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Research Article

Status of Invasive Alien Plant Species (IAPS) in Shreenagar Hill of Tansen, Palpa, Nepal

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Abstract

The non-native plant species which invade and displace native plants causing damage to environment, biodiversity, economy and health called invasive plants. Their status was studied in Shreenagar hill of Tansen, Palpa. Field visit and sampling of size 1m x 1m was done in 120 plots by systematic random sampling method. Asteraceae family and *Ageratina adenophora* species were found to be most dominant with more effect on disturbed area. The invasion was more in highly disturbed areas. All Invasive Alien Species (IAPs) were dicotyledons and most of them (8 out of 9) were herbs. Till now, there is no more impact of IAPs on total plant species richness due to their recent entry but threatening to be epidemic in future. So, there is urgent need of controlling them to prevent from further spread.

Keywords: Invasive; Sampling; Dominant; Threatening; Epidemic; Asteraceae

Introduction

A subset of naturalized species which spread so rapidly and extensively that they impart significant negative impacts on biodiversity, ecosystem, infrastructure, human health and economy in the introduced range are called invasive alien species (IAS) [30]. A biological species introduced in an ecosystem other than its natural home are termed as alien or non-native species. If these organisms become aggressive or spread beyond the manageable boundaries and outcompete native species in the ecosystem, then these are considered as Invasive Alien Species (IAS). They can transform the structure and species composition of ecosystems by excluding native species. They may alter their environment by releasing chemicals with the modification of abiotic environment. They have fast growth, rapid reproduction, higher seed dispersive capacity, higher adaptability to disturbed area, extensive root system and free of predation and diseases.

Inclined biological invasion has become one of the leading causes of decline or loss of indigenous biodiversity [25] and concluded as a reason for being major component of global environmental changes. With constant increase in human movement and expanding global trade, the biological invasion has been increasing its intensity in all ecosystems and landscapes causing serious impacts on ecosystem services [28]. Most of the IAPs in Nepal are native to tropical America [42]. Among 25 IAPS, four species (*Chromolaena odorata, Eichhornia crassipes, Lantana camara and Mikania micrantha*) are included in world's 100 worst invasive species [27]. And recently *Spergula arvensis* has been added to the list of invasive species [31]. Thus, out of 179 species of alien plant that are naturalized in Nepal, 26 species of IAPS are considered as problematic with negative impacts on environment and economy in Nepal [38] but recently 241 naturalized species are found more impactful (37 plants and 8 animal).

More than 3/4th of the naturalized plant species (which also includes IAPS) of Nepal are native to tropical and subtropical region of the world [42] and the southern half of Nepal which includes Terai, Siwalik and Mid Hills governing east-west with tropical to

subtropical climate is more sensitive to biological invasion [6]. Therefore, distribution pattern of naturalized and invasive alien plant species (IAPS) in Nepal appears to be linked with climate of their native region and routes of international trades of Nepal [38].

The plant can spread vegetatively, that is the stems can sprout roots and grow upon contact with earth. The seed is also carried by the wind or water and colonizes disturbed areas, such as fields and areas near human habitation, readily. Seed may also be transported on animals and in soil [45]. The IAPS like *Ageratina adenophora*, *Chromolaena odorata* and Mikania micrantha are mostly dispersed by winds, *Xanthium strumarium*, *Bidens pilosa* are dispersed by animals, *Parthenium hysterophorus* is dispersed by vehicles and agriculture produces, seeds of Lantana camara is mainly dispersed by birds and also introduced to new locations for ornamental purposes due to its attractive flower. Thus, introduction of alien species exclusively depends on human activities while the subsequent dispersal of naturalized species occurs both by natural process as well as human activities [37].

All the species introduced in particular areas are not invasive, but have potential to be invasive [40,42]. The biological invasion usually follows a sequence that begins with intentional or unintentional introduction of species, progressing to establishment i.e., the introduced species survives but could not spread, culminates into spread to become a part of new habitat known as naturalization and finally invasion which shows the expansion and impacts on species, ecosystems, people and development [23]. According to "Rule of Ten" only 10% of introduced species will survive in the wild and 10% of them will become established. Among the established alien species, only 10% will spread and become invasive over time [23]. Therefore, only about 0.1% of introductions are likely to become invasive. Absence of predators and parasites in alien habitat helps in advancing invasive alien species, otherwise IAS are under control in native habitat. It is supported by the Enemy Release Hypothesis (ERH) - the idea that species are more likely to become invasive when they are free from their natural enemies [43]. On the same way, invisibility varies in relation to productivity and disturbance regime [18,19,21]. Although all the ecosystems are found to be susceptible to invasion, the ecosystems exposed to a higher level of human interventions such as agricultural lands and grasslands were more susceptible to invasion of IAPS [46].

It is a pervasive and costly environmental problem. Over the past half century, it has become the focus of intense management and research activities worldwide [24]. The Convention on Biological Diversity (CBD), to which Nepal and 177 other countries are party, calls on governments to prevent the introduction, control or eradication of those alien species that threaten ecosystems, habitats or species (Article 8). However, approaches taken to combat this phenomenon and even the data on which they should be based are clearly insufficient to deal with the onslaught of invasive species in Nepal. Participatory biodiversity conservation programme and an inventory of alien species are being run by International Union for Nature Conservation Nepal (IUCN/Nepal). However, exact estimations of community susceptibility to invasion remain indefinable.

Along with the periodic study the management strategies were suggested by the researchers where [34] proposed the general principles of IAPS management that includes: Prevention, Early Detection and Rapid Response, Control and Management, Education and Public Awareness and [38] also mentioned the very similar management strategies such as prevention, eradication and control.

Timely identification of the harmful species is the better option for prevention and removals (e.g., weeding, ploughing, burning, digging, flooding, etc.) of weeds is immediate step for mitigating their impacts and to control the spreading of such species to non-existing areas [35].

The problem of invasive species is prevalent both in developed as well as developing countries, but their impact is likely to be higher in developing countries like Nepal due to lack of expertise and limited resources available for their management. Early detection of the species is an essential first step in the cost-effective removal or control and management of invasive species [37]. Once established, eradication is the most desirable solution, but it is very expensive to do, so prevention is still the best answer. At the top of these activities, there is a need to prepare a National Strategy for the Management of Invasive Alien Species to effectively harmonize sectoral and cross-sectoral programs including release of biological control agents for high-risk species. Management could be effective when community become aware to those species and take preventive measures.

Method and Methodology

Study area

The study area lies in Tansen Municiality (latitudes: 27°42' N to 27°49' N, and longitudes: 83°23' E to 83°35' E) of Palpa district (latitudes: 27°34' N to 27°57' N, longitudes: 83°15' E to 84°22' E). It lies in Lumbini province, western part of Nepal. The study area is located at an altitude of 1500 meters above the sea level which covers an area of 1373 km^2. The study area has moderate climate with temperatures rarely exceeding 30° Celsius (86° F). About 80% rainfall occurs during (June to September); the monsoon season. In summer it stays mild and charming-hardly exceeds 28° Celsius.

Field visit

The survey was done 3 times and each visit was of 5 days within the period of December 2018- May 2019 at different transect of forest. These transect were considered as the sampling sites for the field survey. Altogether 6 transect were studied categorizing into three parts i.e., highly disturbed, moderate disturbed and less disturbed areas.

Vegetation sampling

To study the current status and impacts of IAPS, 120 plots of 1m × 1m, were sampled by systematic random sampling method in six different transect with 20 plots at each transect. The transects were organized by maintaining 200-250m distance between the plots. From each plot, different parameters such as cover percent of IAPS by visual estimation, species numbers, and altitude and location point of plot were measured. Unknown plant species were collected and identified using herbarium and literatures.

Collection of secondary information

The secondary information related to this study will be obtained from previous thesis done the several published as well as unpublished journals, research reports, websites, etc. related to invasive alien plant species.

Data analysis

The collected data were analyzed to find frequency, density and coverage. One-way ANOVA was performed to identify disturbance variability in species frequency.

Result and Discussion

Overall species composition

A total of 105 species were recorded representing 44 families, 90 genera and 105 species. Among total identified families the most dominant family was the Poaceae (12 genera, 15 species), followed by Asteraceae, Fabaceae, Pteridaceae and Lamiaceae. The Poaceae is found most dominant as it is the largest family of monocotyledons both globally and nationally. It is due to its rapid reproductive rate, fast seed dispersal, most stress tolerance capacity and grasses having perennial habit.

IAPS composition

The 9 IAPs found in the study area are

- *Ageratina adenophora* l.
- *Bidens pilosa* L.
- *Mimosa pudica* L.
- *Parthenium hysterophorus* L.
- *Lantana camara* L.
- *Ageratum houstonianum* Mill.
- *Chromolaena odorata* Spreng
- *Oxalis latifolia* Kunth.
- *Amaranthus spinosus* L.

They are represented by 5 families, 9 genera and 9 species. Among them the dominant family was Asteraceae with (5 genera, 5 species) followed by Amaranthaceae, Verbenaceae, Fabaceae, Oxalidaceae with 1 genus and 1 species each.

Total number and Family

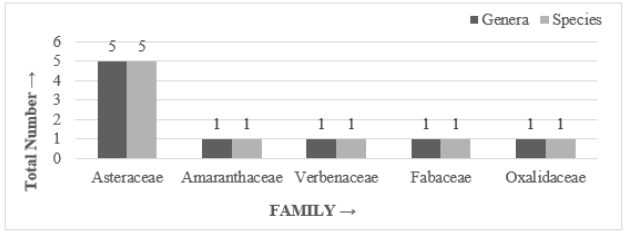

Figure 1: Bar diagram showing family of IAPS along with their genera and species present in the study plots.

The dominance of family Asteraceae might be due be due to its massive seed production and efficient seed and pollen grain dispersal mechanism [32]. Among the 26 IAPS reported from Nepal, Asteraceae was the largest family with 10 species [38]. [4,6,17,41] also reported Asteraceae as the most dominant family in their study area. Similar result was found by this work with Asteraceae as the dominant family with five species among a total of 9 IAPS.

Total number and life forms

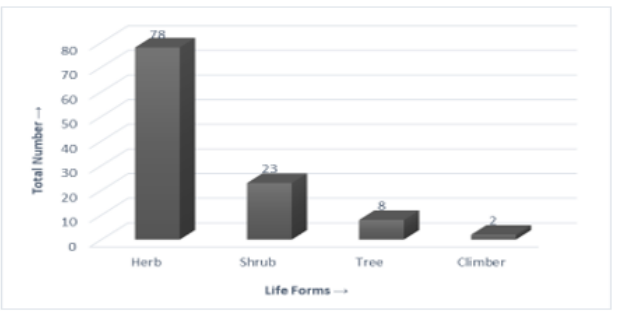

Figure 2: Bar diagram showing functional groups of all species present in the study plots.

The herbaceous flora was higher than shrubs and trees. The study area was signified by 78 herbs, 23 shrubs, 8 tree species and 2 climber species. Since herbs are small and produce large number of seeds. The presence of highest number of herbs might be due to their short life cycle and fast seed and pollen grain dispersal rate. They are also found in places where the weather conditions are not good for most plants. Among the total plant species, the results were similar to those of Singh (2014) [39]; Chaudhary (2015) [11] also recorded 11 species of invasive plant as herbs while 2 species as climber, and only one species as shrub.

Total number and post areas

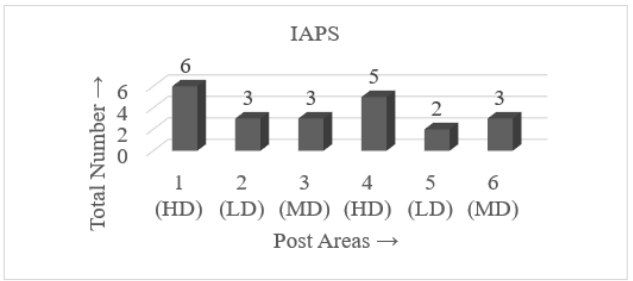

Figure 3: Bar diagram showing total number of IAPS present at different post areas.

Among the 6 sampling sites (post areas), the numbers of IAPS were found higher in post area 1 and 4. It might be due to anthropogenic disturbance such as human movements, cattle grazing, movement of vehicles, industrial product transportation, garbage waste, etc. in highly disturbed areas. While the post area 2, 3 and 6 had similar number of IAPS i.e., 3. This might be due to moderate anthropogenic disturbances and negligible disturbance seems to be happening in post area 5. Although the sampling site 2 has been considered as low disturbed area, the reported number of IAPS from this site was similar with the sampling sites of moderately disturbed post areas. This might be due to movement of human beings in this area frequently as compared to the post area 5 which was also termed as low disturbed area. It could be due to either in initial stage of spread of naturalized plant species.

There are 100 worst weed species in the world [27], among them 14 worst invasive alien species are found in Nepal. Among the 14 worst species, 9 species were found in Shreenagar hill. Nine species were prevalent in Shreenagar hill, and *Ageratina* was the most problematic. Among the 9 IAPS, *Chormolaena odaorata* and *Lantana camara* were recorded in Shreenagar Hill and are listed under the category of world's hundred worst invaders [27].

Frequency of IAPs

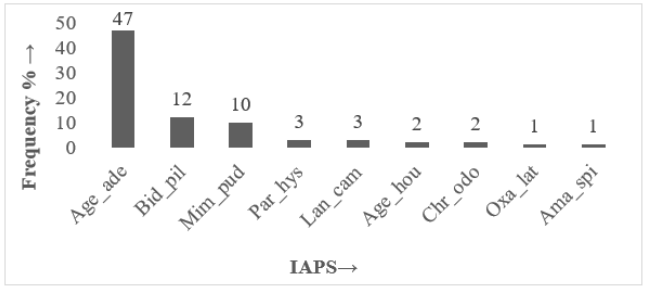

Figure 4: Bar diagram showing the frequency of all the invasive species present in the study plots.

The high frequency of *Ageratina adenophora* is due to small and light seed which can be dispersed easily both by air and water. It can grow easily in any contaminated site. *Amaranthus spinosus* and Oxalis latifolia were measured as the least dominant in the study area. It might favor the environments of agricultural land rather than forest land. The result approximately supports the previous study by Kunwar and Acharya (2013) [26] in Bhadaure Tamagi VDC, Kaski where the frequency of *Ageratina adenophora* was (77.7%).

Density of IAPS

Similarly, density of *Ageratina adenophora* was highest and hence most dominant, followed by *Bidens pilosa*, *Mimosa pudica*, *Chromolaena odorata*, *Lantana camara, Parthenium hysterophorus, Ageratum houstonianum, Oxalis latifolia* and *Amaranthus spinosus* in Shreenagar Hill (SH).

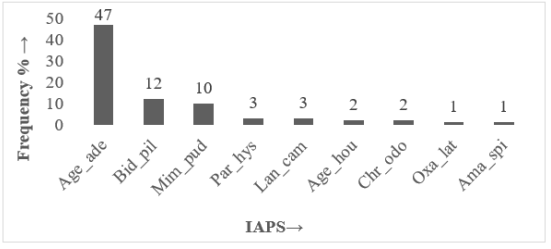

Figure 5: Bar diagram showing the density of all the invasive species present in the study plots.

The high density of *Ageratina adenophora* is due to enormous production of light seeds with high germination rate (90%). Moreover, their comparatively low weight and small size allow seeds to disperse and colonize new areas or gaps in existing communities [9,29]. The plant can spread vegetatively, that is the stems can sprout roots and grow upon contact with earth and colonizes disturbed areas, such as fields and areas near human habitation [45]. Therefore, the plants grow closely replacing other species.

Coverage of IAPS

On the basis of coverage *Ageratina adenophora* is found as major IAPS, which has most coverage in the case of all samples, followed by *Bidens pilosa, Lantana camara, Mimosa pudica, Chromolaena odorata, Parthenium hysterophorus, Ageratum houstonianum, Amatanthus spinosus* and *Oxalis latifolia* in SH

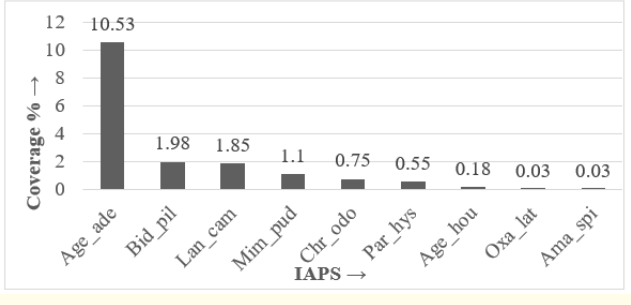

Figure 6: Bar diagram showing the coverage of all the invasive species present in the study plots.

The highest coverage of *Ageratina adenophora* is due to their high density, extensive branching and larger leaves. The coverage of native vegetation significantly decreased with the plant's reproduction. *Ageratina adenophora* showed a creeping growth mode, root development from stems and emergence of large number of new branches. Thus, *A. adenophora's* competitive ability was enhanced. In an *A. adenophora* predominant community, *A. adenophora* occupied a higher competitive superiority position than the other plants which were nearly excluded or replaced due to *A. adenophora's* strong re-productive ability and vitality [44].

Disturbance and species

The highest invasive plant species occur on highest disturbance. More effect on disturbed area might be due to higher chance of dispersal of seeds and spores through the vehicles and different human activities.

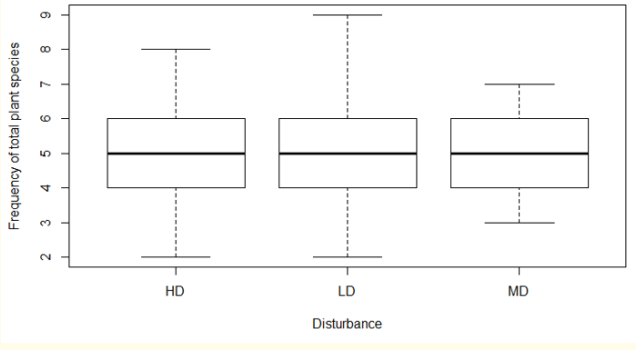

Figure 7: Frequency of total plant species with disturbance (HD = High disturbance, MD = Moderate disturbance and LD = Low disturbance, Total plant species did not show any significant difference with disturbance level).

Roads or trails, which usually occur in transition areas, often function as conduits for the dispersal of alien plants [20]. The invasion level of each IAPS near settlement favored more by the human activities rather than the allopathic nature with high reproductive efficiency of invasive weed [17]. Anthropogenic activities and animal movement may help in arrival and distribution of IAPS spreads in exotic areas where they can easily colonize and then start to alter ecosystem processes affecting native community. Each IAPS measured more dominant and more frequent in forest near settlement than away from settlement supporting the statement of (Fugii., *et al*. 2008) [17]. Hence, it can be said that the settlement zones are the favorable sites for the spreading of the IAPS. The level of invasion found to be decreased on decreasing the human interference gradually [22] from transects near settlement to away from

settlements. The level of invasion is favoured more by the human activities than the allelopathic nature and reproductive efficiency of invasive weed [17]. Thus, introduction of alien species exclusively depends on human activities while the subsequent dispersal of naturalized species occurs both by natural process as well as human activities [37].

Disturbance level	Std.Error	t value	Pr (>|t|)
Low Disturb - High Disturb	0.1709	-3.951	<0.001
Mod Disturbance-High Disturb	0.2092	-3.345	0.003
Mod Disturb-Low Disturb	0.2092	-0.119	0.99

Table 1: Summary of the Tukey's HSD test to show the variability of the frequency of invasive species with disturbance level (high, moderate and low).

Conclusion

Altogether 105 species of plants including 9 IAPS were recorded from the sampling areas in Shreenagar Hill. Poaceae was the largest family when all species were considered whereas Asteraceae was the largest family in case of IAPS. Among 9 IAPS, *Ageratina adenophora* was most frequent with highest frequency, density and coverage in all sampling sites. IAPS was seen more in the highly disturbed areas with higher problematic than in moderate and low disturbed areas. More effect on disturbed area is due to higher chance of dispersal of seeds and spores through the vehicles and human activities. Till now, there was no more impact of IAPs on total species richness due to their recent entry but will have tremendous effect in the future. Therefore, these harmful plants should be managed on time through the prevention, eradication and control.

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