ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

POPULATION STATUS AND DIURNAL ACTIVITY PATTERN OF THE COMMON WARTHOG (*Phacochoerus africanus*) IN THE BALE MOUNTAINS NATIONAL PARK, ETHIOPIA

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DEDICATION

This work is dedicated to my late best friend, EWNETU TEGENGE, from whom I learnt the meaning of friendship.

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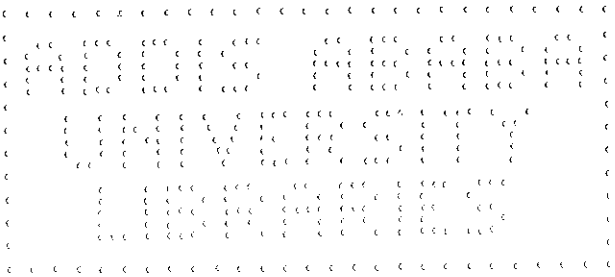

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ABSTRACT

Some ecological aspects of the common warthog (Phacochoerus africanus) were studied from February 2000 to December 2000 in the Bale Mountains National Park (BMNP). Data were collected on the population estimate, age and sex category, and diurnal activity pattern of the species by dividing the study period into dry and wet seasons. Data were analyzed using SPSS computer software package and compared using one-way ANOVA (p=0.05) and t-test for independent sample of groups (p=0.05). Both total and sample counts were used to estimate the population of warthogs in the study area. 576 animals were counted in the whole study area (536 in the dry season and 616 in the wet season). During counting, each individual in a group was identified into its respective age and sex categories. The result of the study showed a great percentage (>50%) of young animals in the population. There is unequal sex ratio in the population. Male to female ratio of the population shows 23.9 % more females than males. The relatively high percentage of young individuals and breeding females shows that warthog population in the study area is increasing. The major activities of the species were feeding and lying down. The amount of hours devoted to each activity by Group I (an adult male) and Group II (a female with her two hoglets) was not significantly different except feeding. The amount of time spent in feeding is related to feeding efficiency based on the size of their mouths and molars. Feeding activity was intensive and reached its peak in the early morning and late afternoon. Resting/lying down increased in the middle of the day. The activity follows the general pattern of ungulates in the Bale Mountains National Park, characterized by morning and evening activity with a period of rest in the middle of the day.

1. INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

The pace of wildlife habitat destruction and species extinction has increased worldwide. During the last 400 years nearly 500 described animal species mostly vertebrates have become extinct (WCMC, 1992). The populations of large mammals are continuously declining in numbers due to the shrinkage of their natural habitats (Fryxell and Sinclair, 1988 and Caughley *et al.*, 1994).

The wealth of big games makes African mammals so unlike that of other continents. Africa is noted for its diversity and abundance of large mammalian herbivores (Kutilek, 1979). Compared to other regions, Africa has the largest number of endemic families and genera of the big games. This degree of endemism is one of the reasons for the African fauna to be so interesting and spectacular (Delany and Happold, 1979).

Although the variation in the topography of Ethiopia has resulted in the diversification of the wildlife (WCMC, 1992; Shibru Tedla, 1995), problems facing the Ethiopian wildlife conservation today are enormous. Since the general level of the economy depends upon agricultural productivity which is very low throughout the country, increase in food production depends on increasing the area under cultivation and grazing. This expansion is usually at the expense of wildlife resources, leading to the loss of both flora and fauna together with their habitats. This ever increasing conflict between the biological resources and human land use is threatening the survival of wildlife conservation areas (Yoseph

Getnet, 1995). In Ethiopia there are nine National Parks, three Sanctuaries, eleven Wildlife Reserves, and eighteen Controlled Hunting Areas but only Awash and Seimen National Parks have been gazetted (Hillman, 1993).

Ungulates are one of the most successful of the animal lineage (Nowak, 1991 and Kingdon, 1997). The extensive tropical and sub tropical savanna biome of Africa provides homeland for the largest number and variety of ungulates (Hirsute, 1975).

Warthogs are non-ruminant Artiodactyls. They are grouped into Subfamily, *Phacochoerinae*. Two living species, the common warthog (*Phacochoerus africanus*), and the desert warthog (*Phacochoerus aethiopicus*) are distinguished (Grubb, 1993). The latter species is differentiated from the more familiar common form by various cranial and dental characters, including the absence of functional incisors, and by its small body size. However, the external appearance, behavior and ecology of the desert warthog are poorly known (Vercammen and Mason, 1993).

Warthogs inhabit open and wooded savannas, grass-steppe and semi-deserts from Mauritania and Ethiopia in the north to Namibia and Natal in the south. The two species have allopatric ranges (Fig. 1). The common warthog still has a very wide range extending from Senegal and southern Mauritania in the northwest, to northern Ethiopia and Djibouti in the northeast, and Namibia, the northern Cape Province and Natal in the south. However, the continuous expansion of the Sahel-zone has resulted in a marked contraction in the species northern former range since the early 1980s and accounts for its probable extinction in Mali and Niger.

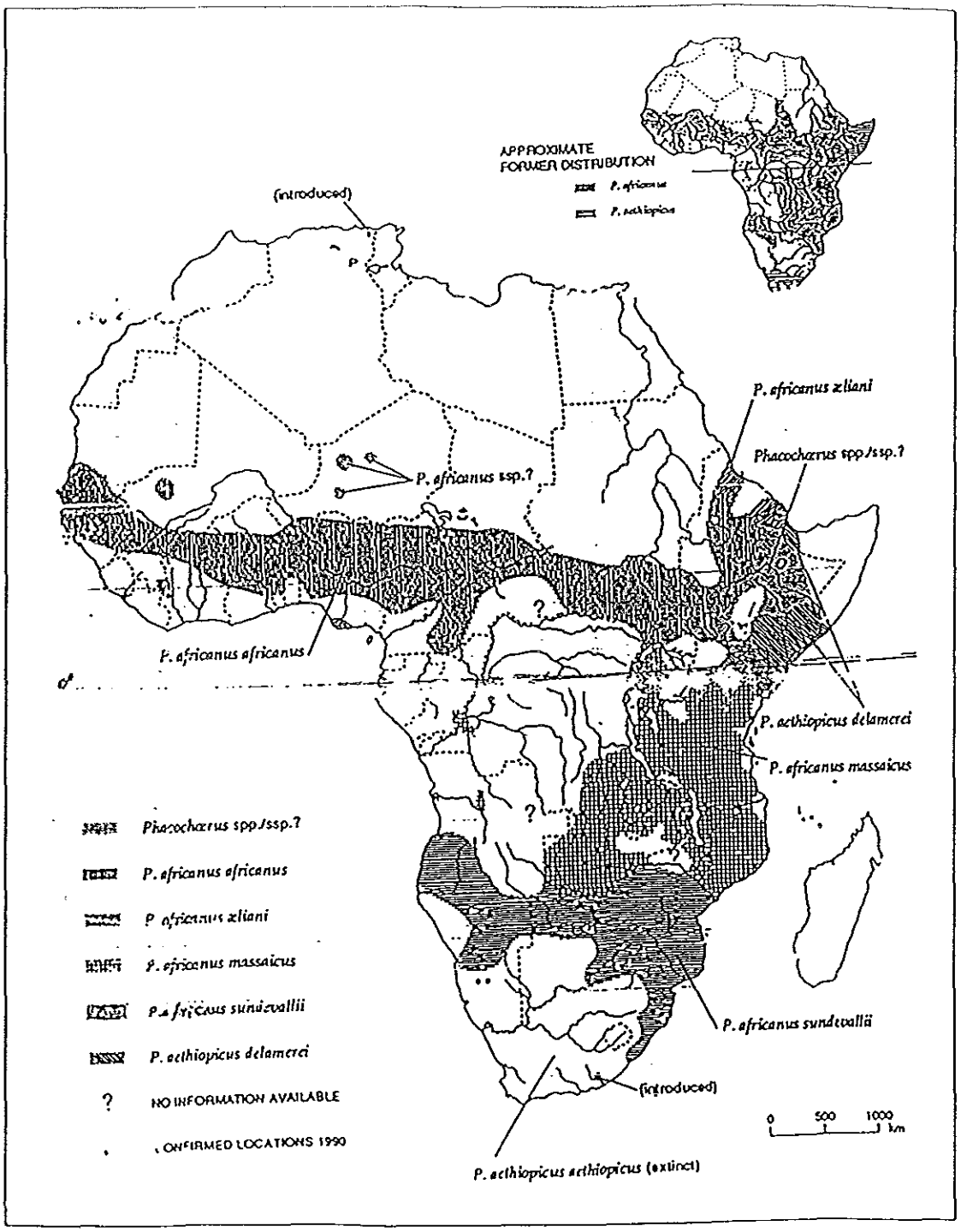

Figure 1. Approximate former and present distribution of the different sub species of the common warthog (*Phacochoerus africanus*) and the desert warthog (*Phacochoerus aethiopicus*) (After Vercammen and Mason, 1993).

Recent data on its status and distribution are lacking from the southern Central African Republic, most of Zaire, and Angola, but elsewhere, the species is reported to survive throughout much of its former ranges.

Its range is expanding in some areas, such as Botswana and Transvaal Province, in response to the clearing of former wooded savanna and the creation of pasture. In addition, warthogs have been reintroduced in Natal and Eastern Cape Province (Skinner and Smithers, 1991; Mason, 1992).

Common warthogs occur over a wide range of altitudes from sea level in Gambia to 3,000 m on the Ethiopian plateaus (Hillman, 1982). The different subspecies of the common warthog are distributed in treeless open grassland and woodland of Ethiopia. In the Bale Mountains National Park, they have been observed mainly in the Gaysay/Adelay area, and rarely in the Web Valley close to the Adelay Ridge. The altitude of its habitat ranges between 1500-3400 m above sea level (Hillman, 1986).

At present, due to lack of research information on the common warthog, the population size, distribution and its ecology in Ethiopia is not determinate. Human persecution in reprisal for crop raiding or overhunting for meat, are probably the most important threats to *P. africanus*. Since the available data are insufficient to assess regional conservation and management problems and priorities at the present time, field status surveys of the distribution and abundance of warthogs and comparative studies of their behavioral ecology are required.

1.2 LITERATURE REVIEW

Warthogs are first described by Pallas in 1766 who examined a live specimen from the Cape Colony by Governor Tulbagh in 1765 (Sclater, 1900). Observations, distribution and records by early explorers, hunters and naturalists on warthogs are well summarized by Shortridge (1934). Bigourdan (1948) cited in Cumming (1975) is the first person to examine warthog biology. He studied warthogs in the field in West Africa. Geigy (1955) published extensive observations made in Tanzania during a study of the vectors of African relapsing fever. Ewer (1958a and 1958b) examined features of the skulls of African suids and described a specialized mode of feeding in warthog. Fradrick (1965) studied warthog behavior in Kenya and in European zoological gardens. His work is the most complete account of warthog behavior and provides information in warthog home ranges. Sowls and Phelps (1966) made important observations on body temperature of young warthog and bushpig in relation to ambient temperature. Variations in the dentition and ageing criteria for warthogs have been described by Child *et al.* (1965). Child *et al.* (1968) used material collected from hunting operations in a study of reproduction and recruitment in warthog populations. Growth patterns in captive warthog is studied by Roth (1965). Field (1968a, 1968b, 1970, 1972) has studied warthog food habits in East Africa. Valuable information on warthog density and habitat preferences appeared in the work of Lamprey (1963 and 1964) on a number of ungulate species in Tanzania. Child (1968) and Jarman (1968) both studied large mammal populations in the Karibia basin and provide further information on warthog populations and their biology.

Warthogs are among the most distinct and highly specialized of all suids (Vercammen and Mason, 1993). In comparison to other suids, warthog appears less deep in the chest, with barrel-shaped bodies which are sparsely haired, except for a distinct mane of long stiff hairs on the neck and shoulder. The face is flattened and bears one or two pairs of warts and, in both sexes, well-developed tusks (Fig. 2).

Figure 2. Physical characteristics of the common warthog (*Phacochoerus africanus*).

A warthog with functional incisors was first described by Buffon in 1776 but was not given a scientific name until 1778. At least eight sub-species have been described, though Grubb (1993) suggests that the majority of those are synonymous that only four sub-species should be (provisionally) recognized at the present (Table 1).

Table 1. The different extant sub species of the common warthog (*Phacochoerus africanus*) and their distribution.

Sub species	Distribution
Phacochoerus africanus africanus	Sahel to Central Ethiopia.
Phacochoerus africanus aeliani	Northern Ethiopia and Djibouti.
Phacochoerus africanus massaicus	Eastern and Central Africa.
Phacochoerus africanus sundevalli	Northern part of the Southern Africa sub region.

According to Vercammen and Mason (1993), the status of warthogs has been given different categories. *P. africanus* is widespread and locally abundant or relatively secure; except for *P. a. aeliani* which is " indeterminate". *P. aethiopicus* is vulnerable and even "extinct" depending on the sub-species.

The distribution of this species is limited by the availability of suitable forage, cover, and human pressures. They occur on treeless open plains and in lightly wooded savanna, but avoid densely wooded vegetation without grazing. They are predominantly grazers and feed on grass, roots, berries, the bark of young trees, and occasionally carrions (Nowak, 1991; Kingdon, 1997). During the period of drought, they may be able to subsist without drinking

water by rooting for succulent rhizomes and bulbs. Compared to the bushpig, (*Potamochoerus larvantus*), warthogs appear much less dependent on the continuous availability of surface water (Cumming, 1975; Mason, 1982; Radke, 1986; Skinner and Smithers, 1991; Kingdon, 1982). Deep burrows are essential to avoid from fluctuating temperatures and escape from predators (Radke, 1986; Skinner and Smithers, 1991).

Common warthogs are largely diurnal and sleep at night in burrows often using aardvark holes. While their body temperatures can evidently vary with a certain tolerance range (Cumming, 1975; Radke, 1986), they usually cope with high temperature by behavioral strategies, such as wallowing. Since they lack fur and surface fat, they insulate their burrows with grass, huddle together and bask in the sun to conserve and gain heat (Kingdon, 1982). Infants are particularly vulnerable to cold exposure and malnutrition during drought which together with predation and other mortality factors may result in juvenile survival rate not more than 50% during the first year (Mason, 1982, 1990).

Lions are the most important predators of warthogs, followed by leopard. Adult warthogs usually escape from wild dogs, but sometimes, they try to protect even their young from leopard and cheetah. They largely escape nocturnal predators, including hyenas, using their burrows (Radke, 1986).

Warthogs breed throughout the year in equatorial regions, but under seasonal climatic conditions, furrowing is cyclical and synchronized with the end of the dry season. Fighting between males, aggressive behavior by males and females towards the yearlings have been observed during rutting season (Child *et al.,* 1968, Boshe, 1984; Mason, 1982,1885). The

gestation period is just over five months (150 to 170 days) and average litter size is 3 with a range of 1-7. Pre-natal sex ratio does not differ significantly from unity (Boshe, 1981; Mason, 1982). Sexual maturity in males occurs at about the age of 16 to 20 months, a month latter than in females (Clough, 1969; Mason, 1986). Males are solitary and are not usually attached to any female except when mating. Courtship is initiated by the male when encountered by an estrus female. Copulation may last up to six minutes (Radke, 1986; Kingdon, 1997).

The basic social units consist of small family groups of females and their juveniles from the last breeding season (Eastes, 1992; Kingdon, 1997). New family units join others that are probably, close relatives. These loose groups live within clan areas averaging about 4 km^2. In warthogs, social grouping is constant throughout the year with a mean group size of 3.4 for all months and a maximum monthly range of plus or minus 1.0 from the mean. During the furrowing period, there is a slight increase in group size (Rodgers, 1977).

1.3 JUSTIFICATION

Although the common warthog is widespread and locally abundant or relatively secure, some of its appearance and behavior is related with the most endangered species of the desert warthog. Therefore, the result of the present study would serve as a springboard and constitute some information for the future study of this endangered and re-discovered species in the Horn of Africa following the recommendations addressed in the IUCN/SSC pigs peccaries and hippos Action Plan (Vercammen and Mason, 1993).

The population status and activity patterns of a wild animal species is an important aspect of its ecology which needs to be understood before it can be managed intelligently, whether this management is intended to ensure its survival or to effect the elimination of excess individuals. This is especially true of species like common warthogs which have wide distribution.

1.4 OBJECTIVES

General objectives

The major aim of the present study is to determine the current population status and activity pattern of the common warthogs in the Bale Mountains National Park (BMNP).

Specific objectives are to:

- determine the current population size of the common warthog in the BMNP and to compare the results with previous information in the same range.
- examine the relative proportion of age category.
- determine the species sex ratio.
- describe the diurnal activity patterns, and
- provide information for the future conservation plan.

2. STUDY AREA

2.1 LOCATION AND TOPOGRAPHY

The study area, the Bale Mountains National Park (BMNP) is located in the southeastern part of Ethiopia. The headquarter for the park is on the northern boarder of Dinsho which is 400 km by road from Addis Ababa (Fig. 3). The Bale Mountains form the southeastern limits of the eastern Ethiopian highlands, along the eastern edge of the Rift Valley. It covers an area of 2471 km^2–at coordinates 06^0 30' – 07^0 00' N and 39^0 30' – 39^0 55' E (EWNHS, 1996). The park was established in 1970 to protect the Afroalpine habitat of the mountains and the endemic animal species (EWCO, 1990).

The park includes a flat high altitude plateau, over 3500 m above sea level as well as lowland tropical moist forest at a lower limit of 1500 m above sea level. It is the largest extent of protected Afroalpine habitat on the African continent. It also includes the Harenna Forest on the southern slope which is one of the largest intact block of forest left in the country (Hillman, 1986; Miehe, 1994).

2.2 THE MAIN SUB-DIVISIONS OF THE STUDY AREA

The park consists of the following three main zones: the northern Gaysay/Adelay grass land and woodland area between 3000-3500 m above sea level, the Central Sanetti Plateau and Pick area between 3500-4400 m above sea level and the Southern Harenna Forest between 1600-3500 m above sea level (Hillman, 1993).

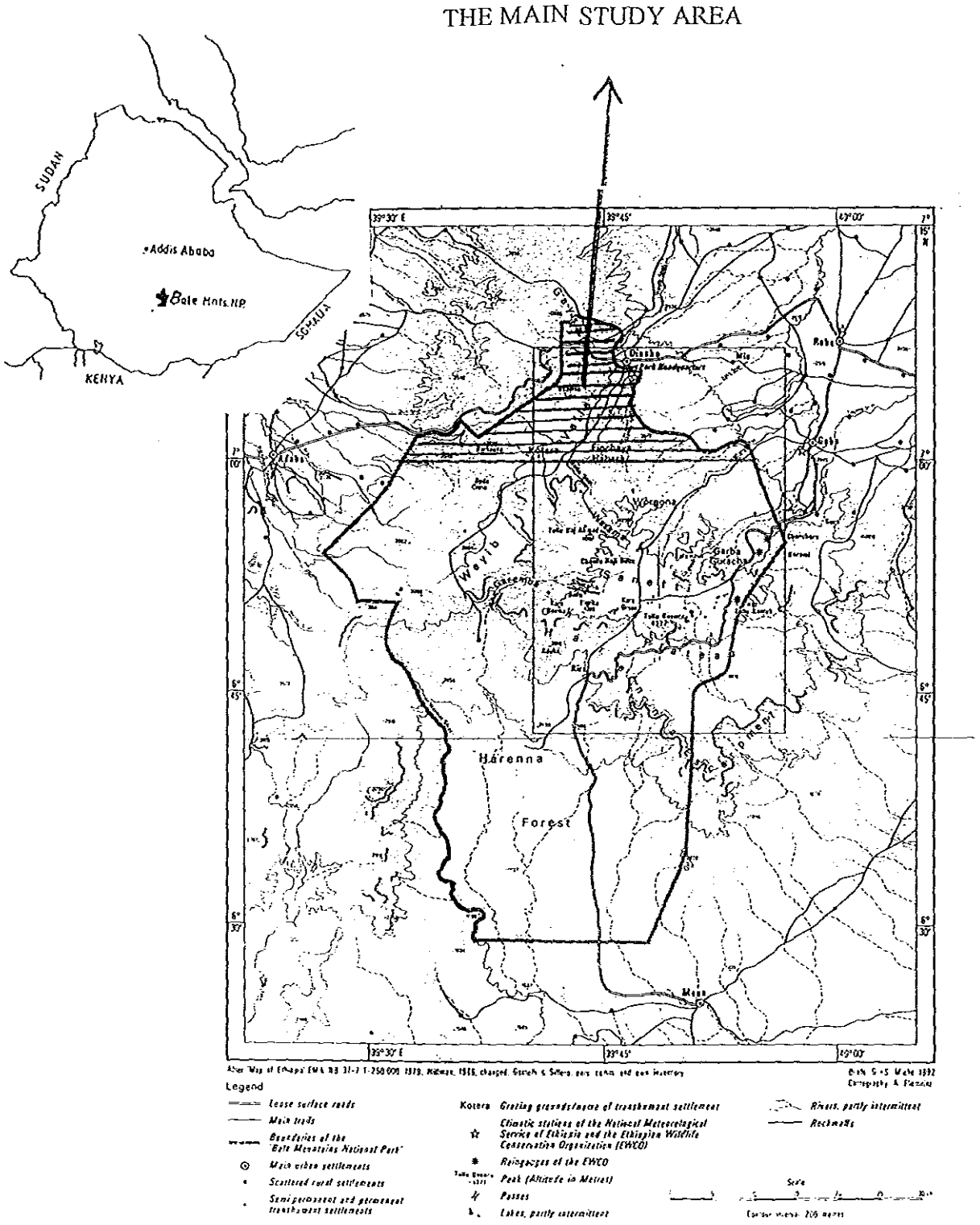

Figure 3. Map of the Bale Mountains National Park.

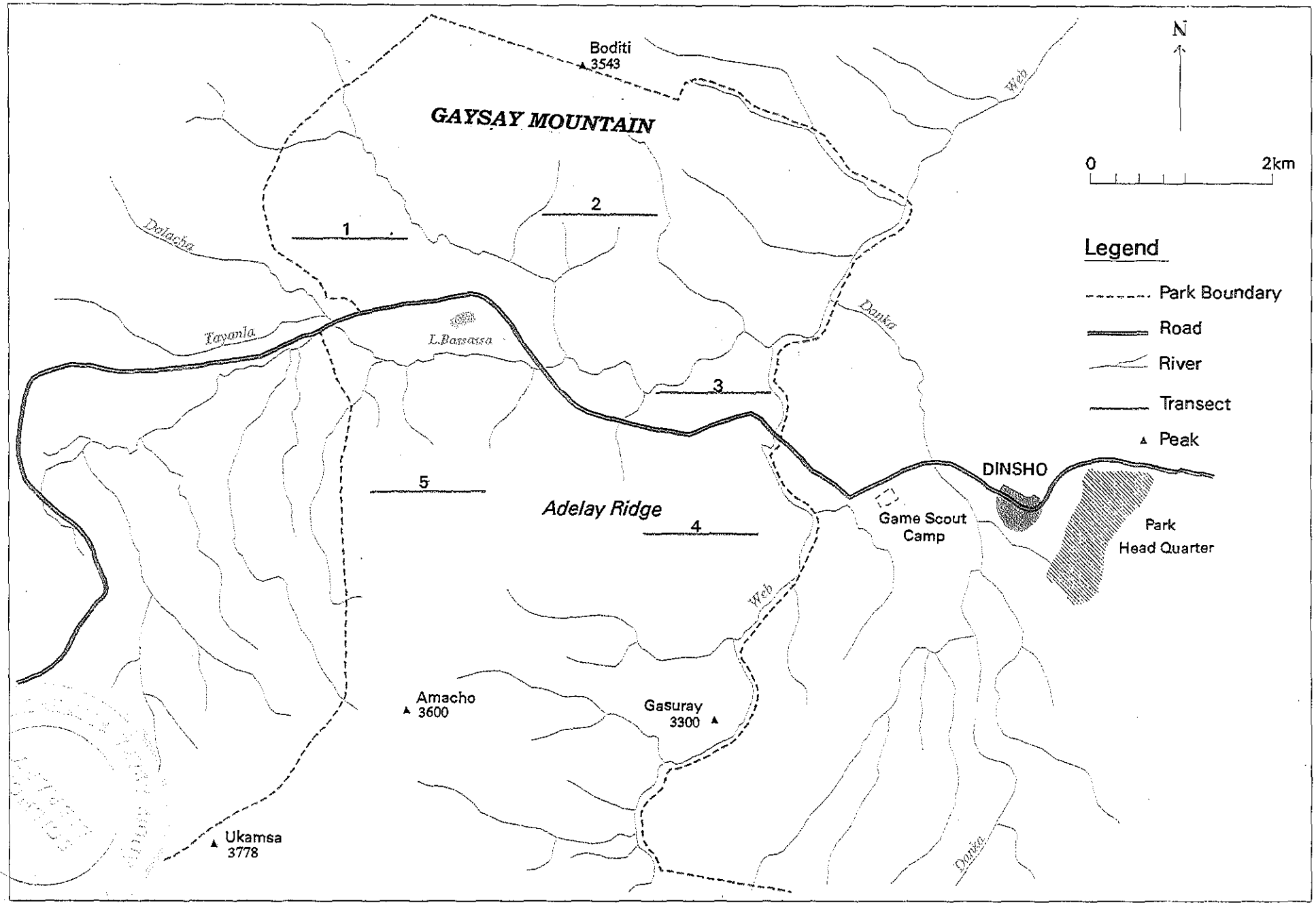

Figure 4.Map of the study area

2.2.1 Northern Gaysay

This is the main area where the present study is concentrated (Fig. 4). This area of broad valleys and high ridges mainly lies between the altitudes of 3000 and 3500 m. It comprises *Juniper/Hagenia* woodlands, broad grassy valleys and swamp areas. It is further divided into two small areas – Gaysay Valley and Dinsho Hill.

2.2.1.1 Gaysay Valley

It is found on the extreme north of the park, west of Dinsho. It is a broad grassy valley with swamps and meadows, where the largest herds of warthogs, mountain nyala, bushbuck and reedbuck are seen. A pack of Ethiopian wolves is also resident in Gaysay.

2.2.1.2 Dinsho Hill

This is the place where the headquarter (the park offices, a tourist lodge, two campsites, a research building and a natural history museum) is found. It is situated near Dinsho, on a fenced hill. It comprises a dense mountain forest and clearings with abundant ungulates.

2.2.2 Central peaks and Sanetti Plateau

The most obvious part of the park is formed on the central peaks and plateau area. It encompasses flat glacial valley called Web Valley at 3500 m above sea level with swamps and green meadows, surrounded by the valley walls. It is 14 km by road from Dinsho. It is formed by lava flows and covered by ericaceous moorlands. Rodents occur at extremely high densities on the valley bottom, supporting an important community of raptors and several packs of Ethiopian wolves. It also consists of vast plateau at over 4000 m, dominated by highest peak in the southern Ethiopia and the second highest in the whole

country, Tullu Deemtu (4377 m). It comprises the largest extension of Afroalpine habitat in the African continent (Sillero-Zubiri, 1981; EWNHS, 1996).

2.2.3 Southern Harrena

It extends along the Harenna escarpments on the southern slopes of the Sanetti down to the park southern boundary near Dolo Mena (Sillero-Zubiri, 1981). The Harenna forest represents a continuous range of undisturbed natural vegetation, from 1500 to 3200 m above sea level. Furthermore, this forest is separated from other forest area by the Rift Valley to the west, the flat high Sanetti Plateau to the north, and arid lowlands to the south and southeast. This makes the Harenna Forest a valuable model for the study of formation and evolution of an isolated forest fauna (Lavrenchenko, 2000). It is an area with a high diversity of fauna and flora.

2.3 CLIMATE

As a result of the great variation in altitude, considerable variation in climate occurs across the park area. Most of the data about the description of the climate came from different stations in and near the park which was obtained from the Ethiopian National Meteorological Service Agency (ENMSA), the park head-quarter and the Ministry of Agriculture. The climate of the study area during the study period is given in Figure 5.

2.3.1 Rainfall

The rainfall of the Dinsho area in the north is characterized as a continuous eight month rainy season followed by a four month dry season (Daniel Gamachu, 1977), but a little bit greater rain fall was recorded in December (dry season) than March (wet season) during the

study period. However, the Mena area in the south shows a single wet season of short duration only from February to June. Annual rainfall of the lower and higher elevations vary from 600-1000 mm and 1000-1400 mm, respectively (Daniel Gamachu, 1977). The park area receives rain from the equatorial westelines and the Indian Ocean air streams.

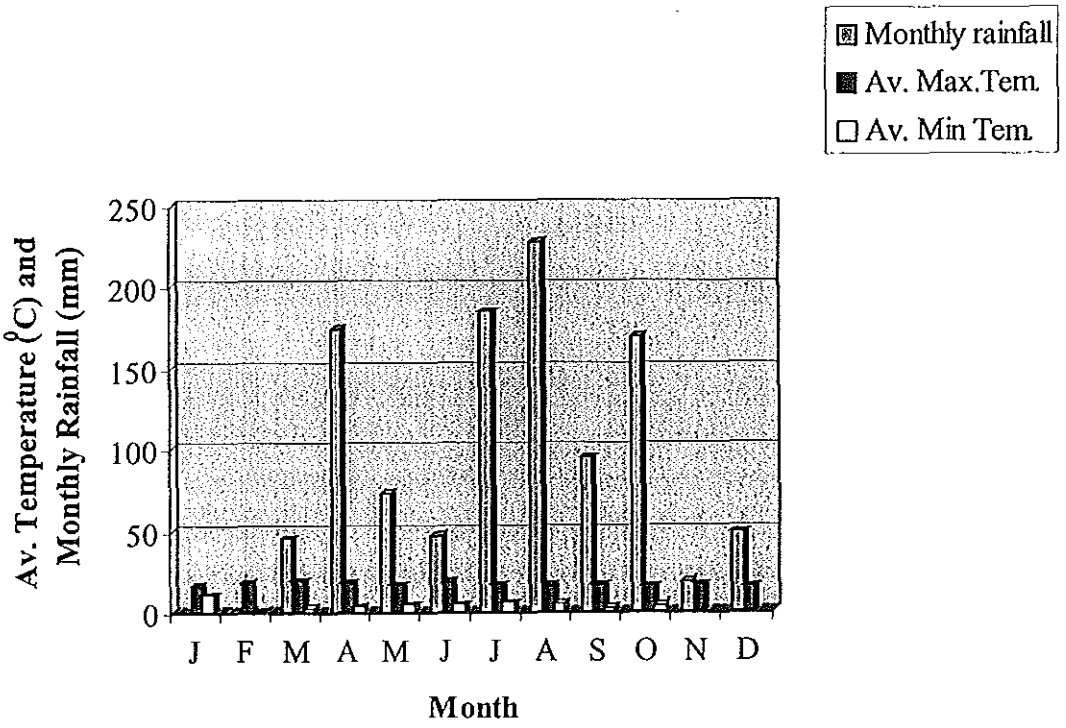

Figure 5. Climate of the study area during the study period (ENMSA, 2000).

2.3.2 Temperature

The daily maximum and minimum temperature depend on the change in altitude. The range of daily temperature is widest during the long dry season, and smallest during the long wet season (Miehe, 1994). Highest and lowest temperatures occur in the dry season. Frost is regularly experienced in Dinsho at night. The maximum range of temperature recorded was in February during the study period. The average minimum and maximum temperature recorded were 0.7^0C, and 18.3^0C, respectively (Fig. 5). In some places, the diurnal temperature range exceeds 40^0C. Hedberg (1951, 1957) described this extreme climate as "winter every night and summer every day".

2.3.3 Humidity

Relative humidity is highest in the wet season and lowest in the dry season. Records exhibit a higher average value for Goba than Dinsho, and Dinsho shows higher humidity during wet seasons than dry seasons (Hillman, 1986). The few records of humidity that existed, is given in Appendix 1.

2.4 GEOLOGY AND SOIL

The Bale Mountains were formed from lava outsprings in the Miocene and Oligocene geological periods. These lavas covered all the previous rock formation, and were formed prior to the formation of the Rift Valley, probably during 40-25 million years ago (Mohr, 1971). The Arsi-Bale massif was separated from northeast Ethiopian mountains by the Rift Valley systems during the Plio-Pleistocene rifting phase (Miehe, 1994). Much of the

original topography of the Oligocene lava outpourings has, therefore, been modified by 20 million years of water, wind and ice erosion, to produce the landscape we see today (Hillman, 1986). As the upper geological strata of the Bale Mountains are entirely volcanic, the soils, mainly drained from the basaltic and trachytic parent rocks, are fairly fertile silty loams of reddish-brown to black color (Miehe, 1994). Weinert and Mazureck (1984) analyzed five profiles in the Bale areas by taking samples from 10-30 m in depth. Even though, the vegetation of the sampling ranges between mountain forest and Afroalpine heath, the soil properties were fairly uniform: in the clay fraction of the silt loams (10-15%), illite or chlorite were the dominant minerals.

2.5 VEGETATION AND WILD ANIMALS

Due to high variation in topography and climate, Ethiopia has a high number of endemic species (Largen *et al.*, 1974; Yalden, 1983). The number of endemic species is also very high in the study area. A large proportion of the Bale Mountains fauna and flora are endemic. The variety of habitats conserved in the BMNP and the isolation of the highland areas of Ethiopia from other similar lowlands contribute for this endemicity (Largen *et al.*, 1974; Hillman, 1993). These authors underline the importance of the Bale Mountains as a center of endemicity and reserve for unknown genetic resources.

2.5.1 Vegetation

The range of habitats in the BMNP are different in both altitude and vegetation cover. These can be divided as the Northern Gaysay area of grassland, swamps and woodlands; the central peak and plateau area consisting of the Afroalpine vegetation and the southern

Harenna area of dense forest (Hillman, 1986). The vegetation cover of the main study area Northern Gaysay can be further divided into Northern Grassland and Northern woodland (Fig. 6).

2.5.1.1 Northern grassland

The area occurs in the extreme north of the park. It comprises the flat land on each side of the Gaysay River, and on the West Bank of the Web River. A very small but important zone of grasslands lies on the flat land. Since its drainage is poor, it is flooded with water in the wet season. As a result, many places are dominated by swamp grasses and sedges, especially of the *Cyprus* and *Scirpus* genera. The higher parts are covered in low bush vegetation, dominated by *Artemesia afra* and *Helichrysum splendium*. The common grasses include those of the genera *Andropogon*, *Bromus*, *Festuca* and *Poa*. The northern grasslands provide rich grazing ground for warthogs and other herbivore community (Hillman, 1986).

2.5.1.2 Northern woodland

This vegetation zone occupies a narrow belt in the northwest, north and north east of the park. The upper limit is the treeline at 3400 m, and the lower is the grassland in flat valley bottom at about 3000 m (Hillman, 1986). The trees *Juniperus procera* and *Hagenia abyssinica* are the species that dominate the northern woodlands. The species *Hypericum revolutum*, provides a dense bush growth at the lower edge of the woodlands, while at the upper treeline, the species grows as a tall, slender tree. Extensive grass areas, with similar species to the flat areas, occur within the woodlands.

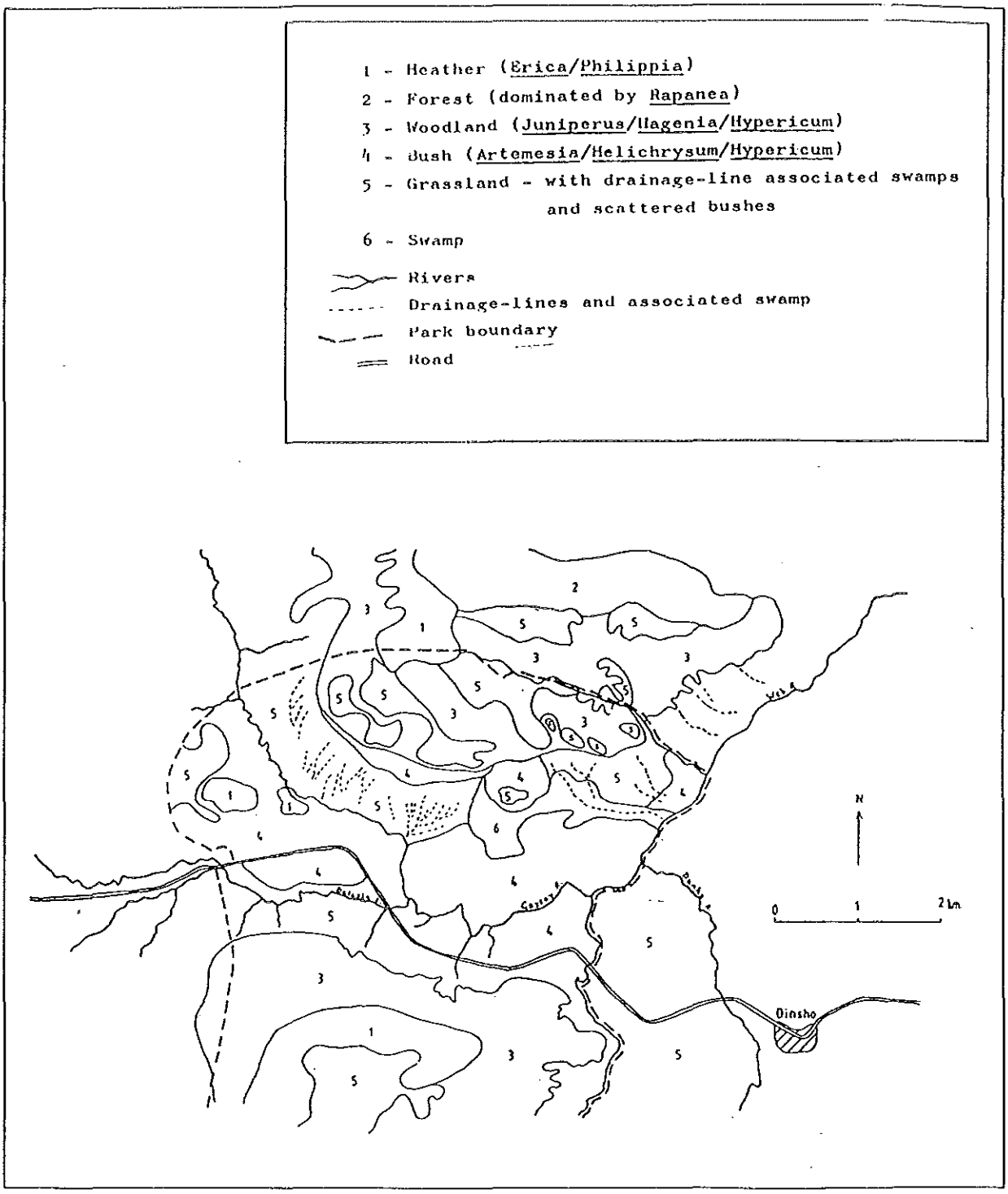

Figure 6. Vegetation map of the Gaysay area (Hillman, 1986).

2.5.2 Wild animals

A broad range of habitats between 1500 and 4377 m altitude of the BMNP provide large niches for wild animals (Urban and Brown, 1971; Largen *et al.*, 1974; Shimelis Beyene, 1986; Gottelli and Silero-Zubri, 1990; Hillman, 1986; 1993). At least, 66 mammals and 262 bird species have been recorded. In addition, reptiles, amphibians, fishes and other animals have a part in the complex ecosystems that have evolved in this unusual area. Mammals of the BMNP is given in Appendix 2. The large proportion of the Bale Mountains fauna is endemic (Appendix 2). The mammals of BMNP represent about 23.8% of the 277 mammals species recorded in Ethiopia (Hillman, 1993). Distribution is relatively even, but the greatest proportion (80%) is found in the northern grasslands and woodlands, showing the importance of this small area to the park.

There are more than 262 bird species recorded in the Bale Mountains National Park area to date; this is 30.4% of the 861 species recorded for Ethiopia (Hillman, 1993). The little collection of reptile sand amphibians that has been done were also found new records for Ethiopia and as well as undescribed species (EWNHS, 1996). Until recently, wild animals of the area, especially that of the Harenna Forest were unexplored. The first zoological expedition in the forest was only in 1986 and found three new species for Ethiopia and two new species to science (Afework Bekele, 1988; Yalden, 1988a,b; Yalden and Largen, 1992). It is likely that more undiscovered wild animals occur in the park area (Lavrenchenko, 2000).

2.6 SETTLEMENT AND LAND USE

It is apparent that there was little settlement in the BMNP area prior to the formation of the park in 1970 (Smeds, 1959; Moony, 1963; Brown; 1966). At present, the park area is being used as permanent settlement, and temporary (nomadic) use of some grazing and of the "horas" – mineral springs. The BMNP and surrounding villages are shown in (Fig. 7). The most extensive use of the park is for grazing domestic animals. There is also some cultivation of barely at 3000 m elevation, rarely extending to 3500 m above sea level (EWNHS, 1996).

The strongest influence of settlers is the use of fire to control the growth of woody vegetation and stimulate new growth for grazing. This is most extensive in the ericaceous vegetation beyond the upper limit of the Hagenia-Hypericum forest (3400-3500 m above sea level). The fire gets out of control during the dry season in ericaceous scrub affecting large areas, even those which are not at all used by man. These burning practices still continue in the park despite all restrictions, especially during pronounced dry season (Miehe, 1994). Traditionally, the forests are used for gathering honey and other forest products, and for grazing. However, a sawmill has been installed in Mena on the south of the Harenna Forest and large timber trees are being logged out. There is also increasing use of the forest to supply construction material, fuel and charcoal for the expanding urban population in the area (Hillman, 1986; EWNHS, 1996).

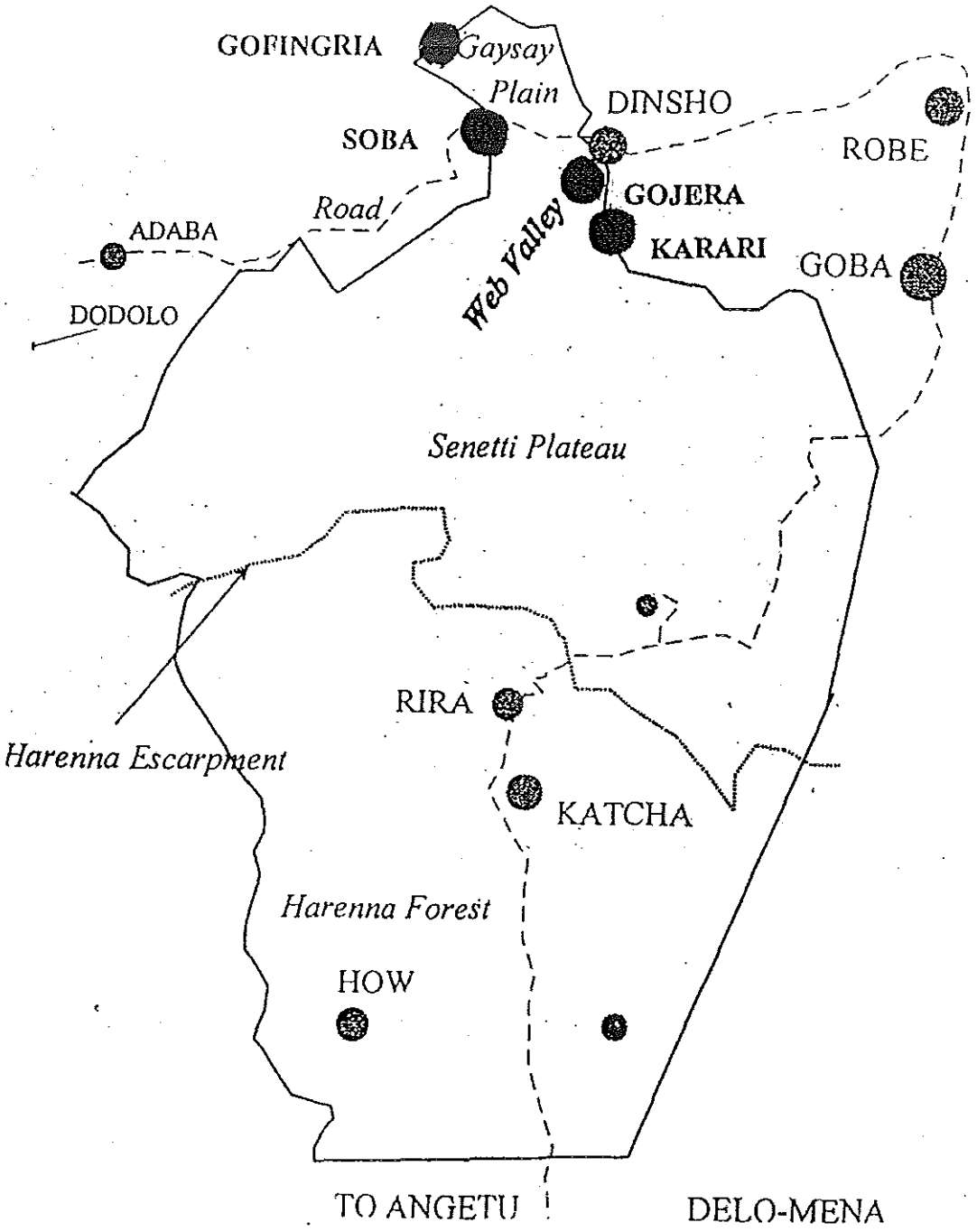

Figure 7. The Bale Mountains National Park and the surrounding villages.

3. MATERIALS AND METHODS

3.1 DATA COLLECTION

Data collection was conducted from February 2000 to December 2000. Reconnaissance observations were made before data collection. The preliminary observations of the study area included assessing the distribution of warthogs, observing the vegetation cover and launching sampling plans. A research design was established depending on these initial observations. Data were collected by dividing the study period into dry and wet seasons. Data collection was carried out for two months during the dry season (February and December) and two months during the wet season (August and October).

Seasonal differences in the population size age and sex categories, and diurnal activity patterns of the warthogs were compared. Separation of dry and wet seasons was based on the change of rainfall pattern and vegetation cover. Quantitative data were collected on the population size, age and sex categories, and activity pattern on the dry and wet seasons.

3.2 POPULATION ESTIMATE

Depending on the information obtained during the reconnaissance observations, the main study site was in the Gaysay area which is the Northern West part of the BMNP. The other zones of the park were also surveyed. Both total and sample counts were used to estimate the population of warthogs in the study area.

3.2.1 Sample count

Estimation of the warthog population in Gaysay Valley was conducted by using sample count. Sample counts were made using a line transect method to estimate the population size as was used by Eberhardt (1978), Eberhardt *et al.* (1979), Burnham *et al.* (1979), Smith (1981), Ratti *et al.* (1983), Brennan and Block (1986). Whitesides *et al.* (1988) and White *et al.* (1989) for different mammals. Line transect sampling was designed based on straight transect lines or a series of straight line segments (Anderson *et al.*, 1978; 1979; Burnham *et al.*, 1980).

Five transects with a total of 5 km were located randomly in the study area using Global Positioning System (GPS). Five transects each measuring 1km were designed randomly, in such a way that the lines should not be very close to each other nor should they overlap. Transects were designed to yield sufficient information and meaningful data so that it would be possible to conduct the proper statistical analysis and to avoid systematic error or biases. Permanent transect lines were delineated by poles and/or natural markers. Complete records of data have been made by using a field form (Appendix 3). Transects were surveyed with two trained scouts. Surveys were conducted when warthogs were most active as suggested by Wilson *et al.* (1996). All transects were covered from 0800 h to 1100 h in the morning and from 1500 h to 1800 h in the afternoon for 10 consecutive days. About an hour was spent on each transect. A Global positioning system (GPS) was used to follow a strait line by sighting of land markers on the line of travel as well as taking bearings to the object(s) relative to the transect line. The following information was recorded each time an animal or a group was spotted: the number of animals in the group, the sighting distance

and perpendicular distance of the animal from the observer. Hayne's estimator of density was used to estimate the population size.

$D_H = n/2L\ (1/n\Sigma 1/r_i)$

Where D_H= Hayne's estimator of density

n= Number of animals seen

L= Length of transect

r_i= Sighting distance to each animal i

Density estimation from line transect sampling is dependent upon four assumptions (Burnham *et al.,* 1980): (1) Animals on the transect are never missed. (2) Animals do not move before being seen or flushed and none is counted twice. (3) Distances are measured and are recorded accurately, and (4) Sightings are independent events. During the study, transects were covered systematically with a constant speed to maximize the probability of seeing all animals on the transect. Animals more than 20 m from the centerline showed little reaction. Animals within 20 m showed variable responses, but were easily observed. Most animals were not moving or were slowly foraging when sighted. Instances of animal flushing were rare. Perpendicular distance was measured accurately by using GPS. The study was designed and the data were analyzed to minimize the violation of the above assumptions and their effects. The censuses were repeated for the two seasons (dry and wet) in order to achieve representative population estimate. Any change in the population size between the dry and wet seasons was noted.

3.2.2 Total count

Total counts were carried out in the Dinsho hill in both dry and wet seasons. Total counts were made rather than sample count because the area is sufficiently small (2.7 km^2). Total counts were made using direct count method based on silent detection to estimate the population size as was adopted by Harper *et al.* (1967), Martinka (1969), Leuthold and Sale (1973), Norton-Griffiths (1978), Melton (1983), Sale and Berkmuller (1988), Caughley and Sinclair (1994) and Wilson *et al.* (1996).

Repeated counting of the same groups was avoided using easily recognizable features such as the individual body conditions, group size, group composition and distinct individuals with broken or malformed tusks as used by Cumming (1975).

Counts were carried out on foot using unaided eyes and/or binoculars two times during the dry season (February and December), and two times during the wet season (August and October). The censuses were conducted when the warthogs were more active (0900h to 1100h) in the morning and (1600h to 1800h) in the afternoon each for five consecutive days following the methods of Wilson *et al.* (1996). Two experienced scouts of the park have participated in the census method. Complete records of data have been made by using a field form (Appendix 4).

3.3 SEX RATIO AND AGE DISTRIBUTION

During counting, each individual in a group was identified into its respective age and sex categories. The categories used were young, sub-adult and adult. The sex of each sub-adult and adult individual was also identified following the method of Bergerud (1971), Kitchen (1974), Bowyer (1984), Schaller *et al.* (1987) and Balakrishnan and Ndhlovu (1991).

Identification of sex and age category was carried out in the field by using body size, tusk size, size of scrotum, mammary glands and mane as described by Laws and Clough (1966), Child *et al.* (1968) and Clough (1969) for warthogs. By using such criteria, it was possible to place individuals of different animals into appropriate age and sex categories in the field. The male warthogs are distinguished from the female by their two pairs of warts, larger tusks, and permanent scrotal testicles which are situated below the anus between the two tights. Whereas, the female has a pair of warts, relatively smaller tusks and mammary glands (Laws and Clough, 1969; Kingdon, 1982). These differences between males and females become more conspicuous when they reach sexual maturity. Sex ratios and age distribution of the population were given depending on this observation.

3.4 DIURNAL ACTIVITY PATTERN

Focal – animal sampling method was selected to study the diurnal activity pattern of warthogs. Focal – animal sampling is a sample taken by focusing observations at one individual (pair, group) during a particular sample period. Using this method, several activities of selected individuals could be measured accurately by observing only one

animal or a group at a time (Altmann, 1974, Lehner, 1996). The activity of four easily recognizable and approachable warthogs was recorded every 5 minutes from 0600 h to 1800 h, following the method adopted by Clough and Hassam (1970).

A single adult male (Group I) and a female with her two hoglets (Group II) were observed at a time for at least three consecutive days. The animals were observed using unaided eyes and/or binoculars and were followed on foot. Observation was facilitated by the animals preference for short grass areas and by selecting strategic site on the hill which enabled to observe even more than a group.

If the focal-animals in the field disappeared from view, the time intervals that the individual being observed is out of sight would be recorded as a missing data. When the out of sight periods was with longer duration than the duration of the common activities, it was deleted from the sample and duration of the sample period was reduced accordingly. On the other hand, whenever the out of sight period was shorter, a guess was made about its activity by referring to what it was doing before and after its absence.

Activities were recorded as feeding, walking (and running), lying down, and other (i.e. standing, wallowing, defecating, urinating scratching, drinking, digging, fighting, etc.) by using the method adopted by Clough and Hassam (1970) and Cumming (1975). The diurnal activities were recorded in both dry and wet seasons. Seasonal changes in the amount of time engaged in various activities were also observed following Cumming (1975).

Data were analyzed by using SPSS computer program. Population estimation on each transect was compared using one way ANOVA (p=0.05). Animals counted under different seasonal conditions (dry and wet), sex and age category of the population were also compared using t-test for independent sample of groups (p=0.05). The differences in the amount of hours devoted to different activities were analyzed using one-way ANOVA (p=0.05). T-test for independent sample of groups (p=0.05) was used to test significance differences of each activity under different seasonal conditions (wet and dry). Activities of group I and II were also compared using t-test for independent sample of groups (p=0.05).

4. RESULTS

4.1 POPULATION ESTIMATE

4.1.1 Sample Count

The results of population size of sample counts for each month on each transect are given in Table 2. There is significant variation among counts of the five transects ($t=147.6$, $p<0.05$). The maximum number estimated was 691 on transect 2 and the minimum was 228 on transect 3. On the average 445 animals were counted in Gaysay Valley. The highest estimate was in August and the lowest was in December respectively. A total of 484 and 416 animals are counted in August and December respectively. Comparisons of counts for each transect between dry and wet seasons using t-test for independent sample of groups is given in Table 3. There was significant difference ($p<0.05$) on the counts of transect 2,4 and 5 between the two seasons.

Table 2. Estimates of sample counts for each month.

Month	Counting Transects					Total	Mean
	T-1	T-2	T-3	T-4	T-5		
February	228	606	264	438	558	2094	419
August	264	828	240	492	594	2418	484
October	240	720	180	564	612	2316	463
December	252	612	228	450	540	2082	416
Total	984	2766	912	1944	2304	8910	1782
Mean	246	691	228	486	576	2228	445

T-1=Transect one, T-2=Transect two, T-3=Transect three, T-4=Transect four and T-5= Transect five.

Table 3. Comparisons of counts between dry and wet seasons using t-test for independent sample of groups.

Transects	t-value	p-value
1	-0.7	0.497
2	-4.78	0.005
3	1.62	0.12
4	-3.01	0.007
5	-2.68	0.011

4.1.2 Total count

Four total counts were carried out at Dinsho Hill. The total counts were undertaken for two months during the dry season (February and December) and for two months during the wet season (August and October). The results of the average total counts for each month are given in Table 4. Counts during wet season were significantly higher than counts during dry season ($t=3.02$, $p<0.05$). On the average 108 animals were counted in Dinsho Hill that is 97 in the dry season and 119 in the wet season. The highest count was 120 and the lowest count was 85 in August and December, respectively.

Table 4. Total counts for each month.

Month	Male	Female	Unidentified	Total
February	21	37	50	108
August	20	32	68	120
October	15	30	74	119
December	9	26	50	85
Total	65	125	242	432
Mean	16	31	52	108

The results of survey of different sites of the park are shown in Table 5. A total of 22 warthogs were counted in Web Valley and Harrena Forest. Warthogs were absent in Sanetti Plateau.

Table 5. Number of warthogs counted in other parts of the Bale Mountains National Park.

Month	Study Areas			Total
	Web Valley	Sanetti Plateau	Harrena Forest	
February	17	0	6	23
August	16	0	6	22
Total	33	0	12	45
Average	17	0	6	23

The results of both census methods of the whole area are summarized in Table 6. An average of 576 animals were counted in the whole study area. Monthly and seasonal comparisons of counted warthogs are given in Figures 8 and 9, respectively. Counts during wet season in general were significantly higher than counts during dry season ($p<0.05$). On the average 536 animals in the dry season and 616 animals in the wet season were counted (Table 7). The highest and the lowest count were in August and December, respectively (Fig. 8).

Table 6. Monthly estimates of warthog counts in different sites of the park

Month	Sample Count	Total Count				Total
	Study Areas					
	Gaysay	Dinsho	Web	Sanetti	Harrena	
February	419	108	17	0	6	550
August	484	120	16	0	6	626
October	463	119	-	-	-	582
December	416	85	-	-	-	501
Total	1782	432	33	0	12	2259
Mean	445	108	17	0	6	576

Table 7. Warthogs counted in dry and wet season

Seasons	Adult		Sub adult		Young	Total
	Male	Female	Male	Female		
Dry	56	84	36	69	291	536
Wet	54	81	42	72	367	616
Total	110	165	78	141	658	1152
Average	55	82	39	71	329	576

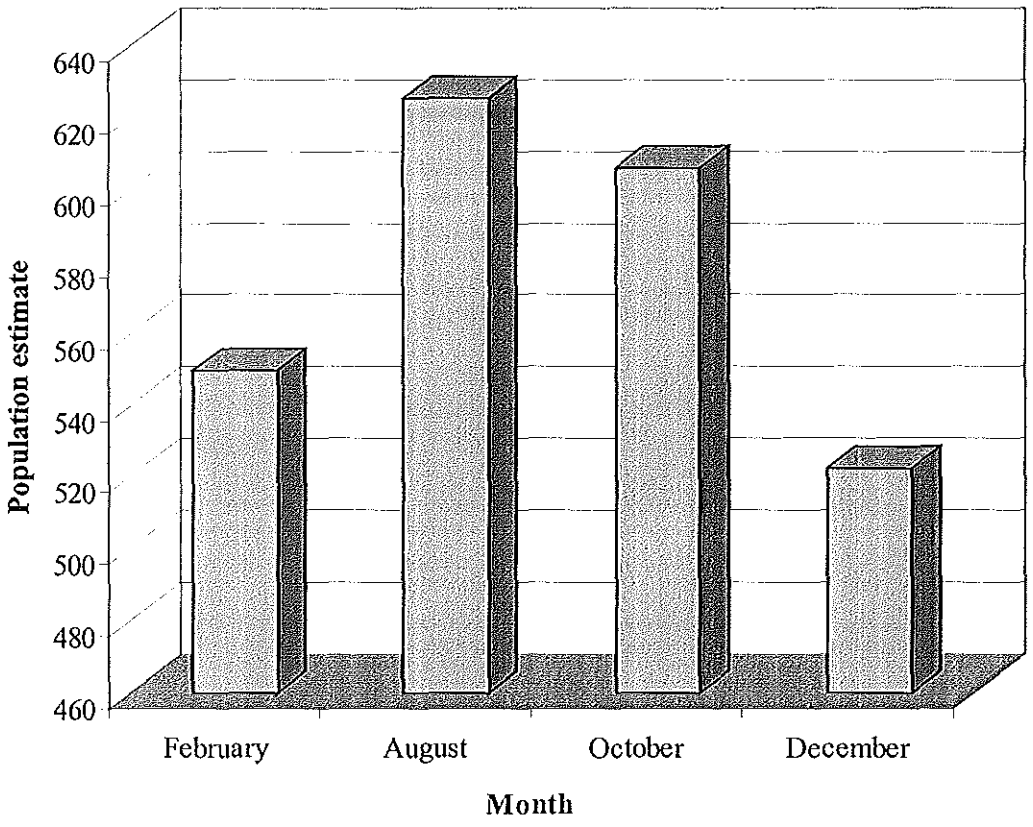

Figure 8. Monthly comparison of counted warthogs.

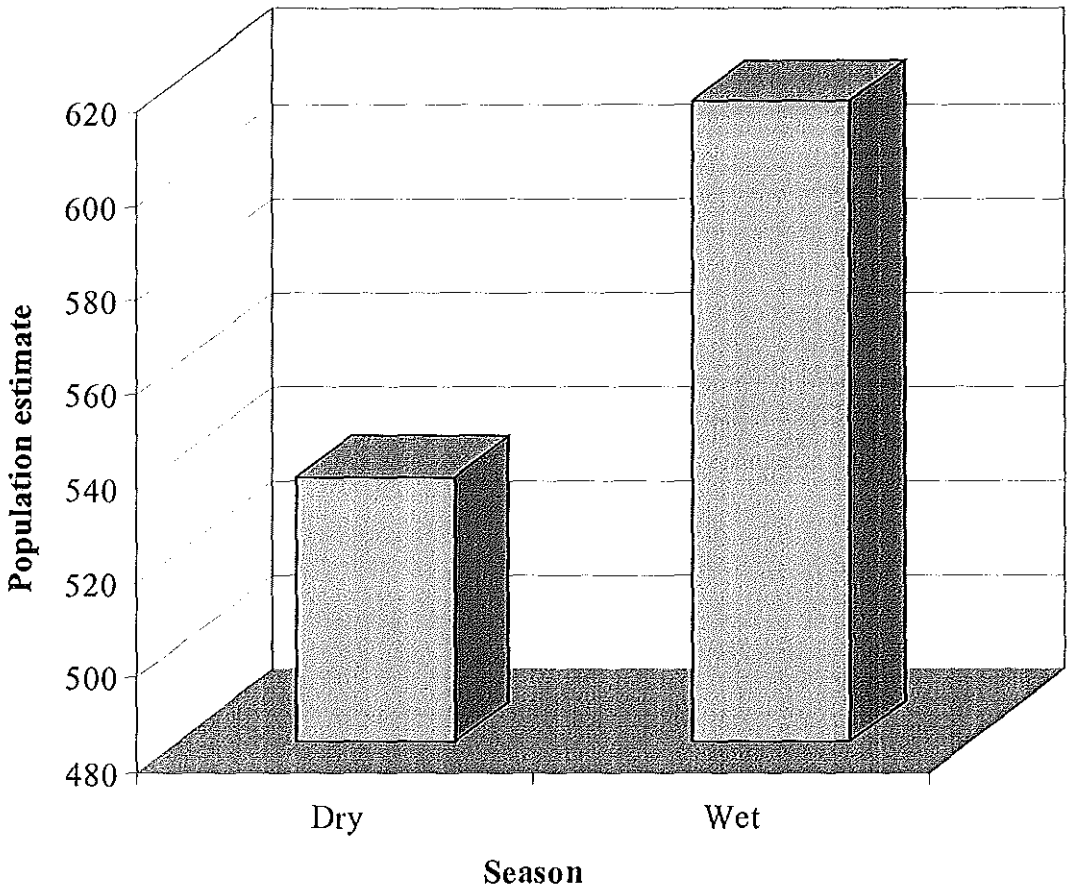

Figure 9. Seasonal comparison of counted warthogs.

4.2 SEX RATIO AND AGE DISTRIBUTION

During both total and sample counts, the age and sex of individuals were identified. The sex of 247 individuals was determined. The age and the sex of individuals for both dry and wet seasons counted during the census are given in Table 8.

Table 8. Age and sex structure of warthogs in dry and wet seasons

Seasons	Adult		Sub-adult		Young*	Total
	Male	Female	Male	Female		
Dry	56	84	36	69	291	536
Wet	54	81	42	72	367	616
Total	110	165	78	141	658	1152
Average	55	82	39	71	329	576

Young*: Hoglets + Yearlings

On the average 42.9 % of all the warthogs were adult and sub-adults while 57.1 % were young individuals. More young individuals were counted than the adult ones ($t=3.80$, $p<0.05$). The percentage of each age category for dry and wet seasons is given in Figure 10. The adult and sub-adult female to male ratio was 1.6. The result shows that there is unequal sex ratio in the population. The number of females was significantly greater than the number of males ($t=5.46$, $p<0.05$). Male to female ratio of the population shows 23.9 % more females than males were counted.

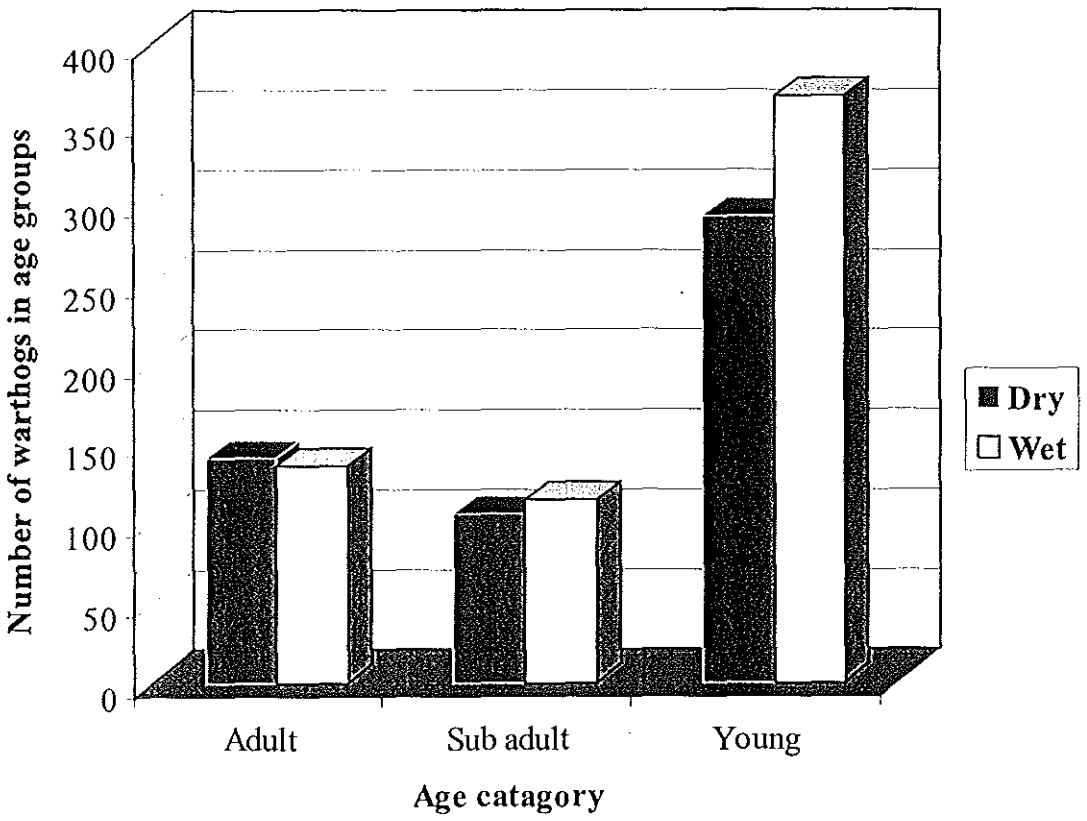

Figure 10. Number of warthogs in each age category during the dry and wet seasons.

4.3 DIURNAL ACTIVITY PATTERN

The percentage of time that each group was engaged in different activities is summarized in Table 9. Figure 11 also shows the percentage of the hourly activity pattern of each group (group I: an adult male, and group II: an adult female with her two hoglets). The differences in the amount of hours devoted to each activity were striking ($t=53.5$, $p<0.05$). Feeding activity was intensive and reached its pick in the early morning and late afternoon. Resting/lying down increased in the middle of the day (Fig. 12 and 13).

Activity of Group I (an adult male)

34.6 % of the adult male daytime was spent in feeding. Feeding activity reached its peak in the early morning (0800-1000h) and late afternoon (1600-1800h) (Fig. 12). Feeding consisted of entirely grazing, except digging for searching rhizomes during the dry seasons. Resting/lying down was the second frequent activity. Resting was frequent during the hottest part of the day and remained in the bush spending more than an hour. Walking (running) was frequent from the hole to the grazing field and from the grazing field back to the hole. During breeding season, walking (running) was carried out to follow the female. Other activities include standing, wallowing, defecating, urinating, scratching, drinking, digging, fighting, grooming, etc. Wallowing occurred during the hottest part of the day. The male spent his time in the hole in the early morning (0600-0700h) before it came to the field.

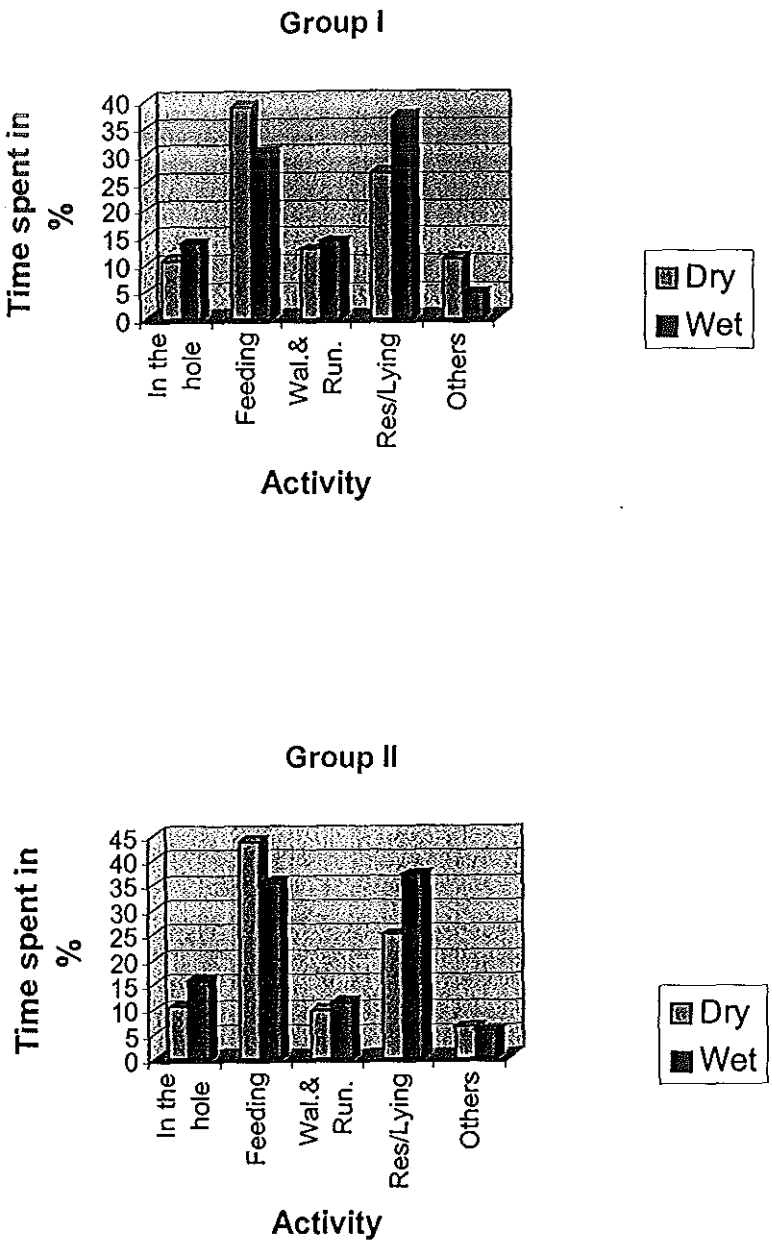

Figure 11. Comparisons between dry and wet seasons in the percentage of time that each group was engaged in different activities.

Table 9. The percentage of time in hours that each group was engaged in different activities

Season	Month	Group I					Group II				
		H	F	W/R	R/L	O	H	F	W/R	R/L	O
Dry	Feb	9.3	45.5	11.0	27.6	6.6	11.5	52.8	8.9	23.0	3.8
	Dec	8.0	31.9	14.5	26.1	19.5	9.2	34.6	10.5	26.9	18.9
	Sum	17.3	77.5	25.5	53.7	26.1	20.7	87.4	19.4	49.9	22.7
	Aver.	8.7	38.7	12.7	26.9	13.5	10.4	43.7	9.7	24.9	6.3
Wet	Aug	9.8	30.3	17.3	34.3	8.3	9.7	36.0	13.4	35.3	5.7
	Oct	11.9	30.8	10.9	39.6	6.9	12.2	34.2	9.3	38.9	5.4
	Sum	21.7	61.1	28.2	73.9	15.2	21.9	70.2	22.7	74.2	11.0
	Aver.	10.8	30.5	14.1	37.0	7.6	11.0	35.1	11.3	37.1	5.5

H=In the hole, F=Feeding, W/R=Walking/Running, R/L=Resting/Lying down and O=Others.

Activities of Group II (an adult female and her two hoglets)

During the period of observation, the two young remained with their mother at almost all time. When accompanying each other, all the three animals had a very similar activity pattern. The activity of the group was recorded by considering the female because the female was often the initiator of any change in activities. The major activity in this group was feeding which occupied over 39.4 % of the animals time. Data show no considerable variations between the activities of group I and group II although individuals in group II tended to spend more time in feeding than did group I (Fig. 11). Similar to group I, the second most common activity was resting/lying down. They were engaged in resting during the hottest part of the day (Fig. 13). Resting was mainly interspersed with other activities mainly with feeding, and walking. Walking (running) came the third activity as in the order of group I. They did wallowing in the hottest part of the day.

The amount of hours devoted to each activity by group I and II was not significantly different except feeding (Table 10). Warthogs in group II spent significantly higher time in feeding ($t= 2.74$, $p<0.05$) than warthogs in group I. The differences in the amount of hours devoted to each activity under different season conditions (dry and wet) were not significantly different except feeding and resting/lying down (Table 10). The time devoted to feeding during the dry season was significantly greater ($t=2.47$, $p <0.05$) than the wet season. While the amount of time spent lying down during the dry season was significantly less ($t=-2.7$, $p<0.05$) than the wet season.

Table 10. Comparison of the activities between groups (Group I and II) and seasons (dry and wet) using t- test for independent sample of groups.

Activity	Group I vs. Group II		Dry vs. Wet	
	t-value	p-value	t-value	p-value
In the hole	0.55	0.59	1.97	0.06
Feeding	2.74	0.047	2.47	0.02
Wal./Run.	0.83	0.42	0.6	0.55
Res,/ Lyin.	0.2	0.84	-2.7	0.01
Others	-2.07	0.05	0.01	0.17

Warthogs appeared earlier from their hole in the morning and returned back latter to their hole in the evening in the dry season than the wet season. Data show that the warthogs were engaged more in resting for an extended time in the wet season than in the dry season in their hole. The early morning and late afternoon activity peaks were more obvious during the dry season, most warthogs remaining inactive during the mid-day which are the hottest hours of the day.

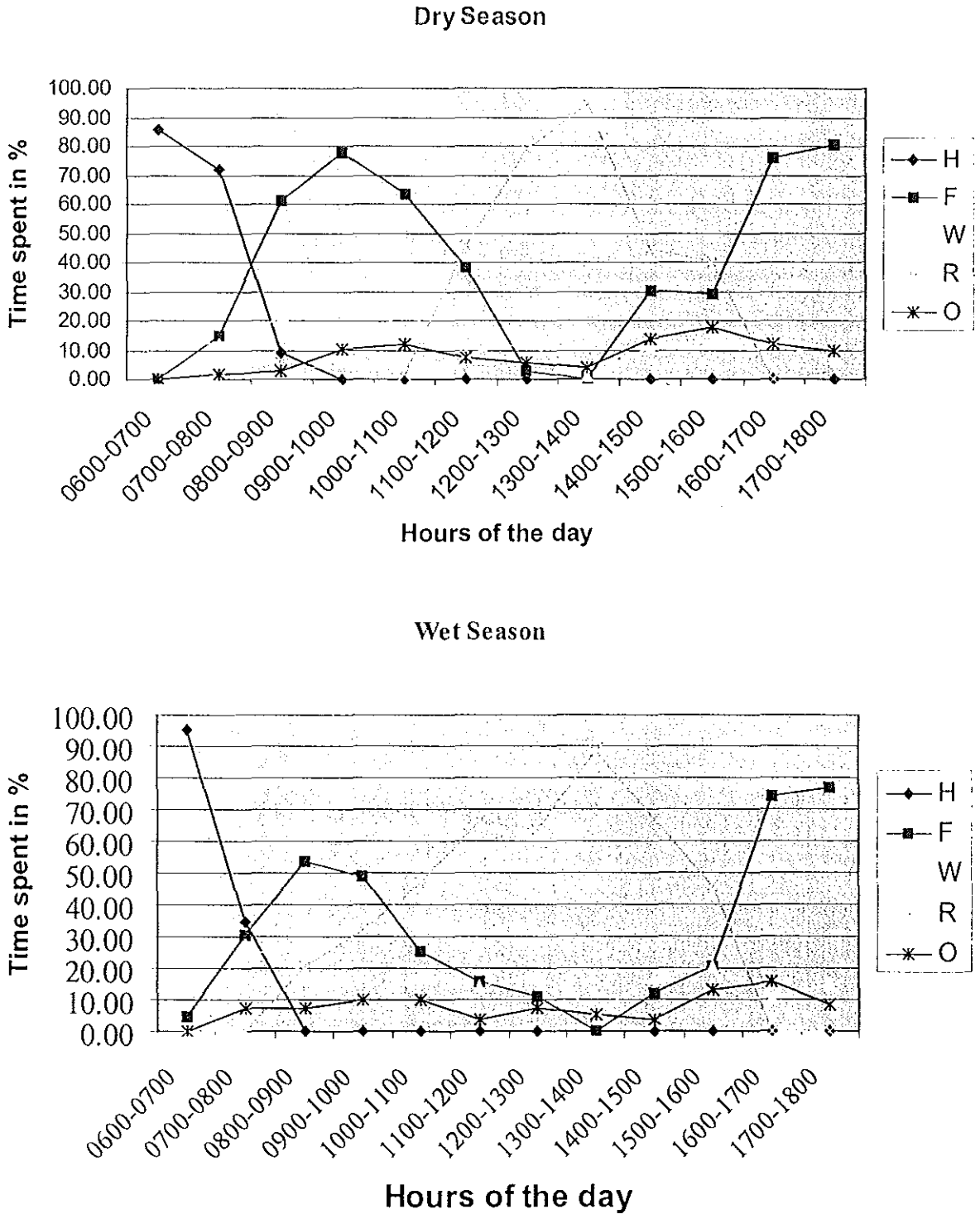

Figure 12. Variation in activities shown by Group I during the hours of a day. (H= In the hole, F= Feeding, W/R= Walking/Running, R/L= Resting/Lying down and O= Others).

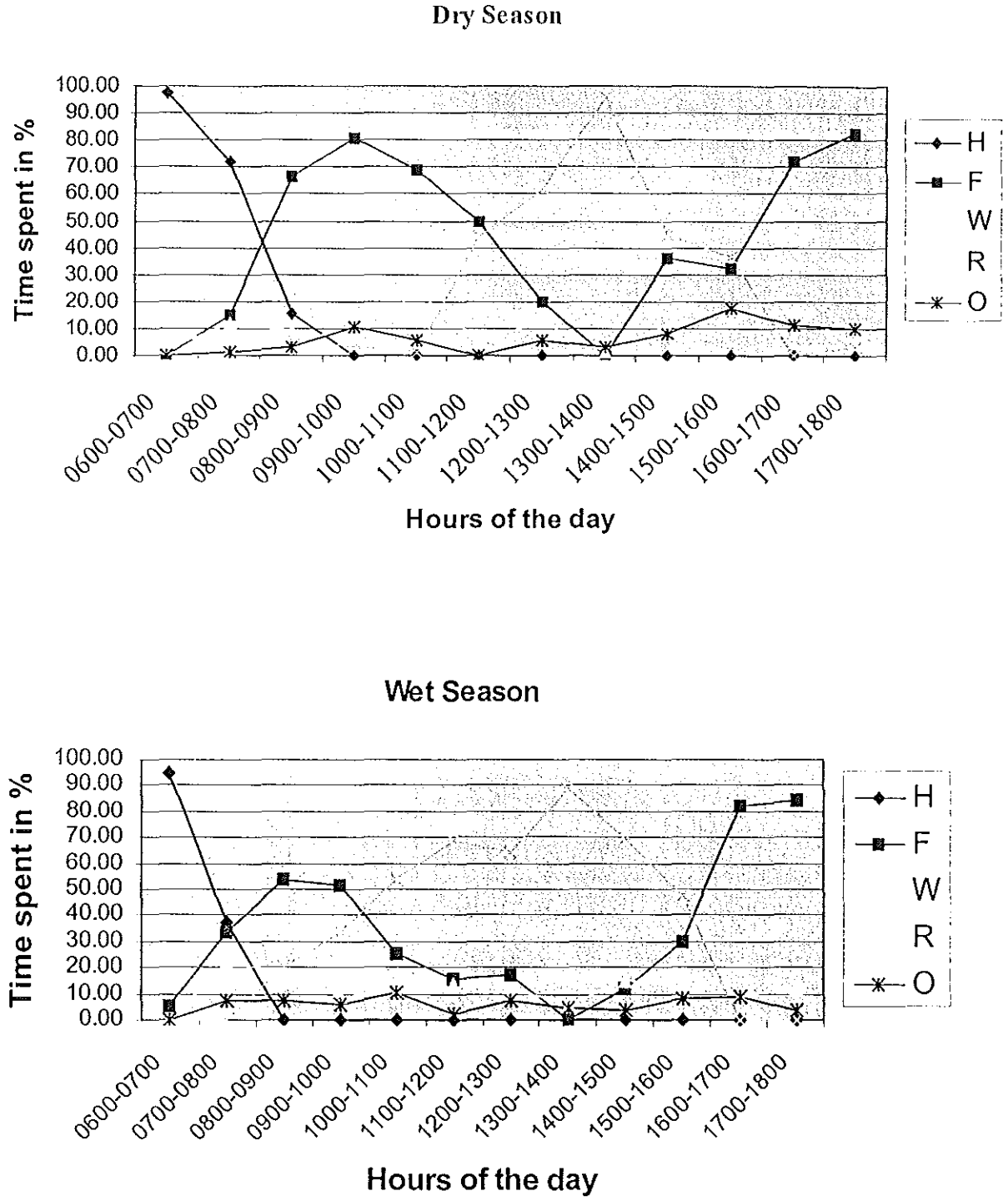

Figure 13. Variation in activities shown by Group II during the hours of a day (H= In the hole, F= Feeding, W/R= Walking/Running, R/L= Resting/Lying down and O= Others).

5. DISCUSSION

5.1 POPULATION ESTIMATE

In order to manage the population of warthogs properly and to take conservation measures accordingly, estimating their population in the study area is important. On the average 576 animals were counted in the whole study area. Separation of the study period into dry and wet seasons was important in order to observe the influence of the different seasons on the vegetation cover and hence, the distribution of animals.

More warthogs were counted during the wet than the dry seasons. It is during the wet season that furrowing takes place in most warthogs. Young are born at the end of the dry season and beginning of the wet season (Child *et al.*, 1968 and Boshe, 1984). A population build up could be expected in the wet season. This is well confirmed by the results of the present study. Furthermore, there could probably be high rate of mortality in the dry season due to physiological stress as a result of shortage of food and water. However, data should be collected on a monthly basis to confirm this.

There was no significant difference ($p>0.05$) on the counts of some transects between the two seasons. This was probably because warthogs graze near the forest and their holes. This made counting more difficult. Since warthogs lack subcutaneous fat and their body is scarcely covered with hair, they do not resist rain and spend less time within the open grassland in the wet season. The longer vegetation cover in the wet season also made counting difficult.

Counts of warthogs among the 5 transects were significantly different ($p<0.05$). This could be due to a number of ecological factors. The relative abundance of animals is naturally associated with preference towards a given habitat. This depends on what the habitat provides in terms of food, breeding site, protection (from predators, overheating, cold, etc.) and free space. However, The tolerance for these needs is different among different groups of organisms. Small mammals for example, give priority to cover than food. Usually they avoid predators by hiding or else, if spotted there is little chance to escape. Large mammals on the other hand emphasize the importance of food in their habitat. Most of them run to avoid predators rather than hide. They can use any standing tree or some behavioral strategies to avoid sun during the very hot hours of the day. Differences in the counts of warthogs in the 5 transects have most likely resulted in the tendency of warthogs to seek for habitat with a good supply of nourishment. The results of the present study are in agreement with what has been found by Cumming (1975) that warthogs are abundant in open grassland habitat.

The highest number of warthogs was 691 in transect 2 and the lowest was 228 in transect 3. The highest count recorded in transect 2 was in accordance with the preference of open grassland by warthogs. The vegetation map of the study area (Fig. 6) shows that transect 2 is mostly covered with open grassland. Counts of warthogs was lowest and consistent in transects 1 and 3. The vegetation map once again shows that transects 1 and 3 are mostly covered with bushes of *Artemesia / Helichrysum/ Hypercium*.

Generally, it was observed that large numbers of warthogs were counted on transects with open grassland habitat. This shows warthogs prefer open grassland, less disturbed and long trees for refuges near the open grassland.

Originally, it was planned to follow transect method in the whole study area, however, the situation in Dinsho did not allow this. This area is small fenced hill which is isolated from Gaysay Valley by the surrounding villages and new settlements. Therefore, total count was conducted in this area. The small size of the study area has contributed in making accurate counts (Plessis, 1972 and Eltringham, 1977). This made it possible to conduct a total count of the warthogs in the Dinsho Hill (2.7 km^2) with a reasonable degree of accuracy. A count of 108 warthogs in Dinsho shows that this fenced area is relatively the most protected part of the park and suitable in terms of vegetation cover.

The survey in other areas showed that warthogs do not prefer forest but they may be found on the clearings between the forests. A total of 6 warthogs were observed in the Harrena Forest (Table 5). Therefore, a few more warthogs are expected to be found in the forest but it is difficult to draw any conclusion about the exact figure. This observation is in conformity with a survey of the forest by Lavrenchenko (2000).

As expected warthogs are absent in Sanetti Plateau. The habitat of such high altitude is not ideal for them. The result from the Web Valley showed that there were a few number of warthogs in the area. Most of the habitat is very cold and not suitable for them. The few remaining favorable habitats are occupied by human beings. There is settlement and

disturbance throughout this area but a few number of warthog are managed to share some places near their refuges.

It is difficult to discuss the population trend of warthogs in the study area, since any periodic (continuous) census has not been made before. Hillman (1986) estimated 588 warthogs in this area. This number was not significantly different with the current estimation. Warthogs are relatively abundant and widely distributed throughout Ethiopia. The main threats at present are hunting, competition with livestock, habitat destruction and disturbance by human activities. The number of livestock in the study area was greater than any other time of the past (Hillman, 1986). An increase in human population and expansion of settlements within and around the park has intensified the competition among the wildlife, livestock and local people. This has an effect on the size of warthog population.

5.2 AGE CATEGORIES

The knowledge of sex ratio and age distribution of individual mammals is vital for evaluating the viability of a species, because these variables reflect the structure and the dynamics of population (Wilson *et al.*, 1996). Sex and age structure of a population at any given point in time is also an indicative of the status of the population (Woolf and Harder, 1979). The result of the present study showed a great percentage of young animals in the population. More than 50 % of the population is composed of young animals. The fairly high population of young animals indicates a healthy, increasing warthog population in the study area similar to the study carried out by Bosche (1981) in the Eastern Salous Game Reserve, Tanzania. An increase of the young numbers recorded during the wet season

observations suggested that furrowing took place at the beginning of the wet season. Hoglets were usually hidden among the dense tall grasses under the bushes until they can fully follow the parent herd. In addition, they do not appear in the vicinity of their burrows before a week after parturition (Child *et al.*, 1968). As a result, the numbers of hoglets could be underestimated although they are quite vulnerable to predation at this stage. During the census, hoglets started accompanying their mothers in the vicinity of the burrows and stayed with their mother all day long after the first week.

5.3 COMPARISON OF SEX RATIO

A total of 245 (dry season) and 249 (wet season) warthogs were sexed. It was difficult to categorize the young into male and female in the field as their primary sexual characteristics were not easily visible. Therefore, only the sex of sub-adult and adult individual was determined. 23.9 % more females than males were observed (Table 7). This agrees fairy well with field observation of sex ratios by various workers in different parts of Africa (Bourlier, 1965, Dasmann and Mossman, 1962, Child *et al.*, 1968, and Cumming, 1975). The prenatal and postnatal sex ratio up to the age of one year did not depart significantly from unity (Boshe, 1981). Therefore, sexual parity was shown after the age of one year and a significant sex ratio in favor of female was seen in adults and sub-adults. The difference in sex ratio may be largely due to increase in mortality of male warthogs as a result of exposure to predation. This was attributed to the isolation of male warthogs from the groups at the age of sexual maturity. In addition, it may perhaps be due to the male tendency to be alone or in fairly small groups which enhance their vulnerability to predation. Such factors are known from the work of Cumming (1975). Mitchell *et al.*

(1965) also found lions killed more males than females in Kafua National Park. Hunting also affects adult males more than females since they are chosen for their large size as observed in different animals (Birhanu Gebre, 2000; Yakub, 1999). Tentative explanation of such unequal sex ratio in many African antelopes is that bachelor males are distributed in often less favorable habitats (Spinage, 1968). Hence subordinate males become weak and eventually susceptible to starvation. In addition, Cumming (1975) explains that sex ratio of adults was significantly associated with the specific month and this was largely due to a marked drop in the proportion of adult males after the rut in each year. The reasons for this post rut decline in the proportion of males are not known but there is circumstantial evidence to suggest that it may be a combination of changes in the behavior of adult males and increased mortality following the rut. These factors may have contributed to the small proportion of adult male in the study area.

5.4 DIURNAL ACTIVITY PATTERN

Warthogs at the Bale Mountains National Park were reasonably tame if care was taken. It was also possible to approach within 20 m to 40 m without causing distrust. This has helped the present study to follow them at a close range. There were significant differences in the amount of hours devoted to different activities ($t=53.5$, $p<0.05$). Warthogs spent more than 50% of their daytime in feeding and resting/lying down. Similar observations were reported by Clough and Hassam (1970), Cumming (1975) and Lewis and Wilson (1979) and for other herbivores by Spinage (1968), Lewis and Wilson (1979), and Birhanu Gebre (2000).

Their activity follows the general pattern of ungulates in the Bale Mountains National Park. The general daily pattern of warthogs was characterized by morning and late afternoon activity with a period of rest in the middle of the day. Feeding was intense in the late afternoon before the animals retire to their hole for the night. Warthogs were active in feeding from 0600-1000 hours. This comprised more than 60 % of the over all activity. But, by the mid day this figure drops. After 1500 hours, the feeding activity rises steadily again and approaching 80% by 1800 hours (Fig. 12 & 13). Usually around the middle of the day warthogs remain resting /lying down (about 90%) under the shade of a tree or on the open grassland to escape the intense heat of the day. Wallowing was clearly associated with ambient temperature. There is a correlation between frequency of wallowing and ambient air temperature of the day as described by Cumming (1975). In the study area, the wallowing activity of warthogs at midday confirmed this. Apart from a thermoregulatory function, the wallowing activity might have an effect on ecto-parasites (Cumming, 1975) but it was difficult to draw any conclusion from the present study.

The result shows basically similar activity pattern for all individuals except some differences associated with sexes and ages. Comparing the results from Group I (adult male) and those of group II (a female and her two hoglets) showed that the major differences were in the time spent in feeding and resting. However, statistical analyses confirmed a significant difference for feeding only ($p<0.05$). The amount of time spent, in the adult male was less in feeding than the adult female and her two hoglets. The adult male spent 34.7% of his time in feeding, whilst the adult female and her hoglets spent 39.4 % of their time. Clough and Hassam (1970) have also obtained differences in feeding, efficiency based on the size of their mouths and molars. Bradley (1968) cited in Cumming (1975) has

also found similar differences in the percentage of time spent on feeding by male as compared to female warthogs in the population he studied in Nairobi National Park.

The differences in the amount of hours devoted to each activity under different season conditions (dry and wet) were not significantly different except feeding and resting/lying down (Table 10). Feeding activity is minimal during the wet season. A decrease in feeding time with increasing food availability during the wet season has been observed but this does not confirm the observation made by Cumming (1975). The time spent on feeding by both groups during the dry season is also accompanied from grazing to rooting. Time spent resting/lying down showed a marked increase in the wet seasons at the expense of other activities particularly feeding. This was probably to avoid rain and cold during the wet season. This result seems contradictory to what has been found by Cumming (1975). There was a positive correlation between the amount of time spent lying down in the shade each day and the amount of temperature.

The animals also appeared from their hole earlier and returned late in the dry season than the wet season. The amount of time spent out of their hole was more in the dry season than the wet season. This can be associated with seasonal changes in day length. Walking activity in the adult males increased during the rutting season to find and stimulate an estrus female.

6. CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The present study provided information on some aspects of the ecology of warthogs in Ethiopia. It can give baseline information for further study on the species. Specific conclusion might not be possible on the trends of warthog population because regular census was not carried out before the present study.

The transect data confirm the general statement of earlier authors that warthog inhabit lightly wooded areas and tend to avoid dense woodland and thickets. The relatively high percentage of young individuals and breeding females shows that warthog population in the study area is increasing.

Diurnal activity of warthogs depended on variation in climatic condition. Seasonal changes affect the timing of feeding and resting (lying down) activities. Similar activity patterns have been recorded for all individuals except some differences associated with sexes and ages.

6.2 RECOMMENDATIONS

Based on the results of the present study, the following recommendations are forwarded:

- Further comprehensive studies are needed to determine the status of warthogs in Ethiopia.

- Field investigations and/or additional questionnaire surveys are therefore required to improve understanding of the present range of this species and to determine its distribution.

- Most of the above recommendations serve as a springboard for the future study of the most endangered and rediscovered species of the desert warthog in the Horn of Africa.

- Census should be carried out on annual basis to see the effect of warthogs on the vegetation and to plan a meaningful management measures.

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APPENDIX

Appendix 1. Mean monthly relative humidity at Goba and Dinsho.

Month	Goba*	Dinsho**
January	77	45
February	86	40
March	79	50
April	74	71
May	76	86
June	-	92
July	80	86
August	82	85
September	79	96
October	82	70
November	84	63
December	75	59
Annual mean	72.8	70.3

* ENMSA 1998 (RH measured at 0600 hrs.)

**BMNP data 1993 (RH measured at 0900hrs.)

Appendix 2. Mammals of the Bale Mountains National Park (Hillman, 1993)

Species	Habitat					Endemic
	NG	NW	EM	AM	HF	
Antelopes						
Mountain Nyala	*	*	*	*		*
Tragelaphus buxtoni (Lydekker)						
Menelik's Bushbuck		*	*		*	* spp.
Tragelaphus scriptus meneliki Neumann						
Bohor Reedbuck	*	*				
Redunca redunca (Pallas)						
Grey Duiker	*	*	*		?	
Sylvicapra grimmia (Linn.)						
Klipspringer		*	*	*		
Oreotragus oreotragus (Zimmermann)						
Pigs						
Warthog	*	*			*	
Phacochoerus aethiopicus (Pallas)						
Bushpig					*	
Potamochoerus porcus (Linn.)						
Primates						
Olive Baboon	*	*	*	*	*	
Papio anubis J.P. Fischer						
Guereza (Colobus)		*			*	
Colobus guereza Rüppell						
Vervet Monkey					*	
Cercopithecus pygerythrus (F. Cuvier) (?)						
Carnivores						
Simien Fox	*		*	*		*
Canis simensis Rüppell						
Golden Jackal	*	*	*			
Canis aureus Linn.						
Spotted Hyaena	*	*	*	*	*	
Crocuta crocuta (Erxleben)						
Serval	*	*	*	*	?	
Felis serval Schreber						
Caracal	*	*				
Felis caracal Schreber						
African Wildcat	*	*				
Felis silvestris Schreber						
Leopard	*	*	*	*	?	
Felis pardus Linn.						
Lion	?	*		*	*	
Felis leo Linn.						

Appendix 2. Continued

Species	Habitat					Endemic
	NG	NW	EM	AM	HF	
Civet		*				
Viverra civetta Schereber						
Egyptian Mongoose	*	*				
Herpestes ichneumon (Linn.)						
White- tailed Mongoose		*			*	
Icheneumia albicauda (G. Cuvier0						
Ratel				*		
Mellivora capensis (Schreber)			*.	*		
Zorilla						
Ictonyx striatus (Parry)						
Rodents						
Giant Molerat	*		*	*		*
Techyorcyctes macrocephalus (Rüppell)						
Common Molerat	*	*	*	?	*	
Tachyoryctes splendens Rüppell						
Grass Rat	*	*	*	*		*
Arvicanthis blicki Frick						
Striped Grass Mouse	*	*	*			*
Dendromus lovati De Winton						
Three- striped Grass Mouse	*	*				
Dendromus mystacalis Heuglin						
Mande Rat		*				
Lophiomys imhausi Milne- Edwards						
Harsh- furred Rat	*	*	*	*		*
Lophuromys melanonyx Petter						
Harsh- furred Rat	*	*	*	*		
Laphuromys flavopunctaus Thomas						
Rat			*			*gen.
Megadendromus nikolausi Dieterlen & Rüppell						
Mahomed's Mouse	*	*				
Mus mahomet Rhoads						
Rat	*	*	*			
Octomys typus (Heuglin)						
White- footed Rat	*	*				*
Praomys albipes (Rüppell)						
Rat	*	*	*	*		*
Stenocephalemys albocaudata Frick						
Rat	*	*	*	*		*
Stenocephalemys griseicaduda Petter						

Appendix 2. Continued

Species	Habitat					Endemic
	NG	NW	EM	AM	HF	
Porcupine			*	*		
HJystrix cristata Linn.						
Bats						
Greater Long- fingered Bat	*	*				
Miniopterus inflatus Thomas						
Bush Horesehoe Bat		*				
Rhinolophus simulator Andersen						
Geoffroy's Horeseshoe Bat		*				
Rhinolophus clivosus Cretzschmar						
Shrews						
Shrew		*		*		*
Crocidura baileyi Osgood						
Shrew		*		*		
Crocidura fumosa Thomas						
Other Mammals						
Rock Hyraz	*	*	*	*		*spp.
Procavia Capensis capillosa Brauer						
Abyssinian Hare	*			*		
Lepus capensis Linn (?)						
Aardvark						
Orycteropus afer pallas	*	*				

Notes: Scientific names as used in the " Catalogue of the Mammals of Ethiopia" (Largen, Kock & Yalden 1974; Yalden, Largen & Kock 1976, 1977, 1980, 1984).

(?)- identity needs confirmation

Habitats – NG Northern Grasslands
NW Northern Woodlands
AM Afroalpine Moorlands
EM Heather Moorlands
HF Harenna Forest

Endemic - *- Species;
* gen- genus and species;
* ssp.- Subspecies

Appendix 3. Data Sheet for Line-Transect

Date _____ Survey Site _____ Transect # _____
Weather _____ Start time _____ End time _____
Investigator(s) _____ Target species _____ Transect direc. _____

Observation	Number of Individuals	Age/Sex	Sighting distance	Perpendicular distance	Comments

Appendix 4. Data sheet for Total Count

Place _____ Date _____

No of Obs.	No. seen	Adult		Sub-adult		Young		Habitat	Remark
		male	female	male	female	male	female		