-	-	5	1	20	1	15.9	79.5	1.246883	2.777778	2.246575	6.271236

Anthropogenic perturbations are causing a biodiversity crisis in the form of invasive plants[1,15] as revealed in the present study. The results indicated that increase in the intensity of disturbance and soil nutrients may facilitate the mechanism of plant invasion as supported by multifaceted hypothesis described elsewhere[1].

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Table-5
Invasive weeds- Site 3: Roadside (disturbed-Ramrikawn site); November 2011

Name of Species	Q1	Q2	Q3	Q4	Q5	No. of Individuals	Density	Freq.	Abundance	Basal Area	Basal Cover	Relative Density	Relative Frequency	Relative Abundance	IVI
Lantana camara	+	+	-	+	+	20	4	80	5	78.55	314.2	4.950495	8.510638	34.25957	47.7207
Ageratum conizoides	+	+	+	+	+	65	13	100	13	7.06	91.78	16.08911	10.6383	10.00746	36.73487
Spilanthes oleracea	+	+	+	+	+	70	14	100	14	3.14	43.96	17.32673	10.6383	4.793287	32.75832
Biden biternata	+	+	-	+	+	32	6.4	80	8	19.63	125.632	7.920792	8.510638	13.69859	30.13002
Spilanthes sp.	-	-	+	-	+	14	2.8	40	7	4.9	13.72	3.465347	4.255319	1.495994	9.21666
Mikania micrantha	+	+	+	+	+	31	6.2	100	6.2	7.06	43.772	7.673267	10.6383	4.772788	23.08436
Clerodendron infortunatum	+	+	-	-	-	8	1.6	40	4	78.55	125.68	1.980198	4.255319	13.70383	19.93935
Imperata cylindrica	+	+	+	+	+	42	8.4	100	8.4	4.9	41.16	10.39604	10.6383	4.487982	25.52232
Par eng (local name)	+	+	+	-	-	19	3.8	60	6.3	3.14	11.932	4.70297	6.382979	1.301035	12.38698
Merremia umbellatum	+	+	+	-	+	22	4.4	80	5.5	19.63	86.372	5.445545	8.510638	9.417784	23.37397
Panicum conjugatum	+	+	+	-	+	32	6.4	80	8	1.76	11.264	7.920792	8.510638	1.228198	17.65963
Kyllingia brevifolia	+	-	+	+	+	49	9.8	80	12.2	0.78	7.644	12.12871	8.510638	0.833482	21.47283

Table-6
Invasive weeds- Site 3: Roadside (disturbed-Ramrikawn site); December, 2011

Name of Species	Q1	Q2	Q3	Q4	Q5	No. of Individuals	Density	Freq.	Abundance	Basal Area	Basal Cover	Relative Density	Relative Frequency	Relative Abundance	IVI
Lantana camara	+	+	-	+	+	18	3.6	80	4.5	78.55	282.78	4.825737	9.302326	34.87933	49.00739
Ageratum conizoides	+	+	+	+	+	56	11.2	100	11.2	7.06	79.072	15.0134	11.62791	9.753089	36.3944
Spilanthes oleracea	+	+	+	+	+	61	12.2	100	12.2	3.14	38.308	16.35389	11.62791	4.725078	32.70688
Biden biternata	+	-	+	-	+	28	5.6	60	9.3	19.63	109.928	7.506702	6.976744	13.559	28.04245
Spilanthes sp.	-	+	+	+	+	39	7.8	80	9.7	4.9	38.22	10.45576	9.302326	4.714223	24.47231
Mikania micrantha	+	+	+	+	+	25	5	100	5	7.06	35.3	6.702413	11.62791	4.354058	22.68438
Clerodendron infortunatum	+	+	-	-	-	7	1.4	40	3.5	78.55	109.97	1.876676	4.651163	13.56418	20.09202
Imperata cylindrica	-	+	+	+	+	38	7.6	80	9.5	4.9	37.24	10.18767	9.302326	4.593346	24.08334
Par eng (local name)	-	+	+	-	-	10	2	40	5	3.14	6.28	2.680965	4.651163	0.774603	8.106731
Merremia umbellatum	+	+	+	+	-	14	2.8	80	3.5	19.63	54.964	3.753351	9.302326	6.779502	19.83518
Panicum conjugatum	+	+	-	-	+	34	6.8	60	17	1.76	11.968	9.115282	6.976744	1.476186	17.56821
Kyllingia brevifolia	+	-	+	-	-	43	8.6	40	21.5	0.78	6.708	11.52815	4.651163	0.827394	17.00671

Table-7
Organic carbon and organic content at different sites (April, 2012)

Soil samples	Replicates	Burette Readings		Means	Organic Carbon Contents	Blank Reading	Organic Matter Content
		Initial	Final				
SITE 1 (Low Dist.)	R1	0	17.4	18.1	1.3	23.1	2.2
	R2	0	18.8				
	R3	0	18.1				
SITE 2 (Moderate Dist.)	R1	0	19.5	19	1.06		1.8
	R2	0	18.6				
	R3	0	18.9				
SITE 3 (High Dist.)	R1	0	18.7	16.8	1.63		2.8
	R2	0	15.4				
	R3	0	16.4				

Table-8
Soil respiration at different sites (April, 2012)

Soil samples	Replicates	Burette Readings		Means	Blank Reading	Soil Respiration
		Initial	Final			
Site 1 (Low Dist.)	R1	0	39.8	38.5	41.3	6.16
	R2	0	37.5			
	R3	0	38.4			
Site 2 (Moderate Dist.)	R1	0	40.5	40.5		1.76
	R2	0	40.8			
	R3	0	40.2			
Site 3 (High Dist.)	R1	0	35.2	34.7		14.5
	R2	0	34.2			
	R3	0	34.8			

Table-9
Soil moisture at different sites (April, 2012)

Soil Samples	Replicates	Wt. of soil samples		Means Of Soil B	Soil moistures (a-b)
		Before drying (A) in g	After drying (B) in g		
Site 1 (Low Dist.)	R1	10	8.5	8.6	1.4
	R2	10	8.6		
	R3	10	8.8		
Site 2 (Moderate Dist.)	R1	10	8	7.8	2.2
	R2	10	7.7		
	R3	10	7.9		
Site 3 (High Dist.)	R1	10	8.2	8.1	1.9
	R2	10	8.3		
	R3	10	8		

Table-10
pH of soil samples at different sites (April, 2012)

Soil samples	Replicates	pH Readings	Mean pH
Site 1 (Low Dist.)	R1	6.21	6.2
	R2	6.25	
	R3	6.24	
Site 2 (Moderate Dist.)	R1	6.61	6.8
	R2	6.92	
	R3	6.89	
Site 3 (High Dist.)	R1	6.42	6.3
	R2	6.28	
	R3	6.32	

Table-11
Soil Nitrogen at different sites (April, 2012)

Soil Samples	Replicates	Burette Readings		Means	% of Total Nitrogen
		Initial	Final		
Site 1 (Low Dist.)	R1	0	5.4	5.2	0.14
	R2	0	5		
	R3	0	5.1		
Site 2 (Moderate Dist.)	R1	0	6.9	6.3	0.17
	R2	0	6		
	R3	0	6.2		
Site 3 (High Dist.)	R1	0	7.6	7.6	0.21
	R2	0	7.7		
	R3	0	7.5		

Table-12
Soil potassium (K) content at different sites (April, 2012)

Soil samples	Replicates	Burette Readings		Means	Potassium Contents
		Initial	Final		
Site 1 (Low Dist.)	R1	0	22	22	0.85
	R2	0	22		
	R3	0	23		
Site 2 (Moderate Dist.)	R1	0	17	16	0.68
	R2	0	16		
	R3	0	15		
Site 3 (High Dist.)	R1	0	13	13	0.5
	R2	0	13		
	R3	0	14		

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