ADDIS ABABA UNIVERSITY

College of Natural and Computational Science
Department of Zoological Science

Analysis of *Prosopis juliflora* (SW.) DC Seeds in Animal Dropping and Its Germination Capacity in Amibara Woreda of Afar Region, Ethiopia

By: Kassahun Hailu Degefa

Advisor: Tamrat Bekele (PhD)

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Analysis of *Prosopis juliflora* (Sw.) DC Seeds in Animal Dropping and Its Germination Capacity in Amibara Woreda of Afar Region, Ethiopia

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Kassahun Hailu Degefa

Addis Ababa University

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GRADUATE PROGRAMMES

This is to cetify that the thesis prepared by Kassahun Haliu Degefa entitiled "Analysis of *Prosopis juliflora* (SW)DC.seeds in Animals Dropping and Its'Germination Capacity in Amibara Woreda of Afar Region" and submitted in Partial fulfilment of the requrements for the Degree of Master Science in Biology complies with the regulations of the university and meets the accepted standards with respect to the original and quality.

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Abstract

Prosopis juliflora is a perennial shrub introduced in the 1970's to the Amibara woreda of Afar National Regional State and now became highly invasive in the study area, due to equipped with a number of biological characteristics. The aim of this study was to identify the possible role of domestic and wild animals for dispersal of P. juliflora seeds in the study area. The samples of animal dropping were collected from animals selected purposely to meet the intended goals of the study. A sample of dropping from domestic animals (cattle, camel, sheep, goats and donkey) and wild animals (warthog) were collected from five villages randomly selected from four kebeles of Amibara Woreda. The study conducted on analysis of P. juliflora seeds in animal dropping and its' germination and seedling emerging capacity, to determine contribution of animals for dispersion of P. juliflora seed after the passage through the intestinal tract. The experimental result reveals that the average number of P. juliflora seedling emerged per 1.25kg sample of donkey, cattle, warthog, goats, camel and sheep dropping were 160, 86, 46, 16, 3, & 2 respectively. Depending on the results, all of the targeted animals consumed seed pod of Prosopis as food and capable to disperse seeds through their dropping from parent tree/shrub to other new area for about 20km. Because of this case, domestic animals of pastoralist play the highest role to foster the rapid invasion of P. juliflora than wind, flood, humans and birds. But the degree of contribution among selected animals as a dispersal agent of P. juliflora seeds per 1.25kg dropping after 50 days, the percentage of P.juliflora seedling emergence are significantly different (P≤ 0.01). Finally from those animals where sample dropping was collected for analysis, the level of animals as a dispersal agent of P. juliflora was forwarded in the order of donkey, cattle, warthog, goat, camel and sheep.

KEYWORDS

P. juliflora, Endozoochory, Droppings, Invasive plant species, Seed dispersal, Seed germination, Seedling emergence, Disseminating agent

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List of Acronyms

ANRS	Afar National Regional State
AAU	Addis Ababa University
EARO	Ethiopian Agricultural Research Organization
HDRA	Henry Doubleday Research Association
FARM-Africa	Food and Agriculture Research Management
IAS	Invasive Alien Species
WARC	Werer Agricultural Research Center
WAS	Werer Agro-metrological station
SER	Seedling emergence rate

1. INTRODUCTION

1.1 Background of the Study

Exotic invasive species have been defined as organisms that colonize areas outside their normal ranges with or without human interference. The introduction of exotic species into new habitats has been a global phenomenon (Huston, 1994). A very good example of such species is *Prosopis juliflora* (Sw.) DC, which belongs to the family Leguminaceae (Fabaceae) and sub-family Mimosoideae, native to South America and widespread throughout the tropics (Catalano et al., 2008). *Prosopis juliflora* was originally introduced as source of fodder, firewood and as a means to control soil erosion in arid and semi-arid areas. However, contrary to the purposes of its introduction in different countries, it has escaped cultivation area and proved to be a very serious invader of farmlands, irrigation schemes, rangelands, etc. (Mohamed,1997).

In Africa alone, *Prosopis juliflora* is believed to have invaded over 4 million hectares, threatening crop and rangeland production, desiccating water resources and displacing native flora and fauna. Furthermore, it is still highly expanding in the Eastern and Southern Africa, tropical Asia and Australia (Matthews and Brand, 2004). It has now expanded to different parts of the world reducing the farm land, chocking out local plant species and drastically reducing the grazing land and now considered as the number one invasive plant (EARO and HDRA, 2005).

In Africa and Asia, however, it remains underutilized and is often taken as an invasive weeds and called a devil tree. The possible benefits of this plant have been dramatically outweighed by multiple negative impacts associated with its invasion, purpose and its eradication through possible means. This may be related to the fact that the indigenous knowledge surrounding its management and use was not introduced along with the tree and lack of recent technologies that reduce its spread by increasing its utilization (Witt, 2010).

For instance, in Ethiopia the spread of invasive plant species in national parks, around lakes, rivers, dams and urban green spaces is a growing concern and is causing huge economic and ecological losses (Kassahun et al., 2005).

Nationally, *Prosopis juliflora* was deliberately introduced for several purposes (i.e, for combating desertification, as a shade, as a wind break) but it escaped the cultivation site and spread to other land system. It has been ranked first to be the most problematic plant invader in Ethiopia. Furthermore, the plant has potentially harmful effects on rangelands, forage lands, irrigation site and farm lands of the pastoralist's communities of Afar Region. Currently, the plant is a major threat to indigenous biodiversity where ever it is established in the Middle Awash area due to its weedy and invasive nature (Taye, 2007).

The success of *Prosopis juliflora* was largely attributed to the high number of seeds produced and their efficient dispersal mechanisms. In addition, its fast growing ability, dormant seeds, attractive pods, seed maintaining viability in the droppings of livestock and wild animals, resistance to browsing, fast ability of re-sprouting and fast coppice growth and high water use efficiency contribute to its surprise invasion. The purposeful planting of the tree has given the plant an opportunity to base in the Middle Awash area. Besides its inherent robust growth, the seeds surviving in animals dropping serve as a vehicle of expansion (Hailu Shiferaw et al., 2004).

Currently, a large hectare of grass lands, range lands, water points, and crop lands were estimated to be occupied by *P. juliflora* and the invasion is still going on with a high rapid rate in the Middle Awash area. These invaded resources are basically key resources for livestock rearing, which are in turn the main stay for Afar pastoralists in their fragile ecosystem. Therefore, this study will generally intend to give the knowledge about the main disseminating agents of *Prosopis juliflora* seeds and the role of domestic and wild animal dropping for dispersion of *P. juliflora* will enable the community to apply appropriate control expansion method of *P. juliflora*.

1.2 Statements of the Problem

Prosopis juliflora (SW.) DC is one of the species that is found in Ethiopia from 44 species of *Prosopis*. The plant is dominantly found in the arid parts of Ethiopia like ANRS, some parts of Oromia, Dire Dawa, and Amhara Regions. This species has the highest capacity to invade new areas within a short period of time and causes modification of environment. Due to the fast invasive nature of this plant, it highly affects the livelihood of the pastoralists in different ways including the vast reserve areas of Allideghi and Awash National Park (Esther and Brent, 2005).

Currently, *Prosopis juliflora* has been a central issue for its thorny, weedy as well as invasive nature. The dense, impermeable thickets formed by the invasion reduce grass availability and stocking density. The invasion is also affecting multipurpose indigenous trees in the valley. The invasion leads to shrinkage of the rangelands and grasslands and will therefore threaten sustained existence of the pastoral system in the area. The invasion of the plant reduces grass availability and stocking density by livestock. It impacts the plant biodiversity by creating a physical barrier on seedlings of other plant species, preventing sunlight to reach to the under canopy vegetation, lowering the water table and by releasing various chemicals that may have negative effect on the native plant species (Ameha, 2006).

Even though, the aforementioned studies and others showed that, the plant had serious effects, but the effects of animals' dung on its rapid invasion is not well researched. In addition, there was no study to be done to identify which animals play a major role as potential seed dispersal of *P. juliflora* under investigation. Thus, the study was focused on analyzing the main disseminating agent of the plant through sample analysis of different animal dung. In order to achieve the stated objectives the study attempted to answer the following research questions.

1. Do animals play role as disseminating agent of *Prosopis juliflora*?
2. Is there a significant difference among animals dropping to foster the invasion of *Prosopis juliflora*?
3. Which animal group (domestic or wild) is considered the most dispersal agent for *Prosopis juliflora*?
4. Is there any other species disseminating through animal dropping in the study area?

1.3 Hypotheses

- Animals are disseminating agent of *Prosopis juliflora.*
- Goat dropping contributes more to the spread of *Prosopis juliflora* than other animals found in the study area.
- There is a difference in the rate of seedling emergence of *Prosopis juliflora* among samples of animals dropping.

- *P. juliflora* seed in sample of cattle dropping produce seedling earlier than samples of other animal dropping.

1.4 Objective of the Study

1.4.1 General Objective

The General objective of the study is to investigate the contribution of animals dropping to the dispersal of *Prosopis juliflora* in Amibara Woreda of Afar Region.

1.4.2 Specific Objectives

1. To analyze germination and seedling establishment of *Prosopis juliflora* seed in sample of animal dropping.
2. To analyze the presence of significant difference between animal dropping to foster the dispersal of *Prosopis juliflora.*
3. To assess the perception of communities of the study area about the disseminating agents of *Prosopis juliflora.*
4. To identify any other plant species emerged from sample of animal dropping.

1.5 Significances of the Study

The pastoralists in the study area are facing challenges from the invasion of *Prosopis juliflora* over new area. Analysis of the major factors that contribute to such rapid rate of spreading of *P. juliflora* over a wide area within a short period of time may be stepping stone to control this invasive plant. Therefore, this study will aim to generate information regarding the contribution of animals (both domestic and wild) for spreading of *P. juliflora* by analyzing the sample dropping obtained from cattle, goat, sheep, camel, donkey and warthog. The finding of this information will help to device the major mechanism through which the spread of *Prosopis juliflora* will be checked or tackled by responsible stalk holders.

2. LITERATURE REVIEW

2.1 Overview of *Prosopis juliflora* (SW.) DC REVIEW

Prosopis juliflora (SW.) DC belongs to genus *Prosopis*, family Leguminaceae (Fabaceae) and sub-family Mimosoideae (Pasiecznik et al., 2001). The species shows the largest genetic variability within the genus *Prosopis* causing it to behave differently in different environments (Pasiecznik et al., 2004). This may be due to obligatory out-crossing as a result of self-incompatibility (Felker and Clark, 1980). Due to its wide range of ecological amplitude, *Prosopis juliflora* occurs on a large variety of soil and wide range of altitudes. The climate of its natural range is characterized by high temperature averaging 20^{o}C. If endures temperature as high as 50^{o}C and resists occasional frost of -12^{o}C (Mohammed.1997). Mesquite is evergreen to semi-evergreen, flat-topped crown, thorny with a bushy appearance of spreading branches touching to the ground.

Prosopis juliflora in Ethiopia is generally described as short multi-stem (6-8 basal stems) with spreading canopy of twisted branches. Its height ranges from 3-12 m and rarely reaches up to 20 m depending on genetics, population and environment. The trunk's diameter reaches up to 1.2 m. In Afar region, it ranges from bush to tree reaching up to 15 m height with an average diameter of 0.2 m. The leaves are pinnate with 1-2 pairs of pinnate having 11-19 dark green leaflets with high tannin content. Greenish-yellow flowers crowded on 5-12 cm long staked spikes give rise to indehiscent pods (Esther and Brent, 2005).

On average a pod has 20-30 cm length and consists of up to 30 seeds. The seeds are half siblings and the resulting seedlings/tree will show considerable variation in its physiological, morphological and ecological characters. Immature pods are green and turn yellow during maturity. The pods contain high levels of protein and sugar and are also palatable to livestock and wild animals. The plant carries stout yellowish poisonous spines coming up in pairs from the heart wood of its branches reaching up to 8cm. (Ameha, 2006; Kassahun et al., 2005).

2.2. Introduction and Invasion of *Prosopis juliflora* in Ethiopia

Documentation is lacking regarding when, from where, how and by whom *Prosopis juliflora* was introduced to Ethiopia, but some speculations exist. The earliest time of notice is believed to be in the late 1970s, probably from India (EARO and HADRA, 2005). It was introduced to the Middle Awash area, specifically to Worere, some 30 years before by a British man named William Ulcro. Ulcro, who was in charge of the Middle Awash Irrigation Project, introduced the species for the first time. Mesquite was planted as hedge around offices, residential areas and along road sides within the compound of Middle Awash Basin Water Resources Agency based at Worere Town.

Apart from the initial plantings, those inherent characteristics of mesquite have contributed to its unrestricted invasion. In addition, a research at Middle Awash area revealed that about half of the seeds which passed through animal digestive tracts have the ability to germinate (Hailu et al., 2004). In addition to this, the seeds can germinate under wide ranges of temperature (20-40^{0}C) and moisture stressed environments. Besides, the strong poisonous thorns and bushy growth habit of mesquite in the Middle Awash area act as repellent for human to utilize its benefits (Abiyot Birhanu and Getachew Taddese, 2006).

So far, *Prosopis juliflora* is estimated to have invaded more than 30,000 hectares of lands in the Middle Awash area only. The species has also occupied a number of hectares in the Lower Awash area of the region and is still expanding to other parts. These lands were basically life supporting units for Afar pastoralists by providing pastures for their livestock and ecological goods such as traditional medicines, wild fruits and materials for the construction of houses. Currently the species is spreading to other parts and the species is declared to be the country as the first invasive plant species (EARO and HADRA, 2005).

2.3 *Prosopis juliflora* (SW.) DC Characteristics

Prosopis juliflora (Swartz) DC (vernacular names mesquite) is a small to moderate sized evergreen tree of 3-4 m height with long drooping branches and spreading crown. This species is largely represented in a shrubby state. There are straight, conical and spine scent stipules of 3-9 mm length. Leaves are bi pinnate, leaflets in 13-25 pairs, oblong (3 x 1.7 mm) and dark green,

Flowering spikes are auxiliary, hanging 6-8 cm long, cream to yellow in color. The pods are highly variable in size and shape, mostly curved or sickle shaped, cream-colored on ripening and indehiscent. They contain up to 30 ovoid seeds, brown to light chocolate in color, firmly embedded in the pod. *Prosopis juliflora* flowers twice a year, in February-March and August-September, and is a prolific seeder. The pods of autumn flowering mature by May or early June and are dispersed before the onset of the monsoon. The monsoon flowering pods mature from early November to mid-December. Summer pods mature over a short period of time, whereas a maturity of post - monsoon pods are staggered. In drought years, autumn flowering is very much affected, with trees often failing to flower, but the same plant flowers and fruits subsequently when there is adequate rainfall.

2.3.1 Pod Production

There is a high variability in pod size and shape, varying from 8-25 cm in length. Seeds are enclosed in a protective square shaped septum, coated with a sweet, thin, dry pulp, whereas the whole septa body is enclosed in a dry, yellow pulp containing 20-30% sucrose. This makes the pod palatable to livestock, also being low in tannin content (0.74-1.5%) (Felker, 1982).

Very little information is available about the pod yield per plant or on a per hectare basis. According to Garcia (1916) who reported that 17 kg pods/tree, while according to Jurriaanse (1973), who reported 90-150 kg from 10 year old trees in central Africa. *Prosopis juliflora* pods contain 13% crude protein, 60% nitrogen free extract, 0.15-0.44% phosphorus and 0.30 - 0.50% calcium on a dry matter basis (Shukla *et al.*, 1984). Ground pods fed to cattle, did not show any adverse effects, but under uncontrolled feeding, the pods gave deleterious effects, resulting in the formation of a compact ball of indigestible pods in the rumen, which caused sickness and even the death of cattle.

2.3.2 Biomass Production

The ability to coppice well is an important attribute in fuel wood species, to ensure continuous biomass production. Tiwari (1983) reported that *Prosopis juliflora* withstood annual coppicing from the second year of establishment, thus becoming a reliable renewable source of wood. Established plants coppice very well after cutting and assume good growth within 1 year.

2.3.3 Fixation and Inhibition

This genus, like many other leguminous genera, *Acacia*, *Albizia*, *Pongamia* etc., is capable of fixing atmospheric nitrogen. Jarrell *et al.*, (1982) found that the growth of *Prosopis juliflora* was enhanced by inoculating it with effective *Rhizobia*, leading to high productivity, and found that nodule formation after 6 weeks of growth. Growth inhibition studies of *Prosopis juliflora* showed that its leaves contain an inhibitor, which affect both the process of germination and the growth of seedling of others species due to large quantities of leaf litter below the tree canopy that do not allow other seeds to germinate (Lahiri and Gaur,1969).

2.4 Ecology of *Prosopis juliflora*

2.4.1Distribution

Prosopis juliflora was introduced into different ecosystem of the world and becomes naturalized in the arid and semi-arid reigions of the globe. With its wide adaptability to arid environments and its drought and disease tolerance, it is now found in many countries has spread widely with high plant densities encountered in many habitats, including rocky terrains and saline lands. Excessive plant populations of *P. juliflora* have suppressed the growth of native species such as *Salvadora persic*, *Acacia senegal* and *P. cineraria*. Many drainage lines are fully covered by *P. juliflora* and dense thickets and spread in to grass land areas which experience with high levels of salinity. This extraordinary colonization of *P. juliflora* proves the ability of this species to with stand a high degree of salinity in which every colonized area has been converted in to *P. juliflora* (Pasiecznik et al., 2004).

2.4.2 Ecological Attributes

Prosopis juliflora is well adapted to warm and dry tropical climates. It grows well in areas receiving 250-600 mm annual rainfall. It is a fast growing tree and has a deep to very deep, well meshed root system. It is capable of growing on inhospitable habitats such as rocky and saline soils, under adverse climate. Being drought hardy, disease resistant and having foliage non-palatable to livestock, it does not require any special care for rehabilitating marginal lands or wastelands.

Major growth takes place after the monsoon, and *Prosopis juliflora* has a great capacity for regeneration and is capable of withstanding drought for long periods of time. In consecutive drought and famine periods, most other plant species fail to withstand the environmental harshness, whereas *Prosopis juliflora* has been recorded to establish and colonize many habitats during such periods due to its aggressiveness and lack of competition. In low rainfall years or prolonged droughts, growing seedlings survive by folding both the cotyledons and protecting the young leaf. Such hardiness makes it valuable for a forestation and rehabilitation work in arid areas. Studies by Dahl (1982) showed that this species is capable of reducing its transpiration rate drastically and drawing firmly held water from the lower substratum. It is also capable of tolerating water-logging for certain periods.

2.5. Seed Viability of *Prosopis juliflora*

2.5.1 Germination and Establishment

As stated by Saxena and Khan (1975), untreated seed gave only 25% germination, but seed extracted with sodium hydroxide, sulphuric acid or boiled water was also scarified in the process and gave 77-90 % germination. Rapid water uptake of treated seeds was observed and sulphuric acid treated seeds showed noticeable swelling to germinate within 24 hour of sowing.

Most seeds start to germinate in 1-3 days after sowing. The primary root emerges and elongates rapidly for 2-3 days while the cotyledons expand slowly and turn from pale yellow to light green in color. The cotyledons unfold, and the primary leaf emerges within 3 days of germination. In the first week after germinations, there is rapid growth in the root rather than the shoot. Seven day old seedlings have a 1:4 shoot: root ratio (Gupta and Balara, 1972). In nature, seedlings have a great capacity to survive despite weed competition. Once the seedlings grow 5-10 cm above ground level, they have the capacity to survive and endure the hot summer months. The upper portion of the stem develops many dormant buds which can sprout and elongate in a suitable environment. It takes 3 years to initiate flowering and fruiting. *Prosopis juliflora* generally develops a bushy shape with multiple stems in natural stands. If the apical bud is maintained and side branches pruned, then the plant can develop in to an erect, well crowned tree.

2.5.2 Seed extraction

Each seed is enclosed in a gummy septum which provides resistance to losses from insect attack. According to Saxena and Khan (1975), a few methods have been developed for the removal of seeds from this septum that is pods are collected and spread in the sun until they are dry and brittle. These pods are threshed mechanically into small segments, each generally comprising of one seed encased in its gummy septum. The removal of seeds from the endocarp can then be under taken by soaking the broken segments in 0.1 M ammonium chloride solution for 24 h; 95% sulphuric acid for 30 min; 1% solution of sodium hydroxide for 30 min or in 70-80^{o}C water for 10-15 min and under room temperature water for 24 h . The segments should then be well rinsed with water, and rubbing with a coarse cloth ensures 100% seed removal.

2.5.3 Salinity/alkalinity tolerance

As reported by Singh *et al*. (1993), *Prosopis juliflora* grows well in areas having high salinity or alkalinity levels, and can tolerate alkalinity as high as pH 9.5, it grow normally in situations where pH is below 9.6 and electrical conductivity (Ec) is below 1.20 ds/m. Similar observations were made in the saline grasslands where thickets of *Prosopis juliflora* have been recorded on soils with a surface pH of 8.1-8.4 electrical conductivities of between 0.29-0.87 ds/m. It also can continue to grow in a scattered fashion with 8.1-9.3 pH and EC of 4.8-5.91 ds/m, even in areas of high salinity, it can be planted by amending the soil with farm yard manure and gypsum.

2.5.4 Natural regeneration

Prosopis juliflora is known to invade vacant sites and establish itself quite successfully. The extensive and quick propagation under natural conditions on various habitats can be attributed to the palatability of its pods to livestock. Seeds are chemically scarified while passing through the intestines of an animal and are encapsulated in the droppings. Each small fecal pellet may contain 1-3 seeds, and provides the desired moisture and nutrition to the germinating seedling. Even under drought conditions the pellet holds moisture for longer, which enables the seeding to overcome the adverse conditions and establish itself in the first year. These features and the acclimatization of saplings, has made it valuable for wasteland development.

2.6. Seed dispersal through animal dropping

Dispersal can play a major role in the species geographical distribution. The term dispersal is used to define the movement of a seed from its parent plant to the ground surface, including horizontal and vertical movement (Chambers & MacMahon, 1994). Plants profit from seed and fruit dispersal. If seeds remain under the plant, mortality by predation, attack by pathogens and seedling competition are high, hence they must move away from their parent plant (escape hypothesis; Jansen, 1970). In addition, considering that habitats are bound to change in time, plants need to disseminate their seeds widely enabling them to colonize new sites resulting from habitat disturbances (colonization hypothesis; Howe & Smallwood, 1982).

Different a biotic (gravity, wind, rainfall, etc.) and biotic (animals) factors participate in fruit seed dispersal. In relation to animals, the two major groups of animal dispersers are vertebrates and ants. Vertebrate dispersal agents include birds, mammals, fish and reptiles. Among mammals, the major dispersers in tropical regions are bats and primates (Janzen et al., 1976). While rodents gain relevance in desert zone as dispersal agents of dry fruits (Sherbrooke, 1976). Dispersal by mammals is regarded as passive when transport is accidental, either because fruits or seeds stick on the fur of animals (Agnew & Flux, 1970) or because they are incidentally eaten, mixed in with other fruit items. Active dispersal of fruit and seeds occurs when they are especially selected by animals. After consuming (chewing and digesting) the fruits the mammals disperse the seeds in their scats. The type of digestion (caecal or ruminal) of herbivores can account for differences in seed survival after their passage through the digestive tract. Dispersal success requires passage through the gut without abrading the seed coat to the point where it is susceptible to moisture as a germination cue (Janzen et al., 1985). The main contribution of endozoochorous dispersal of *Prosopis juliflora* seeds is their release from the enclosing pod segments, their dispersal away from the mother plant and possibly the provision of nutrients by the dung for their establishment and initial growth.

2.7. Effects of *Prosopis juliflora*

Mesquite invasion forms impermeable, dense thickets. It reduces grass cover of grazing lands and consequently affects stocking density. The invasion is a major problem for agricultural lands. The plant is known for diminishing ground water with the help of its long tap root system. The leaves

have allelopathic effects inhibiting under canopy growth and the pollen also causes allergic reactions. The thorns are very poisonous both for humans and animals. It is these elements that enable mesquite to affect the livelihoods of the pastoralists.

The plant has caused considerable damage on indigenous trees and wildlife and reduced the availability of palatable grasses. As a result, herders' livelihoods have been severely affected and led to migration and change in livestock composition. The invasion has caused migration of people to un-invaded locations, increased conflict on remaining limited resources, and increased mosquito infestation aggravating malaria incidence. The people are also quoted blaming mesquite as a hideout for predators and cattle rustlers (Zeila et al., 2004).

Mesquite has invaded important habitats such as grazing lands and watering points of the pastoralists in the dry and semi-dry parts of Ethiopia. Such encroachment of grazing lands reduces grass fodder availability and thereby affects livestock rearing which is the principal component of pastoral livelihoods. In Afar, mesquite has encroached thousands of hectares of valuable lands. Grass availability under its canopy was found extremely rare. The plant is expanding from time to time with its great impact (Gemedo et al., 2006).

Prosopis juliflora is able to improve the soil in which it is growing by means of nitrogen fixation, loosening of a hard soil structure increase of the fauna above and below the ground nutrient pumping from deeper soil layers Kaushik and Kuma (2003). *Prosopis juliflora* is reported to produce good quality fire wood and charcoal because wood is hard, burns slowly and has excellent heating properties (Dubale Admasu, 2008). The mature timber is resistant to pest attack and weathering and thus can be used for furniture making and other useful purposes especially housing (Pasiecznik, 2001). However, there are conflicting reports on the quality of the fuel wood. According to Esther and Brent (2005) the fuel wood is of good quality with high calorific value, whereas report from Kenya claimed that the fuel wood produced poisonous smoke. They also complained that the wood is soft and easily attacked by insects, which make the tree unfit for fuel wood and house construction (Nabori et al., 2007). Similarly in the process of this study observed that the wood is not denser and easily attacked by insects and the fuel wood produced some poisonous smoke.

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location of the Study Area

The study was conducted in the four kebeles of Amibara woreda, in Afar National Regional State (ANRS) which is found in north-eastern part of Ethiopia, The region covers around one-third of pastoral lowlands in the country and about 10% of the total area of Ethiopia. Of the total area in the region, about 64% is bare land owing to the prevailing harsh climate. Amibara Woreda area is found in between the Upper and Lower Awash River basins. The study area located is between 09^{o} 30'and 10^{o} 20'N and 40^{o} 30' and 40^{o} 50' E, about 285km north-east of Addis Ababa at an altitude range from 500 to 820m above sea level. Livestock population of the study area is estimated to be 20,000-25,000 small stock (sheep and goats), 10,000-15,000 cattle, and 5,000-8,000 camels and 1,500-2,000 donkey and estimated 1500 wild animal (warthog) live in the study area (Data obtained from pastoral and agro-pastoral bureau of the study area).The main inhabitants of local people to the region are pastorals as well as agro-pastorals. The main livelihoods of the local inhabitants in the area are sheep, goats, cattle, camel and donkey (Fig-1).

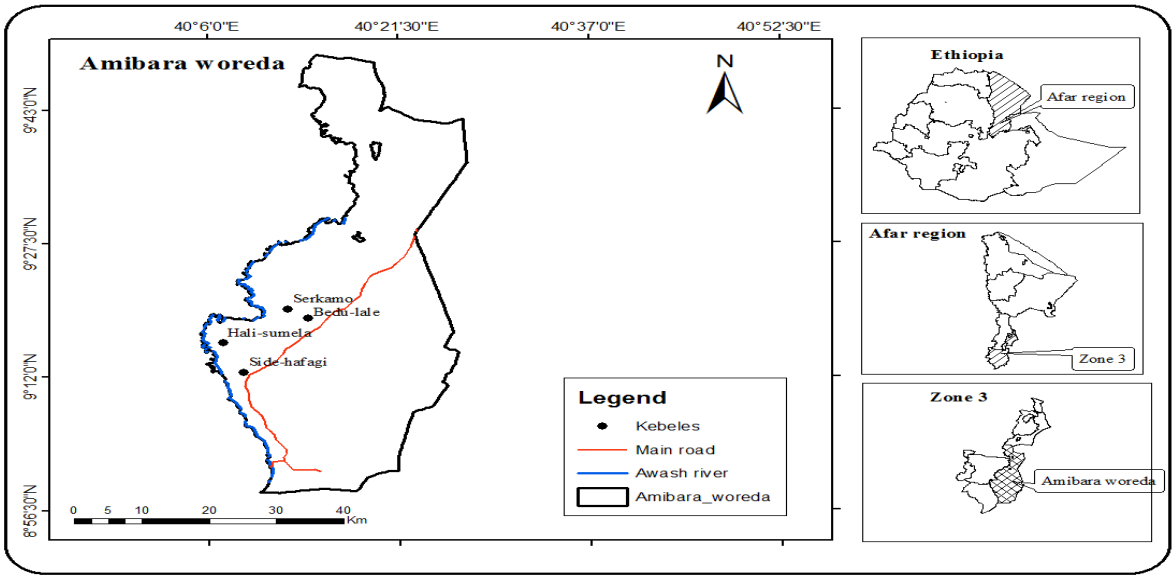

Figure 1: Map of Amibara Woreda of Afar Region showing sampling sites Sideha-Fage, Halay-Somala, Bedu-lala and Serkamo Kebeles

3.1.2 Climate of the Study Area

According to thirty years of meteorological data obtained from Agricultural Center, the study area shows bimodal type of rain fall. July and August are the wettest months with monthly rain fall greater than 100 mm. The second rainy season is from February to April With mean monthly rainfall around 70 mm. The area is characterized by high moisture deficit because of high evapo-transpiration. The mean annual evaporation is 2702 mm which much exceeds the mean annual rain fall of the area which is about 562 mm. The maximum and the minimum temperatures are 38^{o}_{C} and 14.2^{o}_{C} in June and November respectively (Fig-2).

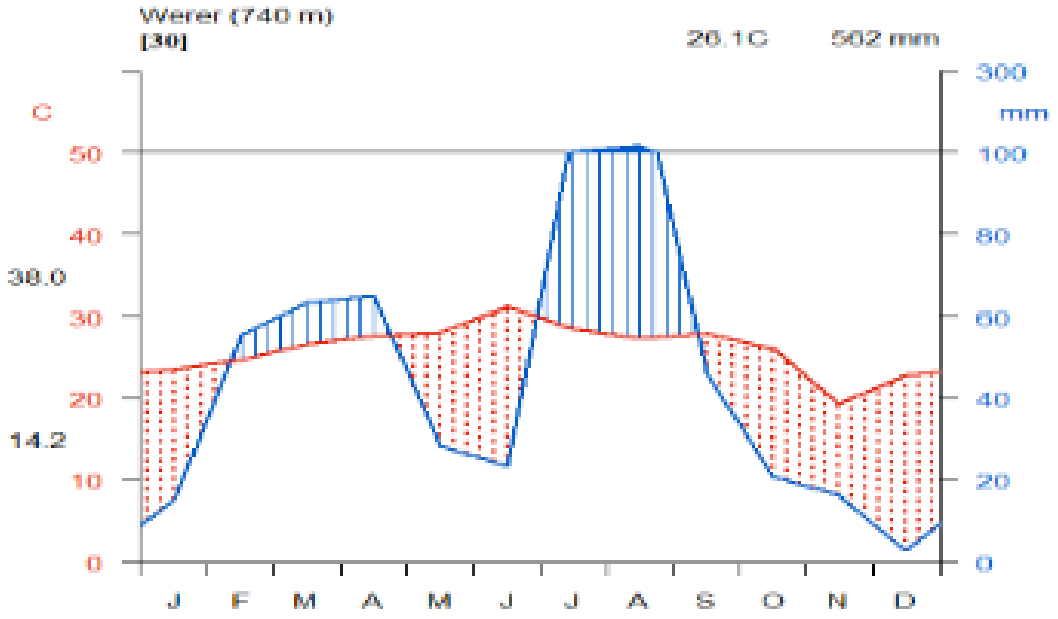

Figure 2: Mean monthly rain fall and maximum and minimum temperature for the last thirty years. Source: werer Agro- meteor logical Station (WAS).

3.2 Data source and materials

Different kinds of data have been collected to conduct this study. The data from primary sources include experiment data and information using interview questionnaire from members of the surrounding community (house holding) on other hand, secondary data were obtained from the study area, topographic maps besides, the published materials including books, journals, and research articles were reviewed. For sampling preparation and sample of plant species data collections plant press, plastic bag, digital camera, balance, plastic pots and also for preparation of green house wood, nail, white plastic were materials used.

3.3 Sampling design and method of data collection

3.3.1. Reconnaissance Survey

Before the actual study was conducted, the researcher carried out a preliminary survey from Jan 12-13/2018 in order to obtain an impression on the dominant plants in the study area particularly the introduction and invasion of *Prosopis juliflora* in order to have a general impression concerning about a major dispersal agent of the plant. This survey was carried out through observation, document analysis and discussion with local pastoralists' communities.

3.3.2 Sampling Technique/Design

After reconnaissance, out of 19 kebeles of Amibara woreda, four kebeles were selected as a sample unit for conducting this research based on the level or degree of invasion of *Prosopis juliflora* (SW) DC. These sample kebeles are Sideha-Fage, Halay-somala, Bedu-lala, and Serkamo kebele from which 2, 1, 1 and 1 villages (five selected villages which are found in four kebeles) were selected using random sampling technique respectively.

To conduct field experiment on the capacity of seed germination and seedling emergency of *Prosopis juliflora* in sample of animals dropping after being ingested by domestic and wild animals, and to analyze the level of contribution of these animals for spreading of *Prosopis juliflora*. A sample of dropping from domestic animals(i.e., from cattle, camel ,sheep goats and donkey) and from wild animals (warthog) were collected from January 31- Feb 5 /2018 within an interval of 24-36 hours after the process of egesting by animals. About 15kg of animal dropping

was collected from each target animal (3kg collected from each selected village) in different plastic bags. Totally from five selected villages, 90kg animal dropping was collected as a sample from those target animals (75kg from domestic animals and 15kg dropping from wild animal (warthog). Then after the collection of droppings, it was air dried. A total of 60 similar types of pots (10 pots for each animal dropping) with the same diameter (35cm) and depth/height (8cm) prepared. Then 1.25kg of 15kg dropping collected from each animal group was placed on pots and placed in temporally prepared green house (3m x 4m x 2.5m). Finally all pots were irrigated daily equally and constantly for about 50 days.

Data were collected mainly from experimental sample pots of animal droppings and secondary data. The primary data for the study were collected from experimentation which was designed to determine the most disseminating agents through analysis of animals dropping. Experimental data concerning germination and seedling emergence of plant species from seeds that obtained in experimental sample droppings were coded, counted and recorded at three days interval continuously for about 50 days. Those sample seedlings emerged from sample of animal dropping were collected, pressed, dried, labeled and identified by using different volume of flora of Ethiopia and Eritrea at the National Herbarium, AAU.

3.3.2.1 Socio-demographic characteristics of respondents'

In addition to obtain further information concerning about dispersal agents of *Prosopis juliflora* and a trend of livestock movement with respect to cause of invasion, 50 respondents was selected from study area. Out of these 70% males while 30% were females. From number of respondents 52% the occupation was pastoralist, 30% agro-pastoralist, 6% merchant (trading) and 12% government employee. A small proportion of the respondents were below the age of 30 years with an overall mean age of 36 years and mean household size was found to be six (Table 1).

Table 1 Socio-economic and demographic characteristics of the respondents

Characteristic	Description	Frequency	Percentage (mean)
Sex n=80	Female Male	15 35	30 70
Age	-20-29 -30-40 -40-49 ≥50	4 13 21 12	8 26 42 24
Responsibility of the respondents' n=80	-House hold -Clan leader -Kebele leader	42 4 4	84 8 8
Occupation status n=80	-Pastoralist -Agro- pastoralist -Trading (Merchant -Government employment	26 15 3 6	52 30 6 12
House hold size	Mean house hold size		6

Data was collected by semi-structured interviews. Both quantitative and qualitative approaches were used for data collection in the survey. These included researcher-administered household questionnaire (Appendix 1) with both open-ended and closed questions. The techniques includes semi-structured interview (individual discussion).Interview discussion were held with local community living in the study site (household head, clan leader and kebele leader), key informants were selected based on responsibility in community and randomly from those total house hold from selected villages, a total of 50 people 42 from household head 4 from kebele leader and 4 from clan leader were selected for surveying. Interview method of data collection is used because it helps to support (substantiate) the results obtained from experimental work and to obtain information regarding perception of pastoral communities about disseminating agents of

Prosopis juliflora seeds through animal dropping and also to know the trend of livestock movement in the study area (Fig-3).

Figure 3: Semi-structured interview with Afar pastoral communities about disseminating agents of *Prosopis juliflora*

3.4. Method of Data Analysis

Based on the collected experimental data concerning the dispersal of *Prosopis juliflora* seeds through animal dropping were examined by computing the number of seedling, as well as those data obtained from interview were arranged, organized and tabulated for further analysis by using statistical descriptive method, such as mean, frequency, percentage and other methods of comparison (ANOVA). The capacity of seedling emergence of *Prosopis juliflora* and any other plant species from all sample pots were compared and interpreted in terms of the level/degree of contribution of animals for disperse.

4. RESULTS AND DISCUSSION

4.1 Results

4.1.1 Result of experiment on the analysis of *Prosopis juliflora* seeds in sample of animal droppings

The result of experiment on the study of plant-animal interaction, particularly concerning the role of animals for dispersion of *Prosopis juliflora* seeds through their droppings, the result of the analysis of *Prosopis juliflora* seeds in animal droppings revealed that all sample of animal dropping has contribution to dispersal of *Prosopis juliflora* seeds, the average number of *Prosopis juliflora* seedlings emerged from 1.25 kg excrements of donkey, cattle, warthog, goat, camel and sheep was 160, 86, 46, 16, 3 and 2 respectively. The proportion of seedlings emerged from sample dropping obtained from each animals was described in percentage (Fig-4).

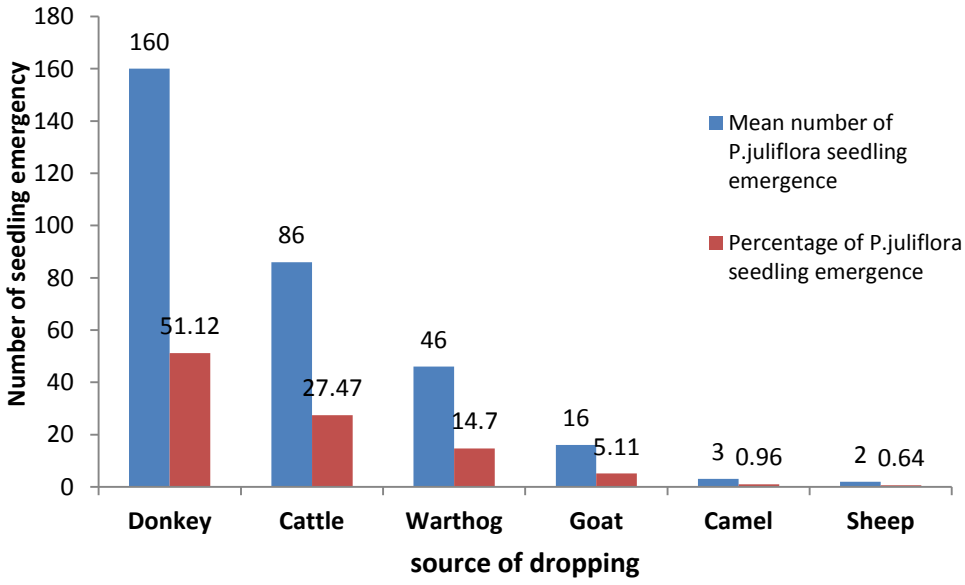

Figure 4: Mean number and percentage seedling emergence of *P. juliflora* per 1.25kg sample droppings.

4.1.2 Plant species dispersed by animal droppings

Domestic and wild animals are not only the main dispersal agents of *Prosopis juliflora* seeds in the study area, but also they are the cause for the dispersal of other plant seeds. Because the way to study and analysis of *Prosopis juliflora* seeds in animal dropping, other plant species were observed to be germinated and established in different sample of animal dropping along with *Prosopis juliflora*. Therefore those plant species that were dispersing through donkey dropping are *Prosopis juliflora* and *Anathoxanthum aethiopicum,* those plant species that were dispersing through cattle dropping are *Prosopis juliflora*, *Cadaba rolundifolica* and *Anathoxanthum aethiopicum,* those plant species that were disperse through warthog dropping are *Prosopis juliflora, Zaleya Pentandra (L.), Pasplidium geminatum and Anathoxanthum aethiopicum,* those plant species that were dispersed through camel dropping are *Prosopis juliflora* (SW.) DC and *Suaeda monoica* and a plant species that was dispersed through both goat and sheep dropping is *Prosopis juliflora.* The relative mean values of seedlings of these species in terms of their seedling number obtained in this sample dropping are listed (Table 2).

Table 2 Plant species that can be dispersed by animal dropping

Sample of animal dropping	Plant species emerged from dropping	Family	Growth	Vernacular name	Mean No of Seedling/ 1.25kg
Donkey dropping	*Prosopis juliflora*	leguminaceae	Shrub/tree	Durgi-hara (in Afar lan..)	160
	Anthoxanthum aethiopcum	Poacea	Grass		6
Cattle dropping	*Prosopis juliflora*	leguminaceae	Shrub/tree		86
	Cadaba rolundifolica	Capparidaceae	Shrub/tree	Anagalli (in Afar lan.)	11
	Anthoxanthum aethiopcum	Poacea	Grass		10
Warthog dropping	*Prosopis juliflora*	leguminaceae	Shrub/tree		46
	Zaleya pentandra	Aizoaceae	Herb		3
	Paspalidium geminatum	Poacea	Grass	Gargaro (somale lan.)	7
	Anthoxanthum aethiopcum	Poacea			7
Camel dropping	*Prosopis juliflora*	leguminaceae	Shrub/tree		3
	Suaeda monica	Chenopodaicea	Shrub/tree	Hurunto (In Afar lan.)	67
Goat dropping	*Prosopis juliflora*	leguminaceae	Shrub/tree		16
Sheep dropping	*Prosopis juliflora*	leguminaceae	Shrub/tree		2

4.1.3 Communities' Perception on disseminating agent of *Prosopis juliflora*

In the study area 42 of the respondent agreed that *Prosopis juliflora* was spread highly through domestic and wild animals. Regarding the level of disseminating agents of *Prosopis juliflora* status, the survey results of the study area indicated that 42(84%)of the respondent put domestic and wild animals, 3(6%) flood, 2(4%) wind, 2(4%) human and1(2%) birds in the decreasing sequence as dispersal agent of *Prosopis juliflora* (Fig-5).

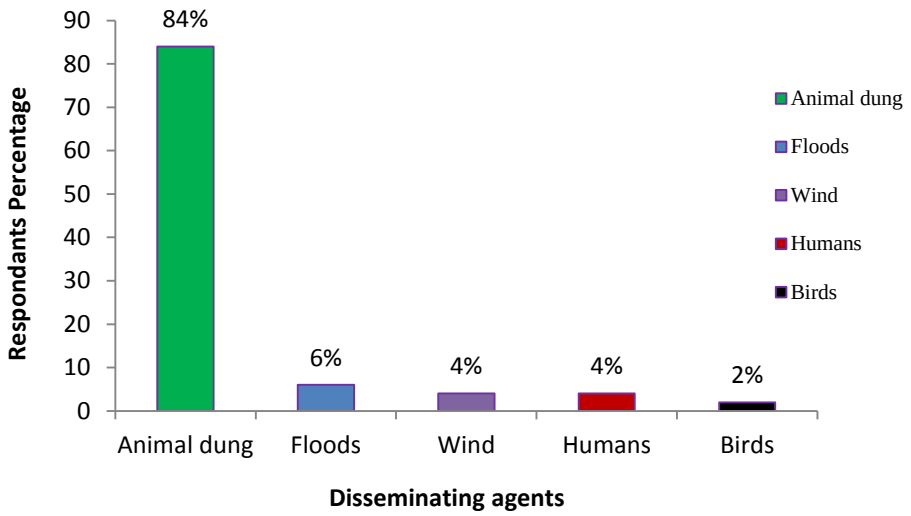

Figure 5: Percentage of respondents' response about disseminating agent of *Prosopis juliflora*

According to community response regarding on the degree level of animals as a disseminating agent of *Prosopis juliflora* on the study area, the survey results indicated that 14(28%) of the respondent put cattle, 12(24%) goat, 9(18%)sheep, 7(14)donkey, 6(12%) and 2(4%)warthog in the decreasing sequence as dispersal agent of *Prosopis juliflora* (Fig-6).

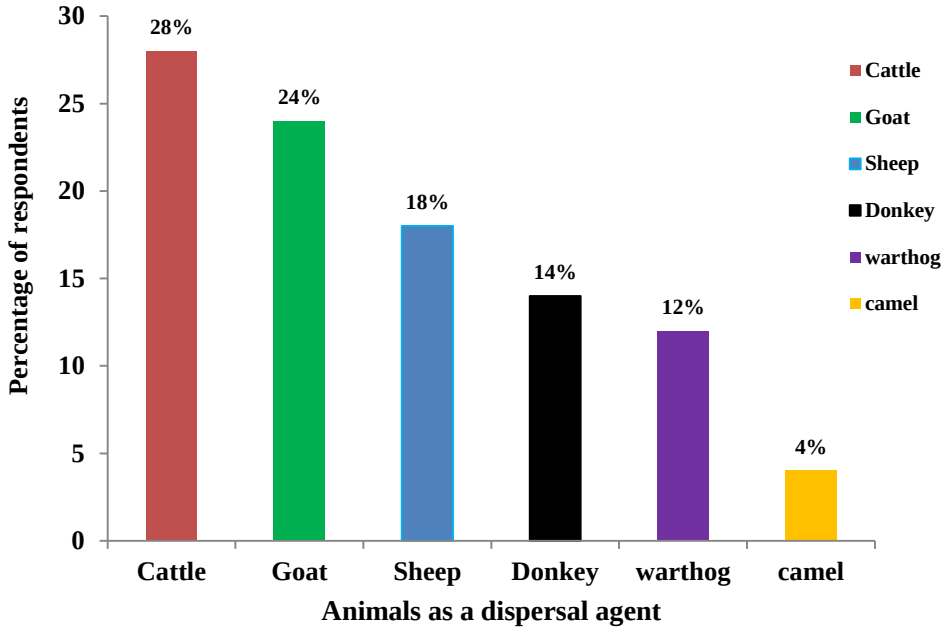

Figure 6: Percentage of respondents' response about animals as disseminating agent of *Prosopis juliflora* in the study area

4.2 Discussion

4.2.1 Analysis of *Prosopis juliflora* seeds in samples of animal dropping

The interaction between plant and animals particularly concerning the dispersal of *Prosopis juliflora* through their dropping in the case of Amibara woreda of ANRS, the present study provides the results obtained from analysis of *Prosopis juliflora* seeds in animal dropping. Among the vegetation of Amibara woreda, *Prosopis juliflora* is a highly dominant species in the communities. The fruits of this legume are highly nutritious, and the seeds are protected by hard resistant coats that delay germination and prevent them from being destroyed when passing through the digestive tract of animals (Solbrig and Cantno, 1975).

Study conducted by Peinetti et al. (1992), suggested that the dispersal of *Prosopis juliflora* by domestic livestock, and confirmed that the presence of a great number of viable seeds of *Prosopis* were found in cattle dung, though dormant, after passing through the digestive tract. Similarly the result of this study shows seeds of *Prosopis juliflora* were found more in dropping of donkey, cattle and warthog than in the dropping of other animals (goat, camel, sheep) based on the quantitative assessment of the number of seedling emerged from each experimental sample dropping. Further assessment shows these seeds found in sample dropping of donkey, cattle and warthog have higher rate of germination and seedling establishment. Depended on the result of this experiment, the degree of dispersing seeds of *Prosopis juliflora* among these animals was significantly different ($P \leq 0.01$).

The above mentioned discussion was proved true because many seedlings of *Prosopis juliflora* during follow up sessions of 50 days after incubation period from sample of goat, sheep and camel dropping were not observed (Fig 7, A &B).

A **B**

Figure 7: Picture showing that *Prosopis juliflora* germination (A) and seedling establishment (B) in different pots sample of animal dropping (Photo by Kassahun, 2018)

4.2.2 Assessing the disseminating agents of *Prosopis juliflora* in the study area

Majority of respondent animals (domestic and wild) are the main disseminating agents of *Prosopis juliflora* in the study area (Fig-5), from these agents of animals according to the result of respondents cattle dung (dropping) is relatively high as a disseminating agent of *Prosopis juliflora* in the study site (Fig-6). The cattle feed on the pods (which is palatable and tasty) and the seeds were distributing all over the places through their dropping.

According to pasieeznic et al. (2001), animals both domestic and wild, feed on *Prosopis juliflora* pods. These animals and flood water are the major dispersal agents of *Prosopis juliflora*. Moreover, birds, bats, reptiles and ants that feed on *Prosopis juliflora* pods are also expected to contribute to dispersal of the seeds.

As shown by the socio economic data, the community almost depends on livestock and this foster the rapid invasion of *Prosopis juliflora* on the pasture land and in all the study area.

4.2.3 Contribution of animals to invasion of Prosopis juliflora

Among the factors that contribute to apparent success of *Prosopis* in invading the study site in particular and the Afar national regional state in general is attributed to its ability to produce

relatively many small seeds contained within the sweet pods on which animals depends on it as a fodder. One measure of the effectiveness of an animal as an agent of seed dispersal is the number of seeds that are normally found in available state in dung.

Dispersal by mammals is regarded active dispersal when fruit and seeds are especially selected by animals. After consuming (chewing and digesting) the fruits the mammals disperse the seeds in their scats. The type of digestion (caecal or ruminal) of herbivores can account for differences in seed survival after their passage through the digestive tract. Dispersal success requires passage through the gut without abrading the seed coat to the point where it is susceptible to moisture as a germination cue (Janzen et al., 1985). The main contribution of endozoochorous dispersal of *Prosopis juliflora* seeds is their release from the enclosing pod segments, their dispersal away from the mother plant and possibly the provision of nutrients by the dung for their establishment and initial growth. According to the result of this study on analysis of *Prosopis juliflora* seeds in animal dropping (dung), with some exception the percentage of germinated seeds that had passed through the digestive tract of caecal animals, such as donkey and warthog were higher than in goat and sheep (ruminant).

Generally the contribution of endozoochorous dispersal of *Prosopis juliflora* seeds is one of the major dispersal ways of *Prosopis juliflora* seed in Afar region regarding with rearing livestock trend. According to the response of pastoral communities about the trend of their domestic animals movement is about 20 km far away from their first place in a day (migrate) during drought seasons to search their food.

Because of this currently, large hectare of grass lands, water points, and croplands were estimated to be occupied by *Prosopis juliflora* and the invasion is still going on with a high rapid rate in many parts of ANRS in general and in study area in particular. In this regard, results and analysis obtained from this study clearly showed that both domestic and wild animals are involved in the dispersal of *Prosopis juliflora*. This dispersal way of seed of *Prosopis juliflora* is one of the major biological characteristics that foster its rapid invasion of new area, which has become very evident in the study site in particular and many parts of ANRS (Fig-8).

A **B**

Figure 8 (A&B): Pictures showing that invasion of *P. juliflora* in the study sites (photos by Kassahun)

Therefore, with the help of animal and other means of dispersal mechanism and its wide range of ecological adaptation, *Prosopis juliflora* is now found and grown in many countries and districts of the world including the study area of this research. Beside its rapid and extraordinary colonization of global and regional ecosystems, *Prosopis juliflora* posses several unpredictable impacts expressed in terms of social, economic and ecological wellbeing of the societies (Kassahun et al., 2005). According a report forwarded by GISP (2004), *Prosopis juliflora* as invasive alien plants species worldwide, currently it is spreading in an alarming rate to invade and threat agricultural lands, range lands, national parks, water ways (lakes, rivers, power dams, irrigation channels), road sides and settlement areas worldwide.

5. Conclusion and Recommendation

5.1 Conclusion

Nationally *Prosopis juliflora* was deliberately introduced for several purposes (i.e. for combating desertification, as a shade, as a wind break, to reclaimed degraded land through erosion) but it escaped the cultivation site and spread to other land use systems including range lands, forage lands, irrigation sites, water ways and farm lands of the pastoral communities of Afar region. Currently, the plants pose a major threat where ever it was established in pastoralist area of Afar region particularly in the study area due to its weedy and invasive nature. The success of *Prosopis juliflora* was largely attributed to large number of seeds it produce which equipped with a number of biological characteristic that help its spread through animals dropping in to new areas. These include attractive and rewarding pods for animals, and sweet mesocarp embodying the numerous small pods sought after (wanted) by both domestic and wild animals.

In addition endozoochoric nature of its seeds offers *Prosopis juliflora* with the following triple advantages: (1), the seeds are dispersed with the dropping at about 20 km away from mother plant (2), seeds that pass through the gut of animals are exposed to some treatments which facilitate germination. And (3) the dropping itself may act as fertilizer in initial, mostly critical stage of establishment of its seedling. Thus, adaptation of seeds of *prosopis* to endozoochory, as clearly demonstrated by results of this study could be attributed as one of the major factor enhancing its rampant invention across the study area. Therefore, because of these characteristics of seeds of *P. juliflora* animals play a major role in dispersion and invasion of this plant over a wide area within a short period of time since from its introduction, according to the findings of this study both the survey and experimental result of the study indicated that animals (both wild and domestic) are the major dispersal agent of *Prosopis juliflora* than other dispersal mechanism of seeds.

Regarding on the levels of animal as a dispersal agent the experiment result with an order of donkey, cattle, warthog, goat, camel and sheep from the highest to the lowest level, but the survey result indicated cattle are the highest follows goat, sheep, donkey, warthog and camel. According to the population of livestock cattle, goat, sheep and camels are greater than donkey and warthog. Therefore both results are not significantly different depend on dispersal agent of *P. juliflora*, but

the number of *Prosopis juliflora* seedlings obtained from 1.25 kg excrements of cattle, donkey, warthog, goat, camel and sheep were significantly different ($P \leq 0.01$).

5.2 Recommendations

In summery it could be possible to realize that the rapid rate of *Prosopis juliflora* invasion across the study area was attributed by the nature of its seeds and pods on which animals consume as a food. Such a relation between the plant and animals increase the chance of its dispersion over a wide area within a short period of time. To this end in order to alleviate the problem of invasion of *Prosopis juliflora* by means of animal dropping, the following recommendations are made:

- Increasing the level of understanding and awareness of pastoral communities about the advantage and disadvantages of *Prosopis juliflora* on their livelihood and ecosystem functioning.
- Provision or finding another alternative source of foraging for the livestock of pastoral communities instead of seed pod of *Prosopis juliflora*.
- Preparing enough grazing land for livestock production by all concerned stalk holder (woreda Agro-pastoral bureau, Non-governmental institution and pastoral communities of the area).
- Support and create awareness of communities to using animal dropping for biogas production by all concerned stalk holder.
- Set up small scale industry that produce livestock fodder through crushing and grinding the seed pod of *Prosopis juliflora.*
- Forming cooperatives groups in each village who are responsible for periodic uprooting of mesquite seedling from grazing areas.
- Support the effort of pastoralist in changing potentially agricultural lands which are invaded by the mesquite in to crop lands. These will help in reducing the *prosopis* seed bank in the basin which in the long run reduces the invasion.
- Facilitate the sustainable transformation life style of the community from pastoralist to agro-pastoralist and crop farming.
- Taking cutting, burning and hand pulling controlling method by different stake holder to control the invasion of *Prosopis juliflora*.

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Appendex-1

Questionnaire

Semi - structured interview concerning about dispersal agents of *P.juliflora* and the trained of livestock movement with respect to dispersion of *P.juliflora*. This questionnaire is prepared to gather supportive information (data) forM.sc. Thesis entitled "Analysis of *P. juliflora* seeds in animal dropping and its germination capacity" The case of four kebeles of Amibara woreda of Afar region. The objective of this study is only for research purpose for research purpose for partial fulfillment of the degree of Master of Science

Interview Questionnaire (for household)

-Name of respondent-- ---------- Kebele ----------Age--------Sex----

-Responsibility of respondent

A, household head B, clan leader C, kebele leader

-Status of respondent

A, Pastoralist B, Agro-pastoralist C, Farmer

Disseminating agent of *Prosopis juliflora*

1. How far do the pastoralist's domestic animals move from their dwelling place to search for food?

A, From 1upto 2km B, From 3upto 4km C, From 5upto 7km

D, From 8 upto10km E, above 10km

2. To searches for food and water, how far does a pastoralist move his/her animal in to other place?

A, From 5 up to10 km B, From10 up to 15 km C, From 15 up to20 km

D, From 25 up to35 km E, From 35 up to 50 km

3. In your opinion, what are the disseminating agents (way) of *Prosopis juliflora*?

A, domestic and wild animals B, wind C, water (flood)

D, Human E, birds

4. Among those disseminating agents that are listed in question three, which ones are the most dispersal agents (ways) of seed of *Prosopis juliflora*?

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5. If you think domestic animals are the causes of seed dispersal, which animal are they?

A, Goat □ B, Sheep □ C, Camel □

D, Donkey □ E, Cattle □

6. If you think wild animals are the cause of dispersal of *P. juliflora* in your area. Which animals are they?

_____ , _____ . _____

_____ , _____ . _____

7. If the seed of *Prosopis juliflora* are disseminated by animals, in what way can they disperse them?

A, disperse seed pod of *P. julifiora* by attaching with animal body.

B, disperse *P. juliflora* seed after digestion through animal dropping.

Appendex-2

DATA ANALYSIS

Table Percentage of respondents' response about disseminating agent of *P. juliflora* in the study area.

Disseminating agents	Respondents
Animals (mammals)	84%
Flood(water)	6%
Wind	4%
Humans	4%
Birds	2%

Table. Seedling emergence rate of *P. juliflora* in 1.25kg sample of animals dropping at 3 day intervals

Dropping	**Parameter**	**4**	**7**	**11**	**14**	**17**	**20**	**23**	**27**	**30**	**33**	**34**	**37**	**40**	**43**	**47**	**50**	**53**
Donkey	SER/3day	10	26	18	18	14	10	1	7	8	8	8	8	5	5	3	8	4
Camel	SER/3day	2	3	2	2	1	2	2	2	1	2	2	2	2	2	2	2	1
Sheep	SER/3day	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cattle	SER/3day	5	14	9	7	5	4	4	4	4	5	3	4	4	4	3	4	4
Goat	SER/3day	1	2	1	1	1	1	1	0	1	1	1	1	1	1	0	2	0
Warthog	SER/3day	1	20	7	1	2	2	1	1	2	0	1	2	2	0	1	2	1

Table. Number of *P.julifloras*eedling germinate and seedling established per sample pot of animal dropping /per1.25kg animal dropping after 50 days.

Test pot	Sample of animal dropping					
	Donkey	Camel	Sheep	Cattle	Goat	Warthog
1	167	0	2	84	18	37
2	170	2	3	64	19	57
3	153	4	3	87	11	46
4	168	4	4	85	13	49
5	166	3	2	81	18	41
6	154	4	4	90	16	48
7	164	4	2	68	18	42
8	149	5	0	87	18	52
9	151	3	0	149	18	53
10	157	0	2	80	12	37
Average	**160**	**3**	**2**	**86**	**16**	**46**

Table: Mean number and percentage of seedling emergence per1.25kg sample of animal dropping

Parameter	Donkey	Cattle	Warthog	Goat	Camel	Sheep
MSE	160	86	46	16	3	2
%SE	51.12	27.47	14.7	5.11	0.96	0.64

MSE-Mean of *p .juliflora* seedling emergence **%SE –** percentage of *P. juliflora* seedling emergence

"ANOVA" RESULT

1 .The seedling emergence rate (SER) of *P.juliflora* between sample of animal dropping is significant ($P \leq 0.01$)

ANOVAs: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column1	17	164	9.6470588	38.36764706
Column2	17	32	1.8823529	0.235294118
Column3	17	2	0.1176471	0.110294118
Column4	17	87	5.1176471	7.360294118
Column5	17	18	1.0588235	0.308823529
Column6	17	46	2.7058824	22.22058824

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1037.225	5	207.4451	18.143108	1.23327E-12	2.3092017
Within Groups	1097.647	96	11.433824			
Total	2134.873	101				

2.Number of *P. juliflora* seedling established per sample pot of animal dropping is significantly different ($P \leq 0.01$)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	10	1599	159.9	62.32222
Column 2	10	29	2.9	2.988889
Column 3	10	22	2.2	1.955556
Column 4	10	875	87.5	537.6111
Column 5	10	161	16.1	8.766667
Column 6	10	462	46.2	46.84444

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	191146.5	5	38229	347.2819	9.52E-40	2.38607
Within Groups	5944.4	54	110.08			
Total	197090.9	59				

Appendex-3

Some pictures showing that experimental procedure of the study

A, preparation of green house

B, Measuring & preparation of 10 test sample pots from each type of animal dropping

C, Samples of **donkey** dropping (1.25kg/pot)

D, Samples of **goat** dropping (1.25 kg/pot)

E. Samples of sheep dropping arrangement in green house

F. Sample pots of animal droppings

Figure: **(A-F):** Measuring & preparation of dropping samples in pots for each animal dropping

Plant seed germination & seedling emerge in each sample sample dropping10 day after incubation period (A)

Plant seed germinate and grow from dropping of animals 20 days after IP (B)

(C) Plant seedling emerged from animals dropping 40day after incubation period (IP)

(D) The plant species grow in different sample pots of animals dropping after 50 days.

Figures: **(A-D):** Plant seed germinate and seedling establishment in different sample pots that contain animals dropping in different days.

Declaration

I, the undersigned declare that this Thesis is my original work and it has not been presented in other universities, colleges or institutes for a degree or other purpose. All sources of the materials used have been duly acknowledged.

Name: Kassahun Hialu Degefa Signature: _____Date _____

This work has been done under my supervision.

Name _____Signature: _____ Date _____

_____ Signature: _____ Date _____