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IMPACT OF PARTHENIUM WEED (*PARTHENIUM HYSTEROPHORUS L.*) ON THE ABOVE-GROUND VEGETATION COMMUNITIES OF CULTIVATED AND GRAZING LANDS IN WOLIATA ZONE, ETHIOPIA

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Abstract

Parthenium hysterophorus **invasion is observed in areas of Woliata Zone. However, its impact has not been determined. Therefore, the objective of the study was to examine the impact of *P. hysterophorus* on species richness and evenness in study area. Stratified random sampling was applied with five categories; None invaded site, Very low invaded site, low invaded site, Moderately Invaded Site and High Invaded Site. After selecting site, 120 quadrants of 5m x 5m were laid. Then, the plant species found in each quadrat were estimated, counted, recorded and identified. The diversity index, evenness, and species richness to determine impact on species diversity were calculated from the data. A total of 55 plant species belong to 44 genera and in 17 families were identified. The number of species, diversity index and evenness reduced by 23.91%, 38.20%, and 31.81%, respectively in *P. hysterophorus* HIS of as compared to NIS. Such a reduction might be due to allelochemicals of the *P. hysterophorus* and altered soil environment. The regression analysis showed that there is a strong negative linear relationship between the cover**

abundance and species richness, diversity and evenness index per study site. *P. hysterophorus* was found to a threat to the biodiversity. Thus, there is urgent need for well organized, coordinated and concerned efforts must be made to control. Further long-term study is needed to verify the impact of *P. hysterophorus* invasion.

Key words: Abundance, Diversity, impact, Parthenium weed

INTRODUCTION

Invasive species are recognized as one of the major threats to native species and ecosystems around the world (Kathiresan *et al*., 2005). Invasive Alien Plant Species (IAPs) refer to plants that are not native to specific ecosystem and whose introduction threatens biodiversity, food security, health or economic development (McNeely *et al*., 2001). Invasive species are of concern because of their capability of spreading fast, their high competitiveness and ability to colonize new areas within short periods. The nature and severity of the impacts of these species on society, economic life, health and national heritage are of global concern (McNeely *et al*., 2001).

According to CBD (2005), invasive alien plant species are introduced deliberately or unintentionally outside their natural habitat, where they have the ability to establish themselves, invade, out-compete natives and take over the new environment. Invasive species have now affected every ecosystem types on the planet and considered as the second greatest global threat to biodiversity, after habitat destruction (Essa *et al*., 2006). Apart from their threat to biodiversity and ecosystem services, invasive species have significant social, ecological and economic impacts. They reduce agricultural yields, irrigated crop lands, grazing areas, water availabilities, and contribute to spread of vector born diseases.

According to Raghubanshi *et al*. (2005), IAPs have unique characteristics over the native ones. They do not need special environmental requirement for seed germination, have rapid seedling growth and produce seeds for longer period of time as long as environmental condition permit, they are also highly tolerant to climatic and edaphic variations and have an ability to compete and drive off other species from their habitat. Moreover, they can reproduce sexually and asexually.

Ethiopia is rich in biodiversity and is one of the 12 Vavilovian centers of origin (UNEP, 2003). However, there are about 35 invasive alien plant species threat the biodiversity of the country (McGinley, 2007). The top-20 among these are *Prosopis juliflora* (Sw.) DC., *Parthenium hysterophorus* L., *Eichhornia crassipes* (Mart.) Solms, *Lantana camara* L., *Opuntia ficus-indica* (L.) Miller, *Opuntia stricta* (Haworth) Haworth, *Argemone mexicana* Sweet, *Ageratum conyzoides* L., *Senna occidentalis* (L.) Link, *Datura stramonium* L., *Mimosa diplotricha* C. Wright, *M. pigra* L., *Cryptostegia grandiflora* (Roxb.) R. Br, *Acacia saligna* (Labill.) H.L. Wendl., *Nicotiana glauca* Graham, *Xanthium strumarium* L., *Caesalpinia decapetala* (Roth) Alston, *Pistia stratiotes*, *Cirsium vulgare* (Savi) Ten, and *Xanthium spinosum* L. (Boy and Witt, 2013).

These IAPs pose the biggest threat to biodiversity after habitat destruction and also pose a serious threat to agriculture (crop and livestock), livelihoods and human health at various levels (Haysom and Murphy, 2003). *Parthenium hysterophorus* causes diarrhoea, severe papular erythematous eruptions, breathlessness and choking (Maishi *et al*., 1998). Exposure to *P. hysterophorus* also causes systemic toxicity in livestock (Gunaseelan, 1987). The milk and meat quality of cattle and sheep deteriorate on consumption of this weed (Lakshmi and Srinivas, 2007).

In the Amhara region, it is estimated that about 37,105 hectares of land is infested with *parthenium* (Bezabieh F. and Araya Tesfaye, 2002). Furthermore, the weed is well established in many districts of South, north, and central Tigray. In one district alone, Alamata, about 10,000 hectares of the land has been infested with *parthenium* (Bezabieh F. and Araya Tesfaye., 2002). Currently, Parthenium is spreading at an alarming rate in Eastern Ethiopia; the central rift valley, and neighboring localities of Afar Region, East Shewa, and Bale and in Southern Ethiopia. Regional State of Oromia although there is no actual survey data on the total area of land infested in the region.

Currently, the invasive alien species have been distributed to different regional states of Ethiopia including Southern Nations Nationalities and Peoples Region State, (SNNPR). Invasion of *P. hysterophorus* is observed in some areas of Woliata Zone, SNNPR. However, there is no adequate information on impacts of *P. hysterophorus* in Woliata Zone. Thus, it is imperative to examine the impact of *P. hysterophorus* on plant species diversity and composition in Woliata Zone.

MATERIALS AND METHODS

Study area

The study was conducted on the Arable and rangelands of Sodo city, Offa, Humbo and Soddo Zuria districts in the Woliata Zone of the Southern Nations Nationalities Regional state, Ethiopia. The four districts were selected because of high infestation of parthenium weed of the districts.

Woliata Zone is located in southern Ethiopia and is bound by geographical coordinates 6.4° and 7.1° N latitudes and 37.4° and 38.2° E longitudes. Its altitude ranges from 1,200 to 2,950 m above sea level. The annual rainfall ranging between 754.6 and 1575.8 mm. March to October is a rainy period and the mean seasonal temperature ranges from 12.1 to 32.7 °C and the mean temperature is 21.5°C. Average monthly rainfall recorded in the area showed that the highest amount of rainfall is received in March and July.

The vegetation of the study area is dominated by eucalyptus trees (*Camaldulensis spp.)*. Remnants of indigenous tree species such as *Croton macrostachyus* Hochst. ex Rich., *Cordia Africana* Lam., *Erythrina spp, Podocarpus falcatus, Olea Africana, Ficus spp* and *Juniperus procera, Acacia spp, Combretum molle, Commiphora bruceae, C. habessinica, Boswellia rivae,* are also present.

Sampling

The road transect survey method was employed (Wittenberg et al., 2004) in 50 m distance to lay a quadrat. A total of 120 quadrats (5m x 5m) were laid for herbaceous data collection. The quadrats were delineated using polyethylene strings around four wooden pegs inserted in to the soil at four corners. Following the methods suggested by Chellamuthu et al. (2005); Shashie et al. (2003), sample sites were visually categorized into five infestation levels: None invaded sites, very low invaded sites (< 10%), low invaded sites (11 to 25%), moderate invaded sites (26 to 50%) and high invaded sites (> 50%) of the total percent area coverage of invasive plants.

Determination of the above-ground species abundance

The cover abundance of herbaceous vegetation at the 12 sampling sites was determined from 120 quadrats (5m × 5m; 10 quadrats for each site). The cover abundance of plant species encountered in each of the quadrats was recorded using Braun-Blanquet 1965 cover method (Wittenberg et al., 2004). This involved visually assigning the plant species to one of six cover classes and then visually assessing their canopy cover percentage in each quadrat. Then, the species cover abundance value was determined by multiplying the number of times a cover class was recorded in the replicated quadrats by the mid-point of that cover class, and the sum of each class was then divided by the total number of quadrats used to find the mean value. Plant species which are difficult to identify in the field, plant specimen were collected, pressed, dried, labeled and identified in the field using flora of Ethiopia in Dilla University. The taxonomic identification of the plant species followed the different volumes of flora of Ethiopia and Eritrea books.

Data Analysis

Species diversity of the plant from the sample sites in the study areas was compared using Shannon Diversity Index (Shannon and Wiener, 1949).

$$\mathrm{H}' = -\sum_{i=0}^{s} \mathrm{pilnpi}$$

Where H‘‘ = Shannon diversity index;

Pi=the importance value of the ith species s=total number of species in the sample quadrat

The Shannon evenness index was calculated as proposed by (Hill, 1973).

$$E = \frac{H'}{lns}$$

Where E= Shannon evenness index

This index explains how equally abundant each species would be in the plant community and high evenness is a sign of ecosystem health. The evenness or equitability assumes a value 0 and 1 with 1 being complete evenness and 0 a single species dominating the area.

The regression of variables such as cover abundance, species diversity, species richness, and evenness among sample sites were done to check if there is any association among sample sites.

RESULT AND DISCUSSION

Effects of parthenium weed on the above-ground species cover abundance

In the study sites, a total of 55 plant species belong to 44 genera and in 17 families were identified (Table 1). Out of these, Asteraceae account the largest (30.9%) followed by lamieceae accounting for 10.9 % and Fabaceae accounts 9.1% of the total species documented. This suggests that Asteraceae dominate the study area. Tamado and Milberg (2000) reported high frequency of Asteraceae and Poaceae families in eastern Ethiopia as they are very rich in species composition.

The cover abundance of species varied along the *P. hysterophorus* intensity from none invaded category to the heavily invaded category (Table 1). *A. hispidum* and *A. figarianum* have the higher cover abundance in invaded sites. The proportion of each of the species was 2.46% and 3.36% respectively. This indicates that these species could be resistant to *P. hysterophoru* invasion. Whereas; non-invaded site was dominated by *M. bojeri* Dc., and *A. hispidum* accounted 11.96%, and 6.50% of the total species recorded respectively. The result indicates no plant out strongly competed *P. hysterophorus* invaded sites. In general, as the parthenium weed infestation levels increased, the percentage cover of each species decreased. The high relative dominance of

P. hysterophorus might be due to its high competitive and/or allelopathic effects on the neighboring plants (Adkins and Sowerby, 1996).

Table 1. Mean cover percentage (m^2) of each species and parthenium weed at in five *Parthenium* invasion levels

Scientific name	**family**	**Life form**	**% Mean cover abundance**				
			NIS (N=3)	**VLIS (N=3)**	**LIS (N=2)**	**MIS (N=2)**	**HIS (N=2)**
Parthenium hysterophorus L.	Asteraceae	Herb	0	10.6	18.10	25.5	57.52
Lantana camara L.	Vervanaceae	shrub	6.47	11.6	28.94	13.3	5.39
Senna didymobotra (Fresen.) Iriwin Bameby	Fabaceae	shrub	5.46	5.08	4.62	5.13	0.57
Aregemone mexicana L.	Papaveraceae	Herb	3.08	0	0.70	5.27	1.18
Datura stramonium L.	Solanacea	Herb	3.25	4.01	4.78	2.59	2.13
Senna occidentalis L. link	Fabaceae	Shurb	7.85	0.28	10.30	8.14	8.21
Acanthospermum hispidum DC	Asteraceae	Herb	6.50	0	2.98	1.58	3.36
Solanum incnum L.,	Solanaceae	Shrub	2.03	2.17	3.39	0.74	1.01
Tagetes minuta L.	Asteracea	Herb	1.27	3.10	0	0.46	0
Commelina latifolia Hochst. Ex A. Rich	Commelinacee	Herb	4.28	4.97	0.08	1.03	0.48
Leucas martinicensis Jacg. R.Br.	Lamiaceae	Herb	3.41	4.49	0.43	3.42	0.51
Bidens biternata (Lour.) Merr.ând Sherff	Asteracea	Herb	1.72	0	0	0.03	0
Guizotia schimperi Sch.Bip. ex Walp	Asteracea	Herb	1.69	4.34	0	2.26	0.11

Ricinus communis L.,	Euphorbiaceae	Herb	1.13	0.23	0.32	0.30	0.80
Bidens pilosa L.,	Asteraceae	Herb	2.24	1.88	0.62	1.079	0.28
Vernonia amygdalina Del.,	Asteraceae	Shrub	0.15	0.33	0.27	0.06	0
Amarantus caudatus L.	Amarantaceae	Herb	0.05	0.29	0.16	0.40	0.32
Xanthium strumarium L.	Asteraceae	Herb	0.92	0.94	0.95	0.40	2.90
Euphorbia hirta L.	Euphorbiaceae	Herb	4.23	0.62	0.40	1.21	0
Ageratum conyzoides L.	Asteracea	Herb	12.77	2.70	1.92	1.46	1.51
Nicandra physaloides (L.)Gaerth	Solanaceae	Herb	0.23	1.30	0.73	1.17	0.37
Amarantus spinosus L.	Amarantaceae	Herb	0	3.19	0	0.95	1.17
Micractis bojeri Dc.	Asteraceae	Herb	11.96	10.87	2.14	8.00	2.05
Alternanthera repens (L.) Link	Amarantaceae		0	0	0	0.15	0.05
Casssia occidentalis L.	Fabaceae	Shrub	0.07	0.48	0.62	0.27	0
Caesalipinia decapetala (Roth) Alston	Fabaceae	Shrub	0.42	1.22	0.70	0.30	0
Acanthus pubescens (Oliv.) Engl.	Acantaceae	Shrub	0.21	0.99	0.97	0	0
Indigofera garckeana Vatke	Fabaceae	Shrub	0.21	2.50	1.49	0.12	0
Ocimum forskolei Benth	*Lamiacea*		0	5.18	0	1.032	0.38
Xanthium spinosum L.	Asteraceae	Shrub	1.11	0	0.65	1.95	0
Cirsium Vulgare (Savi) Ten	Asteraceae	Herb	0.34	0.11	0.70	0.32	0
Vernonia schimperi DC.	Asteraceae	Shrub	0.37	0.51	0.38	0.63	0.47
Solanum nigrum L.,	Solanaceae	Herb	1.03	0	0.081	0.29	0
Girardinia bullose diversifolia (Link) Friis	Urticaceae		0.37	0	0	0	0.70
Leonotis ocymifolia Burmaf. Iwarsson	Lamiaceae	Herb	0	0	0	0.24	0.078
Crotalaria spp	Papilonideae	Shrub	0.34	0.19	0.16	1.49	0.118
Ajuga spp Fariis et al	Lamiaceae	Herb	0	0	0	0.26	0.39
Galium thunbergianum Eckl. Zeyh.	Rubiaceae	shrub	0.68	1.19	0.57	0.77	0.47
Sida rhombifolia L.	Malavaceae	Shrub	0.95	0.36	0.43	0	0.049
Laggera crispata (Vahl) Hepper and Wood	Asteraceae	Shrub	0.13	0.99	0.10	0.69	0.23

Digitaria diagonalis Ness Stapf	Poaceae	Grass	1.27	0.87	1.41	1.34	0
Setaria magaphylla K.Sch.	Poaceae	Grass	0	0	0	3.09	0.47
Digitaria abyssinica Hochst. ex A. Rich	Poaceae	Grass	4.28	3.10	6.79	0.53	0
Arthraxon micans (Nees) Hochst.	Poaceae	Grass	0	1.35	1.44	0.87	0
*Bidens rueppellii (*Sch. Bip. ex Walp.) Sherff	Asteraceae	Herb	2.72	0.77	0.46	0	0.27
Abutilon longicuspe Hochst. ex A. Rich	Malvaceae	Shrub	0	0	0	0	0.41
Abutilon figarianum webb,	Malvaceae	Shrub	0	0	0	0.49	2.46
Mentha Longifolia (L.) Hudson	Lamiacea	Herb	0	0	0	0.46	0
Conyza sumatrensis (Retz.) E.H. Walker	Asteraceae	Herb	0	5.45	0	0	0
Rubus apetala Poir	Rosacea	Tree	0.07	0.04	0.29	0	0
Triumfetta tomentosa Boj.	Tiliaceae		0.71	0.51	0.27	0	0
Acanthus Eminens C.B. Clarke	Acanthaceae	Herb	0.34	0	0	0	0
Delphinium wellby	Rubiaceae		0	0.81	0	0	0
Echinops longisetus A. Rich. ,	Asteraceae	Herb	0.47	0.13	0.38	0	0.019
Ocimum lamiifolium Hochst. Ex A. Rich	Lamiacea	shrub	0.37	0.16	0.10	0	0

Key: NIS= Non-Invaded Sites, VLIS= Very Low Invaded Sites, LIS= Low Invaded Sites, MIS=Moderately Invaded Sites, HIS= Highly Invaded Sites, N=Number of sampling sites

Effect of parthenium weed on the species richness, diversity index and evenness

There was a significant (p<0.05) variations in the species richness between sites with varying levels of *P. hysterophorus* invasion (Table 2). The results indicated the invasion of *P. hysterophorus* significantly affected the richness. There were 46 plant species found in the non-invaded sites of study area. On the other hand, there were, 41, 39 and 35 species found in VLIS, LIS and HIS are a respectively. The number of species reduced by 23.91% in the *P. hysterophorus* HIS of as compared to NIS. A study undertaken on a rangeland invaded with three exotic weeds revealed that the richness of species was nearly 2.2 and 2.6 times more the uninfested area than in weed infested areas (Herlocker, 1999).

Diversity index was significantly different among the five levels of *P. hysterophorus* invasion (Tables 2). The diversity was inversely related to increasing level of *P. hysterophoru* invasion. Table 2 indicates that NIS was significantly different from HIS. The diversity of species declined by 4.65%, 16.6%, and 38.20%, in VLIS, MIS and HIS respectively as compared to NIS. This result validates Kohli *et al*. (2004) findings that the Shannon index showed great plant diversity in non-invaded area whereas the index was reduced by 36 to 51% in the weed infested areas. The higher value of the diversity index indicates the variation in the type of species and the heterogeneity in the community, whereas the lesser value points the homogeneity in the community.

Table 2. Species richness, diversity index and evenness indices of the aboveground vegetation at five parthenium weed infestation levels

Infestation level	**Above-ground vegetation**		
	Species richness	diversity index	evenness indices
NIS	46^{a}	3.01^{a}	0.88^{a}
VLIS	41^{ba}	2.87^{ba}	0.82^{ba}
LIS	39^{b}	2.35^{bc}	0.70^{bc}
MIS	43^{b}	2.51^{ba}	0.75^{bac}
HIS	35^{c}	1.86^{c}	0.60^{c}
p<0.05	0.0063	0.0116	0.0495

Key: NIS=Non-Invaded Sites, VLIS=Very Low Invaded Sites, LIS=Low Invaded Sites, MIS=Moderately Invaded Sites, HIS= Highly Invaded Sites. *Means with the same letter is not significantly different at p = 0.05 according to Least significant different (LSD) test

The evenness index significantly decreased as the invasion became greater (Table 2). The evenness index was reduced by 14.77% and 31.81%, respectively in the *P. hysterophorus* MIS and HIS as compared to NIS. The evenness index was found to be comparatively higher in non-invaded areas. This indicates the species are evenly distributed. On the other hand, the fact that it was lesser in the parthenium-invaded area indicated patchiness in distribution.

Relationship between cover abundance of *P. hysterophorus* and species richness, diversity and evenness in the study sites

The regression analysis showed a strong negative linear relationship between the cover abundance of *P. hysterophorus* and species richness, diversity and evenness index per study site (Figure 2). Hence, the regression equation can be presented as: y= -0.1619x + 44.417 for richness (Figure 2A), y= -0.0198x + 2.961 for diversity index (Figure 2B) and y=-0.0046x + 0.8532 for evenness index (Figure 2C), where y is species richness, diversity and evenness index and x is cover abundance of *P. hysterophorus* per study site. In this case, R^2 =0.724, or 72.4% for richness, R^2 = 0.897, or 89.7% for diversity index and R^2 = 0.868, or 86.8% for evenness index indicated that there is a strong negative relationship between the cover abundance of *P. hysterophorus* and species richness, diversity and evenness index. As cover abundance of *P. hysterophorus* increase species richness, diversity and evenness decrease. Sridhara et al. (2005) similar study indicated that relationship of evenness and diversity index with the percent coverage of parthenium showed negative (y= -0.006x +1.00 and y= -0.031+3.31) and regression coefficient (R^2 =0.92, R^2 =0.95) with evenness and diversity, respectively.

The negative relationship between cover abundance of *P. hysterophorus* and Species richness, diversity and evenness in the study sites might be due to *P. hysterophorus* has allopathic property and high productive mechanism than indigenous plants in the sites. The allelopathic nature of parthenium and water soluble phenolic and sesquiterpene lactones that have been reported from root, stems, leaves, inflorescences, pollen and seeds (Kanchaan, 1975). In other case it might be due to the environmental conditions (soil temperature, rainfall, altitude etc.) were favorable to *P. hysterophorus* than the other plants in the study sites.

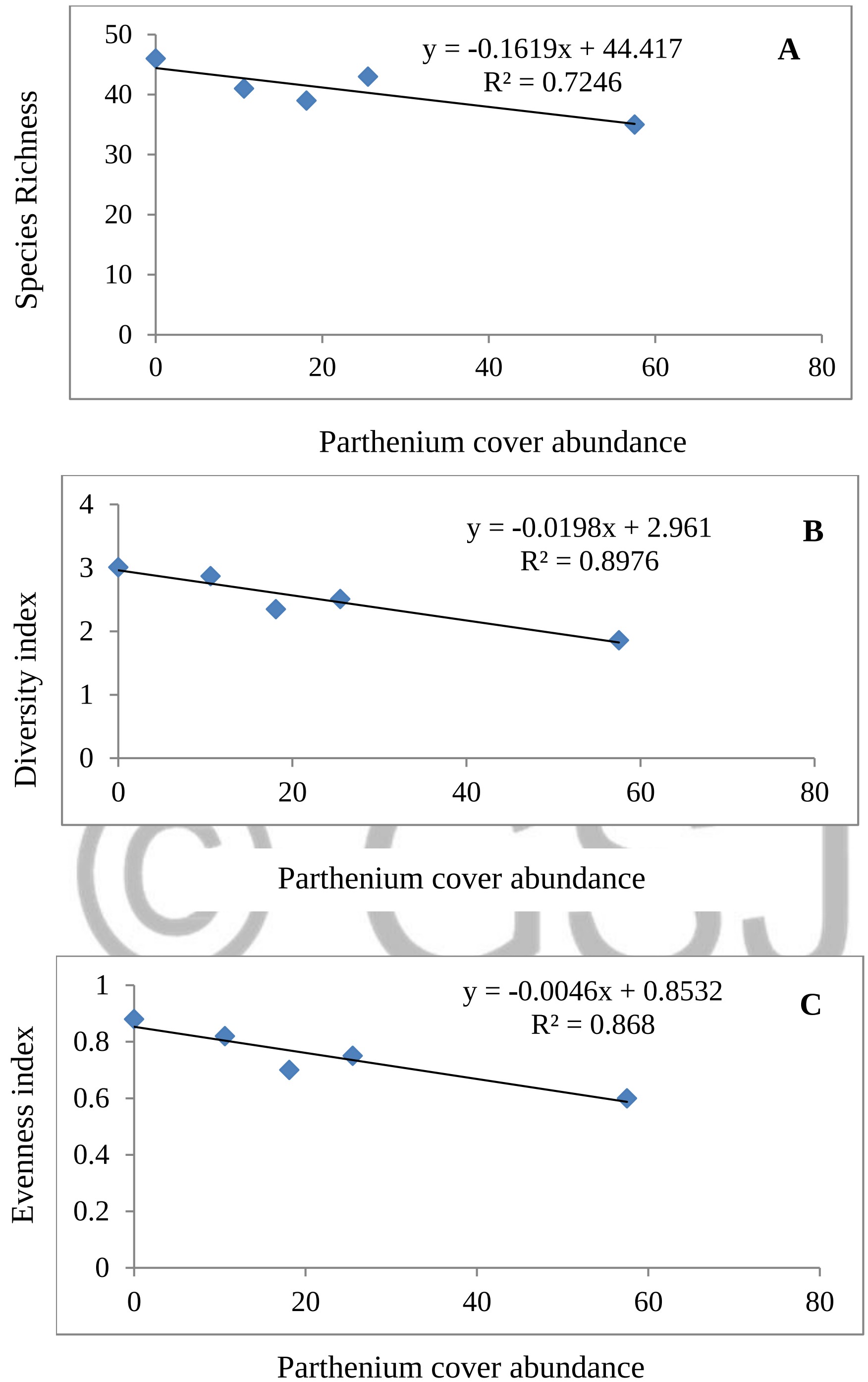

Figure 2. Regression analyses of richness, diversity and evenness index and *P. hysterophorus* cover abundance: (A) cover abundance vs richness, (B) cover abundance vs Diversity index, and (C) cover abundance vs Evenness index

CONCLUSION

The study showed that *P. hysterophorus* have been reducing species richness, diversity and evenness relative to the non-invaded sites. The regression analysis showed that there is a strong negative linear relationship between the cover abundance and species richness, diversity and evenness index per study site. Generally *P. hysterophorus* was found to a threat to the biodiversity of Woliata zone. The study implicated that integrated long-term management programs must be carried out to control. Thus, there is urgent need for well organized, coordinated and concerned efforts must be made to control or eliminate. This requires the local people, scientists, governments and NGO's to work in unison. Foremost, conservations of biodiversity through the most efficient control mechanism need to be given priority since there is a definite relationship between the invasion of *P. hysterophorus* and the increase of species diversity and richness.

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