Impact of *Parthenium hysterophorus* L. (Asteraceae) on Herbaceous Plant Biodiversity of Awash National Park (ANP), Ethiopia

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Abstract

This study was conducted in Awash National Park (ANP), East Shewa Zone of Oromia National Regional Sate, Ethiopia, aimed at determining the impact of parthenium weed (*Parthenium hysterophorus L.*) on herbaceous diversity. A transect belt of 13.5 km * 0.10 km of parthenium weed infested land was identified for the determination of the impact. Four quadrats were purposively laid every 250 m interval two for infested and two for non-infested each from both sides of the road and a total of 216 quadrats of 2 m x 2 m (4 m^2) were considered. A total of 91 species were identified from which five of them were out of the quadrats. All species were categorized into 21 families, from which Poaceae and Fabaceae shared about 40%. The species in the non-infested quadrats were found to be more diverse and even when compared to those of the infested quadrats. Infested quadrats were found to be more abundant and dominant. *Tetrapogon tenellus* was found the dominant specie in the non-infested quadrats while *Parthenium hysterophorus* was found dominant in the infested followed by *T. tenellus*. There was no statistically significant difference between the total stand crop biomass of the infested and non-infested. Parthenium weed have been found creating great challenge on herbaceous plant diversity of ANP.

Keywords

East shewa, infestation, invasive alien species, Oromia, tourism.

Introduction, Hypotheses and problems for Management

Invasive alien species are a serious impediment to conservation and sustainable use of global biodiversity (GEF 2003) with significant undesirable impacts on the goods and services provided by ecosystems. This time biological invasions operate on a global scale and especially in this century, they are rapidly increasing due to interactions with other global changes such as increasing globalization of markets, explosive rises in global trade, travel, tourism, and exchange of goods (Groombridge 1992). Parthenium weed is one of the aggressive invasive species that can cause significant and sometimes irreversible environmental and socio -economic impact at the genetic, species and ecosystem levels (Hens & Boon 2003).

Parthenium weed (*Parthenium hysterophorus*), mesquites (*Prosopis juliflora*) and water hyacinth (*Eichhornia crassipes)*, lantana weed (*Lantana camara*) and witch weeds (*Striga* species) are among the major Invasive Alien Species yet identified in Ethiopia. Since its introduction in 1976 into Ethiopia (Tefera 2002) parthenium weed has been reported as relentlessly spreading throughout the agricultural lands, forests, orchards, poorly managed arable crop lands and rangelands, almost throughout the country. EARO (2002) reported as, Awash National Park, one of the prominent national parks in Ethiopia and where a number of wild animals and various woody and herbaceous species inhabit has been at risk due to the aggressive spread of the weed to the park. Herbaceous vegetations are the dominant component of most wildlife reserve areas. It was reported as parthenium weed has the potential to decline adversely the herbaceous components of the vegetation upto 90% by its aggressive competition and allopathic effect (APFISN 2007; Mahadevappa et al. 2001). This above all can shrink the biodiversity of the Park and hinders the attractiveness, which further results in the decline of the national economy.

Several study results revealed the adverse effect of

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parthenium weed on plant biodiversity (Cock 2001; Tadele Tefera 2002), but yet there is no information on quantifying the sole impact of parthenium weed on herbaceous specie. This study quantified the impact of parthenium weed on the diversity and productivity on herbaceous vegetation.

Materials and Methods

Study area

The study was carried out in the Awash National Park (ANP), 225 km south-east of Addis Ababa at 39° 48' - 40° 10' E and 8° 50' - 9° 10' N (Figure 1). ANP lies to the either side of the main Addis Ababa-Asab/ DireDawa highway between the towns of Metehara and Awash station. Its altitude ranges from 705-2007 m a. s .l. ANP is one of the most geologically active regions of the world (Birdlife International, 2008).

Much of the grassland in the northern and western part of the Park is overgrazed, resulting in up to 50% bare soil and rock and the domination of invasive, unpalatable species such as needle grass *Aristida spp*. Shrubby areas around the grassland are more mixed with some *Acacia*, *Grewia* spp., *Psiadia incana* and *Vernonia* sp (Birdlife International 2008). Awash National Park has been experiencing the semi -arid agro-ecological condition.

Sampling methods

A reconnaissance survey was carried out to see the pattern of parthenium weed distribution and to design appropriate sampling method. Based on the uniform distribution of the weed along the

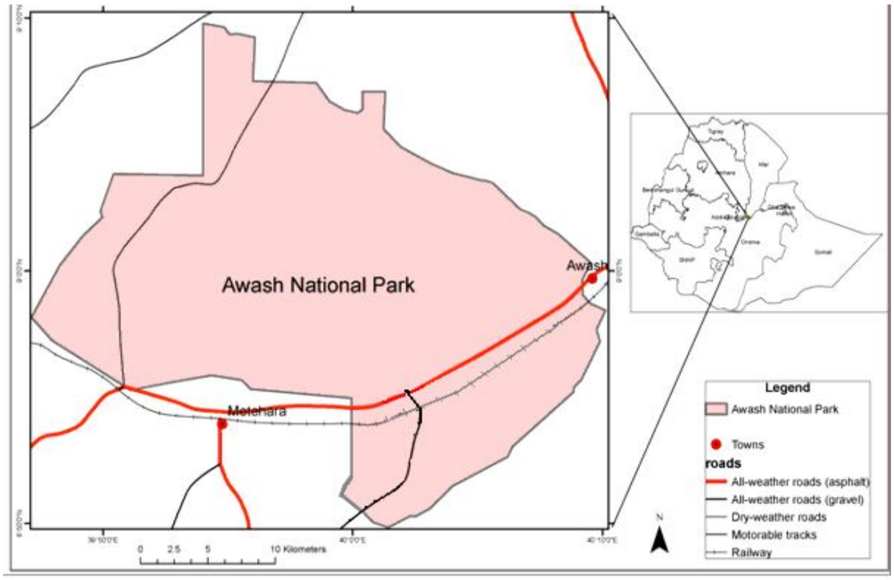

Figure 1. Map of study area (Awash National Park) (Source: Ethiopia Institute of Agricultural Research, GIS unit)

Resumen

Este estudio se realizó en el Parque Nacional de Awash (ANP), Oriente de Shewa, zona de Oromia del Estado Regional Nacional, Etiopía, con el fin de determinar el impacto de la mala hierba parthenium (*Parthenium hysterophorus L.*) sobre la diversidad herbácea. Se realizó un transecto de 13,5 km * 0,10 kilometros en la tierra infectada por la mala hierba parthenium para determinar su impacto. Se colocaron cuatro cuadrantes en intervalos de 250 m, dos para infectados y dos para no infectados a cada uno de los lados de la carretera, considerando un total de 216 cuadrantes de 2 m x 2 m (4 m2). Se identificaron un total de 91 especies, cinco de ellas ubicadas fuera de los cuadrantes. Todas las especies fueron clasificadas en 21 familias, de las que Poaceae y Fabaceae compartían alrededor del 40%. Se encontró mayor diversidad de especies en los cuadrantes no infectados, e incluso en comparación con los cuadrantes infectados. Los cuadrantes infectados resultaron ser más abundantes y dominantes. *Tetrapogon tenellus* se encontró como especie dominante en los cuadrantes no infectados, mientras que *Parthenium hysterophorus* se encontró dominante en el infectado seguido de *T. tenellus*. No hubo diferencias estadísticamente significativas entre la biomasa total de la cosecha de pie de los infectados y no infectados. La mala hierba Parthenium se presenta como un gran reto en la creación de diversidad de plantas herbáceas en el ANP.

Palabras clave

Este de Shewa, infectación, invasión de especies alóctonas, Oromia, turismo.

highway run east-west a total length of 50 m x 13.5 km was considered in both sides of the road. A preferential sampling method was used. The sampling plots were arranged on the transect line laid on both side of the road. A quadrat of 2mx2m was laid in an interval of 250. At each point two quadrats, one from infested (IN) and one from non-infested (NI) and a total of 216 quadrats were considered. Each species available in the quadrat was counted and recorded. Visual cover estimation of each specie was taken. For stand crop biomass determination, 1mx1m area in the center of the main quadrat was harvested at ground level. For the infested plots separation was made to parthenium and non-parthenium (INNP) and kept in separate paper bag. The harvested biomass was made to dry in an oven adjusted to 105^{0}C for 24 hours for Dry Matter (DM) determination. Voucher specimens were collected, coded, pressed and taken to Addis Ababa University National Herbarium and identified to species level following Flora of Ethiopia and Eritrea volumes.

Data analysis

Diversity (H'), Evenness (E), and Species richness (S) of the species for both infested and non-infested quadrats were determined following Shannon-Wiener (1949) diversity indices procedures.

Shannon Diversity Index (H') was computed as:

$$H' = -\sum_{i=1}^{s} pi \ln Pi$$

Where:
H' = Shannon's diversity index
p_i = the proportion of individuals of the ith species
S = total number of species in the quadrate

The evenness was computed from the Shannon index as:

$$J = \frac{H'}{H'_{\max}} = \frac{\sum_{i=1}^{s} pi \ln pi}{\ln s}$$

Where:
J = Species evenness
s = the number of species
Pi = the proportion of individuals of the ith species
ln = log base $_{10}$

Similarity coefficient was determined by the Czekanowski (1913) coefficient. The coefficient has a value from 0 (0%) to 1 (100%), where 1 reveals complete similarity and 0 complete dissimilarity.

$$Sc = \frac{2\sum_{i=1}^{m} \min(Xi, Yi)}{\sum_{i=1}^{m} Xi + \sum_{i=1}^{m} Yi}$$

Where: Xi and Yi = the abundance of species I = the sum of the lesser scores of species i where it occurs in both quadrats
m = number of species

$$\sum_{i=1}^{m} \min(Xi, Yi)$$

Abundance of each category (infested and non-infested) was determined as of MacIntosh (1967a) diversity index (U).

$$U = \sqrt{\sum_{i=1}^{s} ni^2}$$

Where:
U = MacIntosh diversity index
S = the number of species
n = number of the individuals or abundance of the ith species in the quadrat

Importance value (IV) of each species in both categories (IN & NI) was computed following Shabbir & Bajwa (2006). IV is equal to the sum of the relative density (RD) and relative frequency (RF) of species in the stand.

$$RD\% = \frac{\text{Absolute density for a given species}}{\text{Total absolute density for all species}} \text{ X } 100\%$$

$$RF\% = \frac{\text{Absolute frequency value for a species}}{\text{Total absolute frequency for all species}} \text{ X } 100\%$$

$$IV = RD + RF$$

The above ground biomass data was analyzed by SAS statistical software release 8.2 (SAS, 2001).

Results

Impact of Parthenium Weed on Herbaceous Diversity

A total of 91 species were identified (Apendix1) and grouped into 21 families, of which, *Poaceae* is

NO		Non-infested(NI)			Infested (IN)			Difference (%)		
		AF	AD	MAD	AF	AD	MAD	AF	AD	MAD
1	*Becium filamentosum*	8	1525	190.6	5	83	16.6	37.5	**94.6**	91.3
2	*Chloris virgata*	16	3384	211.5	10	423	42.3	37.5	**87.5**	80
3	*Panicum coloratum*	21	2205	105	11	309	28.1	47.6	**86.0**	73.3
4	*Leucas martinicensis*	9	95	10.7	3	11	3.67	66.8	88.4	65.3
5	*Heteropogon contortus*	22	2353	107.0	26	1246	47.9	(-)15.4	**47.1**	55.2
6	*Melinis repens*	31	4562	147.5	32	2256	70.5	(-)3.1	**50.6**	52.1
7	*Ischaemum afrum*	19	3084	162.3	12	992	82.7	36.8	67.8	49.1
8	*Cencherus ciliaris*	21	967	46.1	15	354	23.6	28.6	63.4	48.8
9	*Rullia patula*	9	74	8.2	7	30	4.3	22.2	59.5	47.9
10	*Peristrophe paniculata*	18	320	17.8	16	158	9.9	11.1	50.6	44.5
11	*Blepharis moderaspatensis*	9	652	72.44	6	260	43.3	33.3	60.1	40.2
12	*Tephrosia pumila*	18	353	19.6	9	110	12.2	50.0	68.8	37.4
13	*Blepharis edulis*	34	1188	34.9	19	466	24.5	44.1	60.8	29.8
14	*Urochloa panicoides*	17	2955	173.8	21	2867	136.5	(-)19.1	3.0	21.5
15	*Indigofera schimperi*	31	443	14.3	22	257	11.7	29.0	42.0	18.3
16	*Launa intybacea*	11	105	9.6	14	114	8.1	(-)21.4	(-)7.9	14.7
17	*Phyllanthus maderaspatensis*	10	55	5.5	8	38	4.8	20.0	30.9	13.6
18	*Bidens pilosa*	15	603	40.2	15	523	34.9	0	13.3	13.3
19	*Sorghum arundinaceum*	23	228	9.9	26	235	9.0	(-)11.5	(-)3.0	8.8
20	*Tetrapogon tenellus*	63	22578	358.4	58	19045	328.36	7.9	**15.7**	8.4
21	*Boerhavia erecta*	11	234	21.3	13	289	22.2	(-)15.4	(-)19.0	(-)4.3
22	*Indigofera articulata*	17	138	8.1	13	113	8.7	23.5	18.1	(-)6.6
23	*Solanum coagulans*	26	181	7.0	20	156	7.8	23.1	13.8	(-)10.8
24	*Abutilon fruticosum*	8	54	6.8	7	54	7.7	12.5	0	(-)12.5
25	*Rhynchosia minima*	25	152	6.1	23	166	7. 2	8.0	(-)8.4	(-)15.8
26	*Sida ovata*	13	33	2.5	10	31	3.1	23.1	6.1	(-)18.1
27	*Abutilon bidentatum*	18	48	2.7	15	59	3.9	16.7	(-)18.6	(-)32.2
28	*Eragrostis papposa*	17	736	43.3	12	814	67.8	29.4	(-)9.6	(-)36.2
29	*Cymbopogon commutatus*	24	1635	68.1	19	2568	135.2	20.8	(-)36.3	(-)49.6
30	*Enneapogon cenchroides*	8	127	15.9	6	245	40.8	25.0	(-)48.2	(-)61.1
31	*Ocimum forskolei*	8	68	8.5	5	124	24.8	37.5	(-)45.2	(-)65.7
32	*Dactyloctenium scindicum*	6	172	28.7	5	532	106.4	16.7	(-)67.7	(-)73.1

Table 1. Comparison in absolute frequency (AF), absolute stand density (AD) and mean absolute stand density (MAD) between non-infested (NI) and infested (IN) quadrats of common species.

(-) = The infested greater than non-infested and great negative difference shows good association of the specie with the weed represented by 23 spp. (25%), *Fabaceae* by 13 spp. (14%), *Asteraceae* by 7 spp. (8%), *Acanthaceae*, *Amaranthaceae* and *Solanaceae* each by 6 spp. (7%), *Malvaceae* by 5 spp. (5%) and others by 25 spp. (27%). *Poaceae* and *Fabaceae* comprise about 40% of the total species recorded. Parthenium weed comprised 38% of the infested field, while the non-parthenium component declined by 31% from non-infested quadrats in stand crop density. From comparison made in the same way in mean difference percent and frequency difference percent, more species were (7.94% - 66.67%) frequently found in NI quadrats than in IN quadrats. Conversely, some species were found (3.13% - 21.43%) frequently in IN quadrats than NI quadrats (Table 1).

As shown in Table 1, *Becium filamentosum, Chloris virgata, Panicum coloratum, Leucas martinicensis, Heteropogon contortus and Melinis repens* were among the species highly endangered because of parthenium weed infestation while, *Cymbopogon commutatus, Enneapogon cenchroides, Ocimum forskolei and Dactyloctenium scindicum* were found among species better associated with parthenium weed. Those threatened species were 2-3 times higher than those of better associated species. The similarity coefficient value showed that the non-infested (NI) was more similar to non-parthenium weed component of the infested (INNP) than to the infested components (IN) (Table 2).

From the comparison of species abundance made among the components, the infested (IN) quadrats were more abundant when compared to the non-infested (NI) quadrats. The value showed that the NI component is more diverse in species composition even though lesser in abundance value than IN. In line with the diversity index, the species evenness/ equitability (J) was found to be higher in NI and least in INNP. (Table 3).

The importance value (IV) computed for species of each category (non-infested (NI) and infested (IN)) quadrats showed that *Tetrapogon tenellus* was found to be the dominant species with IV of 51.35 in the non-infested (NI) quadrats and *Parthenium hysterophorus* with IV of 53.21 was the dominant species of infested quadrats (IN) followed by *Tetrapogon tenellus*, *Chloris virgata, Panicum coloratum, Heteropogon contortus, Melinis repens, Ischaemum afrum, Blepharis edulis, Urochloa panicoides, Indigofera schimperi* and *Cymbopogon commutatus* with IV of 40.55, 8.66, 7.20, 7.62, 13.07, 8.54, 7.22, 8.01, 5.39 and 6.58 respectively were the dominant species with IV>5 in the non-infested quadrats. However, only *Heteropogon contortus, Melinis repens, Urochloa panicoides* and *Cymbopogon commutatus* with IV = 5.89, 8.47, 7.89 and 7.10 respectively were with IV>5 from the infested quadrats. *Cymbopogon commutatus* showed greater IV in

		IN	INNP	Difference
NI	**Similarity**	55.86%	69.73%	-13.87
	Dissimilarity	44.14	30.27	+13.87

Table 2. The Czekanowski similarity coefficient (Sc) among the IN, NI and INNP components

Key: IN = Infested, NI = Non-infested, INNP = Infested non-parthenium weed

No.	Categories	Abundance (U)	H'	Evenness (J)	Dominance (D)
1	IN	59369	2.0013	0.4665	0.4984
2	NI	53665	2.4110	0.5619	0.5533
3	INNP	36877	1.6338	0.3820	0.6709

Table 3. Diversity analysis among infested (IN), non-infested (NI) and infested non-parthenium components (INNP) quadrats

infested than in non-infested while the rest showed a decrease in IV or dominance in infested quadrats (Figure 2).

From the comparison made among the stand cover percent of each component at various parthenium weed infestation levels, the impact of increment in parthenium weed stand cover on non-parthenium weed herbaceous vegetation showed the decline in non-parthenium weed herbaceous cover. The proportion of the non-parthenium weed component declining as the stand cover of parthenium weed increasing (unfilled bar), and the total stand cover showed increasing trend (filled bar). The stand covers of the infested quadrats were found to be greater than the non-infested quadrats (Figure 3).

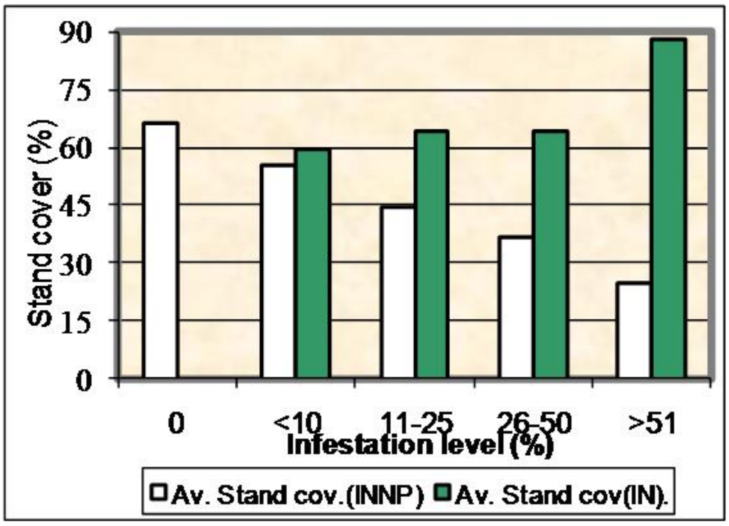

Figure 3. The impact of parthenium weed at different infestation levels on herbaceous stand cover abundance of infested (IN) and infested non-parthenium weed components (INNP) quadrats **(**0 = Non- infested (NI), < 10 = Very low infestation, 11-25% = Low infestation, 26-50% = Moderate infestation, > 50% = High infestation)

Impact of Parthenium Weed on Herbaceous Stand Crop Biomass (DM)

There was no significant difference between total infested (IN) and non-infested (NI) stand crop biomass at probability level α = 0.05. Although it was not statistically significant, mean IN stand crop biomass was higher than the mean NI. There was a strong significant difference (p< .0001) between the means of

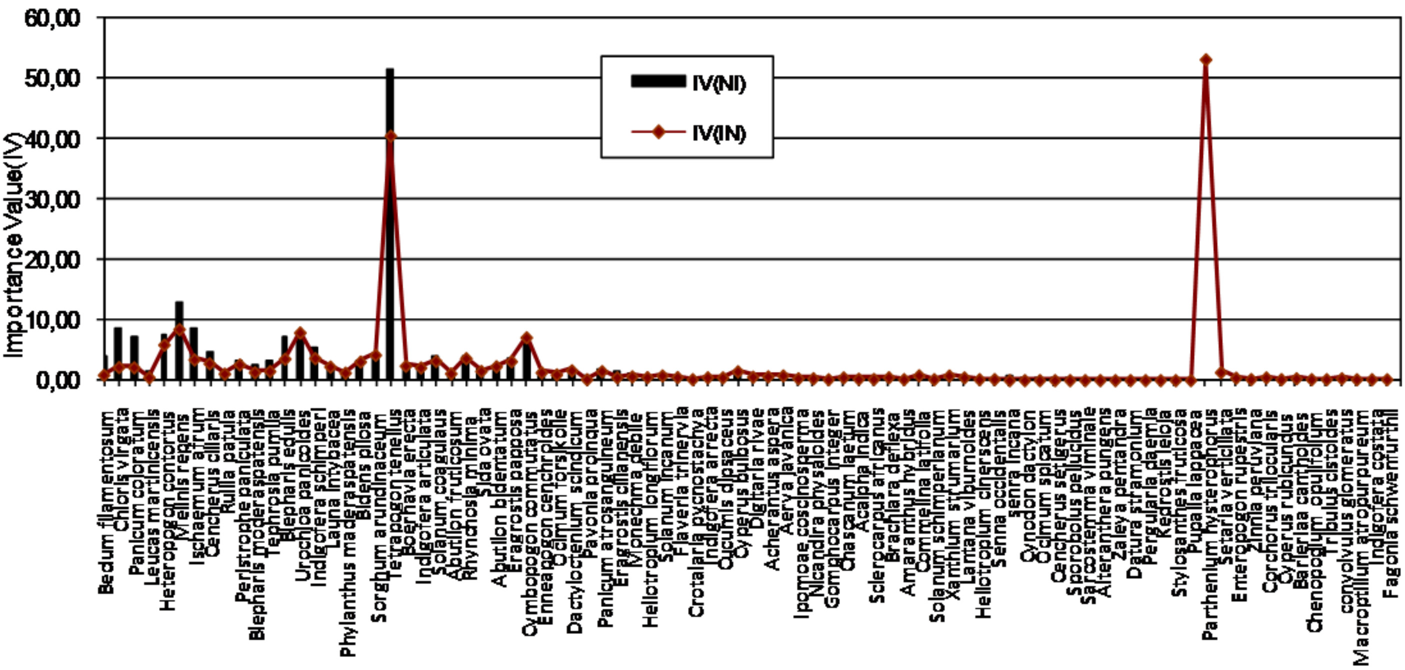

Figure 2. The importance value (IV) of species in infested (IN) and non-infested (NI) quadrats

non-infested (2.468t/ha) and both the infested non-parthenium weed (INNP) (1.463t/ha) and infested parthenium weed component (INP) (1.005t/ha) stand crop biomass (Table 4 and 5).

The NI stand crop biomass exceeds the INNP by 38%. In other words the non-parthenium weed components of infested quadrats stand crop biomass declined by 38% due to parthenium weed infestation. From the infested stand crop biomass parthenium weed comprises an average of 41%.

Sources of variation	Df	SS	MS	F	P
Yield components	3	148.22	49.40	36.34	<.0001
Error	392	532.84	1.36		
Corrected total	395	681.05			

Table 4. Stand crop biomass ANOVA summary

Yield components	Mean
Infested Stand Crop Biomass(INDM)	2.468^{A}
Non-Infested Stand Crop Biomass (NIDM)	2.355^{A}
Infested non-parthenium weed component Stand Crop Biomass (INNPDM)	1.463^{B}
Infested Parthenium weed component Stand Crop Biomass (INPDM)	1.005^{C}

Table 5. Stand crop biomass mean separation

*Means with the same letter are not significantly different at α= 0.05.

Discussion

Impact of Parthenium Weed on Herbaceous Plant Diversity

The conversion of native biotic communities to invasive dominated communities has negative aesthetic and cultural impacts because of its direct threat to the habitat of species that are key to the tourism industry (Raghubanshi *et al*. 2005; www.unep.org). ANP has been providing tourism and conservation services for the country but currently because of parthenium weed it has been losing its previous value. Parthenium weed caused a decline in stand density of herbaceous species by an average 69% within a few years from its introduction into ANP. This is in agreement with what Evans (1997) stated that parthenium weed has the potential to replace dominant flora and suppresses natural vegetation in a wide range of habitats and disrupt natural ecosystems. ARMCA (2000) realized that parthenium weed releases allelopathic chemicals that inhibit the germination and growth of pasture grasses, legumes, cereals, vegetables, other weeds and even trees. Displacement by direct competition reduced structural diversity, increased biomass production and disruption of the prevailing vegetation dynamics (van Wilgen & van Wyk 1999). The same situation was observed in ANP that some patches of parthenium weed monoculture with little under growths were observed.

A difference of up to 94% for dominant species and up to 100% loss for rare species in stand density was recorded. It was in line with a total habitat change due to parthenium weed reported in Australia grass lands, open wood lands, river banks and flood plains (Kohli *et al*., 1992; Chippendale and Panetta, 1994). Similar investigation in Ethiopia showed that about 93.6%, 90.8% and 77.7% variation in density of broad leaved, grass and sedges respectively were accounted for the density of parthenium (Mulisa Urga et al. 2008).

In addition to its aggressiveness and allelopatic effect removal of top soil creates a good opportunity for parthenium weed by minimizing the competition from native species and enhancing the chance of survival for the invading plants (Shabbir and Bajwa 2006; Kohli et al., 1985). It could be due to these facts that high invasion was observed in ANP's degraded road sides and eroded areas following passages of livestock forming a patch of weed monoculture following all its infestation.

Some species positively associated with parthenium weed showed up to 68% difference in stand density from the infested. The result is in consistent to that of a survey made in Pakistan which reported that *P. hysterophorus* and *Desmostachya bipinnata, Lantana camara* and *Senna uniflora* had a high degree of sociability and these formed large stands under different habitats (Shabbir and Bajwa, 2007). Those threatened species ecceeding 2-3 times higher than those better associated with parthenium weed showed that as time goes many species leave the ecosystem and only a few competent species remain in the near future. This leads to the domination of a few species in the system. The increase of dissimilarity value between quadrats due to infestation of parthenium weed confirms this observation (Table 2). If unchecked, ecological systems move from natural heterogeneity to homogeneity over a large scale and timeframe because of domination by single specie or invasive species associations (Foxcroft, 2002). This study also showed that infested quadrats were more abundant than the non-infested quadrats (Table 3). This could be because of that parthenium weed is an addition on the prevailing vegetation and it is moreover denser than any of the others vegetation where infestation did not take place. Although most of the associated species were found susceptible to the competition and allelopathic effect, the over all stand density of the infested was found greater. Despite the increment in total stand density and canopy cover, the species diversity (H') and evenness (J) value declined in infested quadrats. This could be due to the fact that some species were suppressed while a few showed an increment because of the opportunity shared from the suppression of the others. More dominance was observed in INNP. This could be as a result of suppression of some species by the weed influence and on the other hand the advantage shared by those species better associated with parthenium weed. The decrease in stand cover of the infested non-parthenium weed component (INNP) as parthenium weed component increased indicates that the non-parthenium weed herbaceous leave the medium with time while the parthenium weed colonizes till stabilize its population to weed monoculture.

The importance value (IV) showed that *Tetrapogon tenellus* was found to be the dominant species in non-infested quadrats and the second dominant in infested quadrats following parthenium weed with a decline by 10.8 (21%) (Figure2). From its introduction in few years, parthenium weed has got an IV of 53.21 which is by far greater than the IV value of all of the native species. This tells that parthenium weed has a great probability to totally dominate the whole area creating its own weed monoculture.

Impact of Parthenium Weed on Herbaceous Stand Crop Biomass

Valuable species in the infested area which were essential for grazing animals have already disappeared due to the continued increase of parthenium weed and livestock selection pressure. Since the selected site was less prone to the influence of livestock or other grazing animals the declined in stand crop biomass of herbaceous plants in infested quadrats was most probabily due to parthenium weed. As reported by Mahadevappa, *et al*. (2001) parthenium weed caused upto 90% decline in forage production. In the same line a decline in biomass of up to 41% was recorded in ANP. This was recorded from the middle of the Park where interference of livestock was said minimum. Although, not thoroughly seen in this study, areas around the border of the Park where regularly visited by livestock of the neighboring pastoral communities were observed highly dominated by the weed. This clearly indicated that impact of the weed was highly correlating with the soil disturbance level. It was inline with what Carmel and Kadmon (1999) and APFISN (2007) concluded. This study agrees with ARMCA (2000) report that areas little disturbed and densely populated were found rarely infested by the weed. This shows that any type of soil disturbance is the primary root cause for its expansion after its introduction to the area.

Conclusions and Recommendations

Parthenium weed infestation increases the total stand density and then total stand biomass, while species diversity (H') and evenness (J) decreases. Partheium weed has less potential to invade dense pasture, but it invades disturbed road sides and overgrazed pastures. In addition parthenium weed has the ability to utilize the opportunity of drought prone period in the area to use the chance where the indigenous plants deteriorate and leave much bare ground cover. Parthenium weed establishes its weed monoculture on the bare grounds and gradually weakens even the survival of drought tolerant herbaceous plants in the vicinity. Based on these strategic ways of its expansion, parthenium weed can create a great challenge on herbaceous plant diversity of the ANP, the precious wild lives inhabiting the Park depending on the vegetation and values the country gain from the sector.

Most literature sources noted parthenium weed as "weed of road side and degraded land". From this baseline idea a number of people have the tendency to undermine the impact of parthenium weed. But when it comes to the Awash National Park (ANP), other Parks and reserve areas, the situation is taking a different direction. So, protecting those sensitive areas like ANP from IAS through integrated multidisciplinary approach seems mandatory. Closely monitoring and taking immediate measure for major factors contributing for the rapid invasion of the park like construction materials and activities, movement of livestock to the reserve areas and grazing pressure around infested areas need due attention to over come the problem. It has been advised as National parks and Sanctuaries have to be kept limited from any human interference. Continuing with the same fashion in the future in the presence of ever increasing Invasive Alien Species can lead to very danger situation. Thus closely monitoring the parks vegetation status and taking appropriate range management measure will be found mandatory.

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Appendix

Apendix 1. Herbaceous species index of Awash National Park (ANP)

No.	Voucher No.	Botanical Name	Family	Habit
1	AET47	*Barleria acanthoides* Vahl	Acanthaceae	PH
2	AET 08	*Blepharis edulis* (Forssk.) Pers.		AH
3	AET 13	*Blepharis maderaspatensis* (L.) Roth		AH
4	AET 04	*Monechma debile* (Forssk.) Nees		AH
5	AET 06	*Peristrophe paniculata* (Forssk.) Brummitt		AH
6	AET 14	*Ruellia patula* Jacq.		AH
7	AET 72	*Zaleya pentandra* (L.) Jeffrey	Aizoaceae	AH
8	AET 55	*Acherantes aspera* L.	Amaranthaceae	PH
9	AET 68	*Aerva javanica* (Burm. f. Schultes		PH
10	AET 80	*Alternanthera pungens* Kunth		AH
11	AET 64	*Amaranthus hybridus* L.		AH
12	AET 54	*Fagonia schwenfurthii* Hadidi		AH
13	AET 56	*Pupalia lappacea* (L.) A. Juss		AH
14	AET 71	*Gomphocarpus integer* (N. N. Br.) Bullock	Asclepidiaceae	AH
15	AET 61	*Pergularia daemia* (Forssk.) Chiov.		PH
16	AET 09	*Sarcostemma viminale* (L.) R. Br.		PH
17	AET 05	*Bidens pilosa* L.	Asteraceae	AH
18	AET 28	*Flaveria trinervia* (Spreng.) C. Mohr		AH
19	AET 37	*Launaea intybacea* (Jacq.) Beauv		AH
20	AET 02	*Parthenium hysterophorus* L.		PH
21	AET 57	*Sclerocarpus africanus* Jacq. f. ex Murr		AH
22	AET 30	*Xanthium strumarium* L.		AH
23	AET 36	*Zinnia peruviana* (L.) L.		AH
24	AET 20	*Heliotropium cinerscens* DC. & A. DC.	Boraginaceae	AH
25	AET 39	*Heliotropium longiflorum* (A. DC.) Jaub. & Spach.		AH
26	AET 63	*Chenopodium opulifolium* Schrader ex Koch & Ziz.	Chenopodaceae	AH
27	AET 85	*Commelina latifolia* Hochst. ex A. Rich.	Commelinaceae	PH
28	AET 74	*convolvulus glomeratus* Hochst. ex Choisy	Convolvulaceae	PH
29	AET 33	*Ipomoae coscinosperma* Hochst. ex Choisy		AH
30	AET 58	*Cucumis dipsaceus* Ehrenb. ex Spach.	Cucurbitaceae	AH
31	AET 35	*Kedrostis leloja* (Forssk.) C.Jeffrey		PH
32	AET 79	*Cyperus bulbosus* Vahl	Cyperaceae	PH
33	AET 31	*Cyperus rubicundus* Vahl		AH
34	AET 62	*Acalypha indica* L.	Euphorbiaceae	AH
35	AET 38	*Phyllanthus maderaspatensis* L.		AH
36	AET 87	*Crotalaria incana* L.	Fabaceae	AH
37	AET 60	*Crotalaria pycnostachya* Benth.		AH
38	AET 83	*Indigofera arrecta* Hochst. ex A. Rich.		PH
39	AET 75	*Indigofera articulata* Gouan		PH
40	AET 89	*Indigofera brevicalyx* Bak. f.		PH
41	AET 46	*Indigofera costata* Guill. & Perr.		AH
42	AET 76	*Indigofera schimperi* Jaub. & Spach		PH
43	AET 91	*Macroptilium atropurpureum* (DC.) Urb.		PH
44	AET 81	*Rhynchosia minima* (L.) DC.		PH
45	AET 27	*Senna occidentalis* (L.) Link		PH
46	AET 73	*Sesbania quadrata* Gillett		PH
47	AET 52	*Stylosanthes fruticosa* (Retz.) Alston		PH
48	AET 11	*Tephrosia pumila* (Lam.) Pers.		PH

49	AET 25	*Becium filamentosum* (Forssk.) Chiov.	Lamiaceae	PH
50	AET 43	*Leucas martinicensis* (Jacq.) R. Br.		AH
51	AET 41	*Ocimum forskolei* Benth.		AH
52	AET 42	*Ocimum spicatum* Deflers		PH
53	AET 17	*Abutilon bidentatum* (Hochst.) A. Rich.	Malvaceae	AH
54	AET 03	*Abutilon fruticosum* Guill. & Perr.		PH
55	AET 65	*Pavonia proinqua* Garcke		PH
56	AET 69	*Senra incana* Cav.		AH
57	AET 44	*Sida ovata* Forssk.		PH
58	AET 24	*Boerhavia erecta* L.	Nyctaginaceae	AH
59	AET 32	*Brachiara deflexa* (Schumach.) Robyns	Poaceae	AH
60	AET 45	*Cenchrus ciliaris* L.		PH
61	AET 67	*Cenchrus setigerus* Vahl	Poaceae	PH
62	AET 21	*Chloris virgata* Sw.		AH
63	AET 10	*Cymbopogon commutatus* (Steud.) Stapf.		PH
64	AET 19	*Cynodon nlemfuensis* Vanderyst		PH
65	AET 07	*Dactyloctenium scindicum* Boiss.		PH
66	AET 82	*Digitaria rivae* (Chiov.) Stapf.		PH
67	AET 51	*Enneapogon cenchroides* (Roem. & Schult.) C. E. Hubb.		AH
68	AET 78	*Enteropogon rupestris* (J.A. Scmidt) A. Chev.		PH
69	AET 70	*Eragrostis cilianensis* (All.) Vign.ex Janchen.		AH
70	AET 66	*Eragrostis papposa* (Roem. & Schult.) Steud.		PH
71	AET 26	*Heteropogon contortus (*L.) Roem. & Schult.		PH
72	AET 12	*Ischaemum afrum* (J. F. Gmel.) Dandy		PH
73	AET 59	*Melinis repens* (Willd.) Zizka		AH
74	AET 22	*Panicum atrosanguineum* A. Rich.		AH
75	AET 15	*Panicum coloratum* L.		PH
76	AET 34	*Setaria verticillata* (L.) P. Beauv.		AH
77	AET 84	*Sorghum arundinaceum* (Desv.) Stapf		AH
78	AET 40	*Sporobolus pellucidus* Hochst.		PH
79	AET 01	*Tetrapogon tenellus* (Roxb.) Chiov.		AH
80	AET 90	*Tragus berteronianus* Schult.		AH
81	AET 86	*Urochloa panicoides* P. Beauv.		AH
82	AET 88	*Datura innoxia* Mill.	Solanaceae	AH
83	AET 50	*Datura stramonium* L.		AH
84	AET 49	*Nicandira physaloides* (L.) Gaertn.		AH
85	AET 77	*Solanum coagulans* Forssk.		PH
86	AET 16	*Solanum incanum* L.		PH
87	AET 23	*Solanum schimperianum* Hochst.ex A. Rich.		PH
88	AET 48	*Corchorus trilocularis* L.	Tiliaceae	AH
89	AET 53	*Chascanum laetum* Fenzl. ex Walp.	Verbenaceae	PH
90	AET 18	*Lantana viburnoides* (Forssk.) Vahl		PH
91	AET 29	*Tribulus cistoides* L.	Zygophylaceae	AH

Key: AH = Annual Herb; PH = Perennial Herb