ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DUNG SEED BANK OF LIVESTOCK IN WEBERI ADDIS ABABA, ETHIOPIA

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A thesis submitted to the Department of Environmental Science For partial Fulfillment of the requirements for degree of Master of Science in environmental science

Addis Ababa, July 2007

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my advisor Prof. Zerihun Woldu for his inspiring guidance, advice, valuable encouragement, suggesting the specific area of the study and follow up from problem identification up to the completion of the thesis and his consistent help in correcting the manuscript.

I thank the Graduate Studies of Addis Ababa University for its financial support.
I am grateful to Department of Biology and National Herbarium of Addis Ababa University for providing materials and facilitating my work.

I would like to thank my family and all my colleagues for their valuable support.

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Abstract

Dung seed content of cattle, donkey and sheep were studied using a greenhouse technique. Four replicates of 125 g dry weight of dung from each type of livestock were collected during 12 consecutive sessions starting from October 2/2006 – March16/2007 in natural grassland. The comparison is done among animal dung and control as well as within animal dung in 15, 30, 60, 90 and 180 days intervals. Multivariate numerical analysis as resemblance index was used to compare species composition among animals dung sources. A substantial quantity and range of seeds are dispersed by the three livestock species in grazed ecosystems, and this could have a significant effect on the dynamics and species richness of these systems. A total of 7417 seedling from 41 species germinated which is equivalent to 206 germinations per kg of dung. The most abundantly and frequently recorded plant species were *Eragrostis teff and Trifolium tembense* and different *Poaceae* and *Fabaceae* species. Seed density and species richness were further analyzed by Shannon-Weiner Diversity Index.

This study proves the effectiveness of livestock in the dispersal of viable seed via dung. The differences in richness and vegetation composition show clarification over time. This experiment proves the potential utility of this treatment for the restoration of species richness in abandoned pastures.

Key words: Abandoned, endozoochory, livestock dung, restoration**,**
seed dispersal,

1. INTRODUCTION

1.1. Back Ground and Justification

Seed banks are considered essential constituents of plant communities (Harper, 1977), since they contribute significantly to ecological processes. Dung seed banks are reserves of viable seeds present in the dung. The seed bank is an indicator of past and present plant populations. It consists of new seeds recently shed by a plant (Bakker, 1987). Dung seed bank play an important role in ecology and primary productivity of natural grassland particularly where the vegetation influenced by animal species because enormous numbers of viable seeds can be found in the dung (Russi *et al.*, 1989)

Plant seed dispersal by animals is a central process for plant community dynamics and regeneration of species. If large number of seeds can survive digestion in the gut, they may subsequently be disseminated to distant areas. Thus grazing animals can be used to introduce desirable species in to areas undesirable for sowing by conventional method. The seed of many grassland species consumed by grazing ruminants can survive the digestive process in the gut and have been observed as seedling in the dung (Janzen 1984). The recoverability of vegetation after disturbance is believed to lie mainly in the buried seed population (Uhl *et al.*, 1981 and 1982).

The understanding of the dynamics and function of seed banks has become a great challenge to plant community ecologists, as this understanding is necessary to enable determining the role of seed dispersal on the distribution of individuals within populations and on the colonization of new habitats, which in turn affects the rates of gene flow and the genetic structure of plant populations (Dirzo & Domínguez, 1986; Hamrick *et al.*, 1993; Martínez-Ramos & Soto-Castro, 1993; Schupp 1988). Disturbance is one of the most important factors determining the structure and dynamics of ecosystems (Pickett white 1985), enables fugitive species in pastures and other vegetation to persist by preventing their replacement by competitive species (Tilman, 1988) and promoting a shifting equilibrium of small patches in different successional stage (Caswell and cohen1991) .

Grazing facilitates the maintenance and spread of certain species that would be displaced in its absence (Grime, 1979; Lauda, Keeler & Holt, 1990; Gibson & Brown, 1992). Ethiopia has mixed cereal and livestock agricultural system. Low soil fertility, overstocking rates and shortage of animal food are common features. Livestock in the highlands account for 80% of the total population and about 20% of the agricultural gross domestic product of the country (Alemayehu, 1997). The species composition and productivity of the pasture of the common grazing lands are highly influenced by the species of the livestock, the intensity of grazing, climatic and edaphic factors (Zerihun, 1986). Free grazing livestock move to any accessible site and their feeding behavior foraging choice may generate a pattern of association between the plant species and the livestock. This relationship helps in seed dispersal which may be manifested in spatial and temporal difference in ground cover and patchiness. Too much grazing may often lead to land degradation and the loss of biodiversity, while too little grazing may lead to succession from grassland to woodland and the loss of the grassland habitat. Not only is the level of grazing important, but also the timing and the animals species involved. The success of plants and seed situated inside the dung is related to their resistance to their toxic effects from the fresh manure and their ability to penetrate the dung (Welech 1985).

Dispersed seeds defecated in a viable state by livestock play an important role in the recolonization of species, since they get closer to the soil surface in the dung than in soil seed banks. Deposition of seeds with dung gives better chance of survival since sources of nitrogen is available for early seedling growth (Zerihun 1986). Many weed species retain their viability after digestion by animals (Blackshaw and Rode, 1991), new weeds may be introduced, or an increase in the population of existing weeds may occur. However weeds are important feed resource for livestock in land-constrained areas.

Several authors found that large numbers of seeds are dispersed via dung and suggested that endozoochory increases species richness and spatial large-scale homogeneity in grazed systems by intensifying intra- and intercommunity seed flow (Janzen 1984; Russi *et al*. 1992; Gardener 1993; Malo & Suárez 1995a). Essentially, endozoochory transports many seeds to points at varying distances from the parent plant and leaves them in safe sites for germination. The removal of this dispersal mechanism due to changes in grazing patterns can reduce seed input, preventing many species from attaining their normal dispersal rates and hence reducing the probability of successful establishment of plant communities where they are absent (Primack & Miao 1992).Thus, the input of seeds via dung is a potentially simple and inexpensive method, which permits the addition of seeds from the target species to the area under restoration. Endozoochory presumably increases the germination percentage (germinability) and rate (speed) (van del Pijl, 1982).

1.2. Significance of the Study

Seed banks play an important role in the ecology and primary productivity of natural species. Only a few studies put attention to the establishment of plant individuals from endozoochorically dispersed seeds (Wang & Smith, 2002). Due to expanding population of livestock grassland productivity require some attention. The effect of dung application on plant species richness, particularly on the reintroduction of species lost, after grazing abandonment on the dynamic of species composition in the soil seed bank have not been analyzed in depth. Less is known about the survival of seeds of grassland species in the digestive tract and their ecological implication for biodiversity.

1.3. OBJECTIVES

A. General objective

- To study the species composition and richness of germinating seeds in livestock dung

B. Specific objective

- To make temporal comparison of livestock dung seed bank,
- To make comparative assessment of the role of different livestock in maintenance of biodiversity and
- To make a general assessment of the role of livestock in the maintenance of biodiversity of grass land vegetation.

2. LITRATURE REVIEW

2.1. Seed Bank and Dispersal Mechanisms

The seed bank of a plant community represent the memory of previous condition (Templeton and Levin, 1979), and it is an important component of potential of the community to respond to condition in the present and future. The recovery a plant community after disturbance is related to the germination of seed and establishment of seedling, although in some community's vegetative reproduction by perennial plant is another important process (Platt, 1979). Characteristics of disturbances and the storage of germinable seeds vary in both space and time (King, 1976; Thompson and Grime, 1979; Sousa, 1984). Patterns of recolonization on disturbed areas are a function of the characteristics of the disturbance and dynamic of the pool of propagules of which the seed bank is an important part.

Many plant species cannot rely on a long-term persistent seed bank for regeneration after their disappearance from the relict vegetation. Seed dispersal then becomes a serious bottle-neck in restoration management (Verhagen *et al.*, 2001; Pywell *et al.* 2002). Therefore studies on possible seed dispersal mechanisms are of key interest in the understanding of the colonization abilities of plants at the landscape scale.

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 and MacMahon, 1994). Dispersal effectiveness is defined as the contribution a disperser makes to the reproductive success of a plant, and is determined by the quantity of dispersed seeds and the quality by which seeds are dispersed (Schupp, 1993 and 2002). In turn, the quality of seed dispersal can be characterized by the treatment that seeds receive by the disperser and the spatial pattern in which they are deposited (Schupp, 1993 and 2002). Many plant species are dispersed by animals (Ridley, 1930). These plant species include many that have evolved to be dispersed as a result of frugivory (Fleming & Estrada, 1993). Plants profit from seed and fruit dispersal. Seed is important for both the maintenances and the growth of existing population and for the initiation of new populations.

Seed dispersal is an important component of the plant colonization process (Harper,1977) which may influence many key aspects of plant ecology. Dispersal success, however, is constrained by the level of resources available for investment in reproduction, and by the effectiveness of seed dispersal agents. At the community level, dispersal success, measured as the proportion of potential recruitment sites receiving seeds of a given species, has been shown to be extremely low for most species (Hubbell *et al*. 1999). As a consequence, dispersal limitation may be a potentially important mechanism for the maintenance of diversity by greatly slowing the local extinction rate of competitively inferior species (Tilman 1994; Hurtt & Pacala, 1995; Wright, 2002).The importance of consumption for plant dynamics depends both on the frequency and intensity of the interaction and on the availability of time and resource with which to compensate and recover from losses (Dirzo, 1986). In the framework of nature conservation and restoration, seed dispersal by livestock was examined by Welch (1985), Bakker (1989), Malo & Surez (1995) and Stander *et al.*, (1997), who show the potential of endozoochorous seed dispersal in semi-natural landscapes. Moreover those studies indicate that many more plant species are successfully dispersed through endozoochory than previously thought (Pakeman *et al.*, 2002). The lower figure indicates that the dispersal of seed after intake by livestock in temperate grass land.

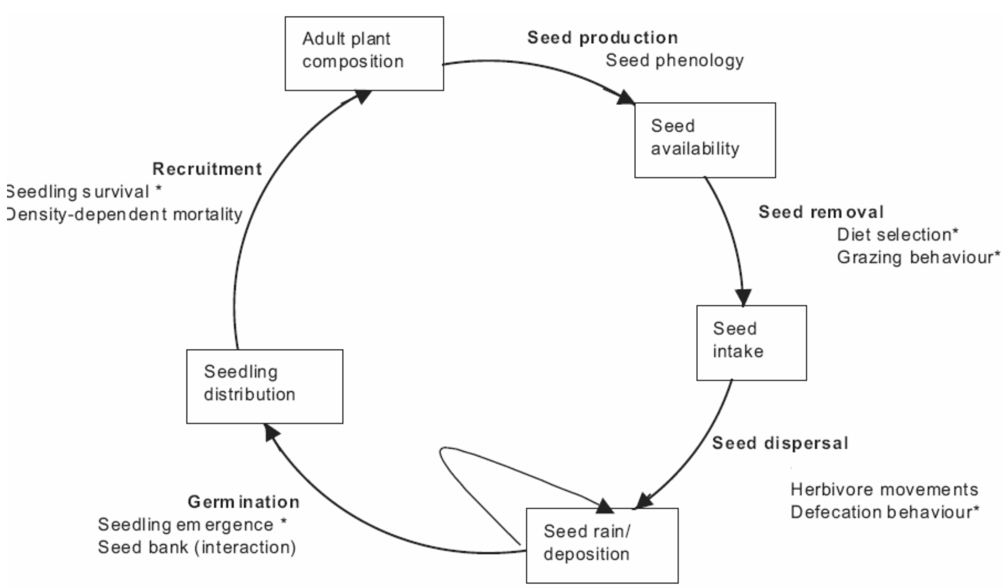

Fig.2.1 The seed dispersal cycle as it happens in grazed temperate habitats with indication of the main patterns (after Wang & Smith, 2002).

2. Endozoochory as a Seed Dispersal Mechanism

Animals can play an important role in the seed dispersal cycle through the active or passive uptake of seeds and the subsequent external (epizoochory) or internal transport (endozoochory) of seeds (Wang & Smith 2002). Depending on the rate of seed passage or adhesive capacities and on patterns of animal behaviors, seeds could be distributed over a large area. Selective habitat use will dictate the specificity of sites where seeds could arrive (Stiles 2000). This potential for directed long distance seed dispersal may be an important aspect of zoochory as compared to other dispersal mechanisms. Kempski (1906), Adams (1907) (cited in Bonn & Poschlod, 1998) and Kerner von Marilaun 1916 (cit in Consyn, 2004) had run some experiments with cattle and horses to get insight in the importance of the endozoochorous seed dispersal process within an agricultural context, e.g. by grazing livestock or by spreading of the livestock manure. Further attempts were made by (Consyn ,2004) who investigated the survival capacity of gut-passed seeds of a selection of investigated the survival capacity of gut-passed seeds of a selection of temperate grassland species.

Endozoochory (diaspores inside an animal) is one of the most important dispersal processes in grasslands under extensive livestock grazing. Several studies have shown that large numbers of seeds are dispersed via dung and suggested that endozoochory increase species richness and large-scale homogeneity in grassland system. A number of plant species which have small seeds with out obvious external, morphological adaptations to a certain dispersal mode, endozoochory may well be the normal dispersal mode for these unassisted seeds. Moreover plants and seeds are selected for this dispersal mode. At the time of seed set plants may promote herbivory by large ungulates to achieve seed dispers Quinn *et al.,* (1994) could underpin this hypothesis in the case of Buffalo grass (*Buchloe dactyloides).* The effectiveness of endozoochory by small herbivores may change as communities develop and mature. It is predicted that effectiveness will be greater in younger communities where a greater proportion of species are annuals, which depend upon recruitment solely from seed sources, and seed limitation of recruitment is likely to be more prevalent (Turnbull *et al.,* 2000). Welch (1985); Malo and Sua´rez

(1995); Poschlod and Bonn (1998) and Pakeman *et al*., (2002) mention large and medium sized herbivores as potentially important seed dispersing agents in a variety of graminoid rich habitats. There results indicated that many grassland species that were assumed to show no specific dispersal adaptations may well be adapted one way or the other to endozoochory (Janzen, 1984). That way, grazers would be indispensable vectors for seed dispersal and establishment of many plant species in temperate grass-dominated habitats. Dung deposition may help to create gaps for the seeds present in the dung. If endozoochory proves to be important as a dispersal mechanism, this would be very important for nature management. Malo and colleagues (Malo *et al.*, 1995; Malo and Suarez 1995a, b) studied the soil seed bank in relation to seed dispersal by rabbit and cattle dung, and conclude that endozoochorous dispersal by rabbits and cattle increase the number of germinable seeds richness and diversity of the seed bank. The lower figure indicates the description of how plants are established from animal dung (Cosyn, 2004).

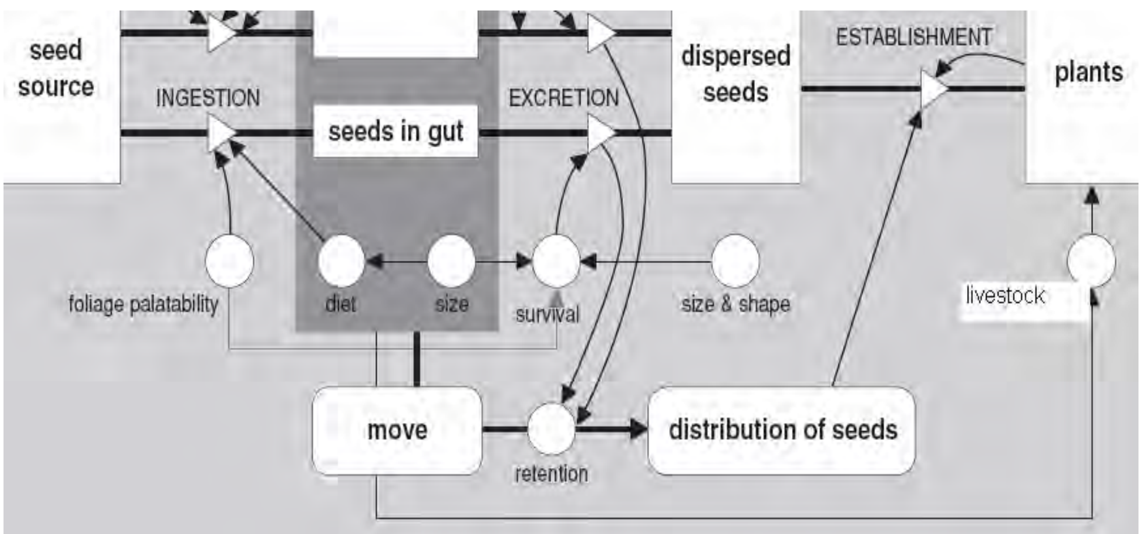

Fig.2.2. Schematic representation of the relation ship between livestock, seed dispersal, establishment (after Mouissie, 2004)

2.3 G razing as Maintenance of Some Species

Most grasslands require periodic defoliation to control succession, if they are not succeeded to scrub and ultimately woodland. The grazing animal has a unique role to play. This is to maintain and enhance structural heterogeneity of the sward canopy, which in turn has a vital influence on diversity. Probably the most important mechanism by which grazing animals create sward heterogeneity is selective defoliation as a result of dietary choices both between species and between plant parts within species. This alters the competitive advantage between plant species both by direct removal of phytomass and by altering the light environment and competition for soil nutrients (Bullock, 2000). Grazing studies have traditionally focused on plant biomass consumption and the disturbances produced by herbivores (Crawley, 1983; Sousa, 1984; Belsky *et al.,* 1993). Both processes have been grouped under concepts such as ’loss rate’ ‘and‘disturbance ‘in order to simplify their modeling (Grime, 1997). However grazing alter determinant process in the whole life cycle of plant species and some of these alternative might not be negative for them nor directly dependent on the volume of consumed plant biomass. In general, these aspects of herbivore-plant interaction have received tangential attention (Crawley, 1983). When applied with care, livestock can increase the availability of target seeds in ecological restoration sites.

The impact of livestock on plant communities can be seen as the change in the abundance and composition of species. Herbivores can directly modify recruitment of seedlings by altering seed number or species composition in the seed rain and seed bank (Edwards and Crawley 1999a; Hanley *et al*. 1995). In most cases, the effects of herbivores on plant species richness are thought to be positive because of the palatability/competitive ability trade-off. The dispersal of seeds by grazing animals contributes to succession. It is suggested that a plant's luscious foliage performs the ecological role of attracting grazing animals. Seeds eaten are then voided with the droppings at a considerable distance from the parent plants (Consyn, 2004).

Seed consumption by herbivores and dispersal of certain proportion through excrement (ENDOZYCOROUS) has scarcely received attention, in spite of hypothesis on their possible importance in dynamics of herbaceous community (Janzen, 1984). As large herbivores have always been part of natural ecosystems, their complementary role as dispersal vectors may be important for maintaining species richness. Much attention was given to the contribution of livestock to plant diversity patterns, both at the local and landscape scale, through their activities of selective grazing, trampling and defecating, which influence processes that enhance local extinction rates. Yet herbivores may also influence plant diversity through processes that affect colonisation rates (Olff and Ritchie 1998).

2.4. Factors Which Determine the Seed Contents of the Dung

The amount of germinable seeds in herbivore dung will not only depend on the amount of consumed seeds but also on seed traits favoring survival of the gastero-intestinal tract after seed ingestion. Janzen (1984) hypothesized that successful endozoochores most probably would have sufficiently small, tough, hard and inconspicuous seeds to escape the molar mill and spitting response of a large mammal. Seed coats have the ability to resist digestion during a transit period of days to months; this trait is also of evident value in, and selecting for, seed dormancy in the soil and litter. Studies on the internal dispersal of seeds (endozoochory) by hares, for example, indicate that passage through the digestive system may break dormancy and highly enhance germination in species with hard seed coats (Janzen, 1984). The other factors that can greatly influence the fate of seeds dispersed through mammal defecation, is the faecal material that accompanies the seed rain. The presence of dung is an intrinsic characteristic of the primary dispersal event and should be considered when assessing the fate of seeds. To understand about the role of large herbivores in the seed dispersal cycle as it could happen in grazed habitats, it is necessary to examine the different intermediary steps and processes in which these animals are involved. Two main phases are of importance. First, the seed intake phase and second, the seed (dung) deposition itself. The first phase deals with such aspects as diet selection and grazing behavior. The second phase involving such aspects as herbivore movements and defecation behavior. In the latter case the amount of seeds that are still germinable after gut passage is of key importance. Without germinable seeds the seed dispersal cycle will get interrupted (Wang and Smith, 2002).

Large herbivores may passively consume considerable amounts of seeds of small seeded herbaceous plant species while they are eating the foliage of the parent plants, which Janzen (1984) proposed to serve as the attractant for large herbivore dispersal of seeds. Therefore, the plants are assumed to be edible at the time of seed set and the foliage of sufficiently high nutrient value to be attractive to the herbivores. Herbivores will select their food non-randomly and show varying degrees of preference and avoidance (Danell and Bergstr m, 2002). Knowledge on the foraging behaviour and diet composition of the large herbivores will contribute to a better understanding of the potentiality of endozoochorous seed dispersal. The foraging movements and behaviour of frugivorous animals therefore have profound consequences on the spatial distribution of recruits (Bleher & Bohning-Gaese, 2001). In turn, foraging behaviour depends at least in part upon abundance and availability of fluctuating food sources, competing species, intra-group relationships and the activity of predators (Janson, 1985). Animal species differ in their dispersal effectiveness depending upon their behaviour, physiology and morphology (Lieberman, 1986; Levey, 1987; Howe, 1989). Increased seed germination and seedling establishment after dung deposition will affect local plant community composition and structure by increasing species richness or by changing relative abundance values. It has already been demonstrated that several plant species had a larger cover on cattle dung than in the surrounding vegetation due to germination from seeds in the dung (Malo & Sua´rez, 1995b; Welch, 1985).

2.5. Implications for Conservation of Grassland Plant Diversity

Plant diversity is affected by herbivores through their impact on dominant plant species, plant regeneration opportunities and propagule transport (Olff & Ritchie, 1998). The latter has become an important issue in plant ecology in general (Primack & Miao, 1992) and restoration management in particular. The reestablishment of characteristic semi-natural plant communities sometimes fails, due to unsuitable abiotic conditions for the target species or because of biotic constraints (Bakker, 1998; Bakker & Berendse, 1999).

Seed dispersal has become an important issue in plant ecology and in nature management in particular, especially in the fragmented landscape of Western Europe (Primack & Miao, 1992; Bakker, 1998; Poschlod & Bonn, 1998; Bakker & Berendse, 1999). If endozoochory proves to be important as a dispersal mechanism, this would be very important for nature management. Since grazers are frequently used now in nature reserve management, their introduction could be helpful in recolonisation. However, extensive surveys on endozoochory by large herbivores, in which a broad spectrum of plant species is involved, are scarce, certainly in the temperate region of Western Europe (but see Welch, 1985; Dai, 2000; Pakeman *et al*., 2002).

The establishment of plant species is of key importance in maintaining and restoring species richness in temperate, semi-natural grasslands. Several studies (Collins, 1987; Burke & Grime, 1996; Carson & Pickett, 1999) already emphasized the role of disturbance in enhancing plant establishment. Species which have immerged from the dung of livestock can be seen as a trait promoting colonization success by adjusting seeds to their environment (Ehrlén & van Groenendael 1998). Such a mechanism seems reasonable because there is evidence that seeds in dung mainly contribute in a quantitative and qualitative way to seed bank build up (Malo *et al.*, 1995; Pakeman *et al.*, 1999; Dai, 2000).

Whether the dispersal of a seed by a large herbivore is advantageous for ecological restoration depends on a number of questions. Is the seed from a species that is part of the target community? If so, is the location part of an ecological restoration site and is it a favorable location for establishment ('safe site'). Many plant species from grasslands appear to be part of the diet of large herbivores and most of these species have at least some probability of surviving chewing and digestion.

Grazing by livestock have become an important nature management tool for conservation and restoration of many habitats in northern temperate regions. Hence, the impact of large herbivores on plant communities has become a critical issue in conservation and restoration ecology (Bakker, 1998). Until now much attention was drawn on the contribution of livestock to plant diversity patterns, both at the local and landscape scale, through their activities of selective grazing, trampling and defecating, which influence processes that enhance local extinction rates. But herbivores may also influence plant diversity through processes that affect colonization rates (Olff & Ritchie, 1998; Bakker & Olff, 2003). Moreover, due to their habitat preferences (Cosyns, 2004) herbivores may connect suitable habitats across different spatial scales. However, this does a priori not guarantee successful establishment of a population (Primack & Miao, 1992). It further became clear that seeds of a considerable number of plant species represented in dung are able to form a persistent seed bank, which can be seen as a trait promoting colonization success by adjusting seeds to their environment (Ehrle´n & van Groenendael, 1998). Such a mechanism seems plausible because there is evidence that seeds in dung contribute in a quantitative and qualitative way to seed bank build up (Malo *et al*., 1995; Pakeman, Attwood, & Engelen, 1999; Dai, 2000). Moreover, activation of the seed bank generally depends on disturbance of the local situation for instance by herbivore activities such as trampling, digging, rooting up etc. Hence, the interaction of the dung seed content with the soil seed bank may be important in determining the final chance of establishment, but this needs further attention (van Wieren & Bakker, 1998). The growing evidence of the role large herbivores could play in the seed dispersal process urge for a well-considered nature management policy that not only focuses on amelioration of habitat conditions, but also considers the spatial arrangement of suitable but still unoccupied patches for critical plant species in order to enable plants to bridge gaps in space and time, which may favor a sustainable conservation of critical plant populations.

Manual seed collection is extremely time consuming (Stevenson *et al*., 1995), whereas seed harvesting with vacuum machines has a limited effectiveness and damages the vegetation and the invertebrate communities of the donor site (Stevenson *et al.,* 1997). Commercial seed mixtures also lack many of the target species and their ecotypes (Lippitt *et al.,* 1994; Chapman & Younger 1995). In contrast, livestock dung sowing has certain advantages. It permits the small-scale reproduction of the natural effect of herbivore defecation, accelerating the process with the dung crumbling stage. It is also inexpensive; permits the use of different genotypes, ecotypes, and varieties with little additional effort; and reduces the likelihood of environmental, climatic, or eco physiological limitations hindering the success of the restoration process (Lippitt *et al*., 1994).

3. MATERIALS AND METHODS

3.1. Study site:

Dung collection was carried out in Weberi Berehe wereda which is 20 km north of Addis Ababa; (09°05.24' N, 038°55.13' E, elevation 2453m). The average annual precipitation is (274-1212 mm), annual Temperature is (15-30°C). The dung collection site was adjacent to an abandoned pasture. The selected area is grazed by different species of livestock. The study area is an agricultural landscape dominated by perennial grasses of *Pennisetum schimperiana*, *Eragrostis tenuifolia* and *Trifolium spumosum*.

Fig 2.3 Ariel view of Study area modified from Google earth 2007

3.2. Dung collection:

Dung sample of cattle, donkey and sheep was collected each day from the grazing area for 15 days and composite samples of dung of each species of livestock were prepared separately. The plant species which were covered by dung and those surrounding the dung could be a potential source of seed-contamination. To avoid possible seed contamination freshly deposited dung was immediately collected, leaving the lowermost part of the dung untouched. The dung were made to dry under shade, and 1 kg of dung sample were brought to the green house spread on a flat surface to dry for further two days. The dung was carefully crumbled to avoid seed distraction and homogenized. The dung collections were conducted for six months starting from the 2nd of October and continue until 16th March, within 15 day interval and these made up a total 12 samples for each animal species.

3.3. Greenhouse germination experiment:

Four replicates of 125 +/- 5 g were extracted from each sample and spread in layers of 15.5 cm height 18 cm top diameter and 11.5 cm bottom diameter pots containing 2 kg of soil. To detect possible germination from the potting soil substrate and contamination in the greenhouse, three pots of soil substrate for each sample were also set up during each 15 days. The soil substrates were not sterilized. The control contained the same volume of soil as in the test pots. The use of soil instead of sand provides the necessary nutrients for healthy growth of plants. The samples were watered daily during the whole germination period to maintain moisture. The temperature was not controlled and varied between 14 – 25 °C. Counting of seedlings was conducted as soon as identification of plant species was possible. Seedlings were counted by species at ten day intervals for twelve weeks.

3.4. species identification

Each of the collected plant specimens was identified at National Herbarium (ETH), Addis Ababa University. Species nomenclature follows Flora of Ethiopia and Eritrea volume 1, 3, 4 and 7 Hedberg & Edwards (1989), Edwards *et al.,*(1995), Hedberg & Edwards (1995), Edwards *et al.,* (1997), Edwards *et al.,* (2002), Hedberg & Edwards (2003), Hedberg *et al.,* (2003), Mesfin Tadesse (2004).

3.5. Data Analysis

The master data sets entered into Microsoft (2003) excel spreadsheet with plant species on the rows and dung sources and the control on the columns for each 15 days for six month. Along the columns numbers 1-4 are assigned for cattle, 5-8 for donkey, 9-12 for sheep and 13-15 for control. The entries are counts of the individuals of germinated seed for each species.

Comparison of species richness between animal dung sources and control samples was performed using analysis of variance using Minitab 13.2 (Minitab, 2002). The result of ANOVA were not significant at p=0.05 because of the many zero entries in every columns. It was then decided to use Multivariate numerical methods such as classification and ordination to explore the data and reveal the difference among the samples in any.

Agglomerative Hierarchical Classification with similarity ratio as resemblances index was used to measure similarities among replicates and among dung sources and the control using SYNTAX (Podani, 2000).

Where Similarity ratio=

$$\textbf{SR}=\sum(x_{kj} * x_{ki}) / ((\sum x^2_{ki} + \sum x^2_{kj}) - (\sum x_{ki} * \sum x_{kj}))$$

The dendrograms were drawn using group average option. The comparisons were made for 15, 30, 60, 90 and 180 days to explore the variation among species and time intervals.

For each dung sample the average seed density, species richness, diversity, equitability was calculated using past (Ryan *et al.* 1995).

Diversity: H’ which measures the information content of a sample unit. The units for H are the log of the number of species of equal abundance.

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Equitability (evenness)*:* is Relative Abundance or Equitability is the evenness with which the individuals are spread out among the species in a community.

Equitability (evenness) = $E_H = H / H_{max} = H / \ln S$

Richness= *Species* Richness, which is the number of species in a community.

Where H’ is Shannon Index
S = the number of species
Pi = the proportion of individuals abundance of the i_{th} species
Ln =log $base_e$

4. RESULTS

4.1 Comparisons of species composition between animal dung sources and control seed bank

4.1.1. Analysis of variance

The analyses of variance for all treatments did not show significant differences among the dung sources and the control because of the many zero entries.

4.1.2. Classification

The dendrograms show dung sources on x- axis and the dissimilarity on the y-axis. The magnitude of dissimilarity is an expression of the difference among the dung sources. Clusters joining another cluster at lower dissimilarity can be considered more similar than those joining at higher similarity.

The dendrogram of October 2-16 indicated that there is no clear difference among the replicates of cattle, donkey and sheep dung sources. They occur in one cluster, while the control replicate occurs in another separate cluster. In situations where the replicates of dung sources do not show distinct cluster, but the replicates of one source is mixed with those of another, we can say that there were not difference between or among animals dung (Fig 4.1). Almost similar results were observed in October 17-30 dung samples (Fig 4.2).

The dendrogram of November 1-15 indicates that the replicates of the control and sheep show separate cluster, but donkey and cattle dung are mixed in one cluster (Fig 4.3). In November 16-30 only sheep dung shows distinct cluster while cattle and donkey dung and the control appear in one large cluster (Fig 4.4).

The dendrogram of December 1-15 shows that cattle and sheep dung seed bank aggregate in one cluster while donkey dung seed bank occurs in a separate cluster. The control seed bank also highly separated from the animals seed bank (Fig 4.5).

The dendrogram of December 16-30 shows that only the control seed bank occurs in separate cluster while the dung seed bank of all animals are mixed in one large cluster (Fig 4.6). The dendrogram of December 31-January 14 shows that the replicate of the control, sheep and cattle dung turn out separately but the replicates of donkey dung is dispersed in the cattle and sheep dung replicates suggesting that there were no sharp dissimilarity among dung sources (Fig 4.7).All the dung seed bank as well as the control seed bank occur mixed in one large cluster in January 15-29 (Fig 4.8).There were no clear differentiation between animals dung seed bank and the control seed bank.

The dendrogram of January 30-Feburary 13 indicated that all animal dung seed bank occur in separate cluster except a single replicate of donkey dung mixed in the cluster of the control seed bank (Fig 4.9). The dendrogram of February 14-28 shows that cattle and sheep dung seed bank occur in mixed cluster while those of donkey dung and control appear in separate clusters (Fig 4.10) but in March 1-15 only the replicates of control seed bank shows distinct cluster because of the absence of any species. The dung seed bank of Cattle, donkey and sheep are appearing in mixed one cluster (Fig 4.11). The dendrogram of March 16 shows that cattle and sheep dung seed bank occur in mixed cluster while donkey dung seed bank and the control seed bank are mixed in a separated single cluster (Fig 4.12).

In October (with two halves lumped together) the dendrogram shows distinctiveness among the dung seed bank. Here the replicates of cattle and sheep dung seed bank aggregate in one cluster, while the replicates of donkey dung seed bank and the control seed bank occur in separate clusters (Fig 4.13). In November (with two halves lumped together) the dendrogram indicated that cattle and donkey dung seed bank occurs in single cluster whereas those of the control seed bank and sheep dung seed bank appear in distinct separate clusters (Fig 4.14).

In December (with two halves lumped together) the dendrogram shows that the control is highly separated from the dung seed bank. The dung seed bank separated among animals except that of cattle does not differentiate it self clearly. Sheep and cattle dung seed bank show less separation .Here cattle dung seed bank is divided into two with high affinity to sheep dung seed bank which make a compact cluster in the first half of the month appears to more different than the second half of the month(Fig 4.15).

In January (with two halves lumped together) the dendrogram shows that all animals dung seed bank and the control seed in distinct cluster separately (Fig 4.16).Almost similar results is observed in the month of March (Fig 4.18).But the dendrogram of February shows that the control is highly separated from the dung seed bank . Among the dung seed bank only cattle dung seed bank was separated. Sheep and donkey dung seed bank occur in mixed cluster (Fig 4.17).

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When the data of the month of October and November are fitting together (O-N), the dendrogram shows an increase in distinctiveness among different dung seed banks. Cattle and donkey dung seed bank have aggregated in a single cluster while sheep dung seed bank and the control occupy distinct clusters (Fig 4.19). Lumping of December and January together (D-J), the dendrogram shows, the animals dung seed bank and control clearly segregated into separate clusters (Fig 4.20).The same is true for the animals dung and the control seed bank of February and March (Fig 4.21).

The lumping of three adjacent months (October, November and December)and (January, February and March) as well as the whole study period (October, November, December, January, February and March) lumping into one, cattle ,donkey and sheep dung harbor different seed bank as clearly demonstrated by the separate dendrograms
(Fig 4.22, 4.23and 4.24) respectively.

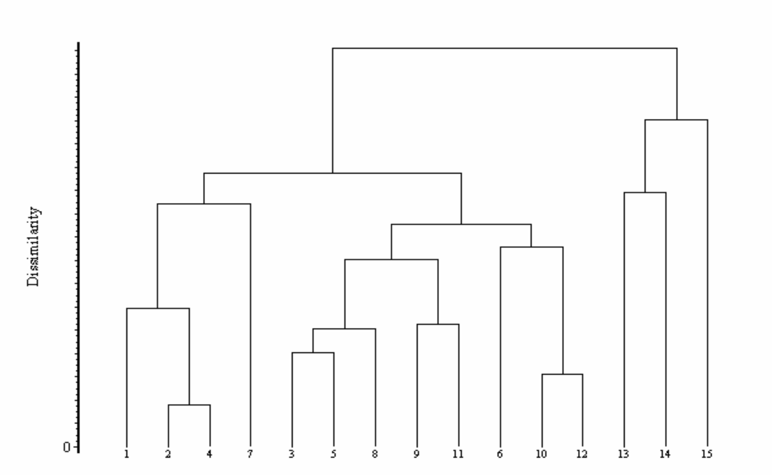


Figure 4.1. Dendrogramof germinated seed in dung replicates and control in October 2-16 (O_1)

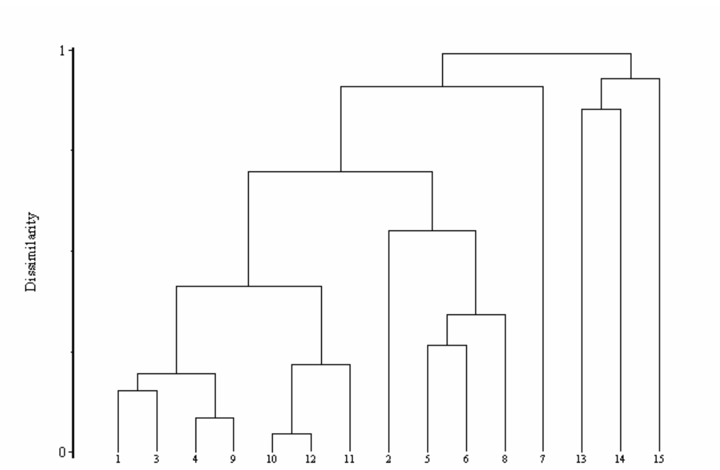


Figure 4.2. Dendrogram of germinated seed in dung replicates and control in October 17 -30(O_2)

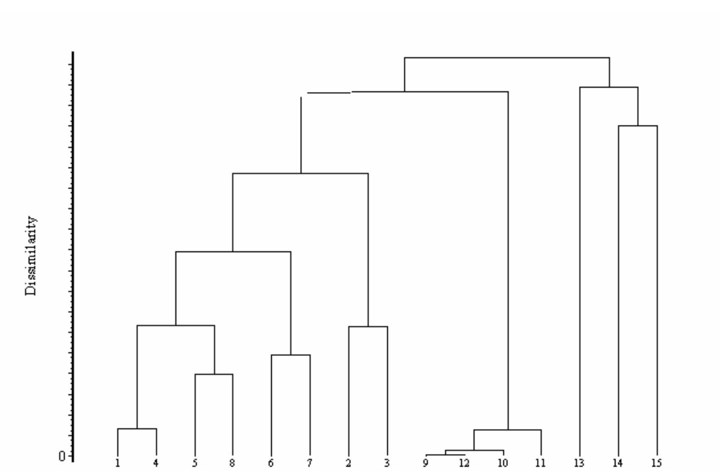


Figure 4.3. Dendrogram of germinated seed in dung replicates and control in November 1-15 (N_1)

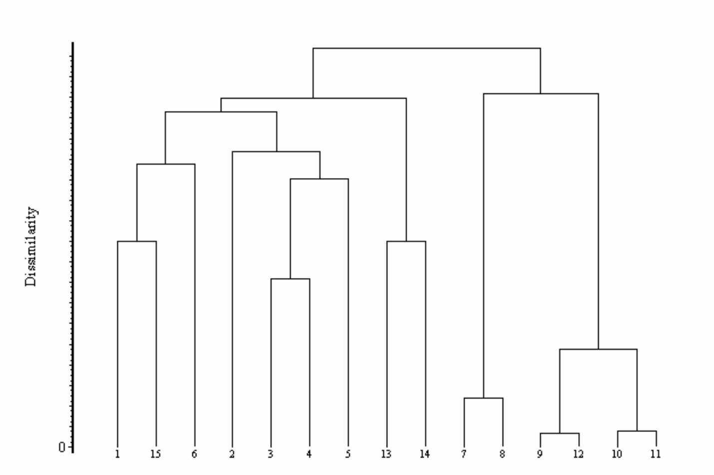


Figure 4.4. Dendrogram of germinated seed in dung replicates and control in November 16-30(N_2)

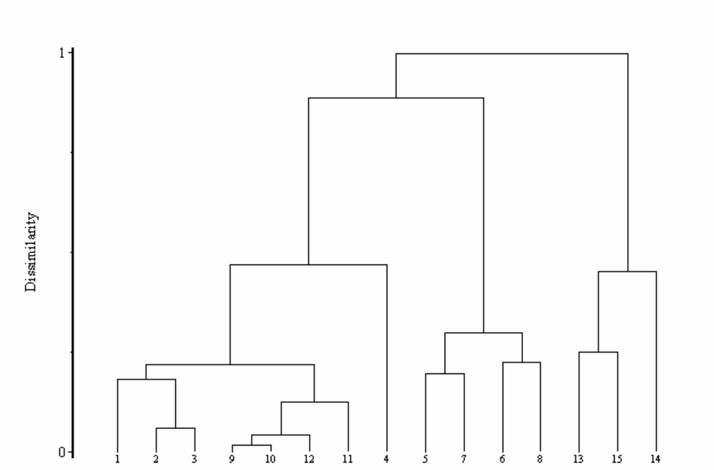


Figure 4.5. Dendrogram of germinated seed in dung replicates and control in December 1-15 (D_1)

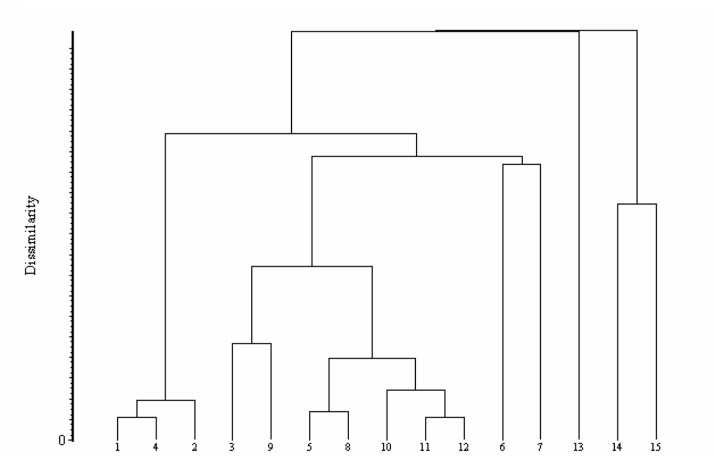


Figure 4.6. Dendrogram of germinated seed in dung replicates and control in December 16-30 (D_2)

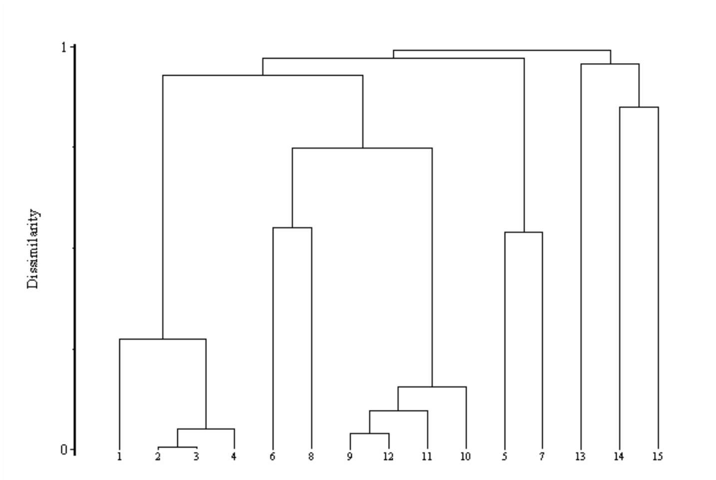


Figure 4.7. Dendrogram of germinated seed in dung replicates and control in December 31- January 14) (J_1)

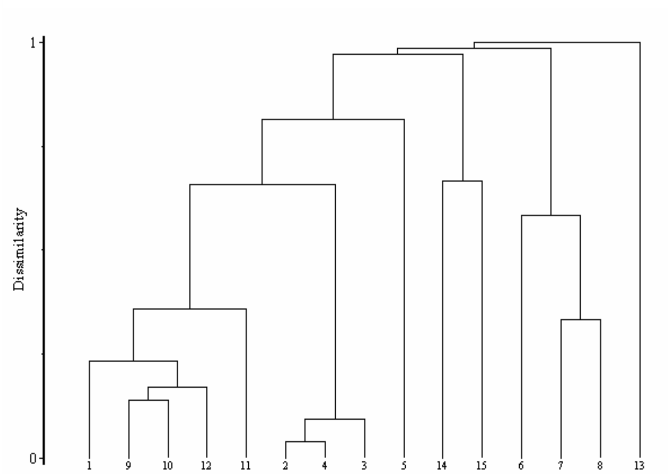


Figure 4.8. Dendrogram of germinated seed in dung replicates and control in January 15-29 (J_2)

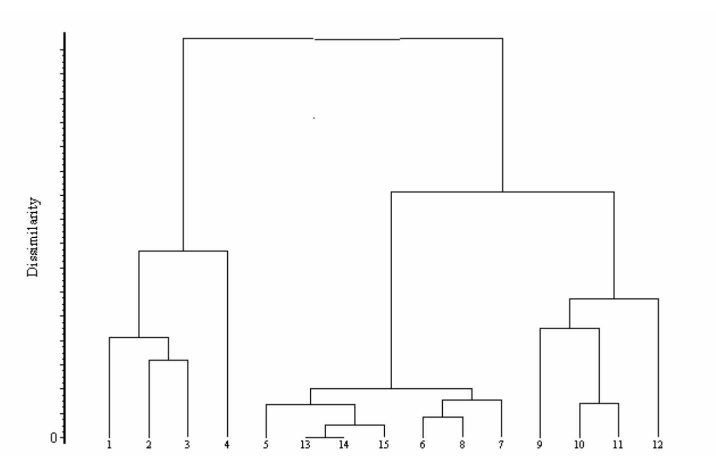


Figure 4.9. Dendrogram of germinated seed in dung replicates and control in January 30- February 14) (F_1)

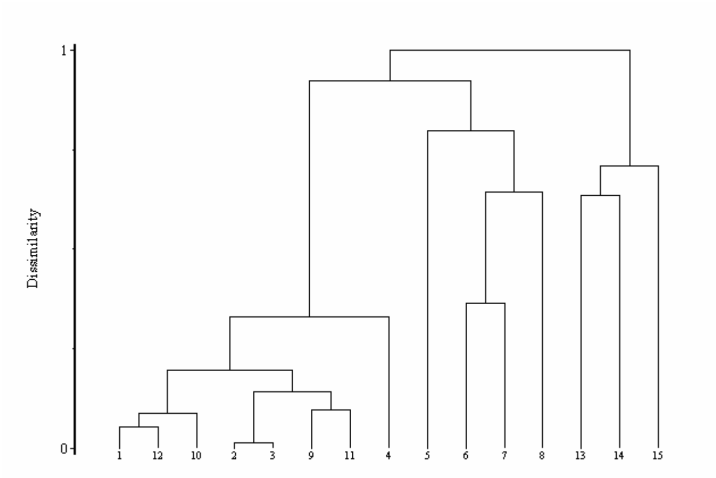


Figure 4.10. Dendrogram of germinated seed in dung replicates and control in February 15-30 (F_2)

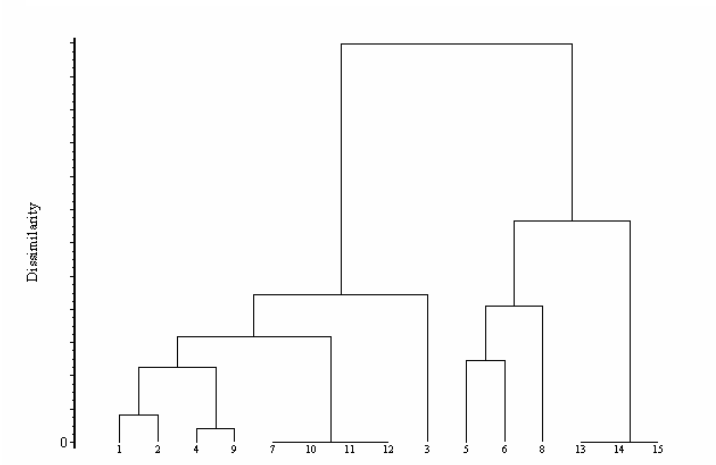


Figure 4.11. Dendrogram of germinated seed in dung replicates and control in March 1-15 (M_1)

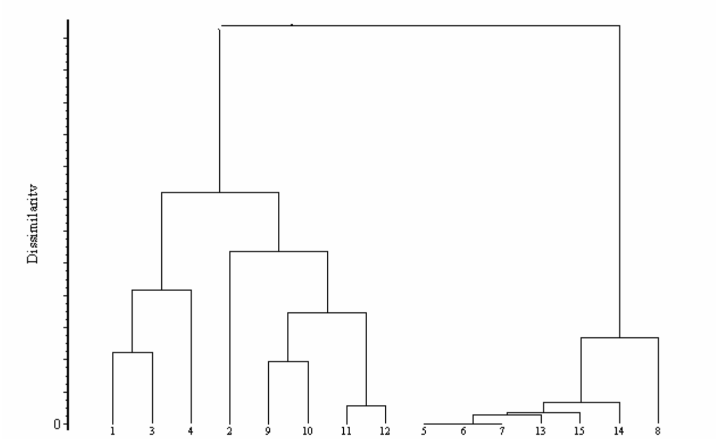


Figure 4.12. Dendrogram of germinated seed in dung replicates and control in March 16 -30 (M_2)

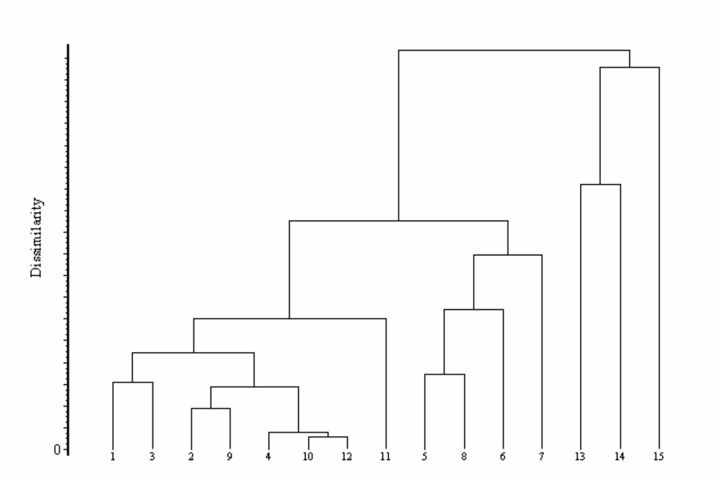


Figure 4.13. Dendrogram of germinated seed in dung replicates and control in October (O)

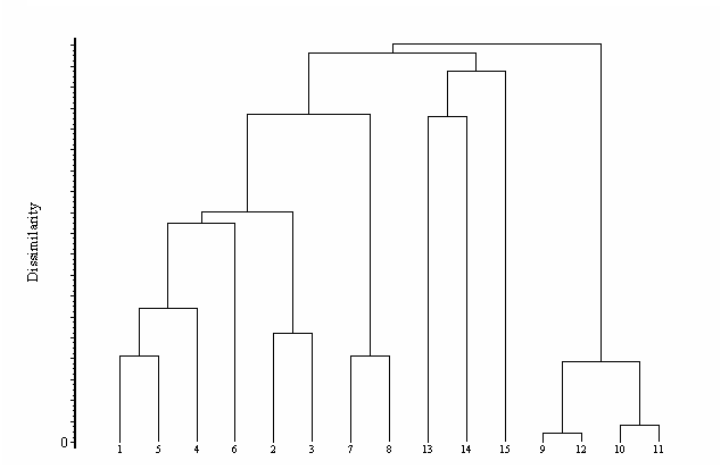


Figure 4.14. Dendrogram of germinated seed in dung replicates and control in November (N)

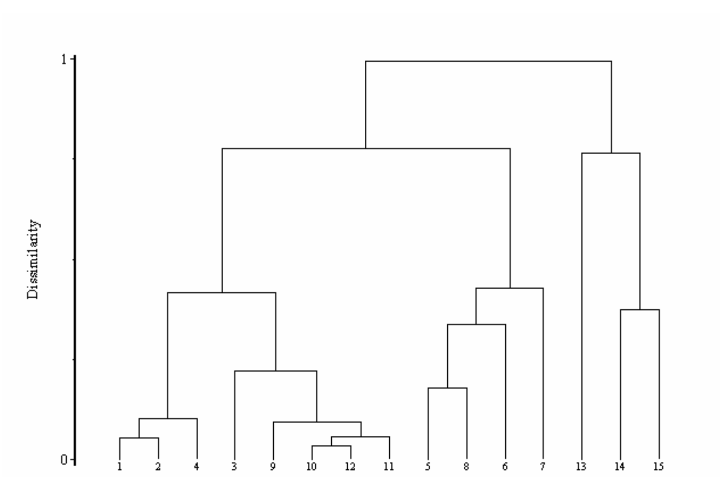


Figure 4.15. Dendrogram of germinated seed in dung replicates and control in December (D)

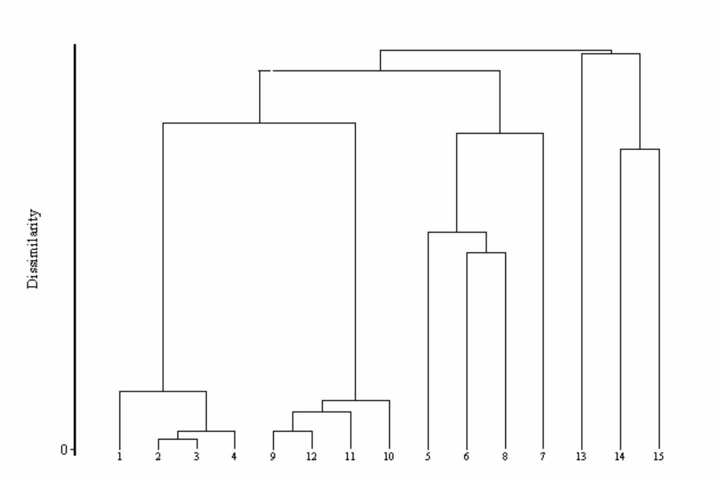


Figure 4.16. Dendrogram of germinated seed in dung replicates and control in January (J)

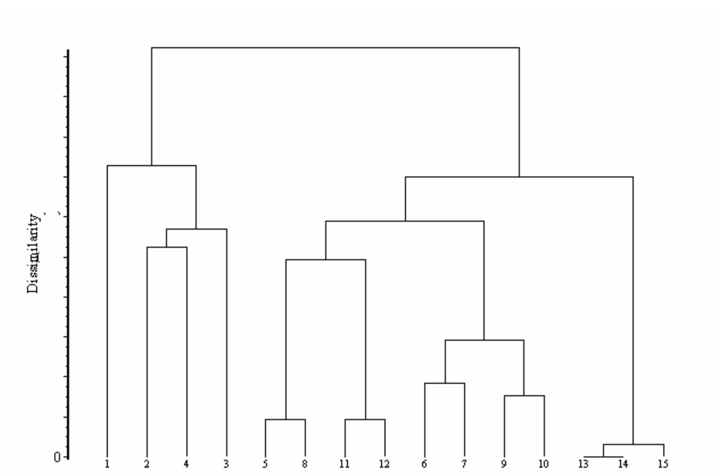


Figure 4.17. Dendrogram of germinated seed in dung replicates and control in February (F)

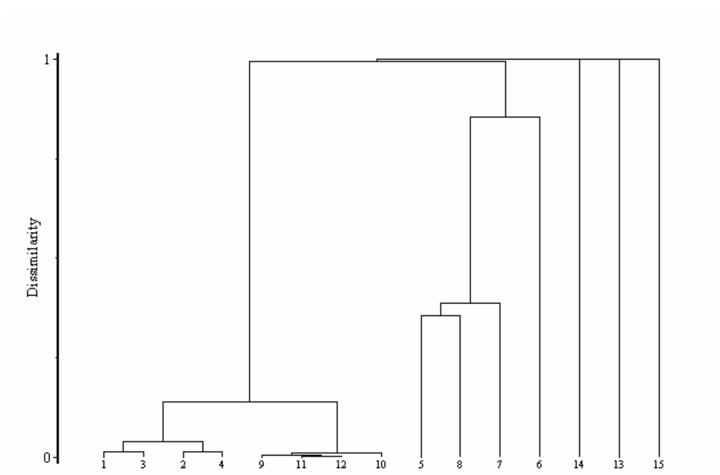


Figure 4.18. Dendrogram of germinated seed in dung replicates and control in March (M)

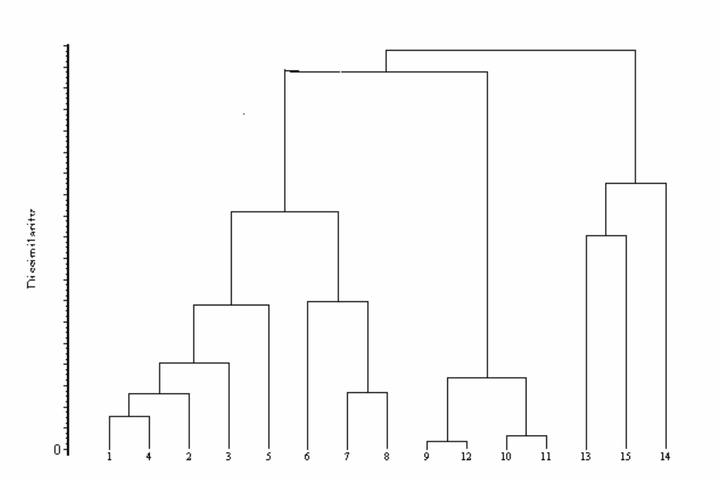


Figure 4.19. Dendrogram of germinated seed in dung replicates and control in October – November (ON)

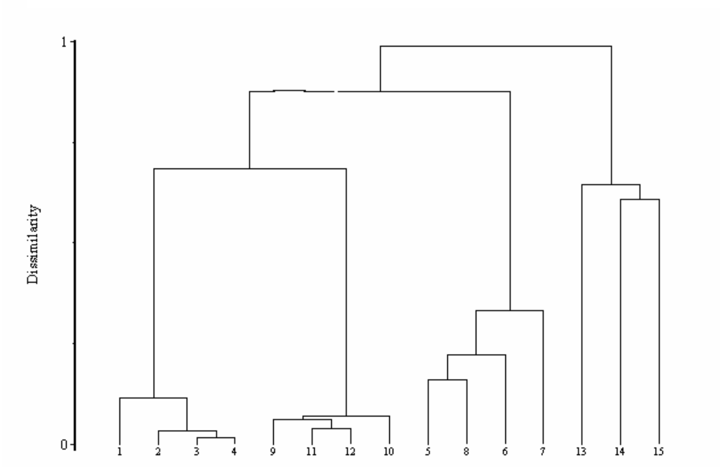


Figure 4.20. Dendrogram of germinated seed in dung replicates and control in December – January (DJ)

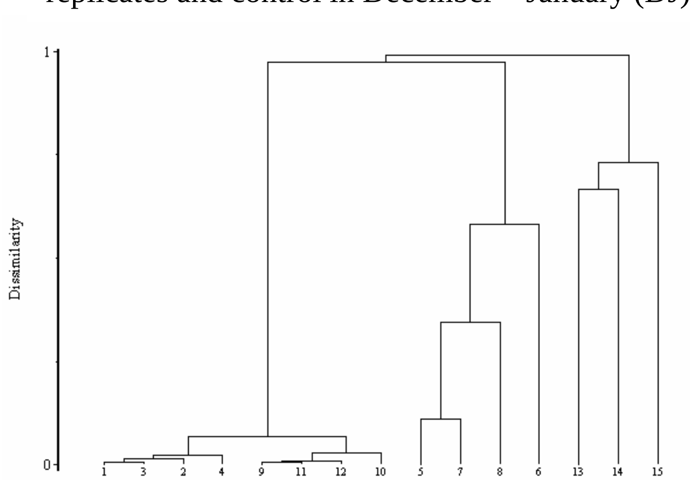


Figure 4.21. Dendrogram of germinated seed in dung replicates and control in February - March (FM)

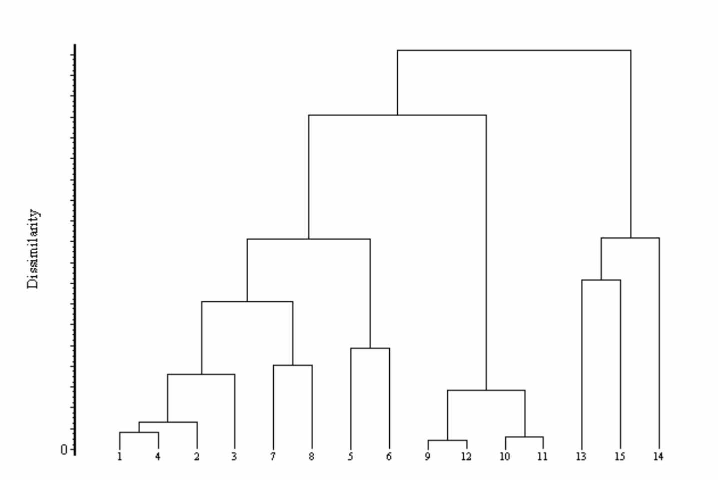


Figure 4.22. Dendrogram of germinated seed in dung replicates and control in October-December (OND)

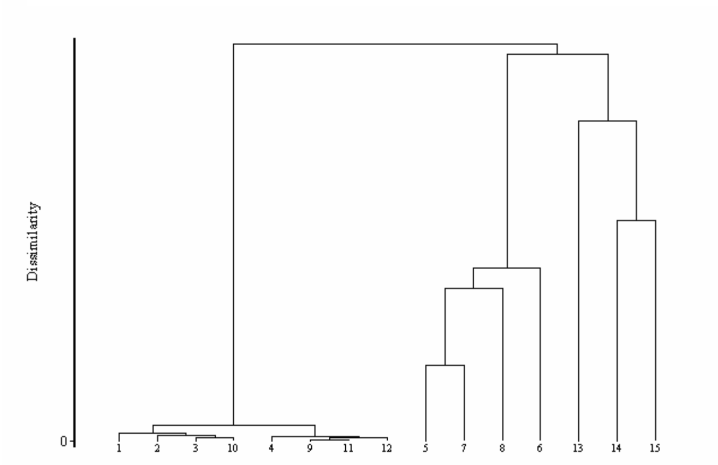


Figure 4.23. Dendrogram of germinated seed in dung replicates and control in January - March (JFM)

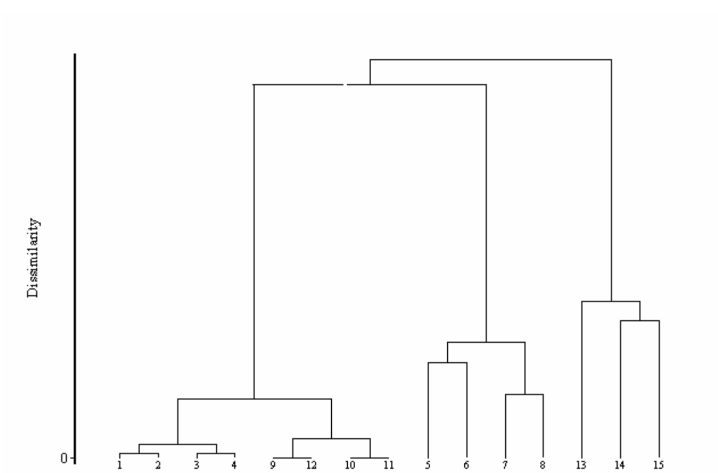


Figure 4.24. Dendrogram of germinated seed in dung replicates and control in October - March (ONDJFM)

4.2 Species Richness and Availability of Seeds in Dung

Cattle, sheep and donkey dung contained number of species (Table 4.2.2a-e). In all samples the control showed lower number of species except in October 2 -16 which was greater than that found in donkey dung (Table 4.2.2a). In each sample of dung seed bank and control there were a number of unique species (Table 4.2.2a-e and 4.2.3a-c).

In October 2-16, eleven species germinated at a rate of 110 seeds/ kg in cattle dung, while it was 12 species at a rate of 58 seeds/kg in sheep dung (Table 4.2.1a and 4.2.2a) .The number of species and the rate was the lowest in the dung of donkey, 6 species at a rate of 56 seeds/kg. A total of 224 seedlings were recorded in the dung seed bank samples (Table 4.2.2a).

In October 17-30 there were 11 species in sheep dung at the rate of 133 seeds/ kg it was the highest density of all animals dung. Cattle dung contained 12 species at the rate of 90 seeds/ kg while donkey dung contained the same number of species as the rate of 36 seeds/ kg (Table 4.2.1a, 4.2.2a). A total of 259 seedlings were recorded in the dung seed bank samples (Table 4.2.2a).

In November 1-15 density of germinable seeds in sheep dung was the highest (with 10 species at the rate of 335 seeds/ kg). There were equal number of seeds and species in cattle and donkey dung (12 species and 59 seeds/ kg) (Table 4.2.1a, 4.2.2a). A total of 453 seedlings were recorded in the dung seed bank samples (Table 4.2.2a).

In November 16-30 four species germinated at the rate of 1169 seeds/ kg in sheep dung while 10 species germinated at a rate of 93 seeds/ kg in donkey dung. The same numbers of species as that of donkey dung germinated in cattle but at lower rate (41 seeds/kg) (Table 4.2.1a, 4.2.2a).A total of 1303 seedlings were recorded in the dung seed bank samples (Table 4.2.2a). In December 1-15 eight species germinated at a rate of 133 seeds/ kg in sheep dung while 11 and 10 species germinated at a rate of 93 and 53 seeds/kg in cattle and donkey dung respectively (Table 4.2.1a, 4.2.2a). A total of 279 seedlings were recorded in dung sources (Table 4.2.2a).

In December 16-30, cattle dung contained 11 species at a rate of 213 seeds/ kg while 9 and 8 species germinated at the rate of 87 and 54 seeds/ kg in sheep and donkey dung respectively (Table 4.2.1a, 4.2.2a). A total of 354 seedlings were found in dung sources (Table 4.2.2a). In December 31-January 14 cattle dung contained 15 species germinated at a rate of 432 seeds/ kg while 10 and 11 species germinated at the rate of 110 and 46 seed/kg in sheep and donkey dung respectively (Table 4.2.1a, 4.2.2a). A total of 588 seedlings were recorded in the dung seed bank samples.

In January 15-30, the highest number of species were recorded in cattle dung 15 species germinated at a rate of 296 seeds/ kg while 10and 6 species germinated at the rate of 120and 15 seeds/kg in sheep and donkey dung respectively (Table 4.2.1a, 4.2.2a). A total of 431 seedlings were recorded in the dung seed bank samples (Table 4.2.2a).

In January 31-Feburary 13, fifteen numbers of germinated seeds at the rate of 260 seeds/ kg is obtained in cattle dung while 6 and 7 species at the rate of 103 and 25 seeds/ kg was found in sheep and donkey dung respectively (Table4.2.1 a, 4.2.2a). A total of 388 seedlings were recorded in the dung seed bank samples (Table 4.2a).

February 14-30 the number of species in dung seed bank were 8,10and 17 species at the rate of 35,341and 333seeds /kg germinated in sheep, donkey and cattle dung respectively, while the trend of H’ is not consistence (Table 4.2.1a, 4.2.2a). A total of 709 seeds germinated in the dung seed bank samples during this period (Table 4.2.2a).

In March 1-15,four species germinated at the rate of 881/kg in sheep dung while 12 and 8 species germinated at the rate of 746 and 28 seeds/kg in cattle and donkey dung respectively(Table 4.2.1a, 4.2.2a).A total of 1655 seedlings were recorded in the dung seed bank samples(Table 4.2.2a).In March 16-30, 7, 9and a single species at the rate of 505, 319 and 2 seeds/ kg germinated in sheep, cattle and donkey dung respectively (Table 4.2.1a, 4.2.2a). A total of 826 seedlings were recorded in the dung seed bank samples (Table 4.2.2a).

Table (4.2.1a) Species Diversity, Richness and Equitability of dung sources and Controls of the sample in 15 days intervals.

Dates	H’				Richness				Equitability			
	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.
Oct 2	1.88	1.33	2.04	2.11	11	6	12	10	0.78	0.74	0.82	0.91
Oct 17	1.62	1.98	0.9	1.75	12	11	11	8	0.65	0.83	0.39	0.84
Nov 1	1.93	1.93	0.53	1.49	12	12	10	6	0.78	0.78	0.23	0.83
Nov16	1.85	1.27	0.52	1.47	10	10	4	6	0.81	0.55	0.38	0.82
Dec 1	1.71	1.40	1.26	1.48	11	10	8	5	0.71	0.61	0.61	0.92
Dec 16	1.53	1.50	1.58	1.77	11	8	9	7	0.64	0.72	0.72	0.92
Dec 31	0.71	2.00	1.52	1.72	15	9	10	7	0.26	0.91	0.66	0.88
Jan 15	1.29	1.53	1.66	1.66	15	6	10	6	0.48	0.85	0.72	0.93
Jan 30	1.60	1.56	0.66	0	15	7	6	1	0.59	0.80	0.37	-
Feb.14	1.26	1.82	0.84	1.36	17	10	8	5	0.45	0.79	0.41	0.84
Mar1	0.55	1.45	0.60	0	12	8	4	0	0.22	0.70	0.43	-
Mar 16	2.00	0	0.76	2.06	19	1	7	3	0.68	-	0.39	0.96

Table (4.2.1b) Species Diversity, Richness and Equitability of dung sources and controls of the samples in 30 days interval

Dates	H’				Richness				Equitability			
	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.
Oct.	1.87	1.96	1.43	2.63	15	14	17	13	0.69	0.74	0.50	1.03
Nov.	1.95	1.82	0.78	1.86	14	13	10	9	0.74	0.71	0.34	0.85
Dec.	1.63	1.79	1.52	2.15	13	13	13	9	0.64	0.70	0.59	0.98
Jan.	1.18	2.08	1.66	2.68	21	10	13	12	0.39	0.91	0.65	1.08
Feb.	1.43	2.10	1.06	1.10	23	14	9	4	0.47	0.80	0.48	0.79
Mar.	1.24	1.39	0.68	0.69	21	8	8	3	0.41	0.67	0.33	0.63

Table (4.2.1c) Species Diversity, Richness and Equitability of dung sources and controls of the samples in 60 days interval

Dates	H’				Richness				Equitability			
	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.
Oct.-Nov	2.05	2.21	1.12	3.18	19	18	18	18	0.70	0.76	0.39	1.10
Dec.- Jan	1.41	2.14	1.69	3.40	23	16	19	17	0.45	0.77	0.57	1.2
Feb.-Mar.	1.40	2.37	0.84	1.67	28	17	12	7	0.42	0.84	0.34	0.86

Table (4.2.1d) Species Diversity, Richness and Equitability of dung sources and controls of the samples in 90 days internal

Dates	H’				Richness				Equitability			
	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.
Oct.-Dec(sp)	2.05	2.33	1.26	3.38	22	21	21	21	0.66	0.77	0.41	1.11
Jan-Mar(sm)	1.35	2.56	0.99	3.15	32	19	18	14	0.39	0.87	0.34	1.19

Table (4.2.1e) Species Diversity, Richness and Equitability of dung sources and controls of the samples in 180 days internals

Dates	H’				Richness				Equitability			
	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.	Cattle	Donkey	Sheep	Con.
Oct.- Mar	1.58	2.52	1.07	5.32	34	25	27	25	0.45	0.78	0.33	1.65

When the 15 days interval was merged, the number of species and density of germinated seeds varied considerably. When the average of October 2-16 and October 17-30 were considered 15 species at a rate of 200 seeds/ kg germinated in cattle dung. Seventeen species at the rate of 191 seeds/ kg in sheep dung while 14 species at the rate of 92 seeds/ kg germinated in donkey dung (Table 4.2.1b, 4.2.2b). A total of 483 seedlings were recorded in the dung seed bank samples (Table 4.2.2b).

When the average of November1-15 and November16-30 (November 2006) was considered 10 species at the rate of 1504 seeds/ kg germinated in sheep dung. Fourteen species at the rate of 108 seeds/ kg germinated in cattle dung while 13 species at a rate of 160 seeds/ kg germinated in donkey dung (Table 4.2.1b, 4.2.2b). A total of 1772 seedlings were recorded in the dung seed bank samples (Table 4.2.2b).

When the average of December 1-15 and December 16-30, the same number of species occur in all dung seed bank (i.e. 13) but the rate of germinated seeds varies, 346,180 and 107 seeds/ kg in Cattle, sheep and donkey dung respectively (Table 4.2.1b, 4.2.2b).A total of 633 seedlings were recorded in the dung seed bank samples (Table 4.2.2b).

When the average of December 31- January 14 and January15-30 was considered 21 species at the rate of 728 seeds/ kg in cattle dung while 13 species at the rate of 230 seeds/ kg were found in sheep dung .The dung of donkey mostly contain the lower number of species i.e. 10 at the rate of 61 seeds/ kg, amazingly control contain greater number of species than donkey i.e. 12 at the rate of 24 seeds/ kg. A total of 1019 seedlings were recorded in the dung seed bank samples of animals dung (Table 4.2.2b).
When the average of January 31- February 13 and February 14-30 , large number of species as well as density of germinated seeds occur in cattle dung 23 species at the rate

of 593 seeds/ kg while 9 and 14 species at the rate of 446 and 60 seeds/ kg germinated in Sheep and donkey dung respectively (Table 4.2.1b, 4.2.2b). A total of 1099 seedlings were recorded in the dung seed bank samples (Table 4.2.2b).

When the average of March 1-15 and 16-30 was considered, 21 species at the rate of 1056 seeds/ kg in cattle dung while 8 species at the rate of 1316 seeds/ kg. The same numbers of species as that of sheep dung germinated in donkey but at lower rate (30 seeds/ kg) (Table 4.2.1b, 4.2.2b). A total of 2402 seedlings were recorded in the dung seed bank samples (Table 4.2.2b).

Table (4.2.2a) Number of total seedling and unique Species of each dung source and control with in 15 days interval.

Dates	Number of unique species					Number of average seedling			
	Cattle	Donkey	Sheep	Control	Total	Cattle	Donkey	Sheep	Control
October 2	2	2	2	5	11	27.5	14	14.5	4.5
October 17	2	3	2	6	13	22.5	9	33.25	5.25
November 1	1	1	1	1	4	16.75	16.75	83.75	3.75
November 16	1	4	1	0	6	10.25	23.25	292.25	3
December 1	5	3	2	4	14	33.25	13.25	23.25	3.25
December 16	3	0	1	4	8	53.25	13.5	21.75	3.75
December 31	7	1	0	3	11	108	11.5	27.5	4
January 15	6	0	1	3	10	74	3.75	30	2
January 30	7	1	2	1	11	65	6.25	25.75	0.25
February 4	6	2	1	0	9	83.25	8.75	85.75	2.5
March1	6	2	0	0	8	186.5	7	202.75	0
March 16	11	0	0	2	13	79.75	0.5	126.25	1.25

Table (4.2.2b) Number of total seedling and unique Species of each dung source and control within 30 days interval.

Dates	Number of unique species					Number of average seedling			
	Cattle	Donkey	Sheep	Control	Total	Cattle	Donkey	Sheep	Control
October	2	3	3	5	13	50	23	47.75	9.75
November	1	1	2	1	5	27	40	376	6.75
December	5	2	1	4	12	86.5	26.75	45	7
January	7	0	0	4	11	182	15.25	57.5	6
February	9	1	0	3	13	148.25	15	111.5	2.75
March	8	0	0	2	10	266.25	7.5	329	1.25

Table (4.2.2c) Number of total seedling and unique Species of each dung source and control within 60 days interval.

Dates	Number of unique species					Number of average seedling			
	Cattle	Donkey	Sheep	Control	Total	Cattle	Donkey	Sheep	Control
Oct.- Nov.	1	3	3	4	11	77	63	423.75	16.5
Dec.- Jan.	8	2	1	4	15	268.5	42	102.5	13
Feb.- Mar.	9	1	0	2	12	414.5	22.5	440.5	4

Table (4.2.2d) Number of total seedling and unique Species of each dung source and control in 90 days interval.

Dates	Number of unique species					Number of average seedling			
	Cattle	Donkey	Sheep	Control	Total	Cattle	Donkey	Sheep	Control
Oct.- Dec	3	5	2	5	15	163.5	89.75	468.75	23.5
Jan. - Mar.	8	1	0	3	12	596.5	37.75	498	10

Table (4.2.2e) Number of total seedling and unique Species of each dung source and control within 180 days interval.

Dates	Number of unique species					Number of average seedling			
	Cattle	Donkey	Sheep	Control	Total	Cattle	Donkey	Sheep	Control
Oct-Mar	6	2	1	5	14	760	127.5	966.75	33.5

In general, the number of species in the dung of each animal increased as the time interval increased. When the average of October and November was considered 18 species at a rate of 1679 seeds/ kg germinated in sheep dung while 19 species at the rate of 308 seeds/ kg germinated in cattle. The same number of species at that of sheep dung germinated in donkey dung but at lower rate (252 seeds/ kg) (Table 4.2.1c, 4.2.2 c). A total of 2239 seedlings were recorded in the dung seed bank samples (Table 4.2.2c).

When the average of December and January was considered 23 species at the rate of 1074 seeds/ kg germinated in cattle dung while19 species at the rate of 410 seeds/ kg germinated in sheep dung. The lower number of species and density of germinated seeds occurred in donkey dung 16 species at the rate of 168 seeds/ kg (Table 4.2.1c, 4.2.2 c). A total of 1652 seedlings were recorded in the dung seed bank samples (Table 4.2.2 c).

When the average of February and March was considered 28 species at the rate of 1658 seeds/ kg germinated in cattle dung while 12 species at the rate of 1276 seeds/ kg germinated in sheep dung. The number of species and germinated seeds were lower in donkey 17 species at the rate of 90 seeds/ kg (Table 4.2.1c, 4.2.2 c). A total of 3024 seedlings were recorded in the dung seed bank samples (Table 4.2.2 c).

When three months are merged and the average of species number and germinated seeds are observed, it became amplified. The average of October up to December was considered 21 species at a rate of 1875 seeds/ kg germinated in sheep dung while 22 species at a rate of 654 seeds/ kg in cattle dung. The same number of species as that of sheep dung germinated in donkey dung but at lower rate (359 seeds/ kg) (Table 4.2.1d, 4.2.2d). A total of 2888 seedlings were recorded in the dung seed bank samples (4.2.2d).

The average of January up to March was considered the highest number of species and germinated seeds occurred 22 species at the rate of 2386 seeds/ kg germinated in cattle dung while 21 species at the rate of 1992 seeds/ kg germinated in sheep dung. Number of species and germinated seeds were lower in donkey dung 19 species at the rate 151 seeds/ kg (Table 4.2.1, 4.2.2 d). A total of 4529 seedlings were recorded in the dung seed bank samples (4.2.2d).

The average value from October up to March was considered 34,27 and 25 species at a rate of 3040, 3867 and 510 seeds/ kg germinated in cattle, sheep and donkey dung respectively (Table 4.2.1e, 4.2.2e). A total of 7417 seedlings were recorded in the dung seed bank samples (4.2.2e).

Table 4.2.3a list of unique species at 15 days interval of time in cattle, donkey, sheep and control

Cattle	Donkey	Sheep	Control
October 2/2006			
Cynodon dactylon	*Plantago lanceolata*	*Solanum marginatum*	*Commelina bengalensis*
Dichrocephala integrifolia	*Polygonum aviculare*	*Solanum nigrum*	*Cotula abyssinica*
			Galinsoga parviflora
			Lotus abyssinica
			Medicago polymorpha
October 17/2006			
Digitaria velutina	*Medicago polymorpha*	*Bidens pilosa*	*Acacia abyssinica*
Eragrostis teff	*Solanum nigrum*	*Rumex bequaertii*	*Amaranthus hybridus*
			Galinsoga parviflora
			Plantago lanceolata
			Vernonia amygdalina
November 1/2006			
Acacia abyssinica	*Trifolium abyssinica*	*Andropogon abyssinica*	*Cotula abyssinica*
November16/2006			
Lychnis abyssinica	*Amaranthus hybridus*	*Andropogon abyssinica*	
	Chenopodium album		
	Poa annua		
	Trifolium siemens		
December 1/2006			
Digitaria velutina	*Cynodon dactylon*	*Andropogon abyssinica*	*Biden pilosa*
Eragrostis tenuifolia	*Oxalis corniculata*	*Eragrostis boteroydes*	*Chenopodium album*
Guizotia scarba	*Tragus berteronianus*		*Cotula abyssinica*
Plantago lanceolata			*Datura stramonium*
Triticum astivum			
December16/2006			
Elusine floccifolia		*Datura stramonium*	*Amaranthus hybridus*
Plantago lanceolata			*Cotula abyssinica*
Triticum astivum			*Galinsoga parviflora*
			Sonchus aspera
December 31/2006			
Cleome hanburyi	*Poa annua*		*Cotula abyssinica*
Digitaria velutina			*Galinsoga parviflora*
Pennisetum clandestinum			*Oxalis corniculata*
Rumex bequaertii			
Solanum nigrum			
Triticum astivum			
Lychnis abyssinica			
January 15/2007			
Cynodon dactylon	*Datura stramonium*		*Argemone Mexicana*
Galinsoga parviflora			*Cotula abyssinica*

Pennisetum clandestinum			*Vernonica amigdanila*
Poa annua			
Triticum astivum			
Lychnis abyssinica			
January 30/2007			
Amaranthus hybridus	*Datura stramonium*	*Eragrostis boteroydes*	*Cotula abyssinica*
Digitaria velutina		*Oxalis corniculata*	
Phalaria paradoxa			
Poa annua			
Polygonum aviculare			
Triticum astivum			
Lychnis abyssinica			
February 14/2007			
Digitaria velutina	*Acacia abyssinica*	*Elusine phyloceph*	*Biden pilosa*
Evolvulus alsinoides	*Cynodon dactylon*	*Medicago polymorpha*	*Chenopodium album*
Lathyrus sativus			*Cotula abyssinica*
Lens culinaris			
Plantago lanceolata			
Poa annua			
Polygonum aviculare			
March 1/2006			
Amaranthus hybridus	*Chenopodium album*		
Elusine floccifolia	*Pennisetum clandestinum*		
Lathyrus sativus			
Polygonum aviculare			
Triticum astivum			
Lychnis abyssinica			
March 16/2006			
Andropogon abyssinica			*Datura stramonium*
Chenopodium album			*Dichrocephala integrifolia*
Digitaria velutina			
Guizotia scarba			
Medicago polymorpha			
Pennisetum clandestinum			
Plantago lanceolata			
Poa annua			
Trifolium simense			
Triticum astivum			
Lychnis abyssinica			

Table 4.2.3b list of unique species at 30 days interval

Cattle	Donkey	Sheep	Control
October 2006			
Dichrocephala integrifolia	*Phalaris paradoxa*	*Biden pilosa*	*Acacia abyssinica*
Digitaria velutina	*Polygonum aviculare*	*Rumex bequaertii*	*Amaranthus hybridus*
	Solanum nigrum	*Solanum marginatum*	*Commelina bengalensis*
			Galinsoga parviflora
			Lotus abyssinica
November 2006			
Acacia abyssinica	*Trifolium abyssinica*	*Andropogon abyssinica*	*Cotula abyssinica*
		Rumex bequaertii	
December 2006			
Digitaria velutina	*Oxalis corniculata*	*Andropogon abyssinica*	*Chenopodium album*
Elusine floccifolia	*Tragus berteronianus*		*Cotula abyssinica*
Guizotia scarba			*Galinsoga parviflora*
Plantago lanceolata			*Sonchus aspera*
Triticum astivum			
January 2007			
Cleome hanburyi			*Argemone Mexicana*
Cynodon dactylon			*Cotula abyssinica*
Digitaria velutina			*Oxalis corniculata*
Pennisetum clandestinum			*Vernonia amygdalina*
Solanum nigrum			
Triticum astivum			
Lychnis abyssinica			
February 2007			
Digitaria velutina	*Acacia abyssinica*		*Biden pilosa*
Evolvulus alsinoides			*Chenopodium album*
Lathyrus sativus			*Cotula abyssinica*
Lens culinaris			
Phalaris paradoxa			
Plantago lanceolata			
Poa annua			
Polygonum aviculare			
Triticum astivum			
March 2007			
Andropogon abyssinica			*Datura stramonium*
Guizotia scarba			*Dichrocephala integrifolia*
Lathyrus sativus			
Plantago lanceolata			
Poa annua			
Polygonum aviculare			
Lychnis abyssinica			
Triticum astivum			

Table 4.2.3c list of unique species at 60 days intervals

Cattle	Donkey	Sheep	Control
October-November 2006			
Dichrocephala integrifolia	*Phalaris paradoxa*	*Biden pilosa*	*Cotula abyssinica*
	Polygonum aviculare	*Rumex bequaertii*	*Commelina bengalensis*
	Solanum nigrum	*Solanum marginatum*	*Galinsoga parviflora*
	Trifolium abyssinica		*Lotus abyssinica*
December-January 2006			
Cleome hanburyi	*Trifolium abbysinica*	*Andropogon abyssinica*	*Argemone Mexicana*
Digitaria velutina	*Tragus berteronianus*		*Cotula abyssinica*
Gyzotia scarba			*Sonchus aspera*
Plantago lanceolata			*Vernonia amygdalina*
Rumex bequaertii			
Solanum nigrum			
Triticum astivum			
Lychnis abyssinica			
February- March 2006			
Andropogon abyssinica	*Acacia abyssinica*		*Biden pilosa*
Guizotia scarba			*Cotula abyssinica*
Lathyrus sativus			*Galinsoga parviflora*
Lens culinaris			*Sonchus aspera*
Phalaris paradoxa			
Plantago lanceolata			
Poa annua			
Polygonum aviculare			
Triticum astivum			

Table 4.2.3d list of unique species at 90 and 180 days interval

Cattle	Donkey	Sheep	control
October- December 2006			
Dichrocephala integrifolia	*Oxalis corniculata*	*Rumex bequaertii*	*Cotula abyssinica*
Guizotia scarba	*Polygonum aviculare*	*Solanum marginatum*	*Commelina bengalensis*
Triticum astivum	*Solanum nigrum*		*Galinsoga parviflora*
	Tragus berteronianus		*Lotus abyssinica*
	Trifolium abyssinica		*Sonchus aspera*
Jan-Mar 2006			
Andropogon abyssinica	*Acacia abyssinica*		*Argemone Mexicana*
Cleome hanburyi			*Biden pilosa*
Guizotia scarba			*Cotula abyssinica*
Lathyrus sativus			
Plantago lanceolata			
Solanum nigrum			
Triticum astivum			
Lens culinaris			

Oct-Mar 2006/07			
Acacia abyssinica	*Tragus berteronianus*	*Solanum marginatum*	*Argemone Mexicana*
Cleome hanburyi	*Trifolium abyssinica*		*Commelina bengalensis*
Guizotia scarba			*Cotula abyssinica*
Lathyrus sativus			*Sonchus aspera*
Lens culinaris			*Lotus abyssinica*
Triticum astivum			

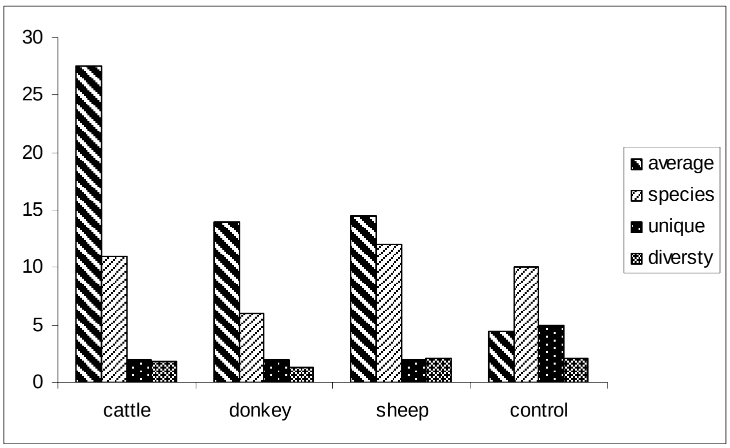
4.3 Species Diversity and Equitability

The result indicated that number of species increases as the time interval increase in all animal dung samples; however, there were also variation within animal dung. This is an indication of species composition variation in different period of time. The diversity and equitability of control is higher in all samples except in January and March. At 15 day intervals diversity and equitability value did not clearly identified among animals dung seed banks (Table 4.2.1 a).But at 30 days interval donkey dung have higher value as compared with sheep and cattle dung except in October (Table 4.2.1b). In 60, 90 and 180 days interval the highest value diversity and equitability obtained in donkey dung, in the contrary sheep dung have lower value of diversity and equitability (Table 4.2.1 c-e).

4.4 Viable Seed Content of Livestock Dung

A total 7417 seedlings emerged from 144 dung samples (on average 206 seedlings per kg of dung) representing 41 different plant species. A total of 34, 25, 27 and 25 different species obtained in the cattle, donkey, sheep dung seed bank and the control seed bank respectively, within six month. Four species were unique for the control seed bank only (Table 4.2.1a-e) .There is viable species found specifically in a single animal dung seed bank as well as in the control seed bank (Table 4.2.3a-d).

The average relative abundance of seedling, amount of plant species and their diversity recorded from animals dung samples and in control seed bank. There were common species occurring in all dung samples and some species exclusively found either in one of the dung seed bank or in the control seed bank (Fig.4.3). *Eragrostis tef* and *Trifolium tembense* were the most abundant germinating species. Seedlings of *Eragrostis tenifolia*, *Eragrostis botroides* and *Chenopodium album* appeared very frequently and were reasonably abundant (Table 4.4). Other plant species showed notable numbers of seedling in part of the samples. Poaceae was the most abundant plant family in the livestock dung followed by Fabaceae and Asteraceae. In dung samples the density of seeds fluctuated within sampling period, it was the highest in November (Table 4.2.2 a-e). *Latirus sativus* and *Lens culinaris* (Fabaceae) were found only in February and March (Table.4.4).



Where

Average =Average number of seedlings
Species=Number of species
Unique=Number of unique species
Diversity=H'

Fig 4.3.1 Bar graph showing the relative magnitude of some variables in dung and control samples in October 2.

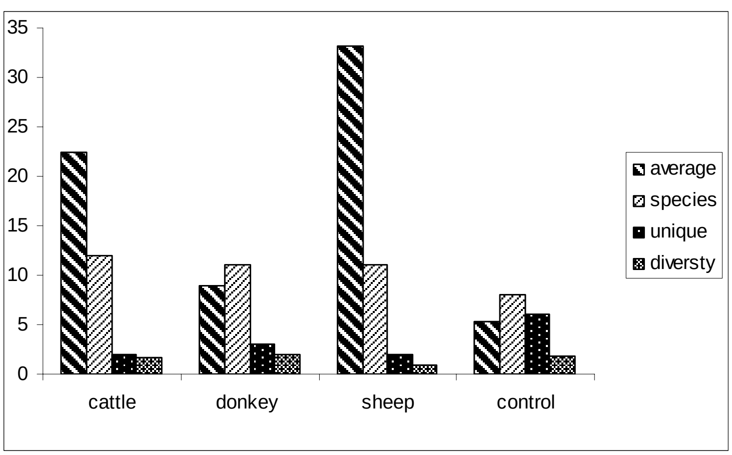


Fig 4.3.2 Bar graph showing the relative magnitude of some variables in dung and control samples in October 17.

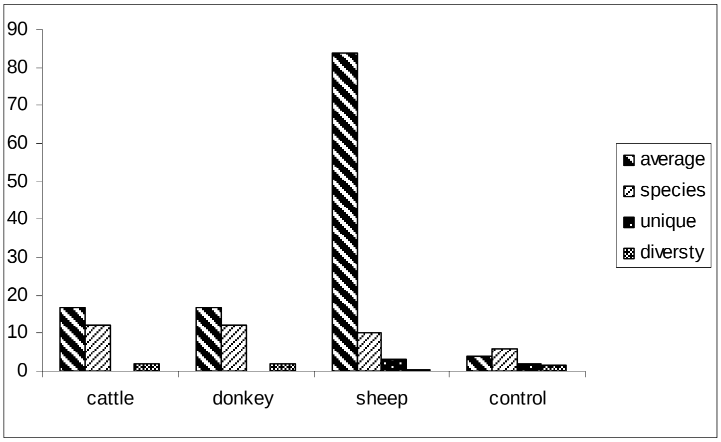


Fig 4.3.3 Bar graph showing the relative magnitude of some variables in dung and control samples in November 1.

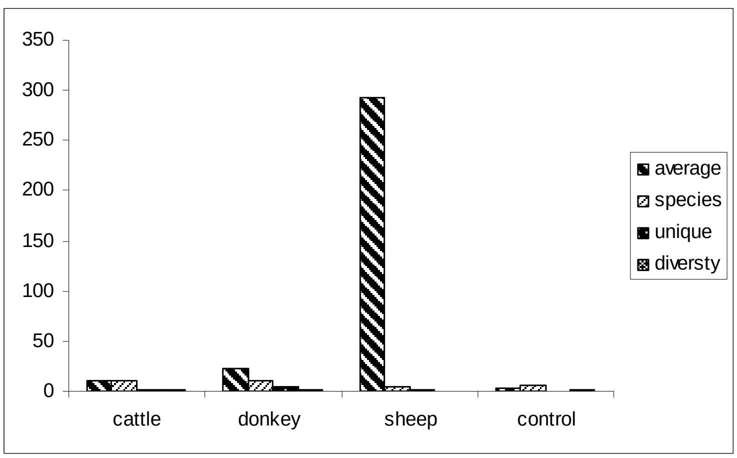


Fig 4.3.4 Bar graph showing the relative magnitude of some variables in dung and control samples in November 16

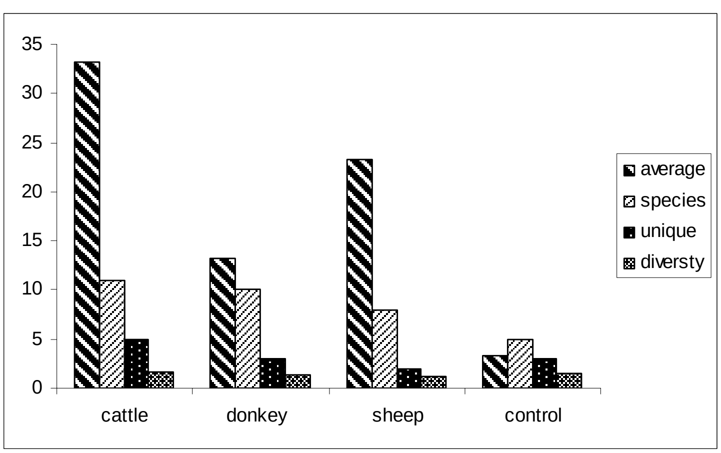


Fig 4.3.5 Bar graph showing the relative magnitude of some variables in dung and control samples in December 1.

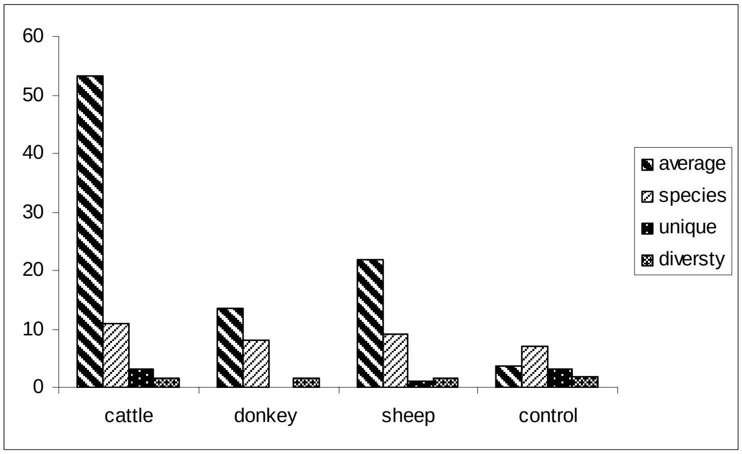


Fig 4.3.6 Bar graph showing the relative magnitude of some variables in dung and control samples in December 16.

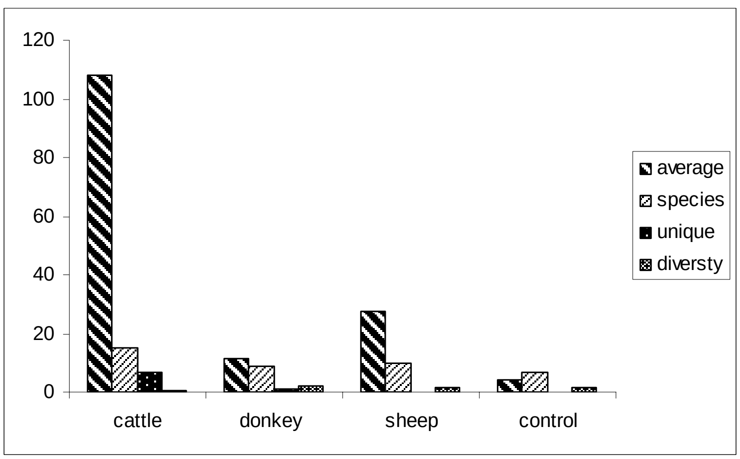


Fig 4.3.7 Bar graph showing the relative magnitude of some variables in dung and control samples in December 31.

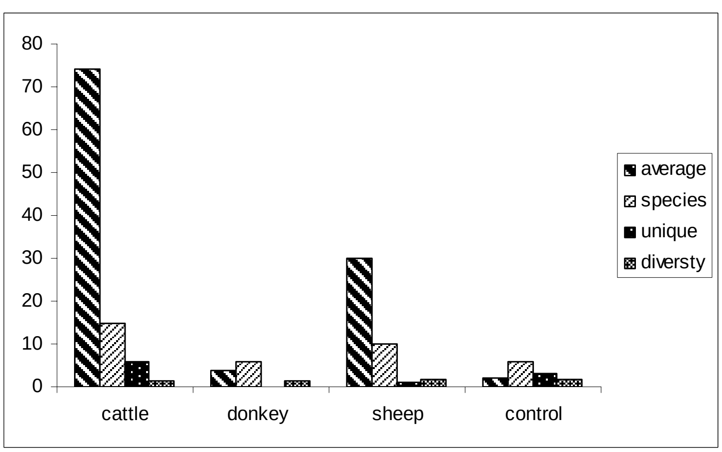


Fig 4.3.8 Bar graph showing the relative magnitude of some variables in dung and control samples in January 15.

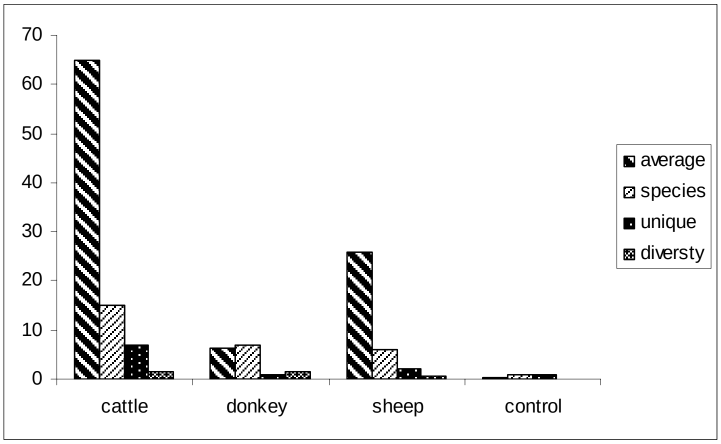


Fig 4.3.9 Bar graph showing the relative magnitude of some variables in dung and control samples in January 30.

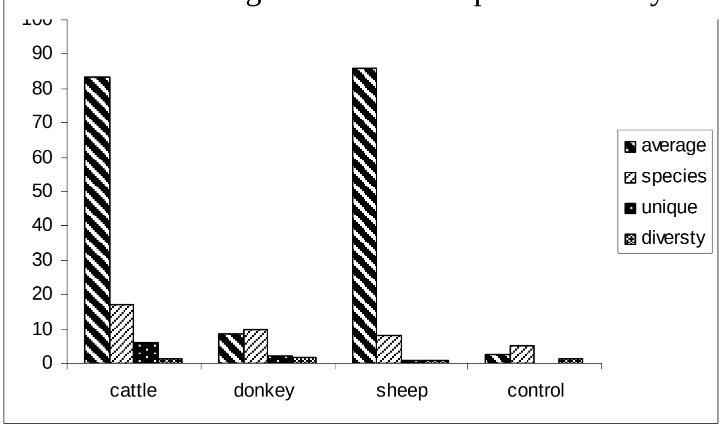


Fig 4.3.10 Bar graph showing the relative magnitude of some variables in dung and control samples in February 14.

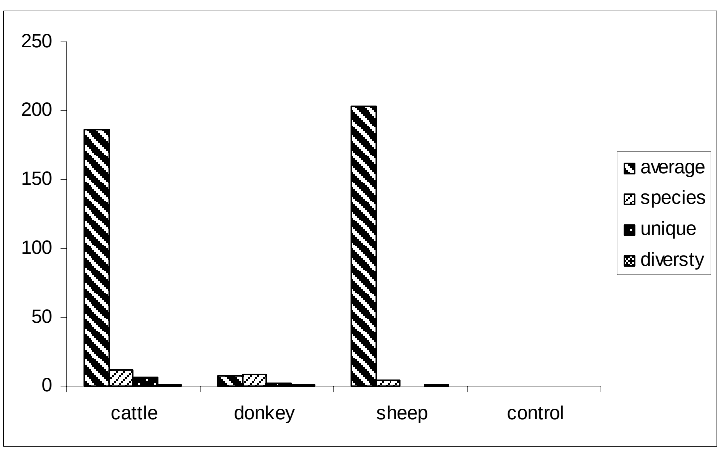


Fig 4.3.11 Bar graph showing the relative magnitude of some variables in dung and control samples in March 1.

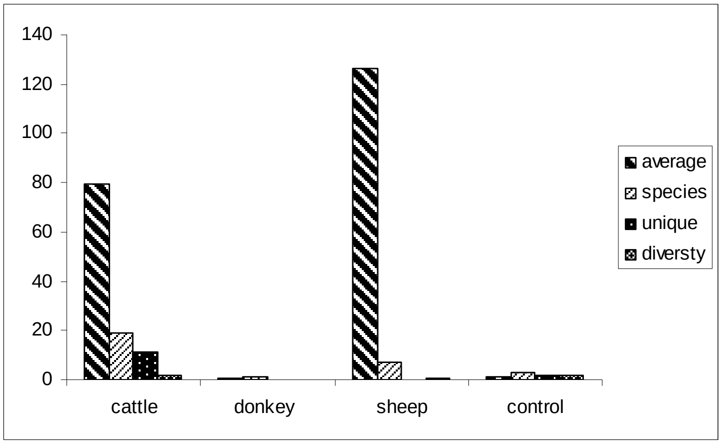


Fig 4.3.12 Bar graph showing the relative magnitude of some variables in dung and control samples in March 16.

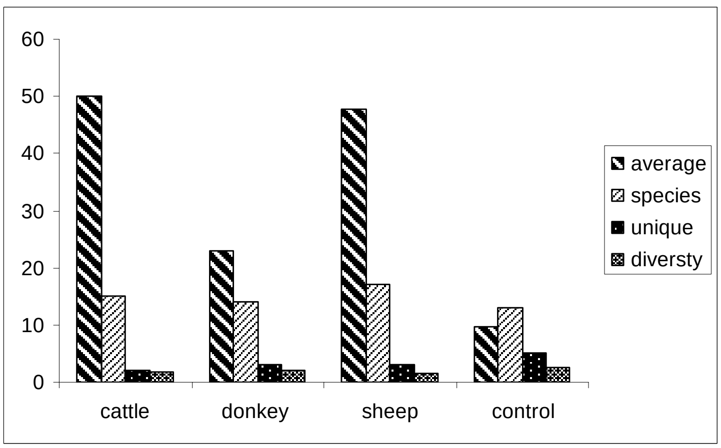


Fig 4.3.13 Bar graph showing the relative magnitude of some variables in dung and control samples in October.

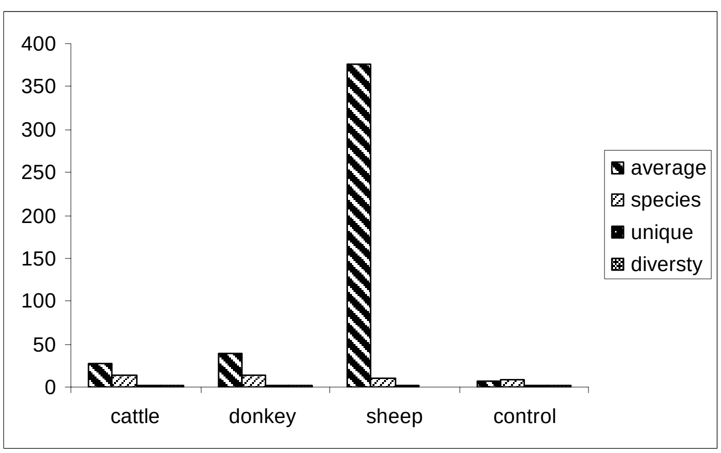


Fig 4.3.14 Bar graph showing the relative magnitude of some variables in dung and control samples in November.

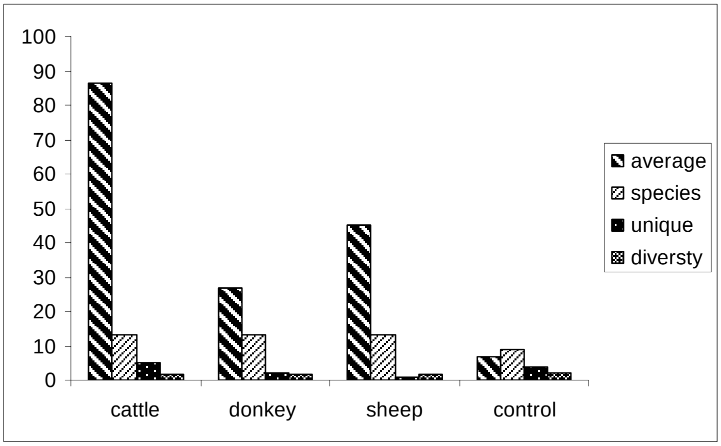


Fig 4.3.15 Bar graph showing the relative magnitude of some variables in dung and control samples in December.

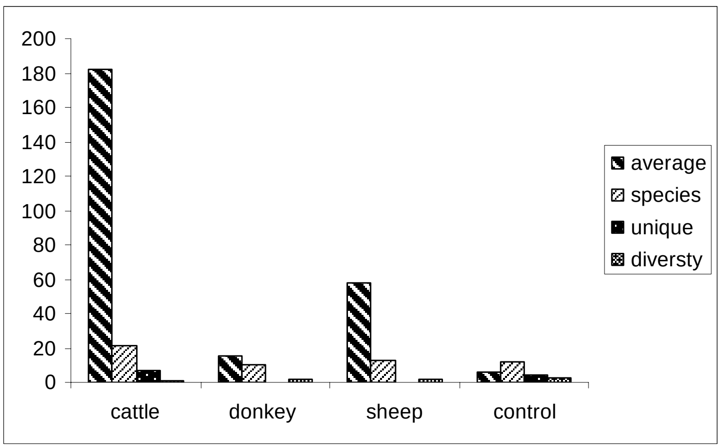


Fig 4.3.16 Bar graph showing the relative magnitude of some variables in dung and control samples in January.

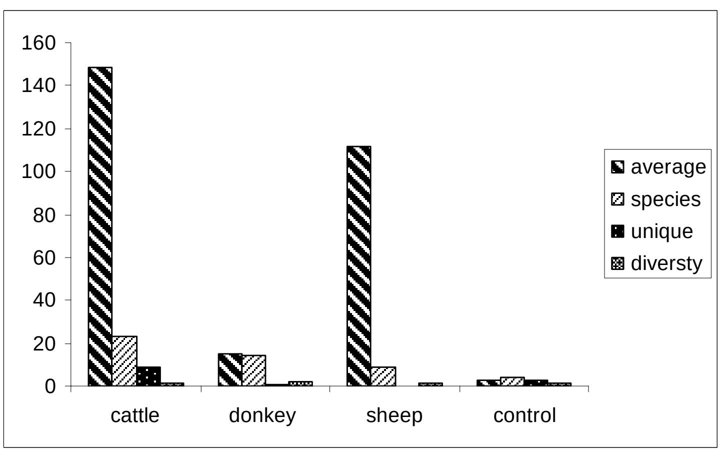


Fig 4.3.17 Bar graph showing the relative magnitude of some variables in dung and control samples in February.

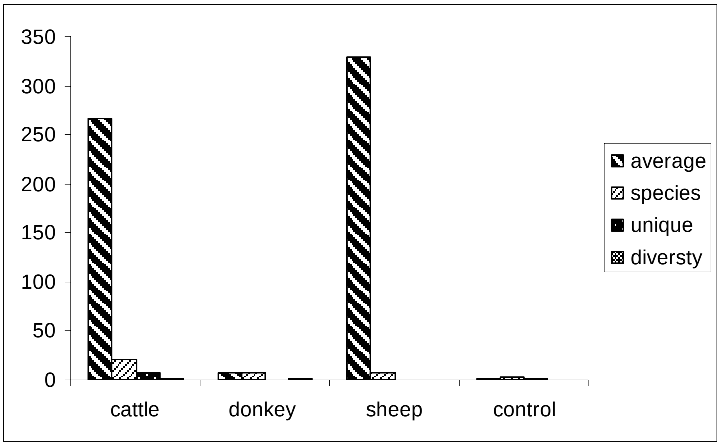


Fig 4.3.18 Bar graph showing the relative magnitude of some variables in dung and control samples in March.

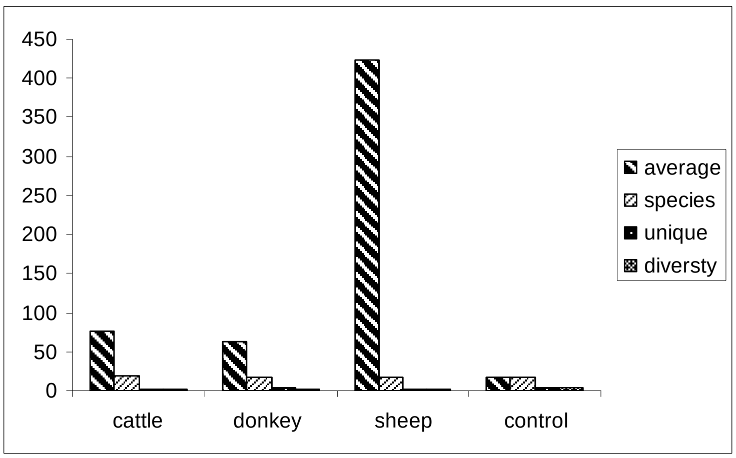


Fig 4.3.19 Bar graph showing the relative magnitude of some variables in dung and control samples in October – November.

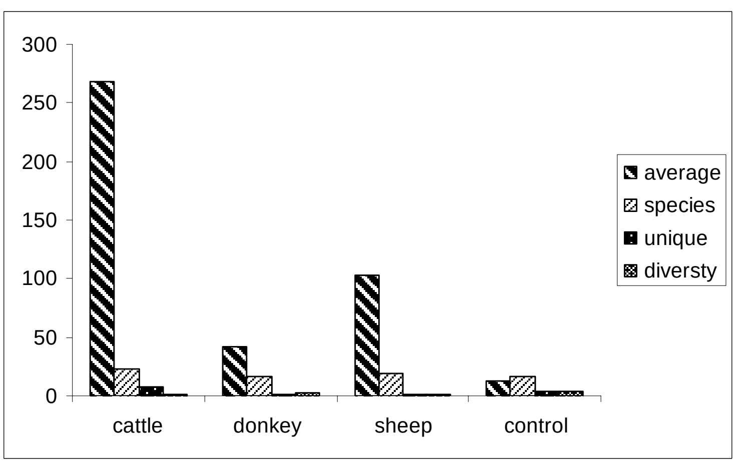


Fig 4.3.20 Bar graph showing the relative magnitude of some variables in dung and control samples in December – January.

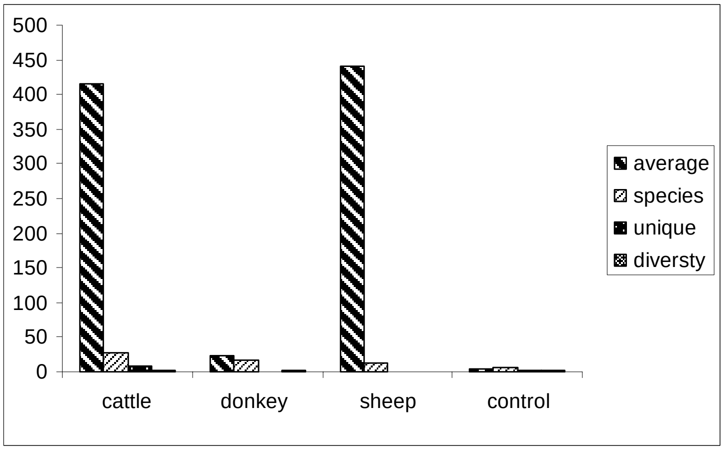


Fig 4.3.21 Bar graph showing the relative magnitude of some variables in dung and control samples in February – March

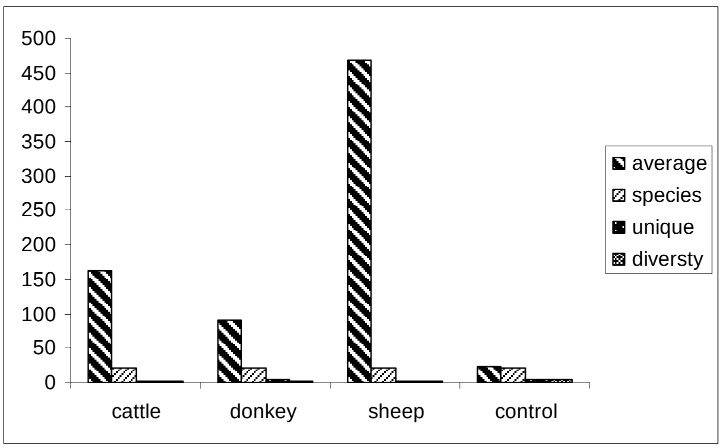


Fig 4.3. 22 Bar graph showing the relative magnitude of some variables in dung and control samples in October – December.

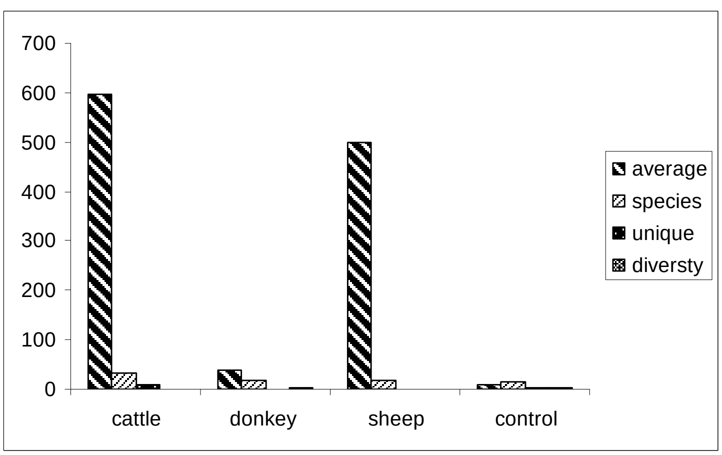


Fig 4.3.23 Bar graph showing the relative magnitude of some variables in dung and control samples in January -March.

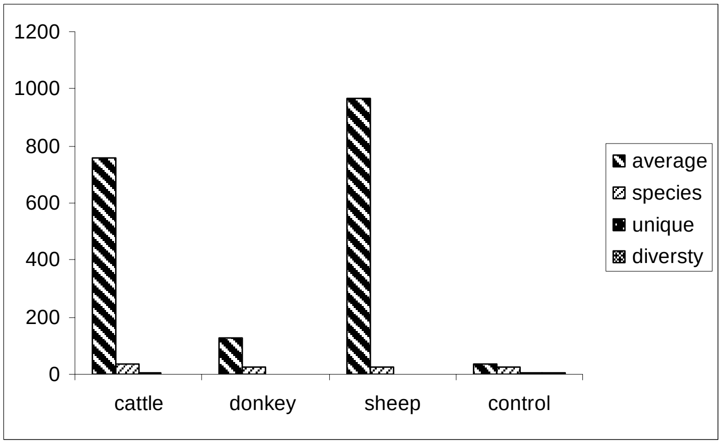


Fig 4.3.24 Bar graph showing the relative magnitude of some variables in dung and control samples in October – March.

Table 4.4. Species found in the dung seed bank and control

	species	family	Number of seeds in dung source			
			cattle	donkey	sheep	control
1	*Acacia abyssinica*	*Fabaceae*	1	0	0	0
2	*Argemone Mexicana*	*Papaveraceae*	0	0	0	1
3	*Amaranthus hybridus*	*Amaranthaceae*	15	11	21	22
4	*Andropogon abyssinica*	*Poaceae*	9	0	5	1
5	*Alopecurus spp.*	*Poaceae*	1	0	1	0
6	*Bidens pilosa*	*Asteraceae*	0	0	4	11
7	*Chenopodium album*	*Chenopodiaceae*	1	7	8	5
8	*Cleome hanburyi*	*Capparaceae*	1	0	0	0
9	*Commelina bengalensis*	*Commelinaceae*	0	0	0	1
10	*Cotula abyssinica*	*Asteraceae*	0	0	0	21
11	*Cynodon dactylon*	*Poaceae*	13	16	6	1
12	*Cyperus sp.*	*Cyperaceae*	2	1	0	0
13	*Datura stramonium*	*Solanaceae*	2	2	4	5
14	*Dichrocephala integrifolia*	*Asteraceae*	5	11	1	4
15	*Digitaria velutina*	*Poaceae*	14	10	0	0
16	*Elusine floccifolia*	*Poaceae*	34	3	8	2
17	*Eragrostis botryoides*	*Poaceae*	10	3	92	1

	species	family	Number of seeds in dung source			
			cattle	donkey	sheep	control
18	*Eragrostis schweinfurthii*	*Poaceae*	0	0	1	2
19	*Eragrostis teff*	*Poaceae*	1660	120	2358	3
20	*Eragrostis tenuifolia*	*Poaceae*	270	38	144	5
21	*Evolvulus alsinoides*	*Convolvulaceae*	4	0	3	0
22	*Galinsoga parviflora*	*Asteraceae*	1	0	0	10
23	*Guizotia scarba*	*Asteraceae*	3	0	0	0
24	*Lathyrus sativus*	*Fabaceae*	2	0	0	0
25	*Lens culinaris*	*Fabaceae*	1	0	0	0
26	*Lotus abbysinica*	*Fabaceae*	0	0	0	1
27	*Lychnis abyssinica*	*Caryophyllaceae*	59	1	1	0
28	*Medicago polymorpha*	*Fabaceae*	26	20	12	12
29	*Oxalis corniculata*	*Oxalidaceae*	4	3	0	1
30	*Pennisetum clandestinum*	*Poaceae*	61	10	17	6
31	*Phalaris paradoxa*	*Poaceae*	8	12	1	0
32	*Plantago lanceolata*	*Plantaginaceae*	6	1	0	3
33	*Poa annua*	*Poaceae*	52	16	7	3
34	*Polygonum aviculare*	*Polygonaceae*	0	1	1	0
35	*Rumex bequaertii*	*Polygonaceae*	3	0	3	0
36	*Solanum marginatum*	*Solanaceae*	0	0	1	0
37	*Solanum nigrum*	*Solanaceae*	1	2	1	0
38	*Sonchus aspera*	*Asteraceae*	0	0	0	1
39	*Spilanthes mauritiana*	*Asteraceae*	0	2	3	0
40	*Tragus berteronianus*	*Poaceae*	0	2	0	0
41	*Trifolium abyssinica*	*Fabaceae*	0	3	0	0
42	*Trifolium siemens*	*Fabaceae*	73	77	4	0
43	*Trifolium tembense*	*Fabaceae*	695	142	8	8
44	*Triticum astivum*	*Poaceae*	19	0	19	0
45	*Vernonia amygdalina*	*Asteraceae*	4	0	0	5

5. DISCUSSIONS

5.1. Comparisons of Species Composition between Animal Dung Sources

The potential of dung seed bank depends on the number of viable seeds consumed by livestock and the effects of digestive system on germination success and mean retention time of germinable seeds. The experiment shows that the variation of the number of species as well as germinated seeds within species in different animals dung. Donkey dung contained fewer numbers of species while sheep and cattle dung contained higher number of seed within a species, even if their amount varies with time. This result is supported by previous surveys of cattle, sheep, rabbit and deer dung (Pakeman *et al*., 2002). These result explained the growth of most plant species in livestock dung. The observed variation in germination success among the animal species indicate the relation between animal species digestive strategy, chewing intensity and effectiveness or body weight and germination success of gut passed seeds. Animal species differ in their dispersal effectiveness depending upon their behavior, physiology and morphology (Lieberman, 1986; Levey, 1987; Howe, 1989).

In the 15 days interval, the compositions of species were not clearly distinctive among the dung of animal species. In October 2 and 17 the germination of plant species showed no clear pattern across animal dung sources (Fig 4.1and 4.2). The dung samples show remarkable similarity across replicates and across dung sources. Only the control replicates were clearly differentiated from dung samples (Fig 4.1 and 4. 2).

In November (1-15) and (16-30) also only sheep dung was clearly differentiated. In the same way in December 1-15/2006 only donkey dung showed variation but in December (15-30) there were not clear differentiation between animal dung sources. This is an indication of similar plant species consumed by different animals. This is expected because during this time there was cultivation of crops in the field and the livestock did not graze freely in the field. The animals are forced to consume almost similar plant species. In January, February and March a single animal dung sample were clearly differentiated, two dung samples show similarity. This is an indication of partial access to free grazing since most of the crops in the farm are harvested. Because of narrowness of the time interval differentiation among animals are not sharp.

In the 30 days interval the dendrogram showed better distinction than the 15 days interval. In October donkey and the control seed bank was segregated where as sheep and cattle seed bank were similar (Fig 4.13). This shows that most of the time cattle and sheep had similar access. At this time the access of grazing for donkey is free than cattle and sheep. It is expected that donkey can graze freely at any time because of its movement for transportation purpose. In November sheep dung showed clear similarity across the replicates and was clearly segregated from the rest whereas cattle and donkey were mixed. The control was also clearly differentiated (Fig 4.14). In January cattle dung and control seed bank segregated whereas sheep and donkey dung seed bank were mixed. This is expected because a wide range of donkey foraging behavior, it can mix with cattle and sheep at different period of time.

In December all dung samples and the control show clear similarity within replicates and clear differentiation is observed among animals dung and controls (Fig 4.15). Similarly in February and March 2007 clear differentiation among animals dung seed bank and the control seed bank were observed (Fig 4.16, 4.17and 4.18). This is an indication of individual animal selectivity of foraging in free grazing field. Foraging behaviour depends at least in part upon abundance and availability of fluctuating food sources, competing species, intra-group relationships and the activity of predators (Janson 1985). This variation found by Shayo & Uden (1998) and Simao Neto *et al.* (1987) who both recovered lower amounts of seeds of tropical plant species from sheep and goats compared with cattle in their feeding experiments. In addition Simao Neto *et al*. (1987) mentioned similar seed passage rates with sheep, goats and cattle and hence attributed the observed large differences in seed recovery to initial mastication and rumination differences between the animal species.

In 60, 90 and 180 days interval the composition of species among animals dung seed bank were clearly differentiated and higher similarities inside replicates except in

October- November (Fig 4.20, 4.21, 4.22 and 4.23). Here cattle and donkey dung seed bank were mixed but sheep dung seed bank and control seed bank segregated. This happens due to lack of grazing land which is occupied by crop cultivation. As a result animals are forced to consume the same plant species around their dwelling (Fig 4.19). In general the dendrograms showed that with increase in time interval the species composition of animals dung become clearly differentiated. At the initial time of the study period it was difficult to differentiate species composition among animals dung but the time is progress and with increase in time intervals the species composition among animal species was clearly differentiated.

5.2. Species Richness and Availability of Seeds in Dung

Dung of livestock is an important vector for the dispersal of plants in grassland both interms of the quantity of seeds and species diversity. The experiment showed that Cattle, sheep and donkey dung contained large quantities of many species. When a species is absent from an area its colonization potential depends on its dispersal mechanisms and the distance its diaspores have to travel to reach the right micro sites for its seeds to germinate (Ehrlén & van Groenendael, 1998). Without the availability of dispersal vectors of appropriate seeds, species from a species-rich source community (in this case grazed pastures adjacent to the abandoned zone) are unable to reach suitable sites to become established in the target community (Bakker *et al.*, 1998; Wijdeven & Kuzee, 2000). The results showed that endozoochory via cattle, sheep and donkey dung increases species richness by facilitating the arrival of species from grazed zones to abandoned areas. These results support other studies that have shown the importance of dung seed bank in grazed ecosystems throughout the world, grasslands in Sweden (Dai 2001, Mitlacher *et al*., 2002) and African Savanna (Miller 1996, Milton & Dean, 2001).

These results support other studies that have shown the importance of endozoochory in grazed ecosystems throughout the world. From this result the restoration potential of cattle and sheep is higher as compared with donkey. The previous author did not quantify seed supply but observed that most species are relatively equally frequent in vegetation as in dung samples (Welch 1985; Malo & Suarez 1995c; Dai, 2001).

The quantity of seeds fluctuates in season as well as between livestock. The importance of seed supply is also reflected in its similarity to seasonal variation in seed density of cattle dung, which was also found by (Malo & Suarez, 1995c). (Table 4.2.1a and b and Table 4.2.2a and b) showed that, within 15 and 30 days interval the experimental results show that in December, February and March high amount of seeds germinated in cattle dung seed bank. But in November the amount of seeds was higher in sheep dung seed bank. The results show that the amount of germinated seed varies in different intervals and duration. (Fig 4.3.1-24) indicate the average germinated seed of different animal species and their species richness.

When the plant species in the dung seed bank of different animals are considered, the germinated seed in dung sources completely varies. At any time interval the amount of germinated seed in donkey dung were lower (Table 4.2.1). The 60 and 90 days interval the results show that higher germinated seed in cattle and sheep dung seed bank occur interchangeably in different months. This indicated that the selectivity of animals vary in month and season due to the availability of different species in the field.

In general the six months results show that large number of species and germinated seed were obtained in sheep dung in all samples followed by cattle dung seed bank (Fig 4.3.24). Quantitatively the potential of dung seed bank becomes obvious when taking into account the animal species. Sheep and cattle dung are capable of providing a number of species, depending on season and animal related characteristics to disperse large amounts of viable seeds. The simple calculation, shown in Table 4.1 and Fig 4.3.24 give the amount of average viable seeds found in individual animal dung source during the study period.

5.3. Species Diversity and Equitability of Dung Seed Bank

Magurran (1988) stated that the term diversity actually consists of species richness and relative abundance (evenness or unevenness). Therefore, donkey dung is the highest in diversity whereas sheep dung is the lowest one (Fig 4.3 1). According to Kent and Coker (1992), the Shannon Weiner index is the most frequently used for the combination of species richness and relative abundance. A value of the index of Shannon-Weiner usually lies between 1.5 and 3.5 although in exceptional case, the value can exceed 4.5 (Pielou, 1969). Thus, the value of Shannon - Wiener Diversity Index of this dung sources occurs between 0 and 2.56. The higher the value of J (equitability), the more even the species is in their distribution. Thus, donkey dung have the highest even distribution whereas sheep dung have the lowest even distribution (Fig 4.3). This is an indication of donkey can consume variety of species.

Probably the most important mechanism by which grazing animals create sward heterogeneity is selective defoliation as a result of dietary choices both between species and between plant parts within species. This alters the competitive advantage between plant species both by direct removal of phytomass and by altering the light environment and competition for soil nutrients (Bullock J.M., Marriott C.A, 2000). Table 4.2.1a and Fig 4.3 show that there were variation of evenness as well as diversity among animals dung source in different interval of time. The results clearly indicated that the diversity and evenness in donkey dung were higher than in sheep dung (Fig 4.3). This is an indication of donkey's access for free grazing at any time. Therefore it has higher potential of regenerating the grazing land in its natural state. Sheep dung has the highest number of species with less diversity index value compare to donkey and cattle dung except in January. In January the value of diversity index was higher in sheep than cattle. Sheep dung has the least evenness due to the dominance of *Eragrosis teff* and *Trifolium tembense* (Table 4.2.1) and (Fig 4.3).

Table 4.2.1 and Fig 4.3 show variation in species richness among animals dung source as well as within animal dung source during different occasions and periods (Table 4.1 a-e). The variation in species richness between animals dung sample may be as a result of accidental attendance of animals in the field and their feeding preference. (Cosyns, 2004) states that within livestock species, dung samples in general consist of a core of 'commonly present' plant species complemented with a varying selection and number of infrequent plant species. Between livestock species the size of this infrequent plant species pool tend to vary according to the observed total species richness with different period of time (Fig 4.3).

5.4. Viable Seed Content of Livestock Dung

Relative germination success differed strongly between plants species (Table 4.4).In the study period a total of 41 species were recorded with a wide range of germination density. The results reflect the high relative germination success of most graminoids, all of which had small, slightly elongated seeds. This result supports the hypothesis that small and round seeds are better survivors than elongated, large seeds (Janzen, 1984).

The large difference in numbers of *Trifolium tembese* seedlings found in dung of sheep versus cattle and donkey are mainly the result of important differences in diet selection i.e. the observed frequent consumption of *Trifolium tembense by* sheep and avoidance of it by donkey and cattle or it may be cattle and donkey masticate the seeds completely or the digestive enzymes act on *Trifolium tembense* seeds (Table 4.3). The high germination rate of *Trifolium tembense* seed is probably facilitated by the scarification of the seeds during mastication and digestion. This finding is supported by studies on the internal dispersal of seeds by hares, indicated that passage through the digestive system may break dormancy by means of scarification and highly enhance germination in species with hard seed coats (Janzen, 1984 and Van del Pijl 1982).

Most of the plant species, which showed high seed densities or appeared frequently in the dung samples, were also regularly recorded by Pakeman *et al.* (2002), Welch (1985) Dai (2000) and Malo & Suárez (1995) emphasizing their great ability to survive passage through the gastro-intestinal tract. This is also found in previous surveys of cattle, sheep, rabbit and deer dung (Pakeman *et al*. 2002), indicating that more species should be classified as internally dispersed by animals. Poaceae are not preferentially dispersed and Leguminosae are preferentially dispersed in Meditereanean dehesa (Malo & Suarez 1995c), whereas Poaceae were far overrepresented in dung from this study. The sole dispersal of la*tirus sativus* and *Lens culinaris* (Fabbaceae) in March, however, is explained by seed supply rather than by livestocks selectivity.

5.5. Implication for Maintaining Grassland Biodiversity.

The influence of livestock on botanical composition and species richness depended on stocking rate. Livestock in free grazing systems had a very important but less perceived influence on vegetation as agents of seed dispersal. The species composition of the dung seed bank has been found significantly different from the plant communities in the field (Zerihun Woldu, 1986). In the dung seed bank most of the species are annuals. All of the studies on livestock` dung, suggested that its potential as a seed dispersal mechanism with a large number of seeds of a considerable number of plant species dispersed during the fruiting season. The relevance of this mechanism is furthermore stressed in this study in quantifying the number of seedling grown from different animal dung sources. A total of 7417 seedling had germinated during the study period. Other studies support the germination of plant species on dung seed bank (Müller- Schneider 1954; Welch 1985; Malo & Suárez 1995; Stender *et al.* 1997; Bonn & Poschlod 1998; Pakeman *et al.* 2002) explained larger fraction of plant species are candidate to be dispersed in this way (41%). This is an agreement with Pakeman *et al.* (2002), who found 37% of the species recorded in the vegetation to be capable of dispersal by dung.

This result emphasized the role of grazing in enhancing plant establishment and the interaction between disturbance and establishment of seed in dung seed bank, which clearly may affect species abundance and distribution patterns in grazed grassland. If the grassland had a limited seed source, it is expected that the addition of seed through animal dung will facilitate the establishment of species. From this experiment it appears that dung of livestock could be a seed source. The higher proportion of members of poaceae in the dung seed bank suggested that both the feeding preference and the small size of the seeds, which could escape mastication, may have contributed to their proliferation. It can be suggested that when livestocks dung are used to improve soil fertility can change the weed flora in favour of members of the poaceae and Fabaceae.

Therefore, although dung can improve soil fertility it may also introduce noxious weeds such as the members of the Asteraceae which are mainly annuals (Stroud and Parker, 1989). However, in land-constrained situations farmers feed livestock with weeds removed from cropland. Therefore livestock dung has certain advantages of increasing species composition by permitting the small-scale reproduction of the natural effect of livestock defecation. The extra nutrient input may have also generated positive effects on the germination requirements of some of the species present in the soil bank; increasing richness in systems that are already oligotrophic (Huston 1979; Carson & Pickett 1990).This can facilitate when the dung does not taken from the field as fuel purpose. It is also inexpensive; permits the use of different genotypes, ecotypes, and varieties with little additional effort; and reduces the likelihood of environmental, climatic, or ecophysiological limitations hindering the success of the restoration process (Lippitt et al. 1994). Results from greenhouse germination experiment resembled those of other authors in similar habitats (Malo & Suárez 1995b) and indicated different species were dispersed despite the fact that the sampling dates prevented the collection of early and late-seeding species.

6. Conclusions

In greenhouse germination experiment, some uncertainties are associated with the experimental set up, which are assumed to be favourable for most of the plant species. But germination conditions can differ between plant species (Grime *et al.* 1988), hence comparison of frequency distribution of different plant species may be biased (Malo 2000). Furthermore, the experiment was terminated after 6 months, because at that moment no significant further germination was detected. Nonetheless, the presence of still viable seeds could not be excluded. For instance, Müller (1955) extracted further 30% of viable *Urtica dioica*-seeds from cattle dung after 9 months germination trial. Because of similar reasons, Malo (2000) recently argued for longer lasted germination experiments. In addition to that plant species which is grown in the control potting soil did not grow in dung samples. This is expected since dung suppressed the growth of plant species which is found in the soil. Therefore, using potting as control can prevent contamination in the greenhouse. Plants require nutrient at seedling stage therefore using potting soil is an appropriate method rather than sand soil.

This research has made it possible to capture the temporal variations within the dung seed bank. The result obtained also show that the potential of different livestock in species recovery. In addition to this the potential of restoring species varies among livestock. Indeed, livestock can improve soil and vegetation cover and plant and animal biodiversity, by controlling shrub growth and by dispersing seeds through their dung, grazing animals can improve plant species composition. Excessive livestock grazing also causes soil compaction and erosion, decreased soil fertility and water infiltration, and a loss in organic matter content and water storage capacity and loss of species diversity. On the other hand overprotected plant communities which are susceptible to natural disasters. Therefore livestock have big role in maintaining landscape and species diversity. The species which is grazed by animals can be replaced by their dung for that reason nature will be imbalance if the resources are utilized properly.

7. Recommendations

- Stocking rate should be maintained as recommended livestock carrying capacity of the area.
- Alternative energy source should be provided to prevent the collection of dung as fuel purpose.
- Further studies will require on cost -benefit analysis of dung left out in grazing land for another purpose.
- Natural grassland should be protected in order to maintain the diversity of species.

8. REFERENCES

Adams, J. (1907). Vitability of seeds swallowed by Animals. Irish Naturalist, 16, 367.

Alemayehu Mengistu, (1977). *Conservation based forage development for Ethiopia*. Self help development international institute for sustainable Development, Addis Ababa, Ethiopia

Bakker, E. S., & Olff, H. (2003). The impact of differentsized herbivores on recruitment opportunities for subordinate herbs in grasslands. Journal of Vegetation Science, **14**: 465–474.

Bakker, J. (1989). *Nature Management by Grazing and Cutting*. Kluwer Acadamic, Publishers, Dordrecht.

Bakker, J P, & Londo, G. (1998). *Grazing for conservation management in historical perspective.* In Wallis De Vries, M. F., Bakker, J. P., & van Wieren, S. E. (Eds.), Grazing and conservation management (pp. 23–54). Dordrecht: Kluwer Academic Publishers.

Bakker, J. P, J. van Andel, and E. van der Maarel. (1998). Plant species diversity and restoration ecology introduction. Applied Vegetation Science, **1**:5–8.

Bakker, J.P., Berendse, F. (1999). Constraints in the restoration of ecological diversity in grassland and healthland communities. Trends in Ecology and Evolution, **14**: 63-68.

Belsky, A .J. Carson ,W.P .,Jenses , C.L.and Fox,G.A.(1993) Overcompensation by plants: herbivore optimization or red herring/Evolution and Ecology, **7**:109-121.

Blackshaw and Rode,(1991). Weed Seed Viability in Composted Beef Cattle Feedlot Manure Journal of Environmental Quality, **32**:1105-1113

Bleher, B. & Bohning-Gaese, K. (2001) Consequences of frugivore diversity for seed dispersal, seedling establishment and the spatial pattern of seedlings and trees. Oecologia, **129**: 385–394.

Bullock J.M., Marriott C.A., (2000) Plant responses to grazing and opportunities for manipulation, In: Rook A.J., Penning P.D. (Eds.), *Grazing management*, The principles and practice of grazing, for profit and environmental gain, within temperate grassland systems, British Grassland Society, Reading, UK, pp. 17–26.

Burke, M.J.W. and Grime, J.P. (1996). An experimental study of plant community invasibility. Ecology, **77**: 776-790.

Carson, W.P. and Pickett, S.T.A. (1990) Role of resources and disturbance in the organization of an old-field plant community. Ecology, **71**: 226-238.

Caswell,H.and Cohen,J.(1991).Communities in patchy environment :a model of disturbance, competition and Hetrogenity.In:kolasa,J.&Pickett, S, T, A.(eds.) *Ecological hetrogenity*,pp.97-122. Springer-Ver lag,new York,NY

Chambers, J.C. and MacMahon, J.A. (1994). A day in the life of a seed: movements and fates of seeds and their implications for natural and managed systems. Annual Review of Ecology and Systematics, **25**: 263–292.

Chapman , R., and A. Younger (1995). The establishment and maintenance of a species-rich grassland on a reclaimed open cast coal site. Restoration Ecology, **3**:39–50.

Collins, S.L. (1987) Interaction of disturbances in tall-grass prairie: a field experiment. *Ecology*, **68**: 1243-1250.

Cosyns, E. (2004). Ungulate seed dispersal. A spects of endozoochory in a semi natural landscape.Ph.D. thesis, Ghent, Ghent Univ.

.

Cosyns, E., Claerbout, S., Lamoot, I., & Hoffmann, M. (2005). Endozoochorous seed dispersal by cattle and horse in a spatially heterogeneous landscape. Plant Ecology, **178**: 149–162.

Crawley, M.J. (1983) Herbivory.The dynamics of animal- plant interactions. Blackwell Scientific publication Oxford.

Dai, X. (2000). Impact of cattle dung deposition on the distribution pattern of plant species in an alvar limestone grassland. Journal of Vegetation Science, **11**:715-724.

Danell, K.and Bergström, R. (2002) Mammalian herbivory in terrestrial environments. In: Plant-Animal Interactions. An Evolutionary approach. (eds. C.M. Herrera & O. Pellmyr) pp.107-131. Blackwell Publishing, Oxford.

Dirzo, R. and Dominguez, C. (1986). Seed shadows, seed predation and the advantages of dispersal. Pp. 237–249 in Estrada, A. & Fleming, T. H. (eds). Frugivores and seed dispersal. Dr. W. Junk Publishers, Dordrecht.

Edwards G.R. and Crawley M.J. (1999a) Herbivores, seed banks and seedling recruitment in mesic grassland. Journal of Ecology, **87**: 423–435.

Edwards, S. Sebsebe Demessew & Hedberg, I. (eds.) (1997). *Flora of Ethiopia and Eritrea*, Vol. 6. Hydrocharitaceae to Arecaceae. Addis Ababa, Ethiopia and Uppsala, Sweden.

Edwards, S., Mesfin Tadsse & Hedberg, I. (eds.) (1995). *Flora of Ethiopia and Eritrea,* Vol.2, 2. Canellaceae to Euphrbiaceae. Addis Ababa, Ethiopia & Uppsal, Sweden.

Ehrlén, J., andJ. M. van Groenendael (1998). The trade-off between dispersability and longevity—an important aspect of plant species diversity. Applied Vegetation Science, **1**:29–36.

Engel, V. L., and J. A. Parrotta (2001). An evaluation of direct seeding for reforestation of degraded lands in central Sao Paulo state, Brazil. Forest Ecology and Management, **152**:169–181.

Estrada, A. and Coates- Estrada, R. (1984). Fruit eating and seed dispersal by howling monkeys (Alouatta palliata) in the tropical rain forest of Los Tuxtlas, Veracruz, Mexico. American Journal of Primatology, **6**:77–91.

Estrada, A. and Coates-Estrada, R. (1991). Howler monkeys (Alouatta palliata), dung beetles (Scarabaeidae) and seed dispersal: ecological interactions in the tropical rain forest of Los Tuxtlas, Mexico. Journal of Tropical Ecology, **7**:459–474.

Fleming, T.H. & Estrada, A. (1993) General introduction. Vegetation, **107/108**: 11-12.

Gardener, C. J. (1993). The colonization of a tropical grassland by Stylosanthes from seed transported in cattle faeces. Australian Journal of Agricultural Research, **44**: 299–315.

Gibson, C.W.D.and Brown,V.K (1992). Grazing and vegetation chang:deflected or modified succession? Journal of applied Ecology, **39**:120-131.

Grime, J.P., Thompson, K., Hunt, R., Hodgson, J.G., Cornelissen, J.H.C. & Rorison, I.H. (1997). Integrated screening validates primary axes of specialisation in plants. Oikos, **79**:259–281.

Grime, J.P., Hodgson, J.G. & Hunt, R. (1988) *Comparative Plant Ecology. A Functional Approach to Common British Species*. Uncirn Hyman, London.

Grime J.P., (1979). *Plant strategies and vegetation processes*. John Wiley & sons, New York.

Hamrick, J. L., MurawskI, D. A. and Nason, J. D. (1993). The influence of seed dispersal mechanisms on the genetic structure of tropical tree populations. Vegetation, **107/108**: 281–297.

Hanley, M. E., M. Fenner, and P. J. Edwards (1995). An experimental field study of the effects of mollusk grazing on seedling recruitment and survival in grassland. Journal of Ecology, **83**:621-627.

Harper, J.L., (1977). *Population Biology of plants*. Academic Press, London.

Hedberg, I. & Edwards, S. (eds.) (1989). Flora of Ethiopia, Vol. 3. Pittosporaceae to Araliaceae. Addis Ababa and Asmara, Ethiopia & Uppsala, Sweden.

Hedberg, I. and Edwards S. (eds.) (1995). Flora of Ethiopia and Eritrea, Vol. 7. Poaceae. Addis Ababa, Ethiopia & Uppsal, Sweden.

Hedberg, I., Edwards, S. and Sileshi Nemomissa (eds.) (2003). Flora of Ethiopia and Eritrea. Vol. 4, (1) . Apiacecae to Dipsacaceae. Addis ababa, Ethiopia, Uppsala, Sweden.

Howe, HF (1989). Scatter- and clump-dispersal and seedling demography: hypotheses and implications. Oikos, **79**: 417–426.

Hubbell, S.P., Foster, R.B., O'Brien, S.T., Harms, K.E., Condit, R., Wechsler, B., Wright, S.J. & Loo de Lao, S. (1999). Light-gap disturbances, recruitment limitation, and tree diversity in a neotropical forest. Science, **283**: 554–557.

Hurtt, G.C. & Pacala, S.W. (1995).The consequences of recruitment limitation: reconciling chance, history and competitive differences between plants. Journal of Theoretical Biology, **176**: 1–12.

Huston, M. A. (1979). *Biological diversity. The coexistence of species in changing landscapes*, Cambridge university press, camridge.

Janson, C.H. (1985) Aggressive competition and individual food consumption in wild brown capuchin monkeys (Cebus apella). Behavioural Ecology Sociobiology, **18**: 125–138.

Janzen, D.H. (1984) Dispersal of small seeds by big herbivores: foliage is the fruit. American Naturalist, **123**: 338–353.

Janzen, D.H. (1983). *The dispersal of seeds by vertebrate guts. In: Futuyma*, D.J. and Slatkin, M. (eds.) Co evolution, pp. 323-262. Sinauer Ass...Sunderland, MS.

Janzen, D.H. (1986). Chihuahuan desert nopaleras: defaunated big mammal vegetation. Annual Review of Ecology and Systematics, **17**: 595–636.

Kent, M., & Coker, P. (1995). *Vegetation description and analysis*. West Sussex, England: Wiley.

King, T. J. (1976).The viable seed contents of ant-hill and pasture soil .New phytology, **l77**:143-147.

Levey, D.J. (1987). Seed size and fruit-handling techniques of avian frugivores. American Naturalist, **129**: 71–485.

Lieberman, M. & Lieberman, D. (1986). An experimental study of seed ingestion and germination in a plant-animal assemblage in Ghana. Journal of Tropical Ecology, **2**: 113–126

Lippitt, L., M. W. Fidelibus, and D. A. Bainbridge. (1994). Native seed collection, processing and storage for revegetation projects in the western United States. Restoration Ecology, **2**:120–131.

Louda, S.M., Keeler, K.H. and Holt, R.D. (1990). *Herbivore influences on plant performance and competitive interactions, Perspectives on plant competition* (ed.by J.B. Grace and D. Tilman), pp.413-444. Acadamic Press, NewYork

Magurran, A. (1988). *Ecological diversity and measuement*. Crllm Hclm, London.

Malo, J.E. (2000) Hardseededness and the accuracy of seed bank estimates obtained through germination. Web Ecology, **1**: 70-75.

Malo, J.E., Betsabé, J., Suárez, F (1995). Seed bank build-up in small disturbances in a Mediterranean pasture: The contribution of endozoochorous dispersal by rabbits. Ecography, **18**: 73-82.

Malo, J. E. and Sua´rez, F. (1995a) . Herbivorous mammals as seed dispersers in a Mediterranean dehesa. Oecologia, 104: 246-255

Malo, J.E. and Suárez, F. (1995b) Establishment of pasture species on cattle dung: the role of endozoochorous seeds. Journal of Vegetation Science, **6**: 169-174.

Martínez-Ramos, M. & Soto-Castro, A. (1993). Seed rain and advanced regeneration in a tropical rain forest. Vegetation, **107/108**: 299–318.

Mesfin Tadesse (2004). Flora of Ethiopia and Eritrea. Vol. 4, 2. Asteraceae(Compositea). Addis Ababa, Ethiopia and Uppsala, Sweden.

Miller, M. F. (1996). Dispersal of Acacia seeds by ungulates and ostriches in an African savanna. Journal of Tropical Ecology, **12**: 345-356

Milton, S. J., and W.-R. J. Dean. (2001). Seeds dispersed in dung of insectivores and herbivores in semiarid southern Africa. Journal-of-Arid-Environments, **47**: 465-483.

Mitlacher, K., P. Poschlod, E. Rosen, and J. P. Bakker. (2002). Restoration of wooded meadows: A comparative analysis along a chronosequence on Oeland (Sweden). Applied Vegetation Science, **5**: 63-73.

Olff, H. and Ritchie, M. (1998). Effects of herbivores on grassland plant diversity. Trends Ecology, Evolution, **13**: 261_265.

Pakeman, R.J., Engelen, J., Attwood, J.P. (1999) Rabbit endozoochory and seedbank build up in an acidic grassland. Plant Ecology, **145**: 83–90.

Pakeman, R. J. (2001). Plant migration rates and seed dispersal mechanisms. J. Biogeograpy, **28**: 795_800.

Pakeman, R.J., Digneffe, G. and Small, J. L. (2002). Ecological correlates of endozoochory by herbivores. Functional Ecology, **16**: 296- 304

Pickett,S.T.A.White,P,S, (1985) . Patch dynamics; a synthesis .In: PickettS.T.A.

Pielou, E.C. (1969). *An introduction to Mathematical Ecology*. Wiley, New York.

Podani, J (2000). Syntax 3: Users manual. *Abstracta Botanica* 12, Supplement 1.

Platt, W.J. (1979).The colonization and formation of equilibrium plant species association on badger disturbances in a tall-grass prairie. Ecological .Monography, **45**: 285-305.

Poschlod, P., & Bonn, S. (1998). Changing dispersal processes in the central European landscape since the last ice age: an explanation for the actual decrease of plant species richness in different habitats? Acta Botanica Neerlandica, **47**: 27–44.

Primack, R.B. and S.L. Miao. (1992). Dispersal can limit local plant distribution. Conservation Biology, **6**: 513–519.

Pywell, R.F., Bullock, J.M., Hopkins, A., Walker, K.J., Sparks, T.H., Burke, M.J.W., & Peel, S. (2002) Restoration of species-rich grassland on arable land: assessing the limiting processes using a multi-site experiment. Journal of Applied Ecology, **39**: 294-309.

Quinn, J. A., D. P. Mowrey, S. M . Emanuele, and Whalley R. D. B. (1994). The “foliage is the fruit” hypothesis: Buchloe dactyloides (Poaceae) and the shortgrass prairie of North America. American Journal of Botany, **81**:1545–1554.

Ridley, H.N. (1930). *The dispersal of plants throughout the world,* L.Reeve & Co., Ashford.

Russi, L., P. S. Cocks, and E. H. Roberts. (1989).The fate of legume seed eaten by sheep from a Mediterranean grass land, Journal of Applied Ecology, **29**: 772-778.

Russi, L., P. S. Cocks, and E. H. Roberts (1992). Seed bank dynamics in a Mediterranean grassland. Journal of Applied Ecology, **29**: 763–771.

Schupp, E. W. (1988). Seed and early seedling predation in the forest understory and treefall gaps. Oikos, **51**: 71–78.

Schupp, E. W. (1993). Quantity, quality and the effectiveness of seed dispersal by animals. Vegetation, **107/108**:15–29.

Schupp, E. W. (2002). *The efficacy of the dispersal agent.* Pp. 357–360 In: Guariguata, M. R. & Kattan, G. H. (eds). Ecología y conservación de bosques neotropicales. Libro Universitario Regional, Costa Rica.

Shayo, C.M. & Udén, P. (1998) Recovery of seed of four African browse shrubs ingested by cattle, sheep and goats and the effect of ingestion, hot water and acid treatment on the viability of the seeds. Tropical Grasslands, **32**: 195-200.

Simao Neto, M., Jones, R.M. & Ratcliff, D. (1987) Recovery of pasture seed ingested by ruminants. Seed of six tropical pasture species fed to cattle, sheep and goats. Australian Journal of Experimental Agriculture, **27**: 239-246.

Sousa, W.P. (1984).The role of disturbance in natural communities. Annual Review. 531–564

Stevenson, M. J., J. M. Bullock, and L. K. Ward. (1995). Re-creating seminatural communities: effect of sowing rate on establishment of calcareous grassland. Restoration Ecology, **3:** 279–289.

Stevenson, M. J., L. K. Ward, and R. F. Pywell (1997). Re-creating seminatural communities: vacuum harvesting and hand collection of seed on calcareous grassland. Restoration Ecology, **5**: 66–76.

Stiles, E.W. (2000).Animals as seed dispersers. In: Fenner M (ed). Seeds: *The of ecology regeneration in plant communities.* CABI, Wallingford, Oxon, United Kingdom, pp 111 – 124.

Staniforth , R.J. & Cavers, P.B. (1977). The importance of cottontail rabbits in the dispersal of *Polygonum* spp. Journal of Applied Ecology, **14**: 261-267.

Stroud, A. and Parker, C., (1989). *A weed identification guide for Ethiopia.* TCP/ETH/4532. Food and Agricultural Organization of the United Nations,Rome.

Templeton, R. and Levin, A., (1979).Evolutionary consequences of seed pools. American Naturalist, **114**: 232-249.

Thompson, K. and Grime, J. P.,(1979). Seasonal variation in the seed banks of herbaceous species in ten contrasting habitats. Journal of Ecology, **67**: 893-921.

Tilman, D. (1988). *Plant strategies and the dynamics and structure of plant communities* Princeton Monographs, Princeton .NJ.

Tilman, D. (1994) Competition and biodiversity in spatially structured habitats. Ecology, **75**: 2–16.

Turnbull, L.A., Crawley, M.J. & Rees, M. (2000) Are plant populations seed-limited? A review of seed sowing experiments. Oikos, **88**: 225–238
.

Uhl, C., Clark, k, Clark, H., Maquirino, p., (1982). Successional patterns associated with slash-and-burn agriculture in the upper Rio Negro region of the Amazon Basin. Biotropica, **14**: 249-254.

Uhl, C., Clark, k, Clark, H, Murphy, P., (1981).Early plant succession after cutting and burning in the Upper Rio Negro region of the Amazon Basin. Journal of Ecology, **69**: 631-649.

van del Pijl, L (1982). *Principles of dispersal in higher plants*. Springer- Verlag, Berlin.

van Wieren, S. E., & Bakker, J. P. (1998). *Grazing for conservation in the twenty-first century*. In Wallis De Vries, M. F., Bakker, J. P., & van Wieren, S. E. (Eds.), Grazing and Conservation Management (pp. 349–363). Dordrecht: Kluwer Academic Publishers.

Verhagen, R., Klooker, J., Bakker, J.P. & van Diggelen, R. (2001). Restoration success of low-production plant communities on former agricultural soils after top-soil removal. Applied Vegetation Science, **4**: 75-82.

Wang, B.C. & Smith, T.B. (2002). Closing the seed dispersal loop. Trends in Ecology and Evolution, **17**: 379-385.

Welch, D. (1985).Studies in grazing of heather moorland in N north East Scotland.IV. Seed dispersal and plant establishment in dung. Journal of Applied Ecology, **22**: 461-472.

Wijdeven, S. M. J.and Kuzee, M. E.(2000) Seed Availability as a Limiting Factor in Forest Recovery Processes in Costa Rica. Restoration Ecology, **8 (4)**: 414 - 424.

Wright, S.J. (2002) Plant diversity in tropical forests: a review of mechanisms of species coexistence. Oecologia, **130**: 1–14.

Zerihun Woldu (1986). Grassland communities on the central plateau of Ethiopia. Vegetation, **67**: 3-16.