

**ADDIS ABABA UNIVERSITY**  
**SCHOOL OF GRADUATE STUDIES**

**Biological assessment and farmers' perception on socioeconomic impact of  
*Parthenium hysterophorus* on native biodiversity in Kobo, Amhara Region**

By

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## ABSTRACT

*Parthenium hysterophorus* is an invasive alien species that is believed to have been introduced to Ethiopia during the 1970s along with the grain aid donated by USA, and for the same reason in the 1980's in the study area. In this study the biological and socio-economic impact of *P. hysterophorus* were assessed in Kobo (North Wello, Ethiopia) to develop up-to-date information for future prevention and control mechanisms. The biological impacts of *P. hysterophorus* were investigated using cover, comparison and soil analysis techniques. The socio-economic impacts due to *P. hysterophorus* was studied by interviewing a total of 114 sample farmers that were selected randomly from the list of farmers in the study area, that is 38 farmers from each stratum (none, medium and high infestation area).

Results showed that from all the sample species *P. hysterophorus* was found the most abundant in grazing land. On the contrary, the majority of the other species account for less than 5% of relative abundance. According to Partial Redundancy Analysis (RDA) 59.8% of the variation in species data was observed in the first four PCA axes and 11.5% of the variation with the first two axes. Biplot diagram indicates that *P. hysterophorus* weed is negatively correlated with the majority of species. According to the patch test the abundance of the sample species is statistically significant at  $P=0.01$  between none and high infested area of *P. hysterophorus* whereas the difference between the height of the species is insignificant at  $P=0.05$ . The percentage of sand, clay and silt is statistically significant at  $P=0.01$ ,  $P=0.01$  and at  $P=0.05$ , respectively, and the pH and moisture content of the sample soil is statistically significant at  $P=0.05$  and insignificant at  $P=0.05$  value, respectively. The average number of nematodes in none, medium and high infested field of *P. hysterophorus* were statistically significant at  $P=0.05$ .

Field survey results showed that all the sample farmers were aware of *P. hysterophorus*, its ways of introduction into their locality, the agents facilitating its dissemination and places where *P. hysterophorus* is densely populated. In the study areas, more than 90% of the respondents noticed that *P. hysterophorus* was the most abundant and threat to the loss of biodiversity. Accordingly, the grass species *Cleome gynandra*, *Amaranthus graecizans*, *Cucumis dipsaceus*, *Bidens pilosa*, *Launaea intybacca*, *Enteropogon macrostachyus*, *Eragrostis cilianensis*, *Euphorbia indice* and *Boerhavia coccinea* are endangered by *P. hysterophorus*.

*P. hysterophorus* weed can cause serious loss on the production and productivity of crops, human health and biodiversity. Hence it has a significant effect on the economic development of the study area. Integration of different control methods are therefore needed to prevent and control the danger of *P. hysterophorus*.

## **1. INTRODUCTION**

Invasive alien species are species introduced deliberately or unintentionally from outside their natural habitats where they have the ability to establish themselves, invade, out compete native species and take over the new environments. They are widespread in the world and are found in all categories of living organisms and all types of ecosystems. The threat to biodiversity due to invasive alien species is considered second only to that of habitat loss (GEF, 2003). They are thus a serious impediment to conservation and sustainable use of global biodiversity with significant undesirable impacts on the goods and services provided by ecosystems.

Biological invasions operate now on a global scale and if counter measures are not taken, they will undergo rapid increase in this century 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). Invasive alien species can cause significant and sometimes irreversible environmental and socio-economic impact at the genetic, species and ecosystem levels. Their management costs include not only costs of prevention, control and mitigation, but also indirect costs due to impacts on ecological services.

Ethiopia is one of the countries found in the eastern horn of Africa, which is endowed with great biological and ecological diversity. Moreover, it is one of the few countries in the world with relatively high level of endemism of biodiversity. This wealth of biodiversity does not only belong to the country but also to the world heritage (EARO, 2002). However, the biological diversity of the country has been badly suffering from degradation because of agricultural expansion, construction, charcoal and fuel wood collection, fire and overgrazing since many decades, and currently because of the impacts of invasive alien species.

The major Invasive Alien Species of plants identified in Ethiopia are *parthenium* weed (*Parthenium hysterophorus*), mesquites (*Prosopis juliflora*), and water hyacinth (*Eichhornia crassipes*, lantana weed (*Lantana camara*) and witch weeds (*Striga species*). *Parthenium* weed (*Parthenium hysterophorus*) is an annual herb with a deep taproot and an erect herbaceous shoot with a multi branched stem that grows anywhere and becomes wood with age (Evans, 1997). It is naturally a weed of subtropical areas of North and South America (Mexico, USA and West Indies), but later *P. hysterophorus* found its way accidentally to tropical and subtropical parts of Africa, Asia and Australia (Aneja *et al.*, 1991).

During the first years of invasion, *P. hysterophorus* remained unnoticed in crop lands and used to grow in undisturbed wastelands, neglected fields along fence lines, irrigation and drainage ditches, bands, rocks and crevices, railway tracks, public places like roadsides, parks and recreational grounds and other non crop situations (Singh, 1997). Therefore, it was considered to be stray weed, which could not withstand close crop competition in the fields. However, this idea proved wrong as, *P. hysterophorus* has slowly colonized the agricultural lands, particularly rangelands, forests, orchards and poorly managed arable crop fields. On the other hand, its density and abundance in the vicinity of other exotic plantations is relatively low. From this observation one can understand that the phytotoxic /allelopathic properties of exotic trees could be exploited to cure the hazard of *P. hysterophorus* (Kohli and Kumar, 1997).

*P. hysterophorus* can also cause health hazard to man and animals leading to socio-psychonomic problems. It is known to cause various skin problems, like itchy lesions over the face, neck and dorsal aspect of the hands, contact dermatitis, contact irritant dermatitis, air borne contact dermatitis and photo phyto-dermatitis (Kololgi *et al.*, 1997). According to Navie *et al.*, (1996) *P. hysterophorus* is widely distributed worldwide. It bears a number of various names as *P. hysterophorus* in Australia, congress grass, carrot weed, bitter weed, and broom bush, star weed in India; false ragweed, and ragweed in USA; whitehead, white top, escobar amarga, and feverfew in the Caribbean.

According to Taye Tessema (2002), *P. hysterophorus* has also different names in different regions of Ethiopia that imply its allelopathic potential, physical form, contaminations and strong competitive nature and /or its introduction. For example “Kinche arem” (Amhara region) means flower/head resemblance to pulverize wheat used for soup preparation. “Merrerta” (Oromiya) due

to its effect on the taste of cows' milk. "Biyabassa" (Oromiya) which means sign to leave the land and "Feremsisa" which indicates how it came with the signature of every body.

*P. hysterophorus* has become the worst weed since its discovery in Ethiopia at Dire- Dawa in Harerge province of Eastern Ethiopia in 1988 (Tamado Tena, 2001). A second major center of infestation was subsequently found at Northeastern Ethiopia. There is a strong implication that *P. hysterophorus* seeds were imported from subtropical North America as a contaminant of grain food aid during the 1980s famine, and distributed with the grain.

By 1999, *P. hysterophorus* was widely spread in Eastern Ethiopia, close to Addis Ababa, and was reported to be spreading into Western Ethiopia. The Awash National Park and the Yangudi Rasa National Park (Afar region) are currently at risk, as the weed spreads in a series of small to large jumps with the accidental assistance of man (EARO, 2002).

Ethiopia is a country of great geographical diversity, with high and rugged mountains, flat-topped plateau and deep gorges, incised river valleys and rolling plains. The altitudinal variation ranging from 110 meters below sea level to high mountains reaching up to 4620 meters above sea level affords the country a wide range of climatic conditions. This has created diverse environments, which are home of a large number of flora and fauna (EARO, 2002). According to the same source, the Environmental Policy of Ethiopia (EPE) and the draft National Biodiversity strategy and Action plan have identified invasive species as posing major threat to biodiversity and the economic well being of the population.

My attention was drawn to assess the biological and socio-economic impact of *P. hysterophorus* on native biodiversity in Kobo, Amahra region, because there is no much attention generally in Ethiopia and particularly in Amhara region about the danger of this invasive alien species. So the study may reveal the danger of the weed.

The focus of the study was to understand the biological impact of *P. hysterophorus* using the two chosen methods (cover and comparison methods) and to know farmers' perception on the impact of *P. hysterophorus* on native biodiversity by interviewing farmers, which are randomly chosen among the community.

## **1. 1. Objectives**

The overall objective of this study was to provide basic information on the impact of *P. hysterophorus* on native biodiversity in Kobo woreda of Amhara region.

## **1. 2. Specific objectives**

1. To determine the biological impact of *P. hysterophorus* on plant diversity in rangelands;
2. To determine the impact of *P. hysterophorus* on soil nematodes, soil texture, pH and moisture; and
3. To know farmers' perception on the impact of *P. hysterophorus* with regards to human and livestock health.

## 2. LITERATURE REVIEW

### 2. 1. Biological features of *Parthenium hysterophorus*

*Parthenium* weed (*P. hysterophorus*) popularly known as Congress grass in India is an erect, herbaceous annual plant, which can grow at any season and almost anywhere. It belongs to the family Asteraceae (Compositae), an extremely diverse family with a cosmopolitan distribution (Towers *et al.*, 1977). At the time of maturity it reaches up to 2 m with a maximum of 2.5 m in good soils (Navie *et al.*, 1996). During early time of growth *P. hysterophorus* forms basal rosette of leaves that spreads rapidly very close to the ground.

The leaves are pale green, branched, and dissected into narrow pointed lobes and measure up to 20 cm in length and 4-8 cm broad, and are covered with soft fine hairs called trichomes. Trichomes are hair like structures, which cover the leaves and the stem. *P. hysterophorus* has got a deep tap root system that enables it to obtain water and minerals from deep within the soil profile. Further, this taproot stores energy reserves for the rapid growth of the plant if slashed or grazed (McFadyen, 1992).

The reproductive ability of *P. hysterophorus* is the other most important biological characteristics. This is because seeds are small, 1-2 mm length and weigh about 50 micro grams, and are flattened with short wing like structures (Navie *et al.*, 1996). *P. hysterophorus* is an extremely prolific seed producer with up to 25,000 seeds per plant. The flowers are creamy white, borne in profusion at the tips of the stems. Clusters of male and female florets are grouped as 5-lobed, 4-8 mm diameter heads.

Brahman (2003) reported that a single plant can produce 10,000 to 15,000 viable seeds that occupy roadsides, tank bunds, fence lines, wastelands, agricultural fields, forestlands, and rangelands. PAG (2000) stated that *P. hysterophorus* could produce large quantities of seed, up to 100,000 per plant and more than 340 million seeds per hectare in the surface soil, compared to 120,000 of native grass seeds.

In temperate regions, Navie *et al.*, (1996) reported that *P. hysterophorus* normally germinates in spring and early summer, produces flowers and seeds throughout its short life and dies in late autumn. However, with the right conditions (rain, available moisture, and mild soil and air temperatures) *P. hysterophorus* can grow and produce flowers at any time of the year. In a good season, four or five generations may emerge. In summer, if plants are stressed it can complete its life cycle in four weeks. Buried seeds have been found to last much longer than seed on the soil surface, and significant proportions can still germinate after eight to ten years (PAG, 2000).

In cultivated lands where only one crop is taken in a year, *P. hysterophorus* grows in the fallow period with one or two rains but its growth and reproductive ability will be affected depending upon soil fertility and rainfall. Frew Mekbib *et al.*, (1996) stated that *P. hysterophorus* could grow under varied soil pH. The plant has a remarkable plasticity and adaptability to environmental stresses.

## **2. 2. Ecology of *Parthenium hysterophorus***

Mahadevappa (1997) stated that high rate of seed production, efficient seed dispersal mechanisms and allelopathic nature enable *P. hysterophorus* to overcome and establish easily in a wide range of ecological adversities and thus continue to survive under stress. Hence in the absence of any effort, *P. hysterophorus* plant may be able to survive for comparatively a period longer than any other species. Navie *et al.*, (2004) stated that *P. hysterophorus* seedlings emerged more rapidly from the soil samples than those of all other species. They further reported that ecology, abundance and the persistence of its seed bank and the rapid emergence of its seedlings are major factors contributing to its aggressiveness in semiarid rangeland communities in Central Queensland. They also noted that the domination by *P. hysterophorus* of the seed banks of these sites suggests that the weed is having a substantial negative impact on the ecology of these plant communities. According to anecdotal evidence, *P. hysterophorus* seeds are capable of germinating, growing and aggressively colonizing croplands, grazing lands and disturbed lands during any season with one or two showers.

Kohli and Rani (1992) noted that even though *P. hysterophorus* has efficient adaptive nature to tolerate drought and saline soil conditions, areas receiving less than 500 mm of rainfall are

unsuitable. Duration of flowering and the life span of *P. hysterophorus* are affected mainly by soil moisture. During dry conditions the life span might take up to 335 days compared to 86 days under optimum conditions (Williams and Groves, 1980).

## **2. 3. Distribution of *Parthenium hysterophorus***

### **2. 3. 1. Distribution of *Parthenium hysterophorus* in the world**

*P. hysterophorus* is naturally a weed of sub tropical areas of North and South America (Mexico, USA and West Indies), but later it found its way accidentally to tropical and subtropical parts of Africa, Asia and Australia during the last five decades (Aneja *et al.*, 1991).

According to Navie *et al.*, (1996) *P. hysterophorus* is widely distributed in South and East Africa (Ethiopia, Kenya, and South Africa) South and South East Asia (India, China, Vietnam, and the Pacific Islands), Australia (Queensland, Central Highlands and North Clermont, New South Wales) and in many other parts of the world cutting across country boundary and climate barrier. That is why *P. hysterophorus* bears a number of common names like *P. hysterophorus* in Australia, congress grass, carrot weed, bitter weed, broom bush, and star weed in India, false ragweed, ragweed in USA, white top, Escobar amarga, and feverfew in the Caribbean.

Invasion of *P. hysterophorus* weed is attributed to many factors like wider adaptation across climates, photo-insensitivity, drought tolerance and absence of seed dormancy. Within a short period of time, *P. hysterophorus* has become a major weed of regional, national or international concern (Haseler, 1976). This might be because of its prolific seed production ability and small and light weight seeds that are capable to travel long distances through wind, water, birds and other animals; traffic and transported goods serve as vectors for the dispersal of seeds.

### **2. 3. 2. Distribution of *Parthenium hysterophorus* in Ethiopia**

*P. hysterophorus* was first reported from Ethiopia at Dire-Dawa, Harerge, and eastern Ethiopia in 1988 (Tamado and Milberg, 2000). According to the recently published volume of Flora of Ethiopia and Eritrea, Asteraceae (Compositae) *P. hysterophorus* is distributed in eastern Ethiopia along the Dire Dawa – Addis Abeba railway, Central Shoa and wollo, northern Ethiopia, Sidamo along the main road from Moyale to Asella (Mesfin Tadesse, 2004). Most are major food-aid distribution centers, and there is a strong justification that *P. hysterophorus* seeds were imported from subtropical North America as a contaminant of grain food aid during the 1980s famine, and distributed with the grain. *P. hysterophorus* has been causing serious damage in Ethiopia since its discovery in 1980's as an exotic invasive species. Frew Mekbib *et al.*, (1996) reported its status, distribution and biology.

Frew Mekbib *et al.*, (1996) reported that *P. hysterophorus* introduction might have occurred during the Ethio-Somalia war in 1976/77 along with army vehicles. Taye Tessema (2002) indicated possibility of transboundary transfer from the presence of *P. hysterophorus* in Kenya and Somalia, and from the capacity of *P. hysterophorus* seeds to travel long distances through wind, water and other means. It is therefore possible that *P. hysterophorus* could have easily been introduced to Ethiopia from these neighboring countries. Taye Tessema *et al.*, (2004) indicated that the presence of *Puccinia abrupta* on *P. hysterophorus* in Ethiopia, might explain indirectly the introduction of *P. hysterophorus* from neighboring countries, Kenya and/or Somalia since the presence of the rust has been reported earlier from Kenya. However, there is no concrete evidence with regard to the question of how and when *P. hysterophorus* got introduced into the country.

## **2. 4. Impacts of *Parthenium hysterophorus***

McFadyen (1992) and Navie *et al.*, (1996) stated that *P. hysterophorus* can affect crop production, animal production, human health and biodiversity in its area of infestation. Hence it causes severe contact dermatitis in a lot of people that becomes chronic after longer exposition. Because of the four reasons indicated above *P. hysterophorus* is considered a noxious plant.

## 2. 4. 1. Effects of *Parthenium hysterophorus* on livestock

Adverse effects of *P. hysterophorus* on animal health have also been well documented. The effect of *P. hysterophorus* on livestock production is direct and indirect by affecting grazing land, animal health, milk and meat quality, and marketing of pasture seeds and grain (Evans, 1997b).

It is known to cause asthma, bronchitis, dermatitis and hay fever in livestock. Chemical analysis has indicated that all the plant parts including trichomes and pollen contain toxins called sesquiterpene lactones. The major components of toxic being 'parthenin' and other phenolic acids such as caffeic acid, vanillic acid, anisic acid, p-anisic acid, chlorogenic acid and parahydroxy benzoic acid are lethal to animals (Kololgi *et al.*, 1997).

Under normal conditions cattle don't eat *P. hysterophorus*. The negative effect of the weed can be observed as inflamed udders on cows that subsequently suffered from fever and rashes. According to Chippendale and Panetta (1994), in 1990-1991, a mail survey of beef producers was conducted in the most heavily infested region in Central Queensland. Annual losses caused by this weed were found resulting in a weed monoculture and reduced stocking rate up to 80% with a net annual loss of Au \$ 16.5 million.

Cattle that are mostly found grazing in *P. hysterophorus* infested pastures are found to be marketed with a lower weight compared to those from weed free areas. They also noted that losses comprised opportunity costs (e.g. reduced stock numbers and live weight gains), as well as additional production and control costs. Increased expenditure on research into *P. hysterophorus* control (especially biological control, for which research expenditure was approximately \$ 350,000 during 1990-1991) is thus warranted. A supply of pasture seed and forage might be hampered since there is legislation to prevent the sale or movement of goods because of their contamination by *P. hysterophorus* seed (Evans, 1977a).

Researches conducted in India on toxicity of the weed to cattle and buffaloes have shown that a significant amount (10-50%) of the weed in the diet can kill these animals within 30 days (Naarasimhan *et al.*, 1977). This is because animals developed dermatitis with pronounced skin lesions and eventually died due to the rupture of tissues and hemorrhage in their internal organs. On the other hand, taints of meat have been detected from sheep given a diet of 30% *P.*

*hysterophorus* (Tudor *et al.*, 1982) and tainting of milk has also been reported from cows (Towers and Subarao, 1992).

Subba *et al.*, (1976) studied the danger of repeated contact with *P. hysterophorus* on a young rabbit by letting it free to move in densely infested area. From the 8<sup>th</sup> day onwards the rabbit exhibited hypersensitivity by showing restlessness. After 3 days, natural falling of hairs from the dorsal region of the neck and back was observed. On the 12<sup>th</sup> day eruption of small boils all over the neck and lateral sides of the neck were observed. This led to oozing of blood on the 13<sup>th</sup> day and mortality on the 17<sup>th</sup> day. It was, therefore, concluded that the weed could be hazardous to animals. On the other hand Subba *et al.*, (1976) reported that feeding the weed to buffaloes and bull calves at different levels causes both acute and chronic forms of toxicity. Ulcerations were caused both in the mouth and digestive tract. Autopsy of the dead animals showed punched out ulcers on the esophagus and abnormal folds.

#### 2. 4. 2. Effects of *Parthenium hysterophorus* on crop production

*P. hysterophorus* is considered as an extremely aggressive colonizer of crops, because it is an extremely prolific seed producer, with up to 25,000 seeds per plant and with an enormous seed bank, estimated at 200,000 seeds per meter square (Navie *et al.*, 1996). Besides, it has completely dominated and prevents other plants to grow due to the allelopathic effects of the weed caused by exudation of inhibitors through the roots as well as leaching of inhibitors from the aerial vegetation. These inhibitors are composed of soluble phenolics (caffeic acid, ferulic acid, vanicillic acid, anisic acid and famaric acid) and sesquiterpene lactones, mainly 'parthenin' and hymenin. Evans (1997b) also stated that *P. hysterophorus* not only compete for nutrients but also release allelochemicals to the substratum via root exudation. Dayama (1986) reported that *P. hysterophorus* inhibited the growth and nodulation of legumes because of the inhibitory effect of allelochemicals on nitrogen fixing and nitrifying bacteria.

Towers *et al.*, (1977) stated that when the pollen of *P. hysterophorus* falls on stigmatic surface of other plants, it inhibits fruit set in tomatoes, beans and maize and reduces forage production by 90%. They also stated that *P. hysterophorus* could cause yield decline up to 40% in agriculture crops. When aqueous extracts of *P. hysterophorus* from leaf and flower reach 10%, it inhibits

seed germination. Moreover it causes complete failure of seed germination of teff (*Eragrostis tef*) (Tadelle Tefera, 2002). Further *P. hysterophorus* pollen was found to reduce the chlorophyll content of leaves with which it comes into contact and can interfere with the pollen germination and fruit set of the nearby species (Kanchan and Jayachandra, 1979). Towers *et al.*, (1977) reported that heavy deposition of *P. hysterophorus* pollen on the stigmatic surface caused 40% reduction in the grain filling of maize and predicted that the weed may still exhibit an inhibitory influence on crops even when grown at a considerable distance.

### 2. 4. 3. Effects of *Parthenium hysterophorus* on human beings

Towers (1981) also reported that due to the reactive toxic classes of compounds known as sesquiterpene lactones, *P. hysterophorus* is the causative agent of asthma, bronchitis, dermatitis, and hay fever. Further, he reported that there has been an epidemic of hundreds of cases of *P. hysterophorus* dermatitis in India and several cases have been reported from USA. According to Fisher (1952) the effect of *P. hysterophorus* is because of its content of parthenin when it enters the dermis, combines with albumin in presence of ultraviolet rays and becomes complete antigen. Thus there will be antigen and antibody reaction resulting in photo phyto dermatitis.

During the first time of *P. hysterophorus* infestation one can observe itching followed by redness, swelling and blisters around the eyelids, face and neck then spreading to elbows and knees. Thickening and darkening of the skin are features of the chronic stage.

Continued close contact with *P. hysterophorus* could develop eczematous contact dermatitis while inhalation of pollen can cause allergic rhinitis that can develop into bronchitis or asthma if the pollen enters the respiratory tract during mouth breathing (Evans, 1997b).

*P. hysterophorus* can cause severe allergies in some people. It is known to cause human health problems, either through direct skin contact with the plant, or the pollen of the plant in the air, like asthma, bronchitis, dermatitis, and hay fever. In Poona (India), one in 60 men is said to be allergic, and so far there have been 12 deaths attributed to the allergy (Kololgi *et al.*, 1997). A study which was conducted in Bangalore (India) showed that 7.1 percent of the study population

was suffering from allergic rhinitis resulting from exposure to *P. hysterophorus* pollen (Sriramarao *et al.*, 1991).

According to McFadyen (1992) human population is very low in *P. hysterophorus* affected areas in Australia because of the dermatitis caused by this weed. He stated that about 15% of individuals regularly exposed to *P. hysterophorus* would develop dermatitis, with another 7-15% developing respiratory problems. Affected individuals have no alternative except to leave the area and seek work elsewhere due to its chronic nature; reports of committing suicide are available in India and other parts of the world (Kololgi, *et al.*, 1997).

## **2. 5. Control of *Parthenium hysterophorus***

Australia has had an on-going campaign to reduce the spread and impact of *P. hysterophorus*. However, the weed has continued to increase and spread (Adkins *et al.*, 1996). Chemical control is possible but too expensive to control all infestations over such large areas. The spread of *P. hysterophorus* can be minimized in cultivated lands to a great extent if it is controlled at the non-crop areas. Therefore, one should apply maximum effort on non-crop areas by using different integrated methods described below.

### **2. 5. 1. Prevention**

Prevention is the simplest way to protect *P. hysterophorus* from establishing (Navie *et al.*, 1996). For example, use clean crop and pasture seeds, cleaning of cultivating and harvesting vehicles before moving them into non infested areas, and short term quarantine of stock that have been in *P. hysterophorus* infested areas.

### **2. 5 .2. Manual and mechanical control**

Manual and mechanical methods are temporary and expensive, because *P. hysterophorus* covers large areas (Bhan *et al.*, 1997). Mowing or slashing of *P. hysterophorus* is not recommended for it results in rapid regeneration of plants from lateral shoots (Gupta and Sharma, 1977). It is suggested that *P. hysterophorus* plants should be uprooted to prevent regeneration from the remaining lateral shoots and that such operation should be done before flowering and when the soil is moist enough to facilitate easy removal.

### 2. 5. 3. Use of competitive harmless plants

Singh (1997) conducted a research and confirmed that plants like *Cassia spp* could exert allelopathic impact and hinder germination and growth of *P. hysterophorus*. Further he stated that the reason why *Cassia species* are chosen to suppress *P. hysterophorus* adaptability, sufficient quantity of seed production and its uses for protection of soil erosion and green manure.

### 2. 5. 4. Application of suitable herbicides

From the time of germination up to the 75<sup>th</sup> day, *P. hysterophorus* is vulnerable for early chemical control (Mahadevappa, 1997). Chemicals like glyphosate and glyphosate ammonium at 1.0-1.2kg/ha and Metribuzin at 1.0-1.5kg/ha have been found effective in controlling *P.hysterophorus* in non-crop wastelands, bunds, and roadsides or railway tracks.

### 2. 5. 5. Pasture and grazing management

Pasturelands should be managed efficiently, because poorly managed pastures increase the chance of invasion by *P. hysterophorus* and the severity of existing infestations (Parsons and Cuthbertson, 1992). In order to rehabilitate pastures infested by *P. hysterophorus*, sowing pasture species is very crucial. Once restoration of pasture is done, the carrying capacity has to be carefully adjusted according to season and rainfall to maintain grass dominance.

## 2. 5. 6. Cultural management

*P. hysterophorus* can be controlled indirectly by using clean seed, use of more competitive varieties, and choice of an appropriate sowing rate and date, and increased amount of fertilizer (Tamado Tena, 2001). On the other hand intercropping sorghum, maize and sunflower significantly reduced *P. hysterophorus* populations (Kandasmy and Sankaran, 1997). In eastern Ethiopia, Tamado Tena (2001) reported the advantage of intercrops under sorghum cultivation systems.

## 2. 5 .7. Control through utilization

Researches have been made to exploit the potential uses of *P. hysterophorus* like its green manure value, compost, bio-control value and soil amendment value (Ramsawami, 1997). Pandey *et al.*, (1993) reported that *P. hysterophorus* residue incorporation in rice field increased rice grain yield. Utilization of *P. hysterophorus* as mulch for checking evaporation from crop field, particularly used in the dry land areas, but the plant should not reach to flowering. However, choice of crops may be limited since *P. hysterophorus* exerts allelopathy. In addition, *P.hysterophorus* can be used for medicinal properties such as anti tumor and anti amoebic activities, skin disorders and other ailments in Caribbean and Central America, as was reported by Seier and Djeddour (2000).

## 2. 5. 8 Integrated *Parthenium hysterophorus* management

There is no single method used to control *P. hysterophorus* as each method suffers from one or more limitations such as high cost, inefficiency, impracticability, environmental safety and temporary relief (Mahadevappa 1997; Bhan *et al.*, 1997). Hence, integrated *P. hysterophorus* management that involves the use of different control option is mandatory. These are: enactment

of acts in *Parthenium*-affected states by giving good publicity through television, video, posters, radio and seminars; advice and organization of people's participation in uprooting, cleaning, and spraying, and seed sowing of competitive plants like *Cassia spp.*

### **3. MATERIALS AND METHODS**

### 3. 1. Study area

The study area is located at 12<sup>0</sup> 04' 21" N and 39<sup>0</sup> 37' 13" E in Kobo district, North Wello in Amhara regional state. The area is characterized by low and erratic rainfall with mean annual rainfall of 577.33 mm (Figure 1). The area has relatively hot climate of 23.1<sup>0</sup>C as compared to other woredas in North Wello. The major crops grown are sorghum (*Sorghum bicolor*) teff (*Eragrostis teff*) and maize (*Zea mays*), accounting for about 41%, 32%, and 4%, of the total production respectively (Figure 2).

The study sites were selected based on the local importance of *P. hysterophorus* distribution and the severity of the threats by the weed on the local diversities, and accessibility of the study site.

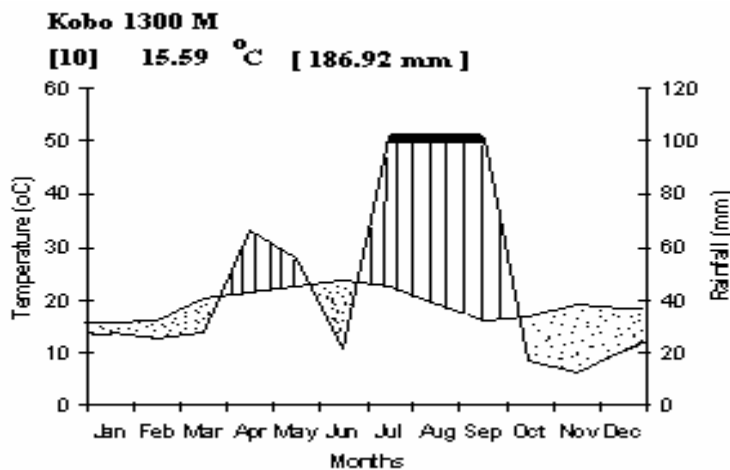
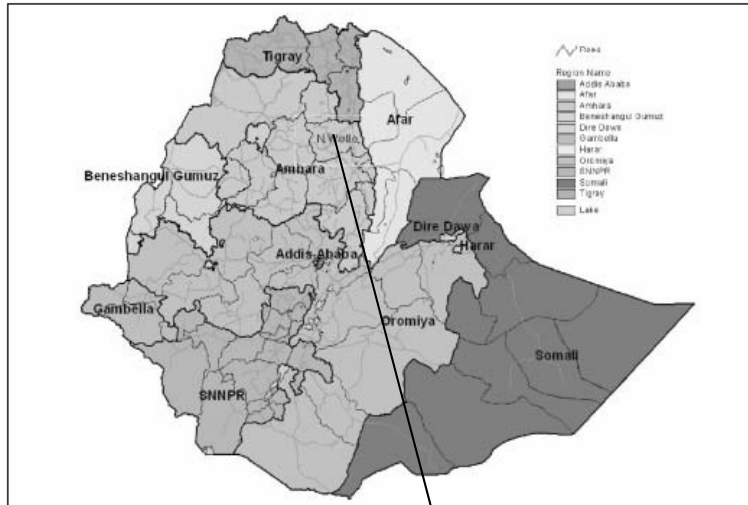


Figure 1 Climatic diagram of the study area (Kobo).

Figure 1: Map of Ethiopia



Source: WFP Vulnerability & Mapping Unit, Addis Ababa



Figure 2 Map of the study area

## **3. 2. Methods:**

### **3. 2. 1. Cover method**

Following Wittenberg, (2003) a single 100 meter long transect was established on land with varying *P. hysterophorus* infestation level. The long transect had 1 m width and was subdivided into 100 1 m by 1 m quadrates. Then after, data on number of individuals of each species, height measurements of the individuals of each species were taken using 0.25 m by 0.25 m iron quadrates. Four same size iron quadrates of 0.25 m by 0.25 m were thrown at one time in order to collect data for each 1 m by 1 m plot.

### **3. 2. 2. Comparison method**

The same rangeland was used to conduct comparison study to assess *P. hysterophorus* impact on plant biodiversity. This was to compare the biodiversity of the completely infested area with the adjacent non infested patches. Nine infested *P. hysterophorus* patches were selected and numbered and out of these 5 patches were randomly chosen for this study. On these selected 5 patches a 3 m by 3 m bigger plot, which was relatively homologous, was established and another 2 m by 2 m smaller plot was established at the center of each bigger plot of the 5 *P. hysterophorus* patches for data collection. Four iron quadrates of 0.25 m by 0.25 m size were thrown by four persons 4 times in each 2m by 2 m plots (16 quadrates per plots). Data on species count and height measurement of each species in the quadrates were collected with the same approach to cover method to compare the diversity level between the two scenarios.

### **3. 2. 3. Soil analysis**

#### **3. 2. 3. 1. Soil nematode analysis**

Soil samples were collected with a 5 cm diameter-coring tool to a depth of 20 cm in September, 2005, because during this period soil nematode population are at their highest level and are most

easily detected. The Christie-Perry Technique was used to extract nematodes from high, medium and non-*P. hysterothorus* infested areas. The main steps in nematode extraction were the following:

1. A 20-gram soil sample was suspended in 3 liter of water and allowed to settle for 90 seconds.
2. The soil water solution was poured through a 15 mm mesh sieve nested over a 400 mm mesh sieve.
3. The screenings from the 400-mesh screen were washed onto two layers of Scotties brand tissue, which have been supported in a 4-inch diameter pot by a wire screen. The water level in the pot should just cover the sample.
4. After 24 hours, nematodes that have migrated through the tissue are collected from each site in the study area randomly from the top 8 to 10 inches of soil using a soil shovel. Samples were mixed thoroughly and 10 gram of soil was taken for laboratory analysis.

### **3. 2. 3. 2. Soil pH**

Soil pH was determined following Juo (1978). A 1: 1 soil suspension in water was made by dissolving 20 g of soil that has passed through 2 mm sieve with 20 ml of distilled water. The suspension was stirred with glass rod and allowed to settle for 30 minutes. The pH was measured using Beckman Chemmate pH meter.

### **3. 2. 3. 3. Soil moisture**

To calculate percent moisture content, soil samples were weighed in the field at the time of collection. The samples were brought to the laboratory and dried in the oven at temperature of 105 °C. Gravimetric method was used for moisture analysis. This method involves drying the soil until a constant weight is obtained (Jackson, 1973). Since the wet samples were measured in the field, the dried weight was measured after a constant weight was obtained.

$$\% \text{ Soil moisture} = \frac{\text{Field weight} - \text{Dried weight}}{\text{Field weight}} \times 100$$

### **3. 2. 3. 4. Hydrometer method of mechanical analysis**

One method of analyzing these particles is mechanical analysis of the soil texture. Knowledge of this attribute helps to characterize the structural condition, water retention and transmission, erodability and workability of the soil. In addition it was also used in estimation of the ion adsorption behavior of the soil (Anderson and Ingerman, 1993).

The most common and the cheapest method of mechanical analysis is hydrometer method. The whole process involves dispersing the soil mechanically and chemically and then allowing it to settle. The method employs principles of Stock's law for determination of particle size. It states that in homogenized soil the velocity of the particle to the bottom of container is directly proportional to particle size and the characteristics of the suspending medium (Juo, 1978; Chopra and Kanwar, 1982).

Fifty-one grams of 2 mm-sieved dried samples was added to 50 ml of 5 % sodium hexametaphosphate along with 100 ml distilled water. The suspension was stirred by mixing with glass rod and then allowed to stand for 30 minutes. The soil suspension was stirred using a multi-mix machine for 15 minutes, and then transferred into a one-liter glass cylinder. The suspension was diluted with distilled water up to a one-liter mark. Covering the mouth of cylinder, by hand and inverting several times mixed the soil suspension. Hydrometer and temperature readings were taken at the 40 seconds and after 3 hours.

The different soil fractions were calculated as follows:

1. % Sand =  $100[H1 - 0.2(T1 - 68)]^2$
2. % Clay =  $H2 - [0.2(T2 - 68)]^2$
3. % Salt =  $100 - (\% \text{ sand} + \% \text{ clay})$

Where H1 is the first hydrometer reading after 40 seconds

T1 is the temperature reading after 40 seconds

H2 is the hydrometer reading after 3 hours and

T2 is the temperature reading after 3 hours

### 3. 2. 4. Farmer perception on the impact of *P. hysterophorus*

Farmer perception on the impacts of *P. hysterophorus* were assessed based on the knowledge of the local farmers. A total of 114 sample farmers were stratified into three categories to investigate the economic impacts of *P. hysterophorus* under varying conditions. This was because of the variability of terrestrial ecosystems in their extent of invasion and impacts brought up by *P. hysterophorus*. The first strata consisted of farmers from high *P. hysterophorus* infested area, the second from medium infested area and the third from non-infested area. Thirty-eight farmers were selected randomly from each stratum from the list of the farmers in the population. Both men and women were interviewed from each stratum and women accounted for 15% of the total sample size. This approach allowed comparison of results from infested area with areas not yet infested, thereby serving as a control.

Enumerators were trained on how to approach and collect the required information from the respondents using a structured questionnaire. During data collection, enumerators have to approach the respondents according to local norms and customs. Moreover, enumerators have to explain to respondents about the purpose of the study and how the study helps respondents in overcoming their own problems. Enumerators were also expected to explain the questions in local languages of the respondents. At the end of the interview, the enumerators were trained to thank the respondents according to tradition of the society. In addition to collecting data, the researcher supervised enumerators during the day-to-day data collection. Informal discussions were also held with community leaders.

#### **3. 2. 4. 1. Evaluating control baseline condition**

To evaluate the baseline condition for controlling the impact of *P. hysterophorus* in the study area, activities by different stakeholders including local communities, local authorities, national government, private sectors, NGOs, and other donors were assessed.

#### **Data collection**

Individuals, community leaders, governmental and non-governmental organizations are sources of information to evaluate control measures of *P. hysterophorus* held in the study area.

Questionnaires were prepared to collect the required information on the activities of stakeholders (government and non government organizations) and the integration among them.

## **Data analysis**

1. Ordination analyses were carried out using the Canonical Community Ordination (CANOCO) package (Ter Braak and Smilauer, 1998). An initial Detrended Correspondence Analysis (DCA) was performed on species data to determine the length of the first DCA axis. Its length 3.06 standard deviations suggested linear species responses along the environmental gradients (Ter Braak and Smilauer, 1998) and we therefore decided to use Redundancy Analysis (RDA). Ground cover, trapping and grazing level were related to the first two axes of direct RDA ordination.

2. The effect of *P. hysterophorus* on plant height, abundances and abundance of soil nematodes and soil analysis were analyzed using a one-way ANOVA and the means were compared with Minitab version 1995.

3. The questionnaires were coded and the data entered to computer for analysis. Statistical software (SPSS) was used to summarize the information and analyze the data. That is descriptive statistics such as means and frequencies were used to summarize the information when appropriate.

## **4. RESULTS**

### **4. 1. Species composition**

A total of 22 herbaceous plant species were recorded from the study area (Table 1). The results and subsequent discussions in this study are restricted to these 22 herbaceous plant species.

*P. hysterophorus* is the dominant species with 6259 individual plant species (18.34%), among the 22 plant species (Figure 3 and 4) followed by *Melanocentris aethiopicus* (1037 plants, 16.56%), *Cynodon aethiopicus* (854 plants, 13.64%), *Xanthium strumarium* (475 plants, 7.59%), *Argemone mexicana* (321 plants, 5.13%), *Commelina benghalensis* (264 plants, 4.22%), *Oxygonum sinuatum* (254 plants, 4.06%) *Digitaria velutina* (238 plants, 3.8%), *Helophytum cineroscens* (225 plants, 3.59%). Most of the sample species had a restricted distribution with less than 5% relative abundance. The three plant species that have a widespread distribution with more than 10% presence were *P. hysterophorus*, *Melanocentris aethiopicus* and *Cynodon aethiopicus*. Abundances and frequencies of the sample species are indicated in Table 1. Among these species, only *P. hysterophorus* had the highest value that is 18.64% of relative abundance followed by 16.67% of *Melanocentris aethiopicus*.

**Table 1 List of species in abundance rank order in the study area.** The column head 'RO'= rank order of the average abundance per plot of the species (N) in a descending; i.e., rank order and one is the first and most abundant species. N= average abundance; %N= relative abundance of the species; F=absolute frequency.

RO	Species	Family	Abundance	N	%N	F
1	<i>Parthenium hysterophorus</i>	Compositae	1148	11.48	18.34	100
2	<i>Melanocenchris aethiopicus</i>	Gramineae	1037	10.37	16.56	94
3	<i>Cynodon aethiopicus</i>	Gramineae	854	8.54	13.64	94
4	<i>Xanthium strumarium</i>	Rubiaceae	475	4.75	7.59	17
5	<i>Argemone mexicana.</i>	Papaveracea	321	3.21	5.13	38
6	<i>Commelina benghalensis</i>	Commelinaceae	264	2.64	4.22	45
7	<i>Oxygonum sinuatum</i>	Polygonaceae	254	2.54	4.06	50
8	<i>Digitaria velutina</i>	Gramineae	238	2.38	3.8	73
9	<i>Helophytum cineroscens</i>	Tillaea	225	2.25	3.59	38
10	<i>Withania somnifera</i>	Solanaceae	221	2.21	3.53	47
11	<i>Datura stramonium</i>	Solanaceae	193	1.93	3.08	38
12	<i>Portulaca quadrifida</i>	Portulacacea	161	1.61	2.57	37
13	<i>Euphorbia hirta</i>	Euphorbiaceae	159	1.59	2.54	55
14	<i>Launaea intybacca</i>	Compositae	116	1.16	1.85	8
15	<i>Euphorbia indice</i>	Euphorbiaceae	116	1.16	1.85	63
16	<i>Eragrostis cilianensis</i>	Gramineae	114	1.14	1.82	49
17	<i>Amaranthus graecizans</i>	Amaranthaceae	85	0.85	1.35	39
18	<i>Enteropogon macrostachyus</i>	Gramineae	84	0.84	1.34	27
19	<i>Bidens pilosa</i>	Compositae	77	0.77	1.23	30
20	<i>Cucumis dipsaceus</i>	Cucurbitaceae	65	0.65	1.04	45
21	<i>Cleome gynandra</i>	Capparidaceae	31	0.31	0.49	22
22	<i>Boerhavia coccinea</i>	Nyctaginaceae	21	0.21	0.34	61



**Figure 3** *Parthenium hysterophorus* at maturity stage



**Figure 4** *Parthenium hysterophorus* at early stage

#### **4. 2. Ordination**

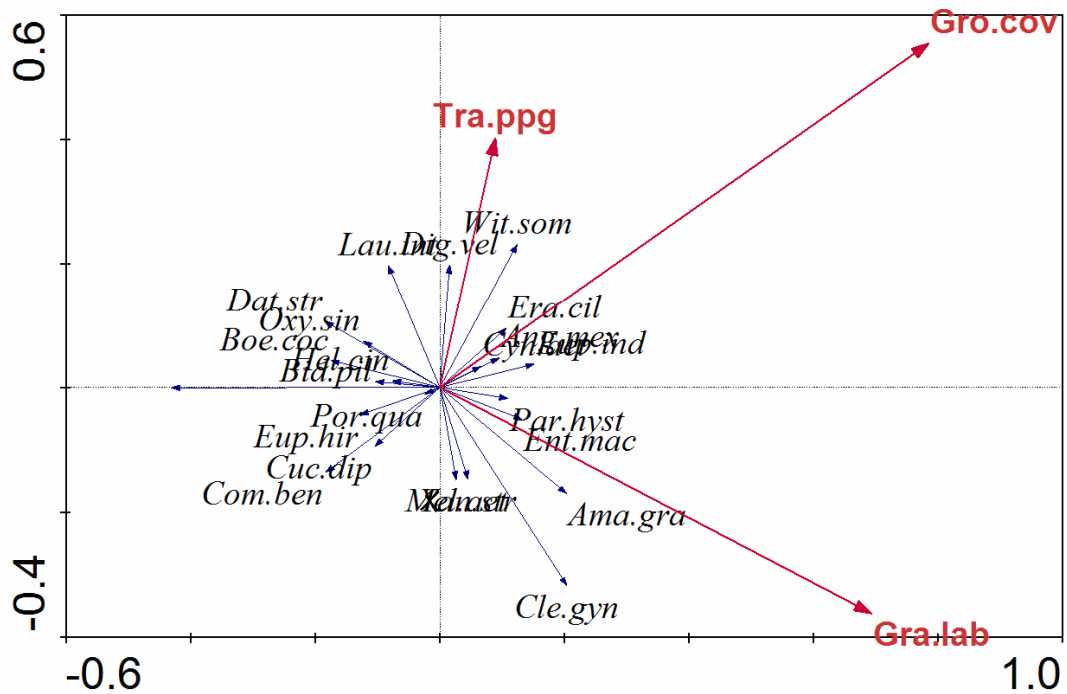
The results of the RDA ordination are presented in Table 2 and Figure 4 that show biplot of 22 species of herbaceous plants and environmental variables from 100 plots of grazing lands. A vector, the longest showing the highest variation within the dataset, represents each variable. The correlation between variables is revealed by the angle between the vectors, when the angle is sharp, correlation is positive and vice versa. A Redundancy Analysis (RDA) biplot of species and environmental variables based on the first (RDA1) and second (RDA2) redundancy analysis account for 10.9% of the variance in the species data, 91.5% of the variance in the fitted species

data, and the same percentage (91.5%) of the variance in the correlations and the class means of species with respect to the environmental variables. The first four Principal Component Analysis (PCA) axes explain 59.8% of the variation in species data, with the first two axes accounting for 11.5% of the variation (Table 2).

**Table 2 Percentage variance explained by the first four PCA axes**

Axis	1	2	3	4	Total variance
Eigenvalues	0.109	0.006	0.005	0.478	1.000
Species environmental correlations	0.439	0.422	0.393	0.000	
Cumulative % variance of species data	10.9	11.5	12.0	59.8	
Cumulative % variance of species-environmental data	91.5	96.1	100.0	0.0	
Total eigenvalues	1.000				
Total canonical eigenvalues	0.120				

The distribution pattern of most species in the species-environment biplot was densely concentrated around the center of the ordination space where the two axes cross each other (Figure 5). The result of analysis indicates *P. hysterothorus* is negatively correlated to most of the species, because the angle between *P. hysterothorus* and other species is greater than 90° (Figure 5 and 6). Figure 7 also indicates the scatter plots of species that is the distance between *P. hysterothorus* and other species were far apart.



**Figure 5 RDA biplot of species and environmental factors**

**Key:-**

*Parthenium hysterophorus* (Par.hys)  
*Melanocenthris aethiopicus* (Mel.aet)  
*Cynodon aethiopicus* (Cyn.aet)  
*Xanthium strumarium* (Yan.str)  
*Argemone mexicana* (Arg.mex)  
*Commelina benghalensis*(Com.ben)  
*Oxygonum sinuatum* (Oxy.sin)  
*Digitaria velutina* (Dig. Vel)  
*Helophytum cineroscens*(Hel.cin)  
*Withania somnifera*(Wit.som)  
*Datura stramonium*(Dat.str)  
*Portulaca quadrifida*(Por.qua)  
*Euphorbia hirta*(Eup.hir)

*Launaea intybacca* (Lau.int)  
*Euphorbia indice* (Eup.ind)  
*Eragrostis cilianensis*(Era.cil)  
*Amaranthus graecizans*(Ama.gra)  
*Enteropogon macrostachyus*(Ent.mac)  
*Bidens pilosa*(Bid.pil)  
*Cucumis dipsaceus*(Cuc.dip)  
*Cleome gynandra*(Cle.gyn)  
*Boerhavia coccinea*(Boe.coc)

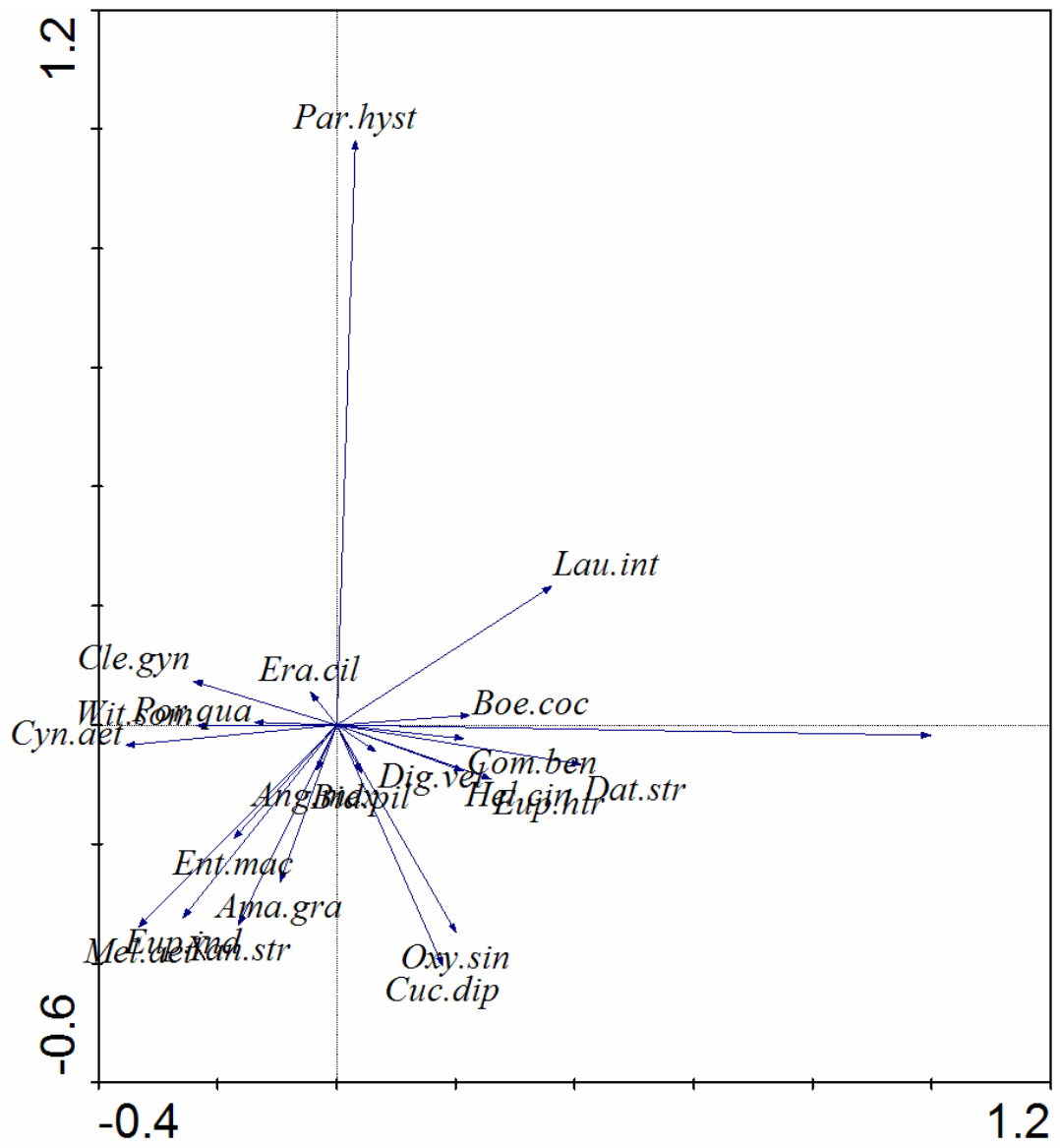


Figure 6 PCA Ordination plots of species

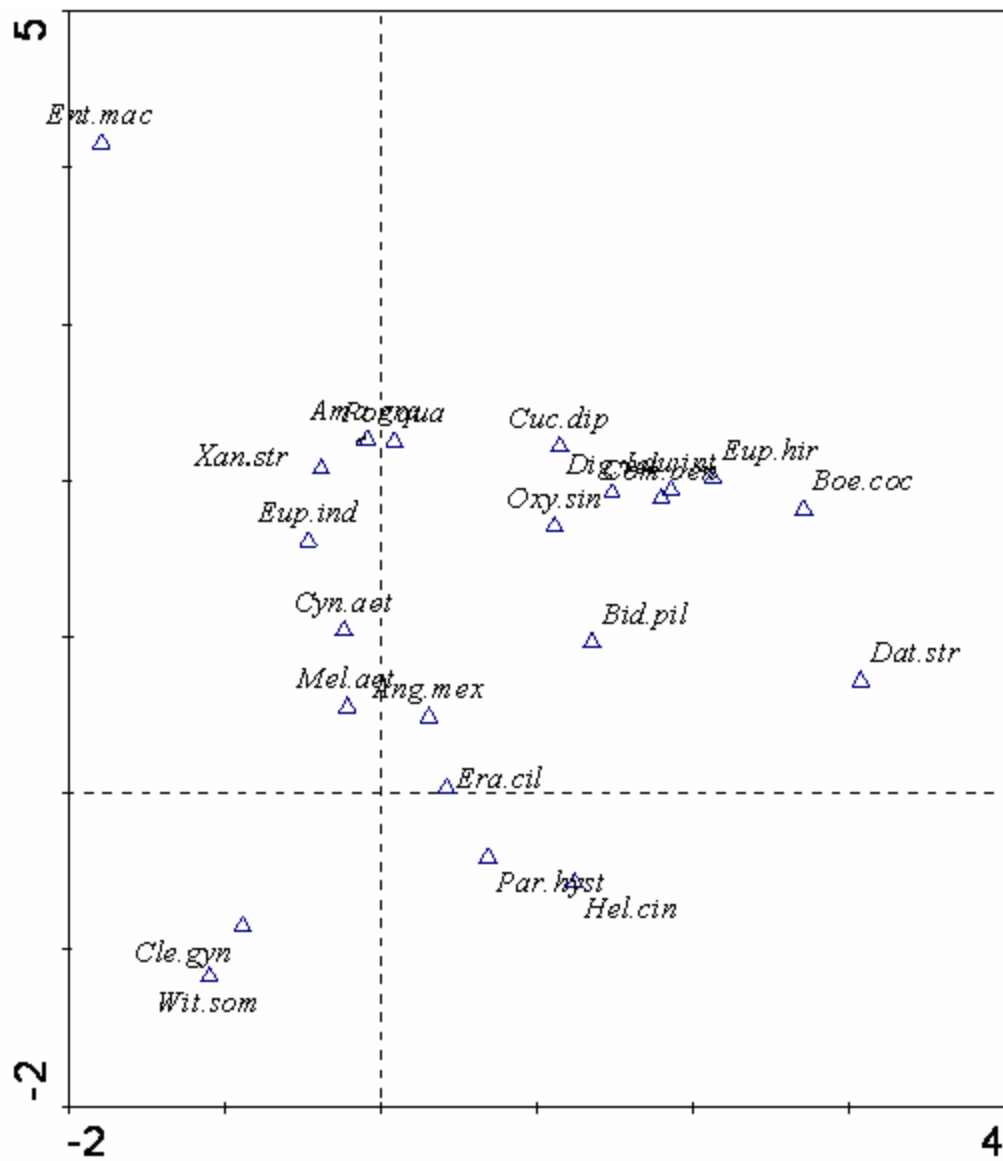
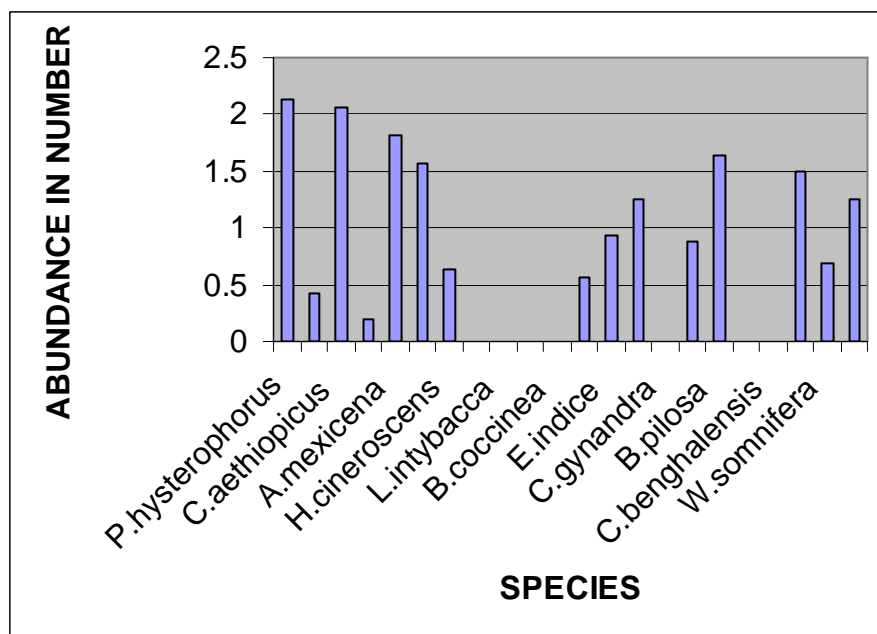


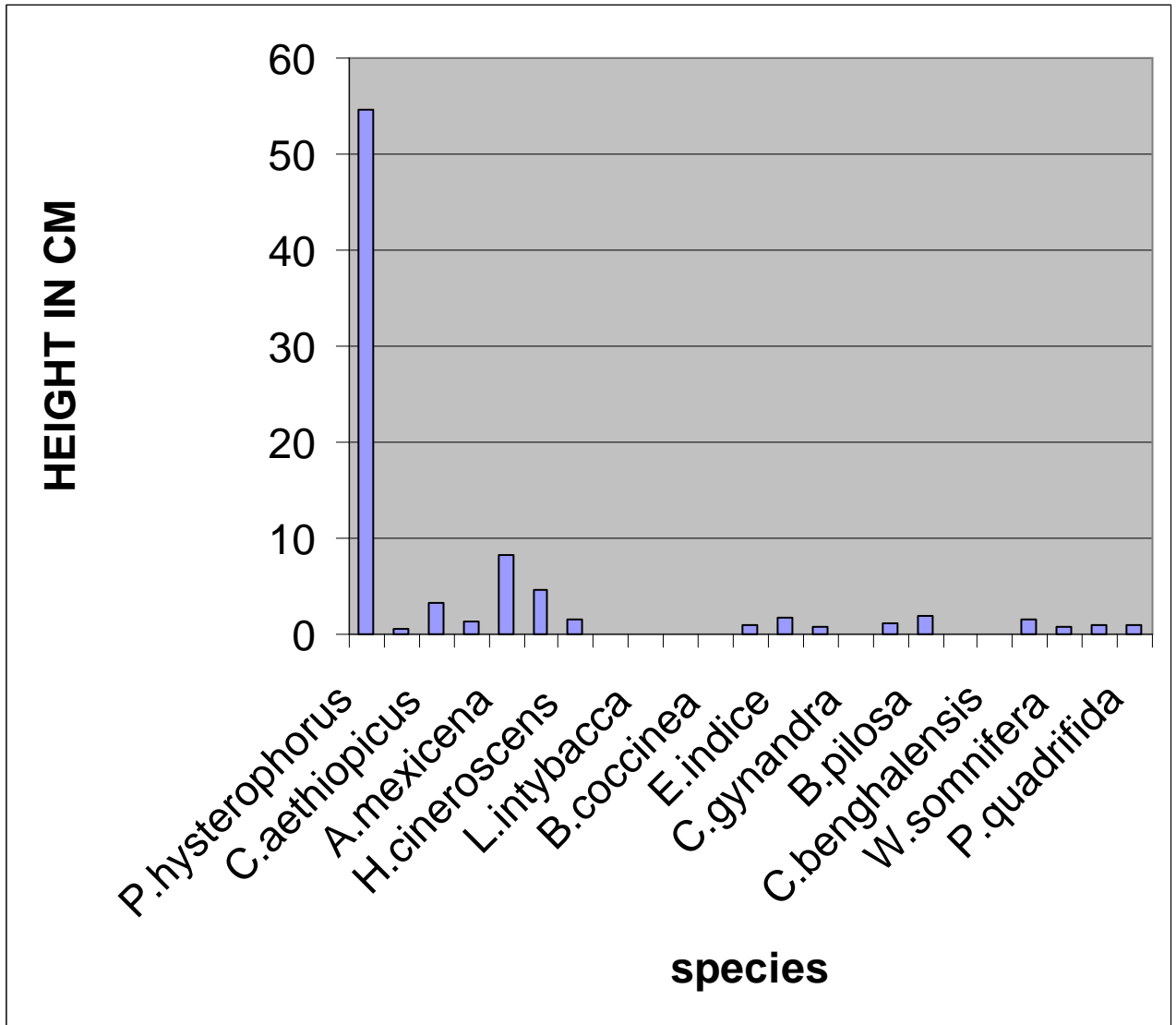
Figure 7 Detrended Correspondence Analysis (DCA) scatter plots of species

#### 4. 3. Patch test

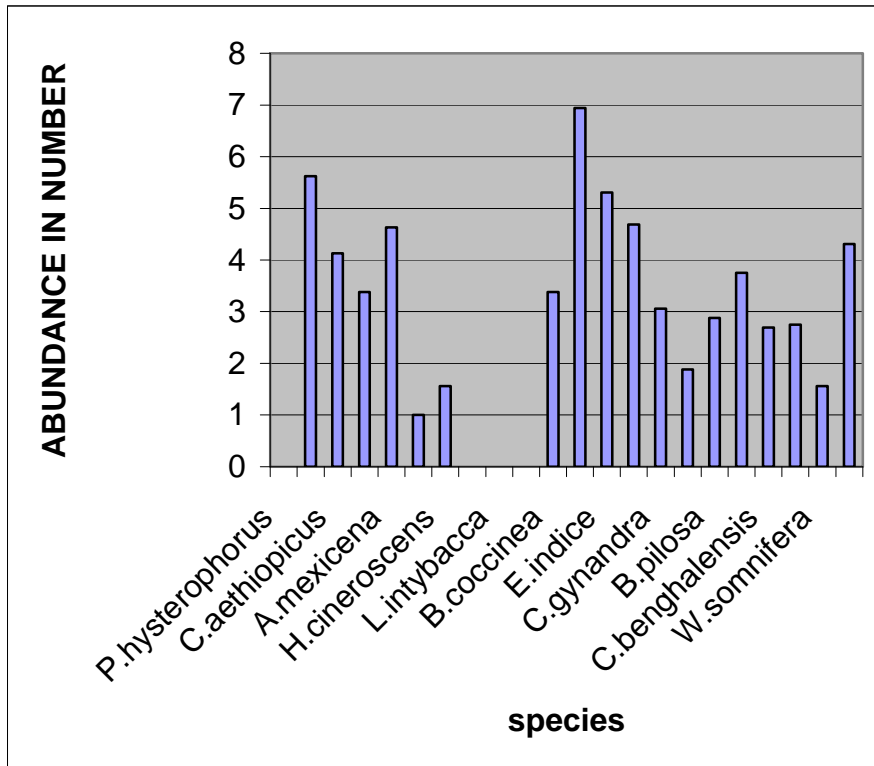
*P. hysterophorus* was the most dominant species in *P. hysterophorus* infested area when compared to other species in non *P. hysterophorus* infested area (Figure 8) and the difference of the abundance of species between high and non infested area of *P. hysterophorus* is statistically significant at  $P= 0.01$ . In Figure 9 the species with the highest height as *P. hysterophorus*. On the other hand in non-infested area most of the species were in good height and number (Figure 10 and Figure 11). On the contrary the difference between the height of the sample species in high and non infested area of *P. hysterophorus* is statistically insignificant at  $P= 0.05$ .



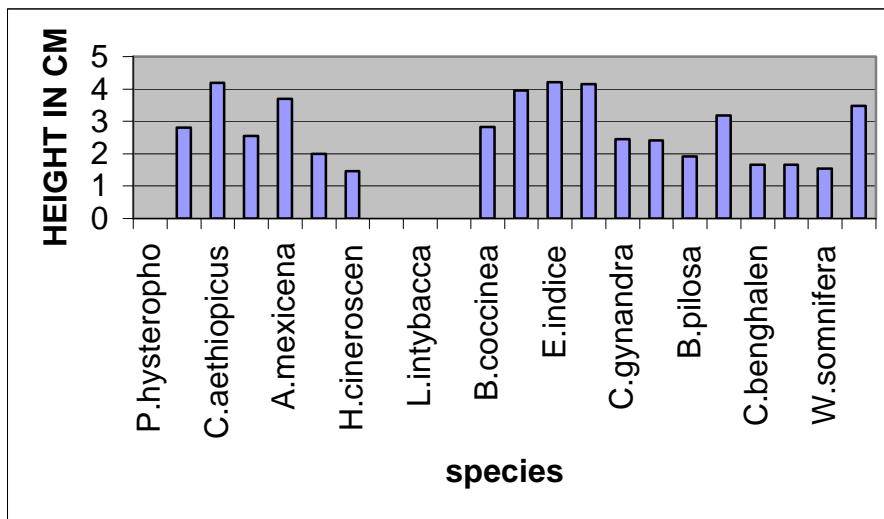
**Figure 8** Abundance of the sample species in highly *P. hysterophorus* infested area



**Figure 9** Height of the sample species in highly *P. hysterothorus* infested area



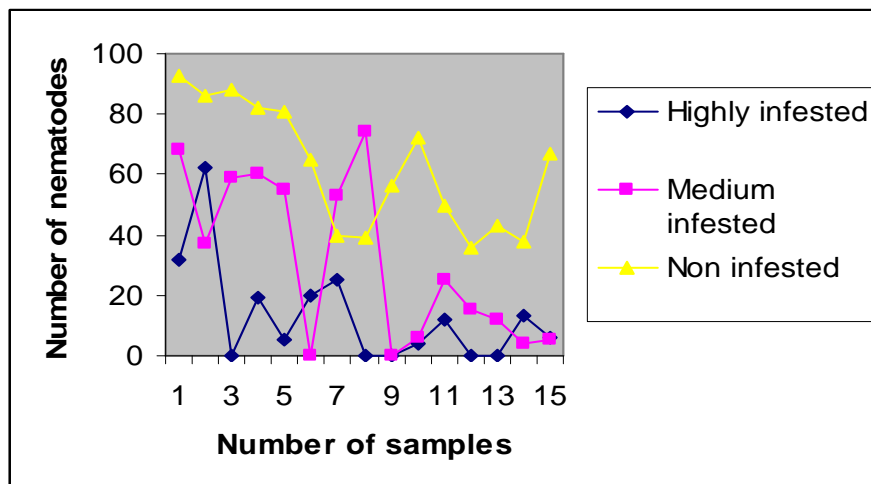
**Figure 10** Abundance of the sample species in non-infested area



**Figure 11** Height of the sample species in non-infested area

#### 4. 4. Soil nematode analysis

Among the 15 samples taken from the soil in highly infested field with *P. hysterophorus*, 5 samples showed the presence of negative reaction to nematodes and also from the same sample taken in medium infested area with *P. hysterophorus* only two were found to have no nematodes but in the field with no *P. hysterophorus*, all the samples were found with the association of nematodes (Figure 12). The numbers of nematodes are 198, 473 and 936 in highly, less and non-infested fields with *P. hysterophorus*, respectively.



**Figure 12 Number of nematodes in the stock solution**

Key:-

HI=Number of nematodes in the stock solution (in 20g soil) in highly infested field with *P. hysterophorus*, MI= Number of nematodes in the stock solution (in 20g soil) in medium infested field with *P. hysterophorus*, NI= Number of nematodes in the stock solution (in 20g soil) in non-infested field with *P. hysterophorus*.

#### 4. 5. Soil texture analysis

The percentage of sand, clay and silt in three categories (high, medium and non) infested area of *P. hysterophorus* is statistically significant at P=0.01, P=0.01 and at P= 0.05, respectively (Table

3). pH and moisture content of the sample soil in the three categories is statistically significant at  $P=0.05$  and insignificant at  $P= 0.05$ , respectively.

**Table 3 Results of soil texture analysis in the study area**

Soil texture	Non infested areas	Medium infested areas	High infested areas
% Sand	64.3	75.6	97.9
% Silt	21.3	16	19.1
% Clay	13.4	92	13.2
pH	8.9	8.5	8.5
% Moisture content	14.4	10.3	10.4

#### 4. 6. Farmer perception on the impact of *P. hysterophorus*

Both men and women were interviewed from each stratum, and women accounted for 39.5% of the total sample size (Table 4).

**Table 4 Sample size in the *Parthenium hysterophorus* study areas of North Wollo Zone, Kobo, 2005**

Infestation Category	Respondents

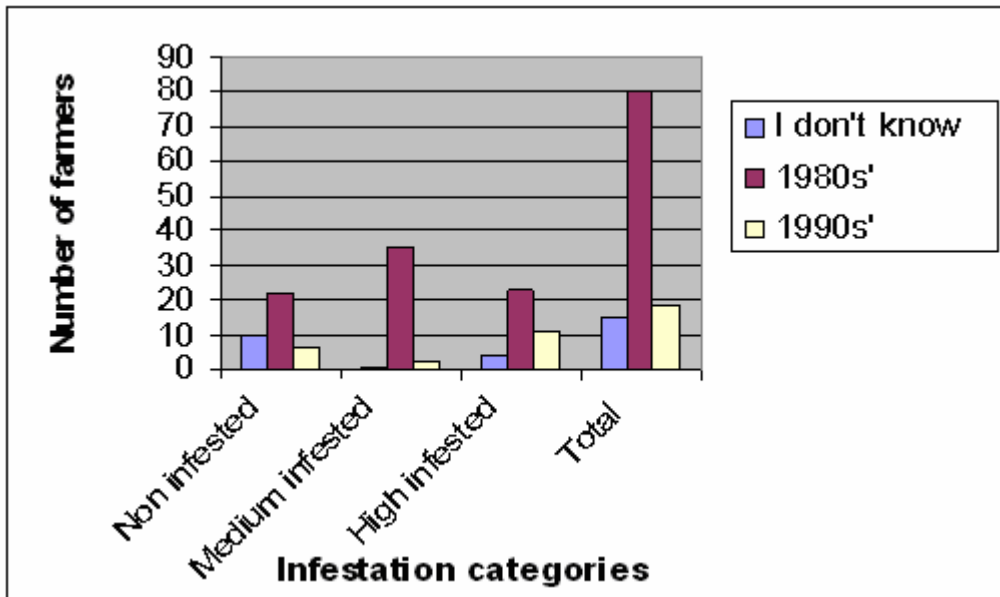
	Men		Women		Total	
	Number of farmers (N)	%	N	%	N	%
Non infestation	23	60.5	15	39.5	38	100
Medium infestation	23	60.5	15	39.5	38	100
High infestation	23	60.5	15	39.5	38	100
Total	69	60.5	45	39.5	114	100

In the surveyed areas, the average age of the overall sample farmers were 39 years ranging from 17 to 72 (Appendix 3). Age is one of the important factors that affects the dissemination and adoption of new technologies.

It was noted that 55.26% of the overall sample farmers were able to read and write, while 44.74% of the overall sample farmers were unable to read and write (Appendix 4). On the other hand the average family size of the overall sample farmers was 5 ranging from 1-9 (Appendix 5).

Respondent in all categories were aware of *P. hysterothorus*. A large proportion of the farmers in all categories became aware of *P. hysterothorus* in the 1980's (Figure 13). In this year 78.95% of the sample farmers became aware of *P. hysterothorus* in the high infestation category while 68.42% and 57.89% of the sample farmers became aware of *P. hysterothorus* in the medium and low infestation categories, respectively.

Farmers around Kobo said that *P. hysterothorus* was introduced into their locality by different ways. A large proportion of the farmers perceived that *P. hysterothorus* was introduced into their locality by livestock dung (40.35%). Farmers in non infestation areas also perceived that *P. hysterothorus* was introduced by livestock dung (36.84%). Like wise more than 30% of the farmers in non infestation category perceived that *P. hysterothorus* was introduced into neighboring localities by livestock dung (Table 6).



**Figure 13 Awareness of the farmers about *P. hysterophorus* over time in the study areas of North Wello Zone, Kobo, 2005**

From the response of the farmers 43.86% of them noted that *P. hysterophorus* was introduced into the locality from the north parts of the country (Table 5) while 17.54% perceived that *P. hysterophorus* was introduced from foreign countries with grain aid. However, 38.6% of the overall sample farmers didn't know where *P. hysterophorus* came from.

**Table 5 Farmer perception on sources of introduction of *Parthenium ysterophorus* into study areas of North Wello Zone, Kobo, 2005**

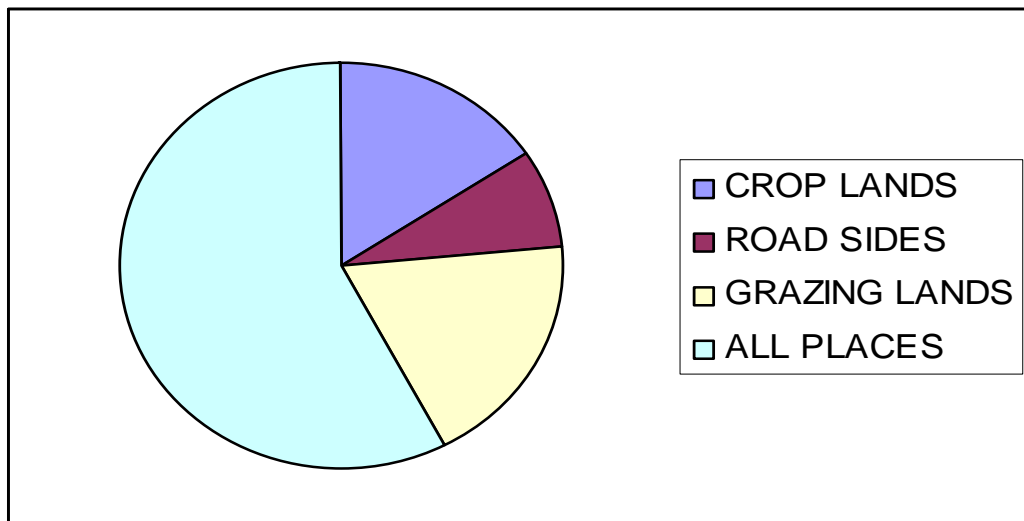
Source of introduction	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38		Overall sample N=114	
	N	%	N	%	N	%	N	%
I don't know	15	39.47	23	60.53	6	15.79	44	38.59
North parts of the country	13	34.21	13	34.21	24	63.16	50	43.86
Foreign country	10	26.31	2	5.26	8	21.05	20	17.54

**Table 6 Means of introduction of *Parthenium hysterophorus* into study areas of North Wello Zone, Kobo 2005**

Means of introduction	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38		Overall sample N=114	
	N	%	N	%	N	%	N	%
I don't know	7	18.42	16	42.11	8	21.05	31	27.19
Following vehicle road	1	2.63	0	0	0	0	1	0.88
By wind	2	5.26	1	2.63	1	2.63	4	3.51
With grain aid	10	26.34	4	10.53	10	26.34	24	21.05
By water	2	5.26	0	0	1	2.63	3	2.63
By livestock dung	14	36.84	17	44.73	15	39.47	46	40.35
By natural means	2	5.25	0	0	0	0	2	1.75
Birds	0	0	0	0	3	7.53	3	2.63
Total	38	100	38	100	38	100	114	100

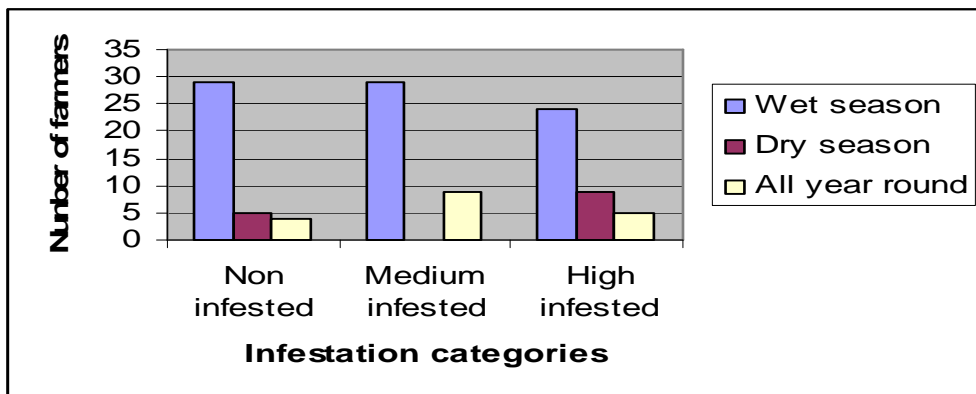
More than 36% of the farmers in high infestation category recognized that *P. hysterophorus* is disseminated at the fastest rate in grazing lands and more than 30% of the farmers in medium infestation perceived the same condition. On the other hand, more than 50% of farmers in non infestation areas observe that *P. hysterophorus* has a capacity to disseminate in all places (Figure

14). From this study the majority of farmers also perceived flooding as the main agent that contributes for its dissemination at alarming rate (Figure 16).



**Figure 14 Farmer perceptions on places where *P. hysterophorus* is densely populated in the *Parthenium* study areas of North Wello Zone, Kobo, 2005**

More than 60% of the farmers in high infestation areas observed that *P. hysterophorus* is growing best during wet season (Figure 15). Moreover, the entire sample farmers in all categories perceived *P. hysterophorus* could grow and disseminate at any season.



**Figure 15 Farmer perceptions on peak season for *Parthenium hysterophorus* growth in study areas of North Wello Zone, Kobo, 2005**

#### 4. 6. 1 Farmer perception on the effects of *Parthenium hysterophorus* on biodiversity

Based on the survey, more than 90% of the sample farmers in all categories observed that *P. hysterophorus* poses threat for the loss of biodiversity. The endangered plant species include grasses, forage plants, and various other species that are economically important for various purposes. The most important are: *Cleome gynandra*, *Amaranthus graecizans*, *Cucumis dipsaceus*, *Bidens pilosa*, *Launaea intybacca*, *Eragrostis cilianensis* and *Euphorbia indice*.

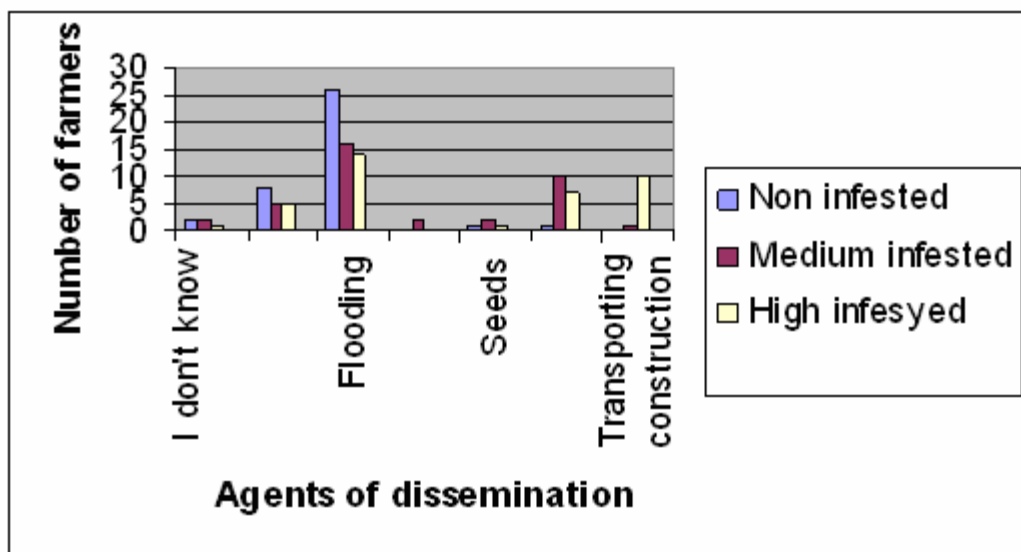


Figure 16 Farmer perceptions on agents facilitating dissemination of *Parthenium hysterophorus* in study areas of North Wello Zone, Kobo, 2005

## 4. 6. 2. The effects of *Parthenium hysterophorus* on crop production

All respondent farmers at all levels have noticed that *P. hysterophorus* imposes considerable impact on crop production (Table 7). Regarding this more than 65% farmer noticed that *P. hysterophorus* has an effect on crop production by suppressing growth (Figure 17).



**Figure 17 *Parthenium hysterophorus* infestations in Sorghum cropland**

**Table 7 Effects of *P. hysterophorus* on crop production as perceived by farmers in study areas of North Wello Zone, Kobo, 2005**

Effect on crop Production	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
There is effect on crop	38	100	38	100	38	100

Production						
There is no effect on crop Production	0	0	0	0	0	0
I don't know	0	0	0	0	0	0
Total	38	100	38	100	38	100

More than 89% and 26% farmers perceived the effect of *P. hysterophorus* on crop production in non and medium infestation, respectively. One farmer also noticed that crops consumed from *P. hysterophorus* infested area tasted sour (Table 8).

**Table 8 Types of effects of *P. hysterophorus* on crop production under different categories of infestation in study areas of North Wello Zone, Kobo, 2005**

Types of Effect of <i>Parthenium</i> on crop production	Non infested areas N=38		Medium Infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
I don't know	1	2.63	1	2.63	0	0
Yield loss	2	5.26	16	42.11	8	21.05
Effect on taste of food	0	0	0	0	1	2.63
Suppress crop growth	34	89.47	10	26.32	25	65.78
Poor gain filling	0	0	0	0	3	7.89
Loss of soil fertility	1	2.63	2	5.26	1	2.63
Loss of soil moisture	0	0	9	23.68	0	0
Total	38	100	38	100	38	100

#### 4. 6 .3. The effects of *Parthenium hysterophorus* on livestock production

All the sample farmers in all categories perceived that *P. hysterophorus* has a potential danger on the production and productivity of livestock (Table 9). *P. hysterophorus* has

also an effect on the production of forage by encroaching grazing lands and suppressing grass species (Figure 18).



**Figure 18** *Parthenium hysterophorus* infestations in grazing lands

The impact of *P. hysterophorus* on livestock production can be explained in different ways. More than 70% of the farmers in all categories observed that *P. hysterophorus* reduces the quality and quantity of milk production (Table 10).

**Table 9 Types of effects of *P. hysterophorus* on livestock production as perceived by farmers in the study areas of North Wello Zone, Kobo, 2005**

Types of Effect of Parthenium on livestock Production	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
Effect on quality and quantity of milk	28	73.68	33	86.85	29	76.31
Encroaching grazing lands and suppressing grass species	0	0	0	0	3	8
Effect on livestock health	5	13.16	0	0	2	5.26
Effect on quality and quantity of meat	4	10.53	3	7.89	2	5.26
Effect on quality of honey	1	2.63	2	5.26	2	5.26

In addition to these, farmers also noticed that *P. hysterophorus* has an effect on quality and quantity of meat and honey.

**Table 10 Effect of *P. hysterophorus* on livestock production as perceived by farmers in the study areas of North Wello Zone, Kobo, 2005**

Effect of Parthenium on livestock Production	Non infested areas N=38		Medium infested areas N=38		High infested Areas n=38	
	N	%	N	%	N	%
I don't know	0	0	0	0	0	0
There is negative effect on livestock production	38	100	38	100	38	100
There is no effect on livestock production	0	0	0	0	0	0
Total	100	100	100	100	100	100

#### **4. 6. 4. The effect of *Parthenium hysterophorus* on human health**

All respondents in all categories noticed the impact of *P. hysterophorus* on human health like asthma, blindness. More over 78% of farmers in non infested areas, 21% of farmers in medium infested areas, and 42% of farmers in high infested areas noticed that death may happen on humans while burning the weed. On the other hand, some farmers also said that *P. hysterophorus* has impact on human health by causing skin irritation, diarrhea, cough, tuberculosis, and aggravates malaria problem by serving as harboring place for mosquitoes.

#### **4. 6 .5. The effect of *Parthenium hysterophorus* on soil fertility**

More than 94% of the farmers in high infestation areas noted the effect of *P. hysterophorus* on soil fertility. Moreover more than 84% and 92% of the farmers in none and medium infestation areas perceived the effect of *P. hysterophorus* on soil fertility, respectively. For example more than 58%, 63% and 68% in none, medium and high infestation areas, respectively, noticed the impact of *P. hysterophorus* on soil by draining the soil moisture. Moreover, most farmers perceived the effects of *P. hysterophorus* on soil fertility such as high nutrient uptake and suppressing grasses from grazing lands by competing for nutrients.

#### **4. 6. 6. Awareness about control mechanisms of *Parthenium hysterophorus***

Governmental organizations have made considerable efforts to create awareness about control mechanisms of *P. hysterophorus*. More than 57% of farmers in high and medium infestation and more than 42% in non infestation areas have received trainings on awareness raising control mechanisms of *P. hysterophorus* in the locality (Table 11). The training mainly focused on the different effects of *P. hysterophorus* on crop and livestock productivity and on its control mechanisms. On the effectiveness of control techniques farmers have different perceptions. About 65% in high infestation, 39% in medium infestation and more than 50% in non infestation noticed that hand weeding is highly effective. On the other hand more than 39% in medium infestation area and more than 36% in non infestation area perceived hand weeding is less

effective (Table 12). This is because of the regeneration capacity of *P. hysterophorus* after weeding. The other technique to control *P. hysterophorus* was using herbicides.

**Table 11. Types of control techniques offered during a training for the control of *Parthenium hysterophorus* in study areas of North Wello Zone, Kobo, 2005**

Types of training	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
I don't know	10	26.32	3	7.89	-	-
Hand weeding	16	42.1	22	57.89	22	57.89
Using herbicides	7	2.64	6	15.8	6	15.79
Oxen plowing	5	13.16	7	18.42	10	26.32
Total	38	100	38	100	38	100

**Table 12 Effectiveness of hand weeding mechanism to control *Parthenium hysterophorus* in study areas of North Wello Zone, Kobo, 2005**

Effectiveness of hand weeding	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
Highly effective	19	50	15	39.47	25	65.79
Medium	4	10.53	8	21.05	8	21.05
Low effective	15	39.47	15	39.47	5	13.16
Total	38	100	38	100	38	100

Only 13% of the farmers in high infestation area and about only 15% in medium infestation area noticed the use of herbicide is highly effective to control *P. hysterophorus*. More than 55% of the sample farmers in high infestation area perceived the effectiveness of herbicides is medium. On

the other hand 94%, 73% and 31% of the sample farmers in none, medium and high infestation areas perceived the low effectiveness of using herbicides, respectively (Table 13).

**Table 13 Effectiveness of herbicides control mechanism on *Parthenium hysterophorus* in study areas of North Wello Zone, Kobo, 2005**

Effectiveness of Herbicide control Mechanisms	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
Highly effective	0	0	6	15.79	5	13.16
Medium	2	5.26	3	7.89	21	55.26
Low effective	36	94.75	28	73.68	12	31.58
Total	38	100	38	100	38	100

#### 4. 6. 7. Biological control of *Parthenium hysterophorus*

According to the findings some crops have the capacity to resist the impact of *P. hysterophorus*. More than 68% of the farmers in high infestation area noticed Sorghum has a better capacity to withstand the effects of *P. hysterophorus*. Even more than 97% in the non infestation area noticed the resistance of sorghum to the effect of *P. hysterophorus*. On the other hand more than 31% in high infestation and 52% in medium infestation areas asserted that there are no plants that could withstand the effects of *P. hysterophorus* (Table 14).

**Table 14 Plants that can withstand the effects of *Parthenium hysterophorus* as perceived by the farmers in study areas of North Wello Zone, Kobo, 2005**

Plants that can withstand the Effects of <i>Parthenium</i>	Non infested areas N=38		Medium infested areas N=38		High infested areas N=38	
	N	%	N	%	N	%
I don't know	1	2.63	0	0	0	0
Sorghum	37	97.37	18	47.37	26	68.42
No plants that can withstand the effects of <i>Parthenium</i>	0	0	20	52.63	12	31.58
Total	38	100	38	100	38	100

#### **4. 6. 8. Evaluation of control baseline condition for *Parthenium hysterophorus***

##### **4. 6. 8. 1. Governmental organizations**

###### **Ministry of agriculture and rural development**

Kobo District Office of Agriculture and Rural Development is one of the governmental offices actively involved in *P. hysterophorus*. The office of agriculture in collaboration with the woreda administration and the rural community were involved in controlling *P. hysterophorus* mainly by creating awareness among farmers and urban dwellers and giving training on how to control the weed. Activities undertaken by this office in the past are outlined.

###### **Training**

To control *P. hysterophorus* trainings were given to farmers focusing mainly on the following points.

- biology of *P. hysterophorus*
- ways of its spread
- agents facilitating *P. hysterophorus* dissemination
- importance of using pure seeds
- time of weeding

-use of herbicides

The trainees were given responsibility to do a coordination and supervision work of *P. hysterophorus* control in their respective peasant associations.

### **Organizing community campaigns**

By mobilizing rural community and urban dwellers, mechanical removal of *P. hysterophorus* has been organized in the study area since 2003. Unfortunately due to the persistent nature of the weed and lack of consistency of the activity, hazards of the weed is prominent.

### **Committee formation**

In order to plan and supervise control activities such as crop rotation, mechanical removal and burning of the pulled-out weed, committee have been formed in 30 peasant associations of Kobo district that are infested by *P. hysterophorus*.

### **Awareness creation**

The office of agriculture in collaboration with the community leaders was responsible to create awareness about the danger of the weed. To perform this activity, special meeting is needed, but due to the lack of funding organizations like non-governmental organizations, much has not been done in infested and non-infested areas of the district. Even if towns are highly infested with *P. hysterophorus*, integration of control effects has not been done between office of agriculture and municipality.

### **Ethiopian Agricultural Research Organization**

A nation wide monitoring of invasive weed has been started since 2002 in order to assess exotic weed like *P. hysterophorus*, delineate the borders of infestation and to alert federal and regional bodies. So far, specimens were collected in invaded areas of central parts of the country, Wollo and Tigray and efforts were made to create awareness for different stakeholders. Research has been conducted in Kobo by Sirinka Agricultural research center to identify the best weed

management options for the control of *P. hysterophorus* and to assess the extent of sorghum yield loss due to *P. hysterophorus*

#### **4. 6. 8. 2. Non-governmental organizations**

Non-governmental organizations are running developmental activities around Kobo district, but none of them gave due attention for the prevention and control of *P. hysterophorus*.

## **5. DISCUSSION**

### **5.1. Species composition**

According to the analysis *P. hysterophorus* is the dominant species in grazing lands, croplands, forestlands and roadsides of the study area. It accounts for the largest proportion among the 22 species of samples. This may be due to the allelopathic nature of the weed. Other workers like, Krishnamurthy *et al.*, (1997), Evans (1997) and Dayama (1986) stated that the allelopathic nature of *P. hysterophorus* has a great impact on plant diversity.

The results of Principal Component Analysis (PCA) ordination plots of species show that *P. hysterophorus* has the longest axis, which indicates that it is negatively correlated with most of the species (Figure 6) and the angle between *P. hysterophorus* and other species is more than 90° which reveals its negative correlation with most of the species. A Detrended Correspondence Analysis (DCA) scatter plot of species also indicates the negative correlation of *P. hysterophorus* with the majority of species (Figure 7), because the distance between the symbols of each species is large. This in turn reveals the dissimilarity of *P. hysterophorus* with most of the species of the samples. Each arrow in Redundancy Analysis (RDA) and Principal Component Analysis (PCA) ordination plots points in the direction of possible increment value of species and environmental factors and it is a measure of fit for each species and environmental factors. On the other hand, the length of the species and environmental factor arrows is the multiple correlation of that species with the ordination axes.

## **5. 2. Patch test**

According to the patch test, *P. hysterophorus* is the dominant species compared to other species in infested areas. On the contrary, plant species have better height and dominance in non-infested areas of *P. hysterophorus* (Figure 9 and 10). This may be due to the inhibitory nature of the weed. Evans (1997) and Dayama (1986) reported the inhibitory effect of allelochemicals of *P. hysterophorus* on both the germination and growth of a wide variety of crops including pasture grasses, cereals, vegetables other weeds and tree species. On the other hand, Kanchan and Jayachandra (1979) reported the influence of *P. hysterophorus* on germination of the nearby species by reducing the chlorophyll content of the leaves. Evans (1997a) also reported the direct and indirect impact of *P. hysterophorus* on the production system is multifaceted.

## **5. 3. Nematode analysis**

Analysis in the laboratory also showed that soil samples taken from highly infested areas of *P. hysterothorus* were negative for nematode count, while samples from non infested fields were positive. The difference between average number of nematodes in the three categories was statistically significant at  $P=0.05$ . Individual count of nematodes was greater in non-infested area as compared to the other two. The numbers of nematodes were high in the sample taken during wet season and a combination of both plant parasitic (*Pratylenchus spp*) and saprophytic nematode types were found in soil samples from medium infested and non infested fields with *P. hysterothorus*. The reason for small count of nematodes in highly infested areas may be due to the chemical compounds released by *P. hysterothorus*. Jayachandra (1971) reported the impact of alkaloids in the roots of *P. hysterothorus* on microbial population of the soil.

#### **5. 4. Soil texture analysis**

The findings of soil analysis indicated significant difference between the three categories of the study area in soil texture and pH. On the other hand, significant difference was not observed on the moisture content of the soil between sites; this might be because the samples were collected during wet season. According to the analysis, *P. hysterothorus* was more associated with sandy and alkaline soil. These may be due to the allelopathic nature of the weed. According to Taye Tessema (2002), the high *P. hysterothorus* infestation in Ethiopia is attributed to the disturbance and clearing of large areas and presence of neutral to alkaline soils that favor *P. hysterothorus* growth.

#### **5. 5. Impacts of *Parthenium hysterothorus* as perceived by farmers**

The results of this study showed that more than 50% of the respondent farmers were able to read and write and the majority of these were also elders. Age and education were the most important factors affecting the dissemination and adoption of new technologies. So it is a good opportunity to design appropriate extension service for the study area.

Farmers in all categories were aware of *P. hysterophorus* since 1980's. Taye Tessema (2002) stated that *P. hysterophorus* seeds were imported from subtropical North America as a contaminant of grain food aid during the 1980's famine, and distributed with the grain in Eastern and Northeastern Ethiopia.

With respect to means of introduction farmers perceived *P. hysterophorus* was spread in the study area through livestock dung and with grain aid. This is because of unrestricted movement of animals and equipments from infested to non-infested areas. Moreover quarantine systems have not been developed throughout the country to control the dissemination of pests. Auld *et al.*, (1983) stated that local dispersal of *P. hysterophorus* seeds occur by wind and water, whereas motor vehicles, machinery and livestock movements, crop and pasture seed contribute for long distance dispersal.

In this study, all farmers in all categories noticed that *P. hysterophorus* could germinate at any season and everywhere. *P. hysterophorus* is an aggressive colonizer of disturbed land, able to germinate, grow and flower over a wide range of temperatures and photoperiods. Similarly, Evans (1997a) reported that it occurs in the humid and sub-humid tropics. Besides, they also stated that it is expanding at alarming rate in grazing lands from year to year.

In the study area, all respondents noticed the capacity of *P. hysterophorus* to disseminate easily. This may be attributed to water and wind because of the very fine nature of *P. hysterophorus* seeds. Aneja *et al.*, (1991) reported that *P. hysterophorus* seed could spread via water, vehicles, and machinery. So it can easily disseminate from place to place.

#### **5. 5. 1. The effects of *Parthenium hysterophorus* on biodiversity**

From the interviews conducted during the study, 90% of the respondents noticed the impact of *P. hysterophorus* on loss of biodiversity. In grazing lands, and roadsides, one can easily observe the prominent influence of *P. hysterophorus* on the height and type of plant species (Figure 18 and 20). This may be due to many factors like wider adaptation across climates, photo insensitivity, and drought tolerance (Haseler, 1976). Similarly Krishnamurthy *et al.*, (1997) described the allelopathic nature of *P. hysterophorus* and its impact on plant diversity. Anecdotal evidence also indicates that *P. hysterophorus* has a great impact on plant and animal diversity. McFadyen

(1992) reported that *P. hysterophorus* is causing a total habitat change in grasslands, open woodlands and floodplains.

### **5. 5 2. The effects of *Parthenium hysterophorus* on crop production**

More than 65% of farmers agreed on the effect of *P. hysterophorus* on crop production by suppressing growth, yield loss, poor grain fill and by reducing moisture of the soil. Moreover, *P. hysterophorus* has made change on the taste of food. In India 40% sorghum yield reduction was reported by Channappagoudar *et al.*, (1990) and Khosla and Sobti (1981). They also reported that the presence of *P. hysterophorus* in irrigated sorghum reduced grain yields from 6.47 to 4.25 tons/ha and decreased grain weight by 30%. In eastern Ethiopia 40 to 97% sorghum yield reduction was observed due to the impact of *P. hysterophorus* (Tamado Tena *et al.*, 2002).

### **5. 5. 3. The effects of *Parthenium hysterophorus* on livestock production**

The results of this thesis showed that *P. hysterophorus* has a great impact on livestock production and productivity in different ways, like changing the quality and quantity of milk, meat and honey. On the other hand *P. hysterophorus* has an effect on livestock health and feed by encroaching on lands and suppressing grass species. Similarly Evans (1997a) also reported the direct and indirect impact of *P. hysterophorus* on livestock production by affecting grazing land, animal health, milk and meat quality, and marketing of pasture seeds and grain. In Australia, Chippendale and Panneta (1994) stated that cattle grazing in *P. hysterophorus* invaded pastures were marketed with a lower weight compared to those from weed free areas, accounting for more losses to the producer.

Vartak (1968) indicated that the impact of *P. hysterophorus* on grasslands could reduce forage production. On the other hand *P. hysterophorus* can reduce the carrying capacity of grazing land by up to 90% (Nath, 1988). Nisar Ahmed *et al.*, (1988) reported animals fed on *P. hysterophorus* developed dermatitis with pronounced skin lesions, became highly emaciated, and eventually died due to the rupture of tissues and hemorrhages in their internal organs. The impact of *P. hysterophorus* on animal health was also reported by Kololgi *et al.*, (1997) where it causes respiratory disease like bronchitis.

#### **5. 5. 4. The effects of *Parthenium hysterophorus* on human health**

78%, 21%, and 42% of farmers in non, medium and high infestation, respectively, observed *P. hysterophorus* has an effect on human health like asthma, blindness and death especially during the time of burning. Moreover it can cause skin irritation, diarrhea, cough, tuberculosis, and it aggravates malaria problem serving as harboring place for mosquitoes. Other workers like Anonymous (1976); Sriramarao *et al.*, (1991); Kololgi *et al.*, (1997) and Handa *et al.*, (2001) also reported effects of *P. hysterophorus* on human health like hay fever, asthma, bronchitis and dermatitis.

Evans (1997a) and Towers and Subba (1992) also reported that close contact with *P. hysterophorus* could cause allergic contact dermatitis while inhalation of pollen can cause allergic rhinitis, which can develop into bronchitis or asthma in susceptible humans. In India, reports of committing suicide are available due to the chronic problem of *P. hysterophorus* (Kololgi *et al.*, 1997).

#### **5. 5. 5. The effects of *Parthenium hysterophorus* on soil fertility**

**This study revealed the danger of *P. hysterophorus* on soil fertility by draining the soil moisture, high nutrient uptake and suppressing grasses from grazing lands by competing for nutrients. Similarly Dayama (1986) also reported the danger of *P. hysterophorus* on soil microorganisms. Batish *et al.*, (2002) noted the impact of *P. hysterophorus* in decreasing the amount of available nitrogen, which could be due to less microbial activity in**

**the rhizosphere. The essential oils from *P. hysterophorus* are known to be antimicrobial (Adkins and Sowerby, 1996). There are also reports that indicate phenolics released from *P. hysterophorus* alter the accumulation and availability of nutrients in soil (Facelli and Pickett, 1993).**

#### 5. 5. 6. Awareness about control mechanisms of *Parthenium hysterophorus*

The result of this study showed that governmental organizations tried a lot to raise awareness about the danger of this invasive species in the study area. The majority of farmers received training on how to control *P. hysterophorus*, even though they had different perception on control mechanism. For instance most of them believed that hand weeding is the most effective control method. Also farmers noted the regeneration capacity of *P. hysterophorus* after weeding. According to Bhan *et al.*, (1997) manual and mechanical control methods give temporary results because *P. hysterophorus* covers large areas and they also stated that no single method of *P. hysterophorus* control has been proved satisfactory as each method suffers from one or more limitation such as inefficiency, high cost, impracticability, environmental safety and only temporary relief.

Mowing or slashing of *P. hysterophorus* is not recommended since it results in rapid regeneration of plants from lateral shoots (Gupta and Sharma, 1977). It is suggested that *P. hysterophorus* should be uprooted to prevent regeneration from the remaining lateral shoots and that such operation should be done before flowering and when the soil is moist enough to facilitate easy removal.

### 5. 5. 7. Biological control of *Parthenium hysterophorus*

According to the findings, some plants had the capacity to resist the impact of *P. hysterophorus*. Most farmers noticed that sorghum and maize had better capacity to withstand the effects of *P. hysterophorus*. Regarding this, Kandasmy and Sankaran (1997) reported that intercropping plants like sorghum, maize and sunflower significantly reduced *P. hysterophorus* populations. Farmers have a good experience of choosing clean seeds and practicing intercrops to prevent infestation of weeds. Besufekad Tadesse (2001) stated that use of intercrops can reduce the impacts of *P. hysterophorus*. On the other hand, respondents also noticed that hand weeding was less effective to control *P. hysterophorus* because of the regeneration capacity of the weed. Farmers are not in a position to exercise deep plough farming because of the traditional agricultural systems, which is very important to bury the seeds of *P. hysterophorus*. Farmers don't have a good knowledge of choosing resistance crops variety to minimize the impacts of *P. hysterophorus*. Tamado Tena (2001) reported that use of clean seed, more competitive variety and choice of an appropriate sowing rate and date are used to control the impact of the weed.

### 5. 5. 8. Evaluation of control baseline condition for *Parthenium hysterophorus*

From the evaluation of baseline condition to control *P. hysterophorus*, the crop protection division has the objective of giving training and advice to farmers on techniques of preventing and controlling pests (weeds, diseases and insect pests) that affect crop production. The division also engages in control activities by involving the community when the need arises. Controlling *P. hysterophorus* is one of the prime objectives of the division, because the office of agriculture considers the adverse effect of the weed.

Even though *P. hysterophorus* infestation is a serious problem in the study area, much effort has not been done to minimize its impact because of the following reasons: -

- a. Non-governmental organizations have not participated in activities related to *P. hysterophorus* control.
- b. Budget allocation from the regional government does not coincide with the scope of the infestation.

- c. Farmers are not much concerned about *P. hysterophorus* infestations outside their farmlands (Figure 19).
- d. There is no quarantine system designed to prevent further disseminations of *P. hysterophorus*.
- e. Lack of consistency in *P. hysterophorus* control mechanisms.



**Figure 19** *Parthenium hysterophorus* on the side of tef farm



**Figure 20** *Parthenium hysterophorus* on the roadside

## **6. CONCLUSIONS**

*Parthenium hysterophorus* is an invasive alien weed that can be expected to continue its dissemination because of the negligence of farmers to control it. It is growing in farmlands, roadside, grazing lands and in gardens. It can germinate and produce seeds throughout the year and can cause a serious problem in humans, animals and crop production and biodiversity.

This study tried to reveal the biological and farmers' perception on the impact of *P. hysterophorus* that can be used by governmental organizations and non-governmental organizations for planning control options. Farmers in the study area were aware of *P. hysterophorus* since 1980, though its infestation is increasing from year to year. On the other hand, it was apparent that *P. hysterophorus* is found densely populated in roadsides and grazing lands. There was no much effort done by all responsible bodies including farmers. It is very urgent task of governmental and non-governmental organizations to train farmers on how to prevent further introduction and dissemination of the weed. Hence, these places are potential sources for the dissemination of the weed into croplands.

*P. hysterophorus* was observed to grow at any season of the year at different stages, which is at shattering stage, at flowering and seedling stages. This implies that any intervention intending to control *P. hysterophorus* should take into consideration of the ability of *P. hysterophorus* to grow at every season of the year.

It was observed that the impact of *P. hysterophorus* decrease the abundance of plant species on rangelands and soil invertebrates like soil nematodes. Moreover *P. hysterophorus* affect livestock production, productivity, and health including human beings. However there was no record from health posts on diseases caused by *P. hysterophorus* on livestock and human health. It was concluded that much has not been done to aware the local people on the danger of *P. hysterophorus* causing biological impacts.

## **7. RECOMMENDATIONS**

Consistent effort should be practiced to control *Parthenium hysterophorus* till the complete seed bank is exhausted because of its high and continuous seed production ability throughout the year.

However these practices need the integration of the community and responsible governmental and non-governmental organizations. Further, quarantine measures should be adopted to check the introduction of weed to non-infested area through transportation of consumer goods, by movement of livestock and flooding. Further study is required to identify the health hazards, impact on soil and soil invertebrates of *P. hysterophorus*, and its management strategy should be developed to control at national level. Joint projects should also be established to prevent and control the danger of *P. hysterophorus* at regional level.

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**Appendix 1** Questionnaire for data collection to assess perceptions of farmers

1. Age of the sample farmers in the study areas
2. Educational level of the sample farmers
3. Family size of the sample farmers
4. Educational level of all the household members
5. Awareness about *Parthenium hysterophorus*
6. Means of introduction of *Parthenium hysterophorus* in the study areas
7. Farmers perception on sources of introduction of *Parthenium hysterophorus*
8. Places where *Parthenium hysterophorus* is found densely populated in the study areas
9. Agents facilitating dissemination of *Parthenium hysterophorus* in the study areas
10. Peak seasons of *Parthenium hysterophorus* growth in the study areas
11. Endangered plant species due to the effects of *Parthenium hysterophorus*
12. Effects of *Parthenium hysterophorus* on crop production
13. Types of effects of *Parthenium hysterophorus* on crop production
14. Effects of *Parthenium hysterophorus* on livestock production
15. Types of effects of *Parthenium hysterophorus* on livestock production
16. Effects of *Parthenium hysterophorus* on human health
17. Types of effects of *Parthenium hysterophorus* on human health
18. Effects of *Parthenium hysterophorus* on soil fertility

19. Types of effects of *Parthenium hysterophorus* on soil fertility
20. Types of control techniques of *Parthenium hysterophorus*
21. Effectiveness of hand weeding to control *Parthenium hysterophorus*
22. Effectiveness of herbicide to control *Parthenium hysterophorus*
23. Plants that can withstand the effects of *Parthenium hysterophorus*

**Appendix 2** Terms of reference to evaluate control measures of

*Parthenium hysterophorus*

- List of activities on *Parthenium hysterophorus* management
- Scope of activities
- Resource allocation and sources
- Beneficiaries
- Area coverage
- Community participation
- Integrated between stakeholders
- Problems encountered in prevention, control and awareness creation programs

**Appendix 3** Age of the sample farmers in the *Parthenium hysterophorus* study areas of North Wello Zone, Kobo, 2005

Respondent Category	N	Mean	Minimum	Maximum
Non infestation	38	37.05	17	72
Medium infestation	38	44.89	30	67
High infestation	38	34.39	19	63
Overall sample	114	38.78	17	72

**Appendix 4** Educational levels of the sample household heads in the *Parthenium hysterophorus* study areas of North Wello Zone, Kobo, 2005

Educational level	High infested areas		Medium infested areas		Non infested areas		Overall sample	
	N	%	N	%	N	%	N	%
Not read and write	18	47.37	18	47.37	15	39.47	51	44.74
Grades 1-3	17	44.73	14	36.8	12	31.11	43	37.72
Grades 4-8	3	7.9	5	13.16	5	13.11	13	11.4
Grades 9 and above	0	0	1	2.67	6	15.78	7	6.14
Total	38	100	100	100	38	100	114	100

**Appendix 5** Family sizes of the sample farmers in the *Parthenium hysterophorus* study areas of North Wello Zone, Kobo, 2005.

Infestation Category	N	Average Family size	Minimum Family size	Maximum Family size
Non infestation	38	4.08	1	9
Medium infestation	38	5.53	2	9
High infestation	38	4.21	1	7
Total	114	4.61	1	9