Distribution and abundance of invasive alien weed species in Wolayita Zone, Ethiopia

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Distribution and abundance of invasive alien weed species in Wolayita Zone, Ethiopia

Nazirawit Tefera¹*, Abreham Assefa² and Gedyon Tamiru³

Abstract: Invasive alien weed species invasion are observed in areas of Wolaita Zone, Southern Nations Nationalities Regional state. However, its distribution and abundance have not been determined. Therefore, the objectives of the study were to assess the distribution of P. hysterophorus, L. camara and A. mexicana in the study area. Data were recorded in a total of 120 quadrants of 5 m x 5 m laid at 10 Km interval on the roadsides. Abundance and distribution of the three selected invasive alien weeds were determined and maps showing these were developed using ArcGIS 9.1 software. A total of 13 invasive weed species that is P. hysterophorus, L. camara, A. Mexicana, Xanthium strumarium L., Ageratum conyzoides L., Xanthium sponsum L., Cirsium vulgare Savi Ten, Senna didymobotra (Fresen.) Irwin Bameby, Senna odontalix L. link, Casia occidentalis L., Caesalpinia decapetala (Roth) Alston, Datura stramonim L., and Ricinus communis L. representing six families were identified in the study area. The result of the study showed that most of the invasive weed species found were belongs to the family Asteraceae followed by Fabaceae. Invasive alien weed species were differently distributed with the relative frequency of 0.83 (P. hysterophorus), 0.83 (L. camara), 0.5 (A. Mexicana), 0.43 (S. odontalix), respectively, while the other IAWs were found less distributed. The result indicated that of the total (120) sampling points P. hysterophorus was found on 100 sampling plots (83.3%). The infestation of L. camara was observed in all districts and Sodo town administration of the zone. A. mexicana was absent on 60 (50.0%) of sampling points which are at Ofa, Humbo, and Sodo zuria districts P. hysterophorus has the highest mean abundance value (22.3%) followed by L. camara (10.0%). Invasive Alien Weed Species were observed in different habitats. Roadside and cultivated lands were the two frequently

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Nazirawit Tefera is an expert in Science and Mathematics Education in Ofa Woreda office of Education, Wolayita Zone, Ethiopia. She has worked as political adviser at Areka city municipality in Wolayita Zone. In the course of the work, she has completed postgraduate study. She has also interest in conducting scientific research.

PUBLIC INTEREST STATEMENT

There are about 35 invasive alien weed species in Ethiopia. They are posing negative impacts on agricultural lands, rangelands, national parks, waterways, lakes, rivers, power dams, roadsides, urban green spaces with great economy and social consequences. Currently, the IAWS have been distributed to different regional states of Ethiopia including Southern Nations Nationalities Peoples Region State. Invasion of IAWS is observed in some areas of Wolayita Zone. In this study abundance and distribution of the Parthenium hysterophorus L; Lantana camara L and Argernone mexicana Sweet were determined and mapped.
P. hysterophorus infested habitats. P. hysterophorus, L. camara and A. mexicana were found to a threat to the livelihood of the Wolayita farming households. Thus, there is an urgent need for well organized, coordinated and concerned efforts that must be made to control. Further long-term study is needed to verify the impact of P. hysterophorus L. camara and A. mexicana invasion.

Subjects: Agriculture; Botany; Plant & Animal Ecology

Keywords: abundance; distribution; Ethiopia

1. 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 (McNeeley 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 (McNeeley et al., 2001).

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 which threaten 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, 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. (Bay & 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 & Murphy, 2003). Parthenium hysterophorus causes diarrhoea, severe popular 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 the consumption of this weed (Lakshmi and Srinivas, 2007). In agricultural areas or secondary forests, L. camara can become the dominant understory shrub, crowding out other native species and reducing biodiversity (Quentin et al., 1995). The formation of dense thickets of L. camara can significantly slow down the regeneration of forests by preventing the growth of new trees (Quentin et al., 1995).

In the Amhara region, it is estimated that about 37,105 hectares of land is infested with parthenium (Bezabih & Araya, 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 (Bezabih & Araya, 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. A. mexicana is a widespread weed and opportunistic plant, often growing in almost pure stands, particularly conspicuous in the dry season; sea level to 2400 m. Gonder, Gojam, Welo, Shewa, Arsi, Sidamo, Harerge region. Lantana has usually been deliberately introduced into
various localities in Ethiopia (particularly urban settings) as an ornamental shrub, and has been quickly spread by birds and animals that eat its fruits but cannot digest the woody seeds. It is common in the eastern part of the country, the Somali 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 IAPS is observed in some areas of Wolayita Zone, SNNPR. However, their distribution and abundance have not yet understood. Thus, it is imperative to assess the distribution and abundance of *P. hysterophorus*, *L. camara* and *A. mexicana* in Woliata Zone.

2. Material and methods

2.1. Description of study area

Wolayita 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. It is located at a distance of 330 km along the main road that stretches north to south from Addis Ababa to Arbaminich, and is also connected with the Southern Nations Nationalities Regional State capital, Hawassa, 160 km, Via Shashemane-Wolayita road to the south. The zone is composed of 12 woredas and 3 administrative towns. Wolayta zone (Figure 1) is characterized by

Figure 1. Map of Wolayita zone of southern nations nationalities people regional state.
three ecological zones: Kola (lowland <1500 m), Woina Dega (mid-altitude 1500–2300 m) and Dega (highland >2300 m). The study districts were Ofa, Humbo, Soddo Zuria and Sodo Town administrative located at 359 km, 347 km, 330 km and 330 km south of capital city, Addis Ababa, and at altitude between 1200–2800, 750–1100, 1950–2400, and 1600–2100 m above sea level, respectively.

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°C to 32.7°C and the mean temperature is 21.5°C (Figure 2). Average monthly rainfall recorded in the area showed that the highest amount of rainfall is received in March and July. The driest months in the study area are December, January and February with less than 23 mm rainfall.

The major soil types found in the Zone are Nitosols, haplic Yermosols, eutric Cambisols, orthic Andisols and calcric Fluvisols. The vegetation of the study area is dominated by eucalyptus trees (*Eucalyptus 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.

Mixed agriculture is the main economic activity but there are some pastoralists in the low land. The major crops grown in the study area are cereals such as teff, maize, barley, sorghum, coffee, and root crops like sweet potatoes (*enset ventricosum* Welw), carrot and fruits like mango, avocado and banana are practiced. Livestock production in Wolaita zone includes cattle (oxen, milking cows and young stock), goats and sheep, equines (horses and donkeys), poultry (mostly local chickens but some improved breeds).

### 2.2. Survey on the abundance and distribution of invasive weeds

The field study was undertaken between April to August 2018 to record data by stopping at 10 km interval along main and sub-roads accessible to vehicles. The study three districts and one administrative town (that is Humbo, Ofa, Sodo zuria and Sodo administrative Town) were selected purposively based on the aggressive invasiveness of weeds with the help of the information obtained from environmental protection and forest development office of Wolayita zone. A total of 120 quadrats were sampled in three districts and one administrative town of the zone. On each of the 120 main quadrats (5 m x 5 m), five sub quadrats (1 m x 1 m) were laid to measure the data on herbaceous weed species cover. Accordingly, a total of 600 sub quadrats were laid for herbaceous data collection. The quadrats were delineated using polyethylene strings around four wooden pegs inserted into the soil at four corners.

The cover abundance of weed species encountered in each of the quadrats was recorded using Braun-Blanquet 1965 cover method (Wittenberg et al., 2004). The total estimate scale (abundance plus coverage) can be shown in Table 1. Weed species which are difficult to identify in the field,
Table 1. Abundance scale and coverage estimates assessment for plot

| Abundances     | Scale | Descriptions                                      |
|----------------|-------|--------------------------------------------------|
| Absent         | 0     | No invasive alien weeds is found                 |
| Present        | 1     | Individuals plentiful, but coverage small         |
| Rare           | 2     | Individuals very numerous; covering at least 5% of the area |
| Occasional     | 3     | Individuals few or many; collectively covering 6–25% of the area |
| Frequent       | 4     | Individuals few or many; collectively covering 26–50% of the area |
| Abundant       | 5     | Weeds cover 51–75% of the area                    |
| Very Abundant  | 6     | Weeds cover 76–100% of the area                   |

plant specimen were collected, pressed, dried, labeled and identified in the field using flora of Ethiopia (Edwards et al., 1997). The taxonomic identification of the weed species followed the different volumes of the flora of Ethiopia and Eritrea books.

(Source: Wittenberg et al., 2004)

2.3. Developing distribution maps

Altitude, latitude and longitude for each sampling plot were recorded using GPS reader in order to locate the global position of the study site. Presence/absence and the extent of occurrence (quantitative estimate) were observed simultaneously and noted on data collection sheet based on the scale indicated in Table 1. In addition, infested habitat was also recorded. The distribution map of IAPS was developed at point data level. Thus, point distribution map showing presence or absence showing area coverage of P. hysterophorus, L. camara and A. Mexicana in zone was developed.

2.4. Data analysis

The data from Excel were imported into ArcGIS 9.1. Latitude and Longitude readings recorded by GPS in different locations of the study area were entered into computer with ArcView GIS 9.1 software and the distribution map of P. hysterophorus, L. camara and A. mexicana was prepared.

\[
\text{Frequency} = \frac{\text{Number of quadrants in which a species occurs in}} {\text{total number of quadrant}}
\]

\[
\text{Relative frequency} = \frac{\text{Frequency of species}} {\text{frequency of all identified species}} \times 100
\]

3. Result and discussion

3.1. Abundance of invasive alien weed species

The result of the study showed that a total of 13 invasive weed species representing 6 families was recorded in the Wolayita Zone. Most of the invasive weed species found were belong to the family Asteraceae followed by Fabaceae (Table 2).

The survey showed that P. hysterophorus, L. camara, A. mexicana, S. oxdentalis, S. didymobotra, D. stramonim, X. strumtarium and A. conyoides were differently distributed in the Zone with the frequency of 0.83, 0.83, 0.5, 0.43, 0.35, 0.37, 0.2, 0.2, respectively, while the other invasive alien weed species were found less distributed in the zone having the frequency of less than 0.2% (Table 3). Invasive alien weed species showed varied infestation in the surveyed areas. They were observed in different habitats that are, roadsides, crop fields, pasture lands, and wastelands.

The result indicated that P. hysterophorus has the highest mean abundance value (22.3%) followed by L. camara (10.0%). This is so because P. hysterophorus and L. camara are tropical in
origin and they possess similar growth strategies. They grow fast; have greater reproductive potential, competitive ability, and allelopathy that make them successful invaders of non-native habitat (Grice, 2006). The following three invasive alien weed species presented here below are among the major invasive in Ethiopia and showed a higher mean cover abundance in the study area.

Table 2. Invasive alien weed species identified in Wolayita Zone

| Scientific name                  | Family      | Local name      | Types of affected habitat |
|----------------------------------|-------------|-----------------|---------------------------|
| Parthenium hysterophoru L.       | Asteraceae  | Partiniya       | Rs, Cl, Wi                |
| Xanthium strumarium L.           | Asteraceae  | Dorisa gariccocha | Rs, Cl, Wi              |
| Ageratum coyzoides L.            | Asteraceae  | Ze”saa          | Rs, Cl, Wi                |
| Xanthium siponsum L.             | Aseraceae   | Dorsa garcochcha | Rs, Cl                    |
| Ciasium vulgare Savi Ten         | Aseraceae   | Unknown         | Rs, Cl                    |
| Senna didymobatra (Fresen.) Irwin Bameby | Fabaceae   | Kutto kuwa | Rs, Ri, Cl, Wi            |
| Senna oxdentalis L. link         | Fabaceae    | Kishkishiya     | Rs, Cl, Wi                |
| Casia occidentalis L.            | Fabaceae    | Kutto kuwa      | Rs, Cl                    |
| Caeslpinia decapetala (Roth) Alston | Fabaceae  | Gom”Riya        | Rs, Cl                    |
| Lantana camerara L.              | Verbanaceae | shaasha         | Rs, Cl, Wi                |
| Argemone Mexicana L.             | Papaveraceae| Necci lebash    | Rs, Cl, Wi                |
| Datura stramonim L.              | Solanaceae  | Machara         | Rs, Cl, Wi                |
| Lantana camerara L.              | Verbanaceae | shaasha         | Rs, Cl, Wi                |
| Ricinus communis L.              | Euphorbiaceae | Qobuwa   | Rs, Cl                    |

(Keys: Rs-Roadside, Rl-rangeland, Cl-cropland, and Wl-Waste land)

Table 3. Proportion of invasive alien weed species in study sites

| Invasive alien weed species | Number of plots species present | Frequency | Relative frequency | Abundance (%) |
|----------------------------|---------------------------------|-----------|--------------------|---------------|
| Parthenium hysterophoru L  | 100                             | 0.83      | 19.17              | 22.3          |
| Lantana camerara L.        | 100                             | 0.83      | 19.17              | 10.0          |
| Senna oxdentalis L. link   | 51                              | 0.43      | 9.93               | 7.0           |
| Argemone Mexicana L.       | 60                              | 0.5       | 11.55              | 3.9           |
| Ageratum coyzoides L.      | 27                              | 0.23      | 5.31               | 3.0           |
| Datura stramonim L.        | 44                              | 0.37      | 8.55               | 3.0           |
| Senna didymobatra (Fresen.)Irwin Bameby | 42                              | 0.35      | 8.08               | 3.0           |
| Xanthium strumarium L.     | 24                              | 0.2       | 4.62               | 1.5           |
| Ricinus communis L.        | 15                              | 0.13      | 3.00               | 1.0           |
| Ciasium vulgare Savi Ten   | 18                              | 0.15      | 3.46               | 0.6           |
| Xanthium siponsum L.       | 16                              | 0.13      | 3.00               | 0.6           |
| Caeslpinia decapetala (Roth) Alston | 11                              | 0.09      | 2.08               | 0.4           |
| Casia occidentalis L.      | 11                              | 0.09      | 2.08               | 0.2           |
| Total                      |                                 | 4.33      | 100                | 56.5          |
3.2. Distribution of Parthenium hysterophorus in study area

Of the total (120) sampling points P. hysterophorus was found on 100 sampling plots (83.3%) indicating that its relative frequency was 19.17% (Table 3). P. hysterophorus was observed in all surveyed districts that are, Humbo, Ofa and Sodo zuria, and Sodo town administration except 20 (16.7%) sampling plots at Sodo zuria district (Figure 5(a)). Therefore, the Districts will need to have strong regulation to control P. hysterophorus from further dissemination. Similarly, Fessehai et al. (2005a) reported the weed is spread in a series of small to large jumps to the southern regions of the country, notably area around Hawassa.

As was observed during the survey, P. hysterophorus was distributed in the study area growing on roadsides, cultivated land, wasteland, and grazing land (Figure 3(a and b)). Roadside and cultivated lands were the two frequently infested habitats (Figure 4(a)). High frequency along the roadside may be attributed to continuous disturbance and transportation of sands and soil for construction and maintenance of roads. This result agreed with Tessema (2002) who reported that P. hysterophorus occurred in the towns, usually on roadsides, and vacant sites and grew only at

Figure 3. Infestation of IAPS in different habitats: (a) P. hysterophorus in roadside in Sodo Town, (b) P. hysterophorus in rangeland in Humbo, (c) L. camara in roadside in Sodo Town, (d) L. camara rangeland in Ofa district, (e) A. mexicana in rangeland in Humbo, and (e) Wasteland in Sodo Town.
Figure 4. Distribution of IAPS in roadside, grazing land, cultivated land and wasteland in Wolayita Zone: (a) Distribution of P. hysterophorus, (b) Distribution of L. camara, (c) Distribution of A. mexican.
irregular intervals. Similarly, Tessema (2002) reported that the extensive dense stands along roadsides in Ethiopia might be due to the routine disturbance and grading of road verges. Accordingly, the presence of the species in the zone suggests that the species may become well distributed and invade croplands in the Zone.

3.3. Distribution of Lantana camara in study area

The survey revealed that L. camara showed varied distribution in the surveyed sampling plots of the study districts. It was registered on 100 sampling plots (83.6%) out of 120 total sampling plots indicating that its relative frequency was 19.17% (Table 3). L. camara was observed in all districts and Sodo town administration of the zone (Figure 5(b)). This implies L. camara is becoming a problem in the area. Unless quick action made to control its spread, the weed will continue to spread and further affect agricultural communities placed in the study area. The study by Binggeli and Desalegn (2002) indicated Lantana is highly detrimental to many human activities (e.g., agriculture, forestry, and tourism) as well as a threat to natural ecosystems.
During the survey, *L. camara* was found to invade various habitats distributed in road sides, cultivated lands, wasteland, and grazing lands in the study area (Figure 3(c and d)). The roadside was the most frequently infested habitats (Figure 4(b)). Areas around habitation extremely infested because far and wide used as ornamental plants and planted as a fence. From habitation area gradually being dispersed to roadsides, and now becoming an important weed in grazing land and cultivated land. Day et al. (2003) also reported that loss of pasture is the major impact of lantana invasion in grazing areas.

3.3.1. Distribution of *Argemone* in the study area

During the survey, *A. mexicana* was absent on 60 (50.0%) of sampling points which are at Ofa, Humbo, and Sodo Zuria districts (Table 3). Its percent cover was 3.9%. Study showed distribution of *A. mexicana* was ranged from absent to rare in the districts (Figure 5(c)). As it is observed in Figure 3(e and f), *A. mexicana* was distributed in the study area growing on roadsides, cultivated land, wasteland, and grazing land. Its growth varying environment might indicate its adaptability to different climates and soil condition. The result showed *Argemone* became less infested in cultivated land and frequent at roadside and on grazing land (Figure 4(c)). This might be cultivated land was not well assessed. No so far research was made showing the distribution and abundance of *A. mexicana* in Ethiopia.

4. Conclusion and recommendations

The result of the study clearly demonstrated that *P. hysterophorus*, *L. camara* and *A. mexicana* exhibited wider distribution in the study sites. It is generally becoming a threat to the sustainability of the livelihood of the Wolayita farming households. The study implicated that integrated long-term management programs must be carried out to control. Thus, there is an urgent need for well organized, coordinated and concerned efforts that must be made to control or eliminate. This requires the local people, scientists, governments and NGOs to work in unison. Foremost, the conservations of biodiversity through the most efficient control mechanism need to be given priority. Further studies must be undertaken to observe the impact of *P. hysterophorus*, *L. camara* and *A. mexicana* on species diversity.

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Competing interests

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