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THE ASSESSMENT OF ELEPHANT POPULATION SIZE AND DISTRIBUTION PATTERNS IN THE MAGO NATIONAL PARK

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A thesis submitted in Partial fulfillment of the requirements
for the degree of Master of Science in
Biology

September, 1998

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

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SEPTEMBER, 1998

ACKNOWLEDGEMENT

This work was stimulated and encouraged by my advisor, Dr. Afework Bekele to whom I owe a debt of gratitude. His presence in the field during the reconnaissance period and his critical comments in reading the manuscript and supplying reference materials are among the few.

My special thanks are due to the Ethiopian Wildlife Conservation Organization for allowing me to persue this programme. Research permission was granted by the Southern Nations Nationalities and Peoples Agricultural Bureau.

This study could not have been carried out without the support of my sponsors: the Wildlife Conservation Society (formerly known as Wildlife Conservation International) with additional funds from World Wide Fund For Nature (WWF). I am grateful to these conservation societies.

I am also grateful for the support of the Mago National Park Office where the study was carried out, for the provision of vehicle and wildlife scouts. I would like to thank Ato Bereket Netsereab, MNP warden, for his consistent assistance during the study period. Again, I am indebted to the MNP staff: Lokya Balguda, Haile Assefa, Abayneh Mengesha, Sheleme Irko, Kiaz Kodbay, Mesfin Negash and Wondyrad Ayalew.

I would like to thank Dr. Assefa Mebrate, Dr. Solomon Yirga (for the provision of video camera during the study period) and Dr. Seyoum Mengistu, from the Department of Biology, Dr. Fekadu Shiferaw from EWCO, Ato Cherie Enawgaw, and Ato Yimer Ayalew for their encouragement and assistance.

I also thank Ato Lemessa Kesseei, from the AAU Herbarium for his support in identification of the plant species collected during this study.

I would also like to thank Almaz Tadesse who took care of tracing all figures, Ato Menassi Gashaw for the provision of computer service, and Dr. Debek of the Statistics Department, for his assistance in data analysis.

Finally, great thanks to my wife, Emebet Seyoum , and my brother, Damte Demeke for their consistent support and encouragement throughout the study period.

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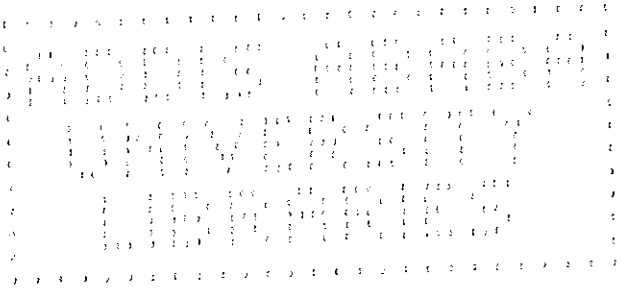

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ABSTRACT

The subspecies of the African elephant, *Loxodonta africana knochenhaueri,* was studied in the Mago National Park to determine population numbers, distribution by seasons and migration routes. The current poaching situation, population age structure and the size of the animals home-range were also assessed. The study was carried out between June 1997 and April 1998.

The population size of elephant was estimated indirectly from the droppings using line transect method within a 1,564 km^2 area. The total estimate of the elephant population for the Mago National Park was between 380 and 442. The observed density for the whole park was 0.18 elephant/km^2. Elephant numbers were also estimated directly from sightings. The maximum number observed in a herd was 182.

Information on the age structure (determined from hind footprint lengths) indicates that the majority of the population was largely composed of subadult males, adult females and intermediates. Yearlings and juveniles were very few.

Observations and information from the local people on elephant migration and movement patterns suggest that some of the elephants move south to Murle Controlled Hunting Area travelling about 43 km outside the park areas. The total range traversed from north to south by elephants of Mago is about 129 km. The calculated average home-range is 1,597 km^2. A total of 82 plant species that elephants feed on were collected and identified.

The study also indicates that poachers have made intensive exploitation of elephants for different purposes. The availability of modern fire arms to the local people in the South Omo has made poaching a serious problem. For example, a total of 37 elephants were killed for ivory between December 1996 and April 1998. Most of the poaching activities took place in the dry season.

The presence of beehives in the Mago National Park has also contributed for the serious decline of wild animals and contraction of their range. A total of ten thousand beehives were estimated for the whole park areas.

I. INTRODUCTION

The wildlife of Ethiopia is very diverse due to varied climatic conditions, different habitats and rugged topography that ranges from 110m below sea level (at Kobar Sink in the Afar depression) to 4,620m above sea level (at the peak of Ras Dejen). Such varied ecological constituents have contributed to the development of large number of species (Shibru Tedla, 1995). However, human pressure has affected the distribution of these species. At present, these diverse wildlife have largely been restricted within a few wildlife conservation areas of the country (Hillman, 1993). These include: national parks, wildlife reserves, wildlife sanctuaries and controlled hunting areas.

Elephants are among the larger mammals of Ethiopia that used to have a wide distribution (Largen and Yalden, 1987). At present, the distribution of these animals is confined to small pockets in restricted regions of the country (Fig. 1). Out of the nine national parks of the country, elephants exist in only three of them: Mago, Omo and Gambella (EWCO, 1991). Very small groups of elephants are also found in Babille Elephant Sanctuary, Shirie and Tama Wildlife Reserves, and the Akobo, Jikau, Tedo, Mizan Teferi, Borena and Metekel-Dabus Controlled Hunting areas (Yalden et al., 1986; EWCO, 1991).

Three subspecies of the African elephants occur in Ethiopia (Largen and Yalden, 1987). These are: L*oxodon*ta *africana oxyotis*, confined along the western border areas of the country between Omo river in the south and Tekezze river to the north; *L. a. orleansi* which occurs only in the Babille Elephant Sanctuary and the surrounding Fafan and Dacata valleys; and *L. a. knochenhaueri*, along the Mago Valley and some parts of Borena region.

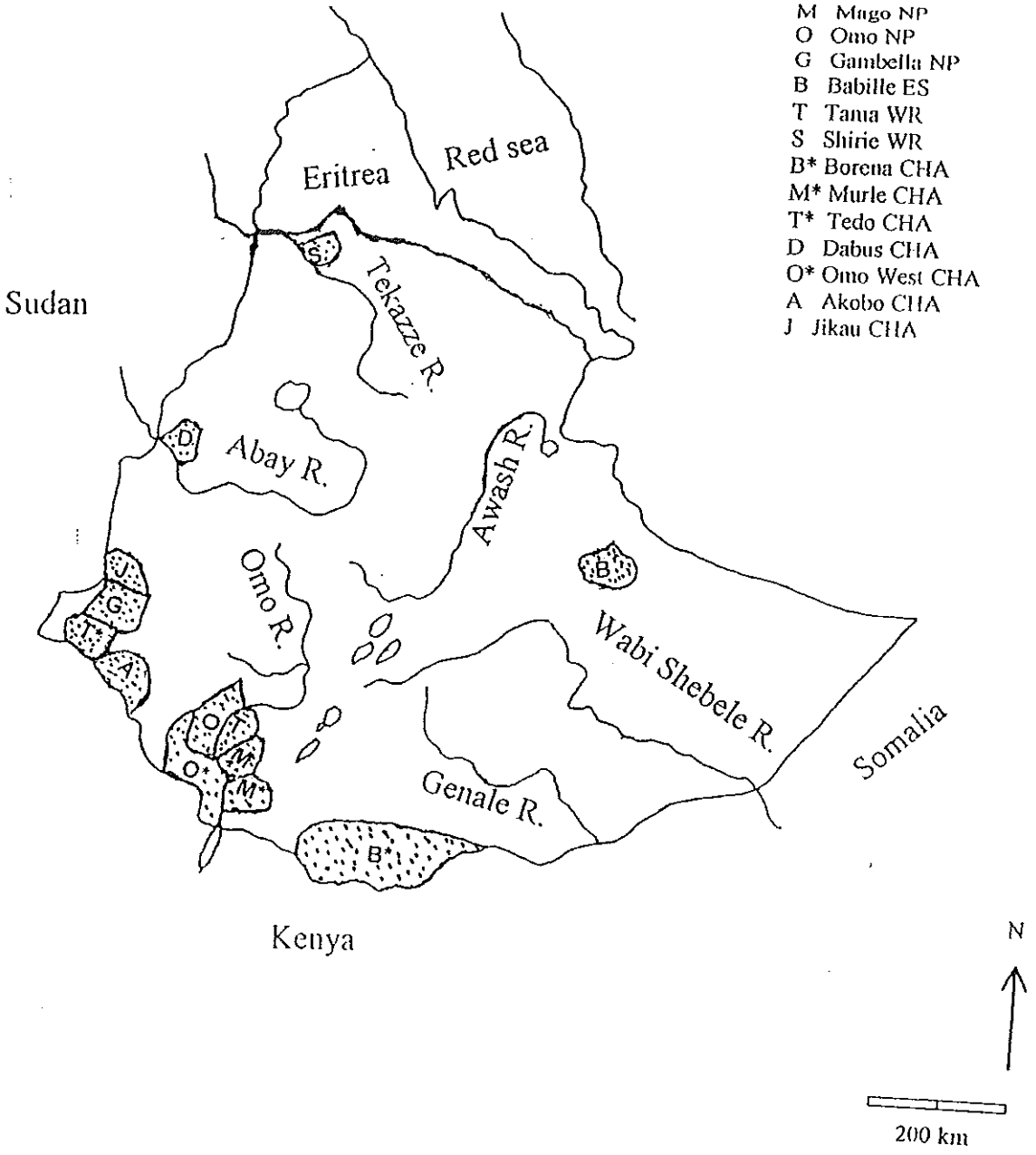

Figure 1. The current distribution of elephants in Ethiopia.

Mago National Park (MNP), where the present study is carried out, was proposed in 1974 and established in 1978. It was primarily established for the conservation of its large numbers of wildlife. These include: elephant (*Loxodonta africana),* buffalo (*Syncerus caffer*), hartebeest (*Alcelaphus buselaphus lelwel*), oryx (*Oryx gazella*), gazelle (*Gazella granti*) and giraffe (*Giraffa camelopardalis*) (Bolton, 1971; Hillman, 1993). Among the three subspecies of elephants, *Loxodonta africana knochenhaueri* occurs in this national park (Ansell, 1971a).

Elephants can dwell in virtually any habitat that can provide adequate quantities of food and water (Waithaka, 1993). In MNP, they inhabit the bush and riverine vegetation (Yirmed Demeke, 1994). Elephants live in groups and are highly social animals (Moss, 1988). Neither sex is territorial, although both use specific areas during particular periods of the year (Martin, 1978; Moss and Pool, 1983; Hall-Martin, 1987). In many places, elephants aggregate during and following the rain season when resources are plentiful (Douglas-Hamilton, 1972; Western and Lindsay, 1984; Moss, 1988; Pool and Moss, 1989). However, the situation is the reverse in the MNP (Yirmed Demeke, 1994), Kenya and Malawi (Leuthold, 1977; Jachmann, 1988).

An increase in human population particularly adjacent to conservation areas, has led to a need for more land. This has resulted in intense competition with elephants for water and preferred mosaic habitats and has displaced elephants from most of their former ranges (Hanks, 1972; Parker and Graham 1989; Kangwana, 1993). The situation has also occurred in Ethiopia. For example, in recent years, only small herds of elephants remain in the patchy forest and bush habitats of Mago (Yalden et al., 1986; Largen and Yalden, 1987; Allen-Rowlandson, 1990). Interviews with local elders indicated that 80 years ago elephants had a very wide distribution

and were comparatively common in the Mago and adjacent areas. However, since then, elephants from the surroundings of Mago had been exterminated (Yirmed Demeke, 1994).

There have been reports that herds of elephants in the MNP have made seasonal migrations to the neighboring areas (Stephenson and Mizuno, 1978; Yirmed Demeke, 1994; Graham et al., 1997). In 1992/1993 a study was made in this national park to gather information on elephant distribution and migration patterns. The result indicated that there was a limited migration of elephants outside the park (Yirmed Demeke, 1994). However, this information did not indicate the time and localities that the animals move to. Thus, the need for a more accurate data on the range and distribution of elephants is important in order to implement appropriate management policies.

Recently, elephant population sizes and ranges have shrunk greatly both inside and outside of the national park (Allen-Rowlandson, 1990; EWCO, 1991; Graham et al., 1996; and monthly reports from the park headquarter between 1996 and 1998). The main reason was due to high hunting pressure (Yirmed Demeke, 1996b). In addition to elephants, large games like buffalo and giraffe have also declined due to intensive poaching (Largen and Yalden, 1987; Yirmed Demeke, 1994; Shibru Tedla, 1995; Cherie Enawgaw, 1996; Graham et al., 1996; Bereket Netsereab, 1996. Increase in the price of ivory, the advent of better roads to most inaccessible protected areas, the availability of automatic rifles to poachers and the animals' low rate of reproduction make the problem critical (Bolton, 1973; Douglas-Hamilton, 1979; Ricciuti, 1980; Yirmed Demeke, 1994). In general, the expansion of people living adjacent to the park areas and poaching are believed to be the primary factors responsible for the contraction of the elephant ranges and the decline of their numbers (EWCO, 1991; Graham et al., 1997).

At present, the number of the surviving elephant population in this national park is unknown. This has brought a major obstacle in developing the Mago's elephant management and conservation policy (Stephenson and Mizuno, 1978; EWCO, 1991; Hillman, 1993; Lamprey, 1994). Most of the previous investigations (aerial surveys and some opportunistic vehicle counts) dealt mainly with rough estimates and guesses. As a result, accurate results have not been obtained (Graham et al., 1997). This is because of the uneven topography, limited visibility, clumped distribution and limitation of the survey design (Jachmann and Bell, 1984; Jachmann, 1986; Jachmann, 1988; Jachmann, 1991; Barnes and Jensen, 1987).

Various attempts were made to estimate the larger animal populations including elephants in the MNP (Stephenson and Mizuno, 1978; Graham et al., 1997). Since the beginning of elephant observations (1973), a total of 35 sightings were made: 14 from the air and the rest from the ground by vehicle and on foot (Table I). Twenty years ago, about 60 animals were observed by Bolton (1971). The 1977 aerial survey of Stephenson and Mizuno (1978) showed between 700-1000 individuals in Omo and MNPs. About 900 elephants were also estimated to live in the MNP, Tama Wildlife Reserve and Murle areas by the Ethiopian Wildlife Conservation Organization staff (Largen and Yalden, 1987). In 1986, the staff of MNP counted about 400 elephants. Since 1992, attempts have been made to assess their numbers, distribution and migration routes (Yirmed Demeke, 1994). In addition, Graham et al., (1996 and 1997) made two aerial surveys in the national park and estimated 120 and 250 elephants in 1996 and 1997, respectively. However, at present reliable estimates of elephant populations and migration routes in and around the national park have not clearly known.

The present study aims at collecting data using different types of observations in order to get up to date and relatively more accurate estimate of elephant numbers using line transect technique, as well as distribution by season and migratory routes inside and outside the park boundaries. It also attempts to suggest possible solutions on the current conservation status of elephants in this national park.

Objectives of the study

General objective:

To estimate the elephant population size of Mago National Park, describe its distribution, seasonal and/or periodic movement patterns and to make recommendations for better protection and management of the species.

Specific objectives:

· To assess the current poaching situation and areas of highest poaching pressure,
· To determine the age structure of elephant populations, and
· To determine the home-range of elephants in the MNP.

II. DESCRIPTION OF THE STUDY AREA

2.1. Location

The study area, MNP, is situated in southwestern Ethiopia, west of the main Rift Valley (Fig. 2). It lies between latitude N 05^0 19'- 05^0 19' and longitude E 35^0 56'- 36^0 26'. The elevation of the study area ranges from 400m, the low lying plains in the south, to 1,776m a. s. l. on top of Mt. Mago. The interior section (the major portion) of the park consists of mainly flat plains. However, the peripheral and boundaries except to the south are formed by Mago and Mursi Mountains and associated ridges and chains of hills. The park's area is traversed by the permanently flowing river, the Mago, and two of its tributaries, Neri and Usno rivers. The Omo river covers the southern and southwestern boundaries. In addition, several seasonal water courses convey flood water from the eastern and western rift walls (Stephenson and Mizuno, 1978; Yirmed Demeke, 1994; Hillman, 1993).

The area in which the study was conducted is bordered by three conservation areas: Tama Wildlife Reserve to the west (currently inhabited by the Mursi people), Omo National Park to the southwest and Murle Controlled Hunting Area to the south. MNP is surrounded by settled agriculturists and semi-pastoralists of six tribal groups. The park headquarter (PHQ) is located 783 km southwest of Addis Ababa. The study area can be reached by 4 WD vehicle or small aircraft on a temporary landing airstrips located just at 2.5 km south of the park headquarter.

2.2. Climate

The characteristic climate of MNP is comparatively dry and semi-arid with high mean annual

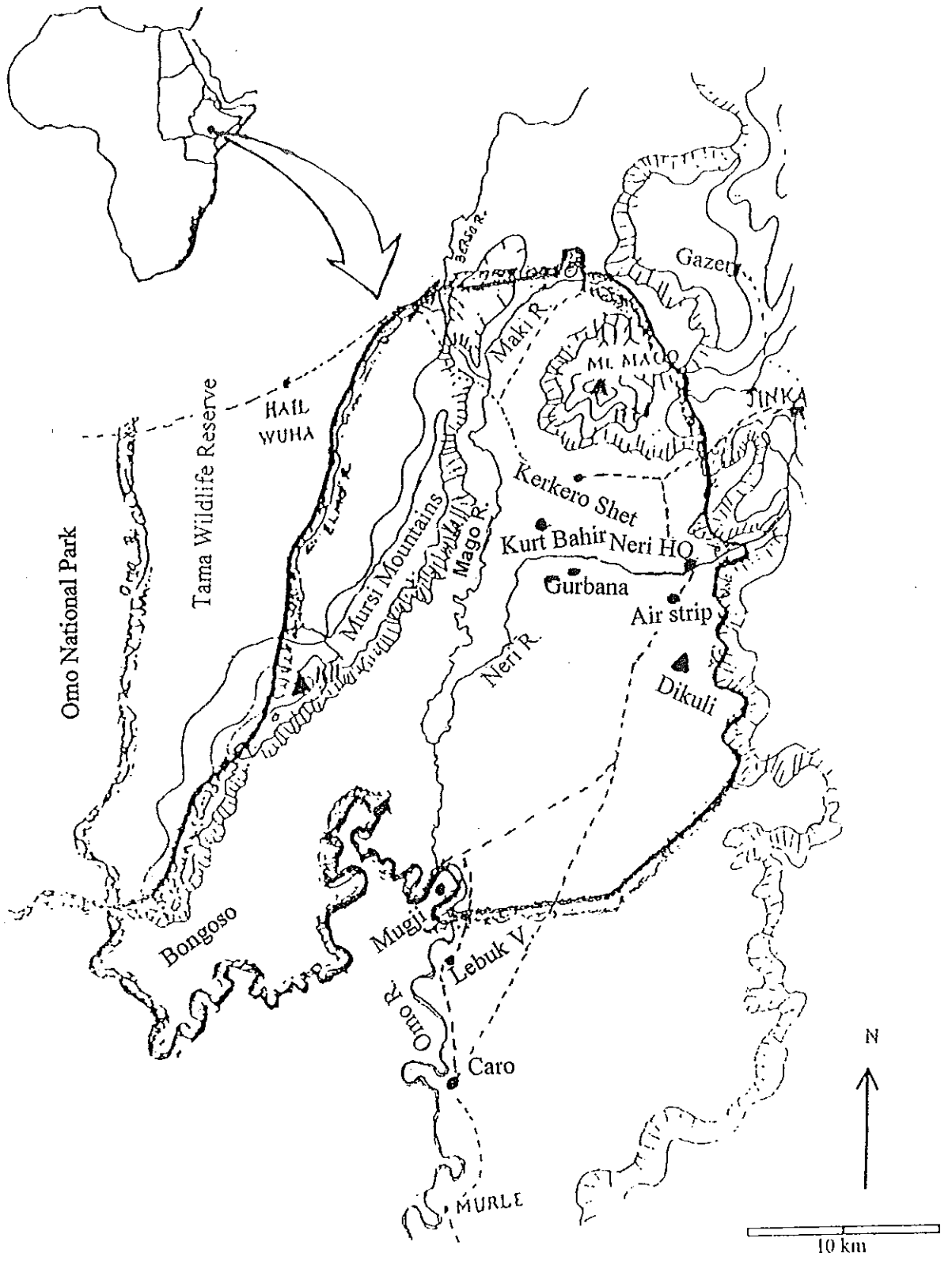

Figure 2. Map of Mago National Park.

temperature and radiation (Stephenson and Mizuno, 1978). It has a relatively low rainfall and humidity. Information on the climate of the park is limited. The data on temperature and rainfall from the PHQ were collected over one year from January 1992 to December 1993. The average annual minimum and maximum temperature were 24 ^{0}C and 38 ^{0}C, respectively. The minimum temperature was recorded in June (21 ^{0}C) and the maximum (47 ^{0}C) in January (Yirmed Demeke, 1996b). Generally, the rain here tends to fall in two well separated rainy seasons (Urban and Brown, 1968): the heavy rains from March to April and the small rains from August to September. The total annual rainfall in 1992/1993 was 830.7mm (Yirmed Demeke, 1994). Information for the other years is lacking. The rainfall data for the period between August 1997 and April 1998 is different from the normal rainfall pattern as the rains were exceptionally heavy and unusual (Fig. 3). The total rainfall recorded during the study period (from August 1997 to April 1998) is 789.9mm. The usual dry season ranges from December to the first weeks of March.

2.3. Physical characteristics

As described by Davidson et al., (1973 and 1976) Mt. Mago and part of Mursi range are formed by extrusion of the volcanic activities of the Miocene. The rest of the park is covered with a series of sand, silt or clay laid by the major rivers of the area. In general, the oldest rocks in the study area are crystalline from Precambrian age.

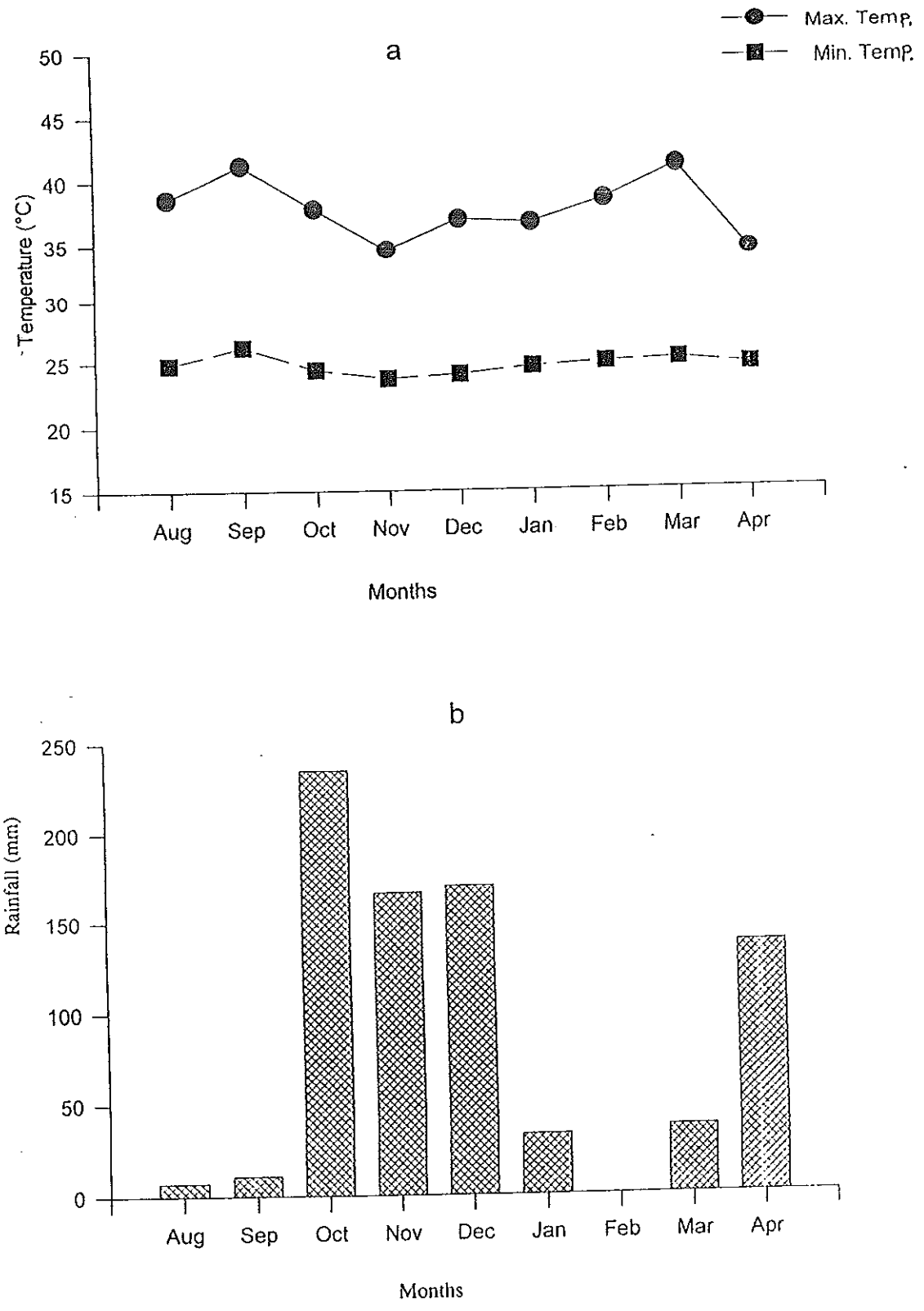

Figure 3. Monthly average temperature (a) and rainfall (b) for 1997/1998 at Neri Headquarter.

2.4. Wildlife

2.4.1. Vegetation

The dominant vegetation of the study area in the Mago Rift Valley was described and mapped by Stephenson and Mizuno (1978). Fifty percent of the area was bush and the rest was forest, savanna bushland , savanna grassland and open grassland. *Acacia horrida, A. mellifera, Grewia bicolor, G. villosa, Combretum aculeatum*, and *Cordia gharaf* constitute the bush vegetation. T*amarindus indicus, Terminalia brownii* and *Ficus sycamorus* are important components of the forest which are mainly found along the rivers. The grass species is dominated by *Setaria incrassata, Chrysopogon plumlosus, Ischaemum afrum* and *Pennisetum menzianum*. However, since then, many changes on the vegetation composition have been noticed (Yirmed Demeke, 1996b). Therefore, a new systematic vegetation study is necessary to prepare a new park management plan.

2.4.2. Wild animals

The fauna of MNP is diverse: at least 81 species of mammals, 239 species of birds (Hillman, 1993; Yirmed Demeke, 1996a), 24 species of reptiles (Spawls, 1992; Yirmed Demeke, 1997), 14 species of fish, and unknown number of amphibians and invertebrates have been recorded. During the establishment of the park, Stephenson and Mizuno (1978) mentioned that MNP contained the major portion both in numbers and variety of all Ethiopia's wildlife species. However, the situation has changed since then.

III. MATERIALS AND METHODS

3.1. Population estimate

Sampling methods: Several methods can be used to estimate elephant populations: aerial census, vehicle survey, foot survey, and dung count. However, dung count using line transect technique, is the most common type of indirect census method for estimating elephant numbers (Norton-Griffiths, 1978; Burnham et al., 1985; Barnes and Jensen, 1987; Dawson and Dekker, 1992; Barnes, 1993). The use of line transect method gives estimates that are less biased and have a lower standard error (Burnham et al., 1985). The basic concept here is just converting estimates of dung-pile numbers into estimates of elephant numbers. Therefore, using this method all the forest and other riverine vegetation (following the Omo, Mago and Neri rivers) of the study area was stratified into three strata: high, medium and low dung-pile densities (Fig. 4) based on the elephant's use of the habitats and the extent of human disturbances (Barnes, 1993).

Transects were localized around the rivers (in the forests and other riverine thick vegetation). This is because, the study was conducted during the dry season and during this period different herds of elephants join together around the rivers to form a large group. In addition, during the dry season palatable vegetation and water are largely restricted to along the rivers (Omo, Mago and Neri). During this period the intensity of poaching is very high and this restricts the wide distribution of elephants. As a result, elephants confine themselves following the rivers in the forest and other riverine vegetation. Hence, transects were made within the reverine vegetation. Transects were allocated in proportion to the approximate dung-pile densities i.e. 1:2:3 for the

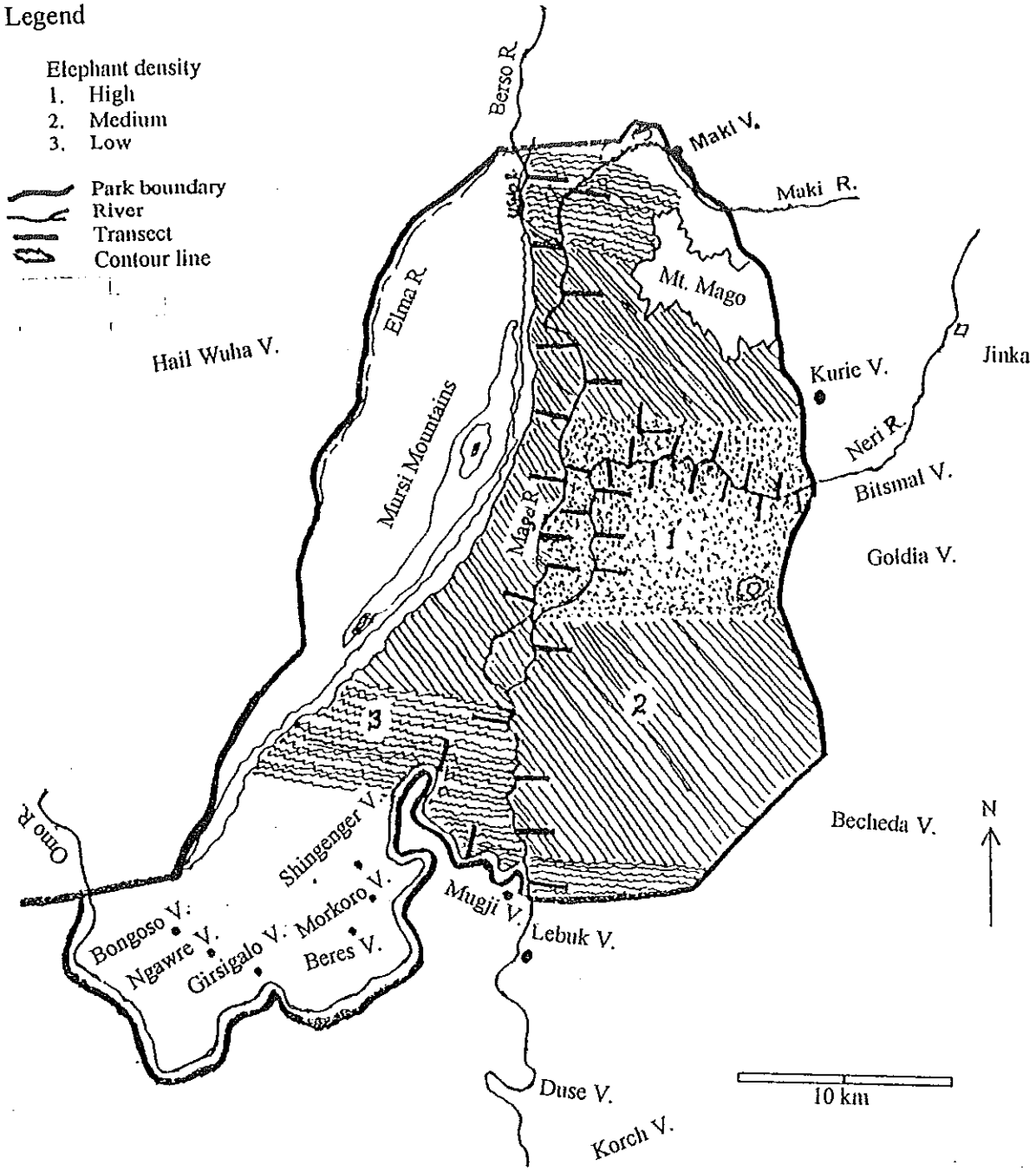

Figure 4. Map of the study sites showing the distribution of transects and villages.

low, medium and high density strata, respectively. A total of 36 transects each having three km length were run perpendicular to the base-lines, the longest axis of the stratum, (Omo, Mago and Neri rivers) (Fig. 4). Transects were placed at regular intervals: two km for the high, four km for the medium and six km for the low density strata. Consecutive transects were set at alternate directions. The starting point of the first transect was determined by random number table. Then the remaining transects had equi-distance from the first point. Distance between consecutive transects were measured with a pedometer. Similarly, to measure the length of transects (distance walked), a "Hip Chain" was used. To complete a transect survey, a total of 108 km length of transects were walked between 24 February and 4 March 1998 (Table 2). The observer walked slowly down the center-line of the transect in search of dung-piles. Compass was used to maintain a straight line. The perpendicular distance (xi) of each dung-pile sighted from the center-line was measured with a tape (Appendix 1). The distance walked in km, category or stage of dung-piles, perpendicular distance from the center-line, elephant signs, vegetation types and other notes were recorded systematically following the methods of Norton-Griffiths (1978), Burnham et al., (1980) and Buckland et al., (1993).

Data analysis: The ELEPHANT programme recommended by Dawson and Dekker (1992) was used to analyze the dung-pile densities. Converting dung-pile densities to elephant densities involves: dung-pile density (Y), defecation rate (D) and decay rate (r).

3.1.1. Estimating dung-pile density (Y)

To estimate the total dung-pile densities, the program ELEPHANT was used. A file containing the data on perpendicular distances was developed. The program reads this file and uses the

perpendicular distances of dung-piles to calculate f(0). Using the steady state assumption, the density of dung-piles, Y, was calculated as:

$$Y = \frac{n.f(0)}{2L}$$

Where

n = the number of droppings

L = the total length of the transects

f(0) = an estimate of the reciprocal of the effective strip width

The data for each stratum was analyzed separately and finally combined to give an overall estimate for the whole study area following the work of Barnes et al., (1995) and Norton-Griffiths (1978).

3.1.2. Estimating defecation rate (D)

The defecation rate is defined as the average number of dung-piles produced per elephant per day (Barnes and Jensen, 1987). It is determined by following a known number of elephants usually for about 12 hrs and recording all droppings (Tchamba, 1992). From these data, it is possible to calculate the number of dung-piles per elephant per day. During the study period it was impossible to carry out field work on defecation rate in the study area. This is because of the frequent mobility of elephants due to high hunting pressure. Several field workers have estimated different values for defecation rate (Wing and Buss, 1970; Merz, 1986; Coe, 1972; Tchamba, 1992). In this study, the figure, which was based on several observation hours, of Tchamba, (1992), D = 19.77 dung-piles per elephant per day with SE of 0.23, was used for the dry season data analysis.

3.1.3. Estimating decay rate (r)

The decomposition of elephant droppings can be estimated by monitoring dung-piles until they disintegrate i.e. until they pass from morphological stage D to stage E (Barnes and Jensen, 1987). In the field, dung-piles can be classified in one of the five categories, A-E, according to their shape and state of existence (Barnes, 1993). Since there was unusual rain in December, it was impossible to gather data on dung decay rate during the study period. Instead, I used my 1992/1993 dry season figure (Yirmed Demeke, 1994). It was carried out between 13 December 1992 and 28 March 1993. To carry out this field work, the area was searched regularly for 50 sample fresh dung-piles of various sizes from areas with different vegetation types and recorded from the eastern and central areas of the park. Each dung-pile was measured, marked and mapped and then monitored on a weekly basis until they disappeared.

Percentage for the daily decay rate was calculated from Barnes and Barnes (1992) as:

$$r = \frac{\ln (No) - \ln (Nt)}{t}$$

Where:

No = initial number of droppings

Nt = numbers left after t days

r = rate of decay

t = number of days

Using this calculation the mean decay rate of elephant droppings in the MNP for the dry season was 0.009 (SE=5.6).

Then the number of elephants present in the MNP during the dry season was estimated by the equation,

$$E = \frac{Yr}{D}$$

Where:

E = number of elephants

Y = number of dung-piles

D = defecation rate

r = decay rate

3.2. Age structure

Elephant hind footprint impressions left in the mud and /or dust were used to estimate their age classes. Three hundred and sixty two footprints were measured from 12 sites (Lenin Meda, Kerkero Shet, Mago bridge, Omo-Mago road junction, Gurbana, across the tracks to Mugji and Caro roads, Air strip, west of Dikuli and the rest from Neri and Mago river banks) (Fig. 2). It was carried out between August 1997 and February 1998. The measurement was taken from the back of the footprint to the internal arch of the middle toe using a five meter steel tape. Detail information on foot lengths in relation to the age of elephant was provided by Western et al., (1983), Jachmann and Bell (1984), Lee and Moss (1986 and 1995) and Manspeizer and Yilma Delellegn (1992). The footprint data were converted to the known elephant age groups as practiced in Amboseli National Park, Kenya (Western et al., 1983). All footprint measurements less than 23.80 cm were grouped as calf, between 23.8 cm to 30.20 cm, juvenile, between 30.30 cm to 38.50 cm intermediate, 38.60 cm to 45.10 cm, subadult male or adult female, and greater than 45.10 cm were adult males (Fig. 5).

3.3. Determining home-range, distribution and movement patterns

All park areas and adjacent localities were assessed to acquire information about the home-range, distribution and movement patterns of elephants. These were monitored by following the

characteristic tracks, droppings and feeding signs where elephant herds leave behind when passing through the bush, savanna grassland and riverine vegetation. To locate elephants and/or their signs, a total of forty six vehicle surveys were made in all available tracks at two weeks intervals between July 1997 and April 1998. Ten drives north to Mago bridge (32 km) and further to Maki village (51 km), eight and twelve drives south to Caro (67km) and Mugji (40 km) ways, respectively, and sixteen other drives to both sides of Neri river were made. Each driving was accompanied by foot walks to find how far elephants explore the surrounding areas. A total of 4,448 km vehicle drive, and about 1,016 km foot walk were made. Seventeen series fixes (four of them outside the national park) were produced and marked on a map. By connecting these fixes by straight lines, the boundaries of the home-range was established. The area of the polygon was then calculated (Whyte, 1993) from the map to adequately represent the size of the animals' home-range (Fig. 8).

Along with home-range studies, the distribution of elephants was assessed in both the dry (January to the beginning of March) and wet (March to April and August to December) periods. Seasonal and periodic long distance movements were also noted both from inside the park areas and across its boundaries. Data were collected by recording signs for the presence of elephants, the localities seen, the nature of the tracks, and direction of movements (Whyte, 1993). The field work was carried out on foot and from a vehicle. Two drives per month (July 1997 to April 1998) to the south, east and north side of the park were made. In addition, three long distance foot walks: the first from 27 to 29 August 1997, the second from 19 to 22 February 1998, along the western side of the park, from Mago bridge following the eastern foothills of Mursi mountains via Bongoso to Mugji, and the third tripe from Mago bridge south to Mago

and Neri rivers junction and then east to the park headquarter) were made (Fig. 6). In general, two full circuits were made to assess across boundary movements.

Questions were prepared (Appendix 2) to gather additional information about the present and/or past elephant movement routes, the nature of distribution, poaching intensities and population size. Interviews were conducted in six different tribal groups of twelve villages dwelling inside and outside the national park from 8 October to 12 November 1997 (Fig. 4). Traditional leaders or elders, committees and other people were selected systematically for the discussions. Six translators were used during the survey period.

Information on foraging behavior was noted during the study period. A total of 82 plant species that the Mago elephants feed on were collected. These were identified to their species level. The lists are presented in Appendix 3.

In addition to studying elephants, identification and recording of new and rare or peculiar wild animals i.e. reptiles, birds and mammals were also made. A total of three bird and four reptile species which have not been identified for the park were recorded. These and other recordings are given in Appendix 4.

IV. RESULTS

4.1. Population estimates

Very few groups of elephants were observed along the tracks and paths of the park. Seven elephant sightings were recorded during the study period. The maximum number observed in a herd was 182. Comparison of elephant sightings between 1973 and 1997 together with the present study is given in Table 1.

Table 1. Elephant sightings recorded between 1973 and 1998.

Year	Pop. estimate	Locality	Method of survey	Source
1972	60	?	air	Bolton, 1973
1975	80	East of Usno river	?	Stephenson & Mizuno, 1975
1977	850	Omo & Mago NPs	air	Stephenson & Mizuno, 1978
1977	650	Usno river	air	Stephenson & Mizuno, 1978
1977	175	Hot spring	air	Stephenson & Mizuno, 1978
1977	130	Hot spring	air	Stephenson & Mizuno, 1978
1977	625	Usno river	air	Stephenson & Mizuno, 1978
1977	32	Usno river	air	Stephenson & Mizuno,1 978
1986	900	Mago, Tama & Murle	air	Largen & Yalden, 1987
1990	500	Mago, Tama & Murle	air	Allen-Rowlandson, 1990
1990	423	Mago	air	Alen-Rowlandson, 1990
1991	118	Observation site	vehicle	Yirmed Demeke, 1994
1992	67	Gurbana	vehicle	Yirmed Demeke, 1994
1992	300	Observation site	foot	Yirmed Demeke, 1994
1992	250	Zinjero Maderia	foot	Yirmed Demeke, 1994
1992	45	Zinjero Maderia	vehicle	Yirmed Demeke, 1994
1992	475	Lenin Meda	vehicle	Yirmed Demeke, 1994
1992	65	Observation site	foot	Yirmed Demeke, 1994
1992	273	Zinjero Maderia	vehicle	Yirmed Demeke, 1994
1993	124	Observation site	vehicle	Yirmed Demeke, 1994
1993	26	Omo-Mago junction	vehicle	Yirmed Demeke, 1994
1993	47	Observation site	foot	Yirmed Demeke, 1994
1993	79	Air strip	foot	Yirmed Demeke, 1994
1993	1242	Observation site	vehicle	Lamprey, 1994
1994	252	Usno valley	air	Graham et al., 1996
1996	120	Neri river	air	Graham et al., 1997
1997	250	Neri river	air	Yirmed Demeke, 1997
19 July '97	87	Omo--Mago junction	vehicle	Yirmed Demeke, 1997
21 July '97	70	Kella	foot	Yirmed Demeke, 1997
24 July '97	135	Observation site	foot	Yirmed Demeke, 1997
25 July '97	45	Zinjero Maderia	foot	Yirmed Demeke, 1997
13 Aug. '97	182	Lenin Meda	vehicle	Yirmed Demeke, 1997
26 Nov. '97	64	Dikule	vehicle	Yirmed Demeke, 1998
08 Mar. '98	80	South of Kurt Bahr	foot	

In addition to direct counts, elephant population sizes were also estimated from their droppings using line transects from the forest and other riverine areas of the park (Table 2). Considering the mean decay rate of 0.009 (SE =5.6), defecation rate of 19.77 droppings per elephant per day and mean dropping density of 738 droppings/stratum for the dry season, the total estimate for the whole study area was 411 ± 31 (380 to 442) elephants. The observed density for the whole park was 0.18 elephant /km^2.

Table 2. Dry season dung-pile density.

Stratum	Stratum area (km^2)	No. of transects	Length of transects (km)	Sample area (km^2)	No. of drop. in sample area	Dropping density (Drop./strat.)	Eleph. density (Eleph./km^2)	Eleph. no.
1	397	19	33	0.13	129	992	0.45	179
2	540	11	57	0.09	56	622	0.28	152
3	292	6	18	0.04	24	600	0.27	80
Total	1229	36	108	0.26	209	x=738	x=0.33	411

The number of elephants in herds during this study period is low (the maximum in a herd was 182) compared to previous estimates (Table 1). The result of transect survey together with the low number seen indicates that elephant numbers and their total range in this national park is low.

4.2. Population age structure

A total of 362 hind foot impressions were measured and recorded. The data from this study were compared to elephant footprint measurements from Amboseli National Park, Kenya. These results are shown in Figure 5.

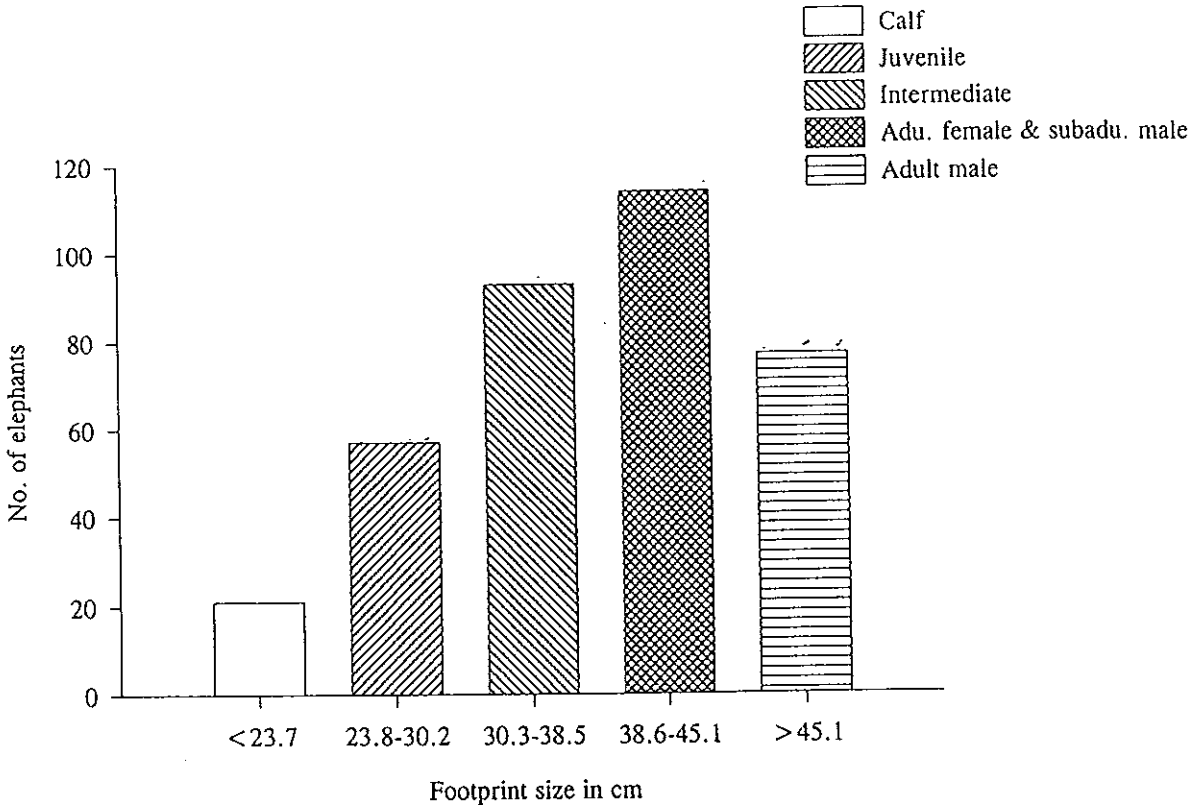

Figure 5. Age structure of elephants in the MNP as determined from hind foot lengths.

The majority of the population were grouped under the age structure subadult males and adult females and intermediates. However, yearlings and juveniles were very few (Table 3).

Table 3. Percentage of age structure from hind footprint measurements.

Age class	Percentage
Calves	5.8
Juveniles	15.7
Intermediates	25.7
Subadult males & adult females	31.5
Adult males	21.3

4.3. Analysis of home-range, distribution and movement patterns

Distribution: It was possible to identify the present and previous movement routes and areas of distribution. Based on the interviews with local people, elephants used to inhabit the surroundings of Jinka town, Woito valley, the Hamer and the adjacent Omorate areas, as well as the whole of Tama Wildlife Reserve (Fig. 7). However, it was noted that, the people coming from the central and northern part of the country (from Gojam, Shewa and Wello) had made intensive exploitation of elephants for. ivory and to mention their braveryness. Such continuous poaching activities have made elephants to be exterminated from most parts of the South Omo zone. Even at the time of the park's establishment, elephants were believed to move north through Maki and west to Tama, Omo National Park, and most of the eastern parts of Murle Controlled Hunting Area.

Currently, elephants of MNP had a restricted distribution during the dry season of January to the beginning of March 1998. During this period when there was scarcity of food and water, and elephant killing was more frequent, elephants of several herds come together to form a large group. The herds always concentrate in the interior park areas following the Neri and Mago rivers up to the junction with the Omo river, commonly south of the Mago bridge (Fig. 6). These three rivers are the only sources of permanent water for elephants and other wildlife species in the dry season. These areas are dominated by riverine forests and thick bush. The elephants of Mago have not frequently used the extreme south and north and adjacent areas of Mago and Neri rivers. This is most likely due to a high level of human activities. In other words, the peripheral areas of the park which were frequented by poachers were avoided by elephants.

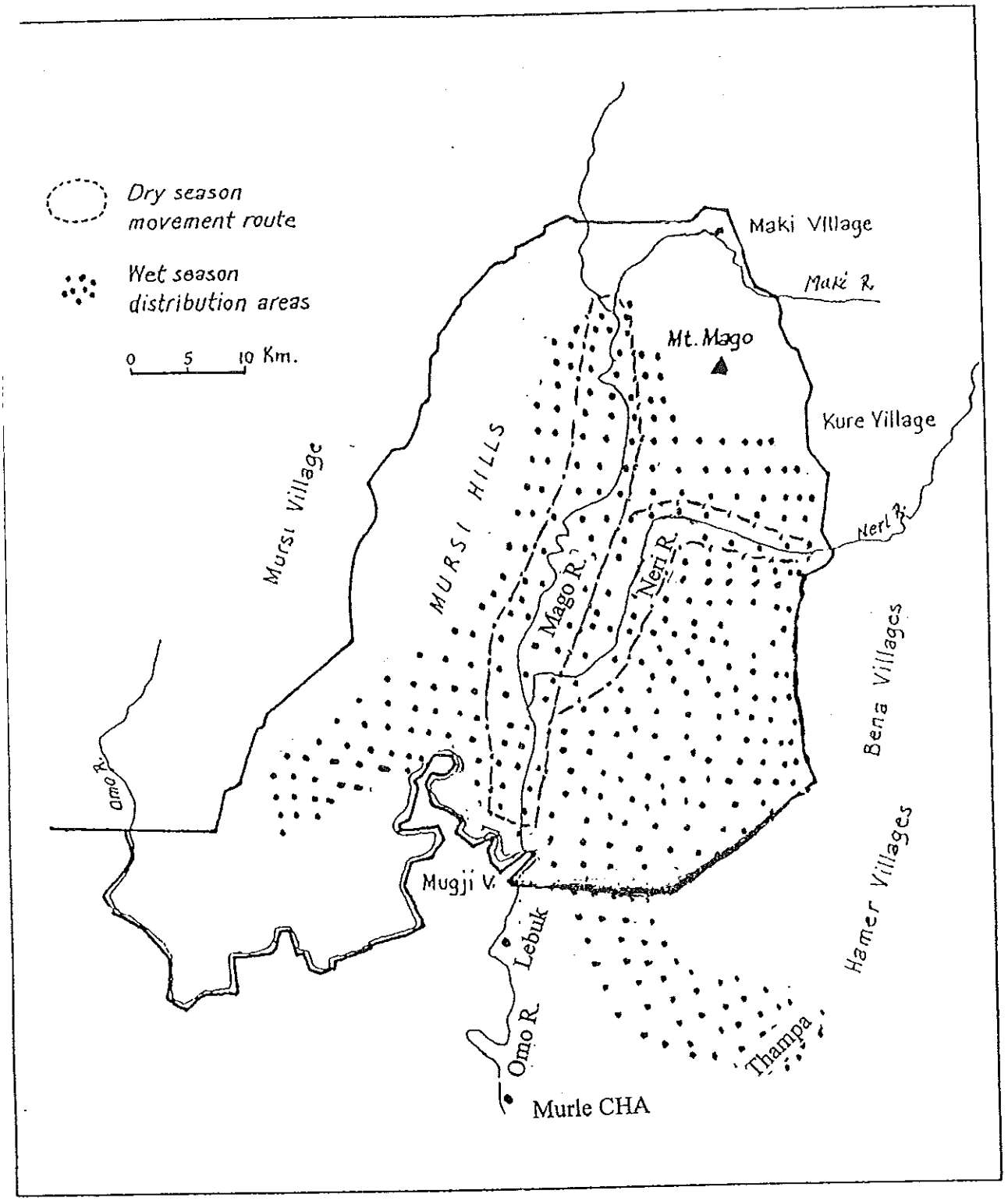

Figure 6. Dry and wet seasons distribution of elephants in MNP.

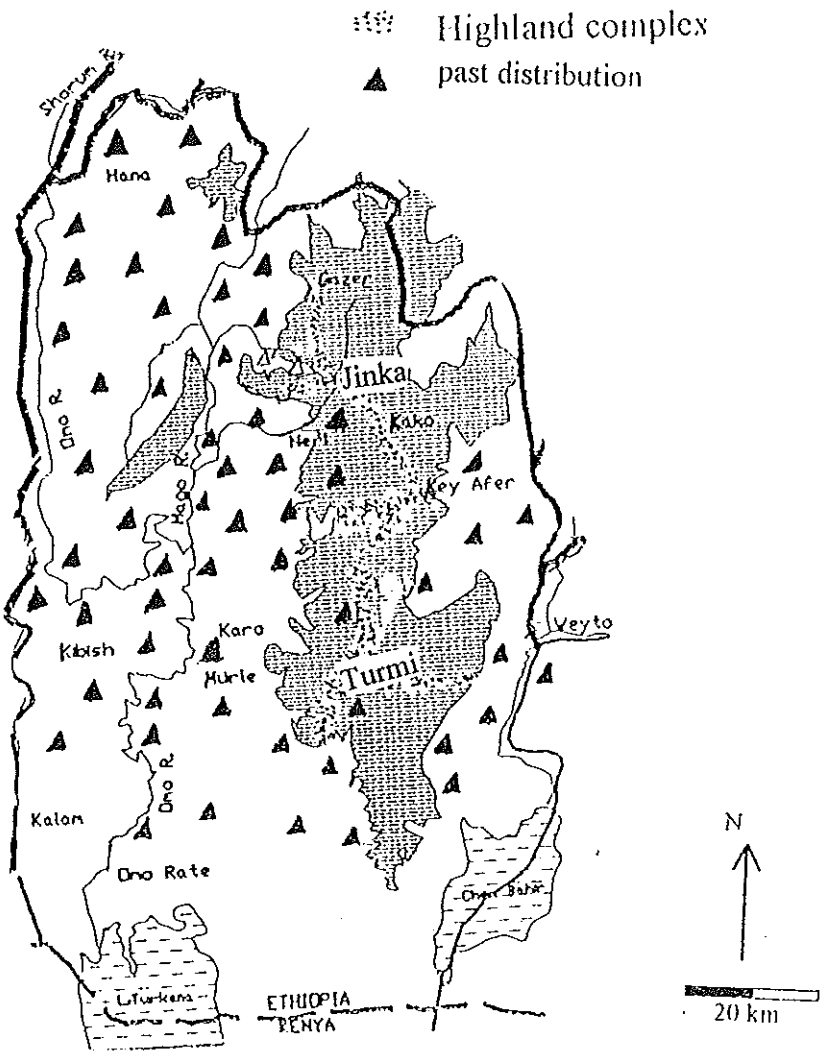

Figure 7. Past distribution of elephants in the South Omo Zone (1900 - 1980).

During the rainy months of August to December 1997, elephants were observed splitting into smaller groups as soon as the rains start. During this period, elephants had a wide distribution and explore all the plain areas of the park as far as the base of Mt. Mago, Mursi and associated mountains and ridges. Such a wet season elephant distribution appears to extend outside the national park boundaries (Fig. 6).

Seasonal movements: Information on elephant migrations was gathered and observations were made. The study shows that elephants in the MNP are a resident population. However, part of the population occasionally forage outside the park areas. These short distance movements to Murle Controlled Hunting Area (MCHA) occur at night during the rainy season. Because during this period the activities of people in the national park is very minimal.

During the study period, two movements (one in September 1997 and the other in March 1998) were noted across the national park boundaries. They move south to MCHA travelling about 43 km south outside the park boundary. These animals move between the eastern escarpment and parallel to the Omo river passing through east of Lebuk, Duse and Korch villages (Fig. 8). By passing through the broken terrain of the foothills which borders MNP to the east and southeast, the animals reach a small valley surrounded by ridges known as Thampa. To the east the area is bordered by the Hamer mountains. It is dominated by extensive bush vegetation. Elephants stay here for up to a week depending on the presence of people. This is the only site observed during the study period where elephants move outside the national park. Therefore, at present, all movements except to the south are totally closed (restricted in side the national park) due to the progressive settlement and human activities in the national park.

Home-range: From this study, a better picture of the animal's home-range was emerged. Accurate grid references of the location of elephants were mapped by demarcating various fixes. Between these points, various elephant tracks and feeding signs were noted. The range traversed by elephants of MNP from northwest of Mt. Mago to southeast of MCHA is about 129 km. The calculated average home-range of the animal was 1,597 km^2 (Fig. 8).

4.4. Major threats to elephants

Based on the present study, poaching, honey gathering and settlement expansion are the three major threats to elephants in the MNP.

4.4.1. Poaching

Shooting elephants is a major problem in the national park. Poachers stay at the sites for a week feeding on the meat of wild animals. Poaching of larger wild animals has been observed in all the entire park plains. During the present study, three carcasses of elephants with skins and no tusks were encountered in the central plain areas of the park: a young female elephant carcass with age between 6 and 7 years old was found on 13th August 1997 just half km north of Omo-Mago road junction, one bull elephant with age between 16 and 17 years old was killed on 17th August 1997 close to Neri river, 14 km south of the park headquarter and another very young female elephant was also killed on 8 September 1997 close to the park headquarter. Few other skeletons were also found widely scattered on the riverine and forest areas of Mago and Neri rivers. A total of seven carcasses were sighted. In addition, information from the local people indicated that additional 19 elephants were killed by people living adjacent to the park areas. During the study period, three tusks were encountered in the Shingerger (Mursi) village. It was

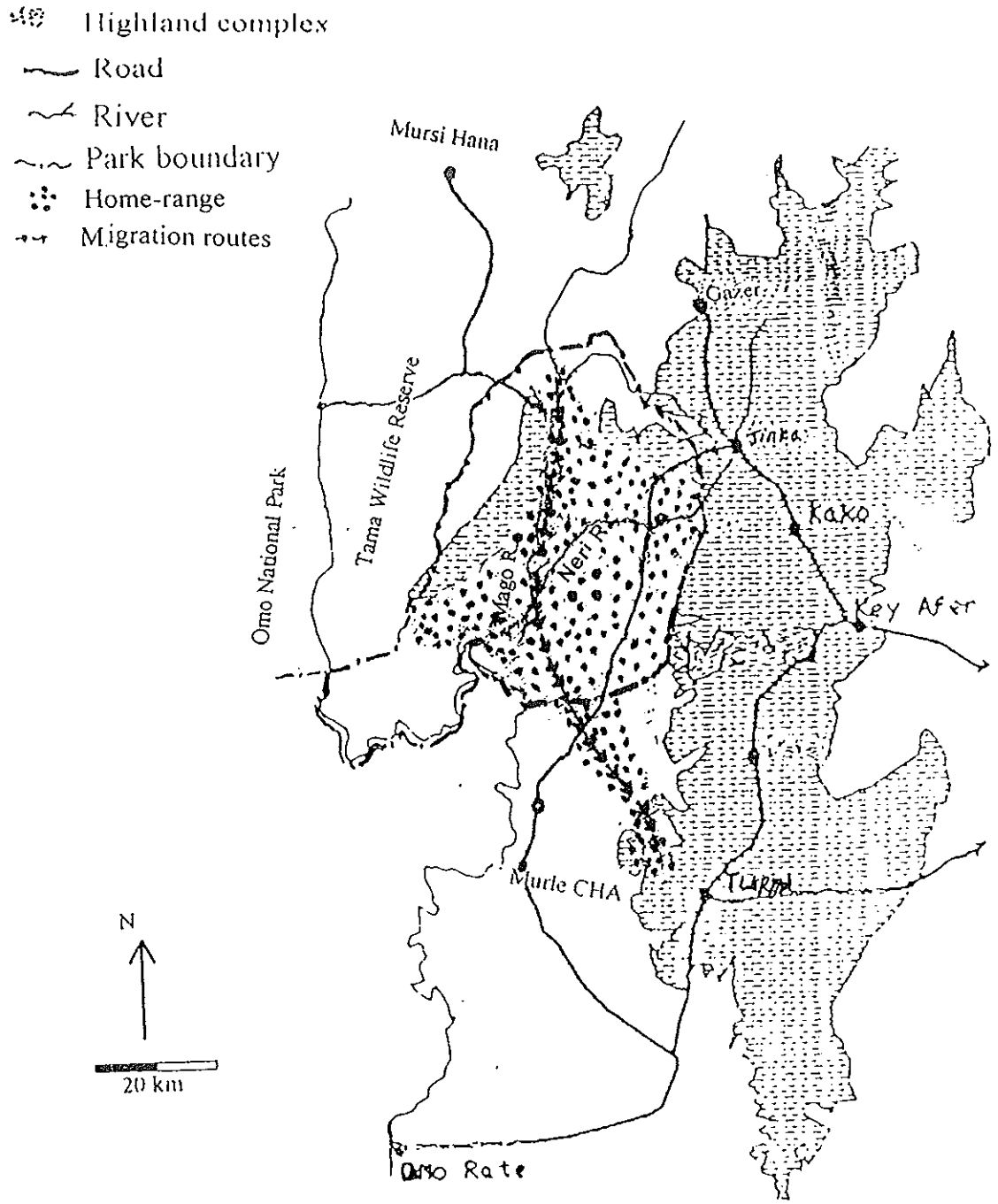

Figure 8. The migration routes and home-range patterns of elephants in the MNP and adjacent areas.

reported that there were many more kept in this and other nearby villages. This gives an estimate of 26 carcasses for the whole park areas between August 1997 and April 1998. During the present study, poachers with various fresh and dry wild animal meat were encountered frequently.

Most poaching activities took place in the dry season when the people were free from agricultural activities and were ready to collect honey. Table 4 shows elephants hunted since

Photo 1. Skulls of a bull and a female elephant killed by poachers.

December 1996. Most of the elephants were killed by hunters from the Mursi, Bena, Hamer, Mugji and Lebuk villagers. In addition to elephants, 6 hartebeests, 23 lesser kudus, 8 buffaloes, 11 warthogs, 5 waterbucks and 3 zebras carcasses were recorded during the present study.

Table 4. Records of poached elephants between December 1996 and April 1998.

Date	Number	Locality	Tribe
December 1996	11	Caro and Murle CHA	Hamer and Caro
August 1997	3	Omo-Mago road junction and Kurt Bahr	Mursi and Bena
September 1997	1	Gurbana	Bena
November 1997	3	Mago bridge	Mursi
February 1998	2	West of Gurbana	Mursi and Bitsmal
February 1998	5	Mago river	Bongoso (Mursi)
Unknown	12	Gurbana, following Neri and Mago river	Unknown
Total	37		

Different body parts: skin, fresh and dry meat, horns and tail hairs were collected by the field team. A total of 37 elephants were killed mostly for ivory between December 1996 and April 1998. Over half (57%) of the elephants were poached by two tribes (Mursi and Bena). The nearby villages bordering the park from which poachers come most frequently are shown in Figure 4.

Photo 3. Poachers were encountered at various sites with fresh wildlife meat.

4.4.2. Honey gathering

In the MNP honey can be obtained either by making beehives and rearing it (known as domestic honey) or as wild forms (honey obtained from termite cast, rock and tree holes). The Caro, Lebuk, Mugji, Bena, Bitsmal and Kure make beehives although sometimes they were seen in the park looking for wild bee nests. Whereas the Mursi people are totally dependent on wild honey. A group comprising 2 to 15 men visit the park areas periodically (usually three times per year) looking for honey. Based on the researcher and park staff observations and guesses, a total of 10,000 beehives were estimated to be present within the park. Approximately 6-8% of the park areas have been used to rear beehives. Figure 9 shows the current distribution of beehives in the park areas. Almost all the chains of Mt. Mago, along Neri river for about 13 km from the PHQ, following Mago river, south of Mago and Neri rivers intersection, to the point where it merges with Omo river, are the main sites where people hang their beehives on the trees (Fig. 9). These same sites are the most important hiding and feeding areas for larger animals like elephants and buffaloes.

4.4.3. Settlement expansion and grazing

Agricultural expansion at Kure, Maki, Bongoso, Mugji and Lebuk villages has resulted in an apparent reduction of elephant numbers and destruction of migratory routes. The small forests at Kure, the bush vegetation at Maki and the riverine or marginal forests on both sides of the Omo river have been cleared for establishing villages and agriculture.

During the course of this study, five Mursi villages, which the park authorities were not aware of their presence in the national park, were identified (Fig. 4). Hunting, fishing and flood retreat of small cultivation along the bank of Omo river are the common practices for all settlements

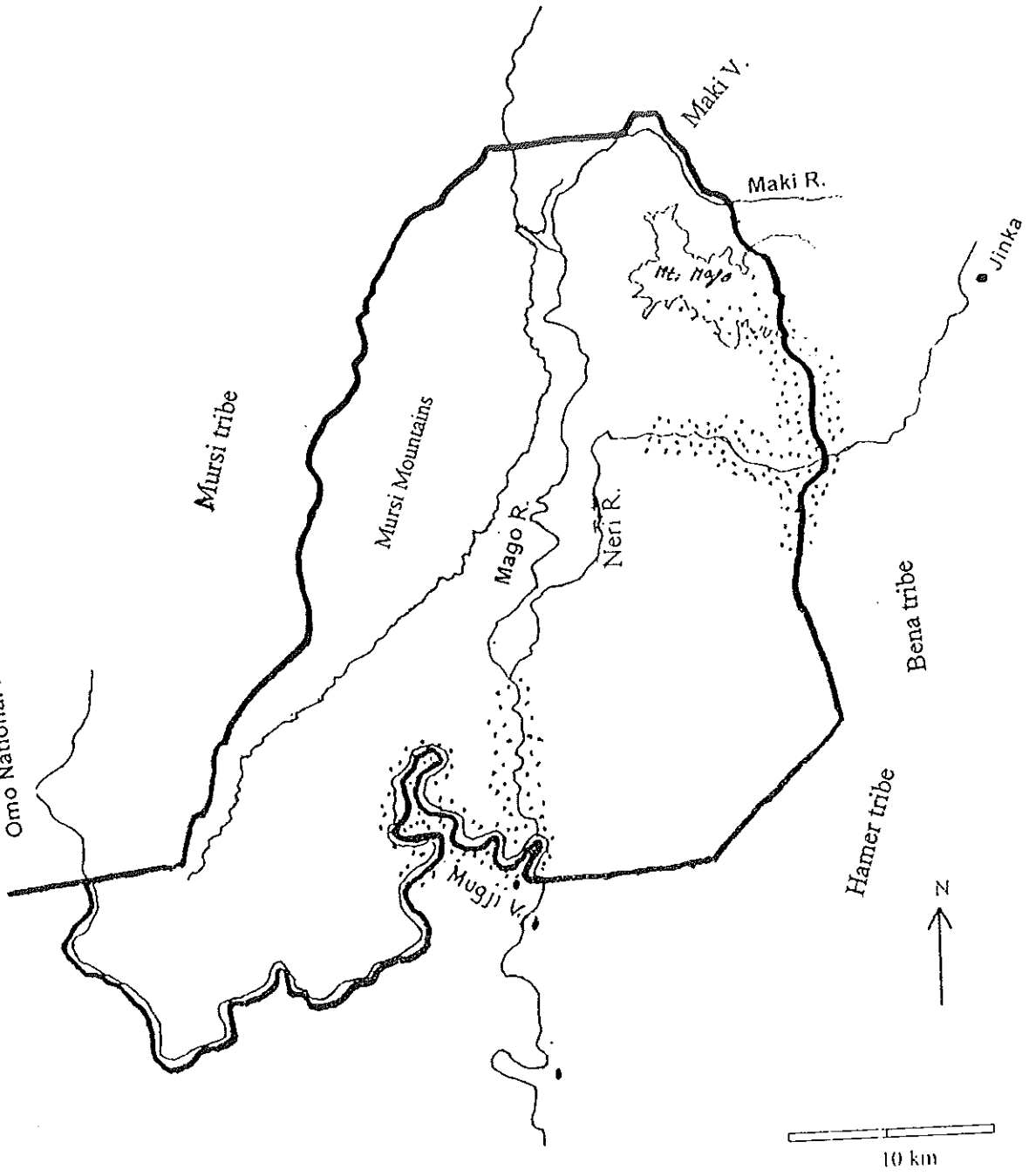

Figure 9. The distribution of beehives in the MNP.

established on both sides of Omo river. The major means of subsistence for these villages are indicated in Table 5.

Table 5. The main subsistence of people living inside and outside the park.

Tribe	Village	Means of subsistence	Date interviews were carried out	No. of individuals interviewed
Ari	Kure	Agriculture, beehives and small numbers of cattle	29 Oct. 1997	19
	Bitsmal	Agriculture, beehives and small numbers of cattle	02 Nov. 1997	14
Mursi	Maki	Cattle, small farms, hunting and fishing	15 Oct. 1997	18
	Bongoso	Cattle, fishing, flood retreat, small farms and hunting	08 Oct. 1997	21
	Hail Wuha	Cattle, small farms, hunting and honey	25 Oct. 1997	8
Mugji	Mugji	Fishing, flood retreat hunting, honey	05 Oct. 1997	16
Caro	Duse	Small farms, fishing, honey and hunting	21 Oct. 1997	20
	Lebuk	Small farms, fishing, honey and hunting	14 Oct. 1997	22
Hamer	Becheda	Agriculture, hunting (rarely) and Cattle	23 Oct. 1997	13
	Shanko	Agriculture, hunting (rarely) and Cattle	24 Oct. 1997	9
Bena	Goldia	Agriculture, hunting (rarely) and cattle	26 Oct. 1997	15

V. DISCUSSIONS

The number of elephants during the present study period was estimated as 411 ± 31. This finding supports earlier data suggesting that MNP supports small number of elephants: Lamprey, (1994) estimated 252 elephants; the estimate of Yirmed Demeke, (1994) was 976 elephants and the 1996 and 1997 aerial surveys of Graham et al., (1996 and 1997) estimated 120 and 250 animals respectively. It is not possible to compare the above estimates directly, as they used different survey methods. However, we can say whether the population increases, decreases or remains stable by analyzing the extent of poaching and the number of elephants counted in several herds. As shown in Table 1, the number of elephants in a herd during the study period was small (maximum 182) compared to the previous records (the maximum 475 in 1992, 1242 in 1993, most likely including immigrats either from Omo National Park or Kenya, and 252 in 1994). Therefore, the very small number of elephants in all sightings in this national park implies that there has been a serious decline in elephant numbers.

Dung-pile visibility was limited by the thick nature of vegetation. As we see in Appendix I, the number of dung-piles counted declines as we move away from the center line. The maximum recorded visible distances from the center lines were 7.5, 6.5 and 6.4ms for the stratum 1, 2 and 3, respectively. The mean sighting distance for stratum 1, 2 and 3 were 2.2 , 2.9 and 2.8 ms, respectively. In stratum 1, the dense vegetation has made difficulties to see dung-piles from distance. The majority of the dung-piles fall between 0 and 0.9 m.

Direct counts, sexing and aging was difficult because of the animals' nocturnal habit (due to continual harassment by poachers) and the dense vegetation. Particularly, during the dry season the encroachment of people in the national park was high. As a result, the activities of elephants

to the nearby savanna and bush habitats were restricted during the night. This has made difficulties in direct observation of elephants during the day time.

The 1992/93 study (Yirmed Demeke, 1994) showed that disintegration of dung-piles were quite slow in the MNP (0.9% per day). The majority of the droppings were decayed on the 13th week of the dry period. Barnes and Jensen (1987) estimated the mean daily rate of decay (2.4% per day). This shows quite a big difference with my previous observation (Yirmed, Demeke, 1994). There are various factors governing decomposition rates, such as, birds and monkeys in search of seeds, termites and dung beetles (whose activities were restricted to the wet season) and other decomposer invertebrates (Jachmann and Bell, 1984). Of these, dung beetles, termites and birds, which facilitate decomposition, were observed frequently in the study area. The activities of decomposers are influenced by rainfall, temperature and relative humidity (Barnes and Jensen, 1987).

Elephants select the most nutritious and palatable plants that are available in high quantities (Western and Lindsay, 1984). As indicated by Jachmann (1988) the wide distribution of elephants during the rainy season is to overcome nutritional stress and build up new energy reserves. In addition, poachers activities, which is very minimal during the rainy period, is another factor for the wide range seasonal distribution (foraging behavior) of elephants.

Elephants and humans interact in a number of ways when they occupy the same area. Elephants are displaced by continuous settlement expansion, agriculture, poaching, roads and other development projects (Parker and Graham, 1989). On the other hand, elephants cause damage to human life and property, by destroying crops, killing people and competing with humans for

water and forage resources. As a result, the surrounding people see elephants as a threat to their livelihood and as a major competitors for resources.

The size of the home-range of an elephant is an indication of the availability of food and water resources and the extent of human disturbances in the surrounding areas. And this is determined by the size of the protected area that the animal is occupying. The estimated home-range of elephants in MNP (1,597 km^2) is relatively large compared to Kruger National park, Tanzania, which has a mean of 909 km^2 (Whyte, 1993). However, in a resource scarce environment like Namibia, the average size of the home-range was between 5,860 km^2 and 8,693 km^2 (Lindeque and Lindeque, 1991). Therefore, the area of MNP is relatively large with abundant forage and plenty of water. This can probably harbor a very large number of elephants, about 4,400 individuals (Parker and Graham, 1989).

The discussion with the local people and park staff and the work of EWCO, (1991) and Yirmed Demeke (1994) indicate that, ten years ago, elephants from MNP used to visit Tama Wildlife Reserve, Omo National Park and the northern areas of Mt. Mago. These areas are the most preferable wild animal habitats (Stephenson and Mizuno, 1978). However, currently most of the elephants home-ranges and such migratory corridors have become closed and narrowed due to continuous settlement expansion, agriculture and poaching.

Different guesses by the park staff (less than 300), all other previous estimates (Allen-Rowlandson, 1990; Yirmed Demeke, 1994; Graham et al., 1997) and this study suggest that similar population decline has been observed for giraffe, hartebeest, buffalo and waterbuck as well. The population trends of Mago was calculated by Graham et al., (1997): elephant showed a decrease of 6%, giraffe 30%, buffalo and hartebeest 9% each and waterbuck 5% per annum.

Destruction of natural habitat and harassment by an ever-expanding human population with an ever-increasing demand for land have undoubtedly contributed for rapid decline of these species.

Villagers living adjacent to the park hunt larger game regularly with automatic rifles, snares and traps (Yirmed Demeke, 1996b). The danger of poaching can be viewed from several perspectives. Formerly, poachers were very few in numbers and used traditional weapons which did not have a serious effect upon the larger animals. However, nowadays, the availability of various kinds of modern fire arms in the South Omo has changed the situation. Even, at present, the wild animals of both Mago and Omo National Parks and the surrounding areas are an open-access resource to the surrounding people. This is because of the absence of patrols and lack of a strict wildlife law.

In all of the direct sightings of elephants during this study period, it was uncommon to see large sized animals since large bodied elephants might be hunted selectively. The major problem is that bulls do not start reproducing in a population with a normal age distribution until they are over 30 years of age (Pool, 1989a), whereas the age of female elephants at first conception can be as young as 10 years (Hanks, 1972). Such a delay and low rate of reproduction make the problem critical (Calef, 1988; Chanda and Tembo, 1993).

At present, the park office could not differentiate poachers from honey gatherers. This has become a challenging issue confronting the park authorities. The presence of beehives in MNP has brought dual problems: the wildlife have been displaced and pushed further to narrow areas and these wild animals particularly the larger ones have been hunted discriminately by honey gatherers. As it has been observed for several years in this national park, hunting elephants for

meat is not a frequent phenomenon but for ivory. However, during the period of drought, few people of Mugji and Mursi used to kill elephants for food.

It is believed that the very high densities of people, their settlement, agriculture and livestock have been displacing the wildlife species permanently (Alers et al., 1992; Fay, 1993; Barnes et al., 1991). As pointed out by Parker and Graham (1989), normally with a human density of around 10 individuals/km^2, an elephant density of 0.5 animals/km^2 would be expected. In the MNP and adjacent areas, the constant increase of the Mursi people with their permanent and semi-permanent villages and herds of cattle have pushed the wild animals to the interior of the park areas (Graham et al., 1997). Since they are semi-nomadic and keep their cattle and goats back and forth crossing the Mursi range, elephants have never visited these sides of the park areas. However, these people do not bring their herd to the interior areas of the park because of the presence of the two species of tse tse fly (*Glossina fuscipes* and *G. pallidipes)* at the dense bush. As Graham et al., (1997) suggested, the number of cattle adjacent to MNP have increased at 11% per annum to a population of nearly 55,000. Incursions of the Hamer tribesmen with their cattle, goats and sheep into the main plain areas to the south is a very recent activity. Graham et al., (1997) estimated that at least 40,000 people encroach into the park with 9,000 different types of fire arms which are potentially available for hunters. And these have resulted in range restriction of different wildlife habitats and in the modification of the ecology of the area. In general, the people living inside and adjacent to the park and the very poor management of the park are responsible for such destruction which may ultimately exterminate elephants and other large games from this area.

The dropping count seems a suitable method for estimating elephant population sizes in forests vegetation (Jachmann, 1991; Barnes, 1993). Since dung-piles persist long without complete decay , four months in the MNP (Yirmed Demeke, 1994), it indicates where the animals were during that period. However, to appreciate and standardize the method, it is advisable to repeat the technique intensively in the same area to compare the result with aerial and other ground census methods.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1. The importance of elephant population in the MNP

Elephants play varieties of roles in a given ecosystem (Waithaka, 1993; Western, 1993). Their ecological role is invaluable in maintaining the linkage in a food web. They are agents of seed dispersal. These is an indirect effect of shaping the biodiversity by modifying vegetation as they contribute to changing the bush vegetation into open grassland (Wing and Buss,1970; Waithaka, 1993). This would result in a significant increase in grazer communities, such as buffalo, gazelle, oryx, zebra and hartebeest. When there are only few elephants present, the vegetation will be dominated by a few species resulting in low species richness (Waithaka,1993). Elimination of elephants from this park and the rest of the elephant areas would undoubtedly mean the loss of a major influence on this ecosystem.

In addition to the ecological role, elephant utilization ranges from non-consumptive use through game viewing by tourists, to consumptive uses such as sport hunting, cropping, culling, and trophy sales. These practice are mostly carried out legally and generate revenue. The revenue should be shared with the local communities who live among the elephants. At present, the most common form of sustainable use of elephants in Ethiopia has been through non-consumptive tourism. The other sustainable forms of elephant utilization are no longer feasible. It is possible to see the profits from other countries that have good elephant protection management scheme. For example, licensed sport hunting in Tanzania, contributes about $ US 4,000 per elephant and the country's hunting industry has an annual turnover of $ US 20 million. Elephants in Kenya also contribute $ US 23 to 30 million per annum through the Kenyan tourist industry (Brown and Henry, 1993). However, such activities are insignificant or

non-existent in Ethiopia. The wildlife managers in Ethiopia need to look into the future in enhancing the value of elephants when developing their respective management plans.

6.2. The fate of Mago's elephants

Elephants in the MNP are few in number and live in a semi-arid bush and riverine forests. So far, the national park is a potential big protected area capable of harboring significant elephant population. This may be the most viable population in the country. Almost the entire areas of the national park (except top of Mt Mago, which is rocky) consists of suitable elephant habitat.

Based on the previous data and this study, it is clear that elephants in this national park are in danger of extinction. This is due to poaching and habitat destruction (Largen and Yalden, 1987; Allen-Rowlandson, 1990; Yirmed Demeke, 1994; Graham et al., 1997). The MNP is a convenient conservation area to manage and control any form of illegal activities. If the present state of decline in elephant numbers is allowed to continue by improper management policy, extinction of elephants in the park is inevitable.

This study is an attempt to describe the population size, density, distribution and migration patterns of the elephants of MNP. However, it is quite useful to know all these parameters in depth including other aspects of ecology, such as the habitat types and how they utilize these habitats and the population dynamics (population growth rates, ages and sex structures and rates of increase of the population as a whole in relation to habitat conditions) for proper management.

It is worthwhile to increase the efficiency of this protected area by having more trained staff and providing better equipment, and transport facilities. Establishing anti-poaching groups to lessen poaching activities should also be encouraged.

In addition, other important points which should be sought carefully are listed below:

- Dissemination of public awareness about the need for the wildlife conservation and protection in general, and that of the elephants in particular,
- Establish elephant research center in the southwest Ethiopia,
- Restore up to date information on the population size, dynamics, ecology and movements, and build up the park's capability to conserve and manage the elephant population,
- Minimize or stop the frequent incursions by people with their cattle, sheep and goats because they cause serious disturbances to the wildlife or, in general, to the ecology of the area,
- The consideration of local people's life styles and their economies in all management and planning is essential for the success of the park conservation efforts. A healthy discussion can be reached with the park authorities and people residing inside and adjacent areas. The park should adopt a program of regular and continuous discussions with the people in and around the park,
- Strict control of the use of fire arms by the people living inside and adjacent to this park should be practiced, and
- The migratory routes and foraging areas should have been given a complete protection to maintain the animal's natural migratory patterns without disturbance. In addition, it is better to maintain free access (migratory corridors) between Omo National Park, Tama Wildlife Reserve and Murle Controlled Hunting Area.

In addition, the park authorities should seek alternatives before the entire park area is invaded by beehives. Based on the previous experience, at least, two possibilities can be suggested for the park's further survival:

1. Establish modern beehives in suitable sites outside the national park, and
2. Establish a buffer area so as to accommodate both the modern and traditional beehives.

If elephants are to be secured from the threat of eventual and total extinction, urgent and effective conservation measures (promotion of policies, wildlife laws, regulations and restrictions of harmful human activities) is needed. This will help to ensure the long-term survival of the small number of elephants.

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III. APPENDICES

Appendix 1. Perpendicular distance (xi) measured from the center-line of the transect for each observed dropping

Stratum 1

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19
	1.2	1.9	1.5	0.6	2.4	1.7		4.6	4.8	1.3	0.8	2.3	1.4	1.5		0.4	2.3	1	1.6
	2.8	0.4	1.1	0.1	2.7	0.9		3.1	6.3	1.2	1.3	4	0.4	0.1		5.9	7.5	2.8	2.3
	0.5	1.3	0.4	2.1	0.8	0		0.9	2.5	0.1	0.5	5.3	2.2	0.5		5.2	3.5	4.8	2.9
	0.9	0.5	2.6	2.3	3.2	1.3		2.4	2.8	0	0.6	1.9	5.8	0.9		2.3	4.3	6.4	0.4
		2.5	1.4	0.3	3	2.9		0	0	1.7	1.8	0.9	6.1	7.3		5.1	6.6	0.8	4.3
		3.1	0.1	0.7	2.1	1.7		6.1	0.4	1.1	5.4	3.2	3	1.8		4.3	1.9	3.9	4.5
		1.5	1.3	3.1	0.6				3.3	1.5		5.6	0	0.5			0.5	1.2	6.5
		0.8		3.6	0.7				0.3	0.8		4	1.2				0.2	0.7	2.8
				1.8					.0	0.7			5.5					3.1	
													4.4						
													0.6						
Mean	1.35	1.5	1.2	1.6	1.9	1.4	0	2.8	2.3	0.9	1.7	3.4	2.8	1.8	0	3.9	3.4	2.7	3.2
T.d	4	8	7	9	8	6	0	6	9	9	6	8	11	7	0	6	8	9	8

T= Transect

T.d.= Total number of droppings around each transect

* All measurements are in meter

Stratum 2

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
	1.9	1.5	2.1	5.3	4.2	3.7	1.8	2.1	2.4	3.4	1.4
	0.3	0.2	1.3	4.1	2.1	2.8	1.5	3.7	5.3	2.2	1.8
	1.6	0	3.8	2.9	4.6	5.6		6.5	0.5	0.4	2.6
	1.7	0.8	0.6	7		6.5		2.9	0.8	4.2	
	4.7	3.8	4.5	3.3				3	4.3	3.1	
	6.1	0.9	4.3	4.3					3.1		
	0.7	5.8	0.4	5.1					1.3		
		0.3	0.9	2.5					1.2		
		1.8	5.8								
		6.1	3.2								
		5.6	6.2								
		3.2									
		3.8									
		0.7									
Mean	2.43	2.5	3	4.3	3.6	4.7	1.7	3.7	2.4	2.7	1.9
T.d.	7	14	11	8	3	4	2	5	8	5	3

Stratum 3

	T1	T2	T3	T4	T5	T6
		3.6	0.6	2	3.1	
		1.9	4.1	2.9	0.8	
		1.5	1.5	3	6.2	
		4.1	5	0.4		
		6.4	1.7	4.6		
			2	0.9		
			0.7			
Mean	0	3.5	2.3	2.3	3.4	0
T.d.	0	5	7	6	3	0

T= Transect
T.d.= Total number of droppings around each transect

* All measurments are in meter

Appendix 2. Questions used to interview the local people living both inside and outside MNP.

1. What is your ethnic background?
2. How long did you reside in the village?
3. How many house heads live in this village?
4. Do tourists visit this area?

   If yes, what attracts them? People, wild animals, etc..
5. What wild animals do you see in your surroundings?

   Do you see them in the national park as well?
6. Have you ever seen signs of elephants? Dead elephants, live elephants, elephant tracks, feeding signs etc.

   If yes, how frequently do you see live elephants and in which season?
7. Do you know how far elephants move on the park side of your village?
8. Have elephants ever eaten or destroyed your crops?

   If yes, what kinds of crops were destroyed? How often was the damage?

   How much damage was done the last time elephants destroyed your crops?

   What methods do you use to stop crop raiding by elephants?
9. What animals do people hunt inside the national park?

   What are the hunted animals used for?

   Have you noticed any changes in the numbers of elephants around this area?

   Other wildlife species?
10. It is possible that in the next few decades there may no longer be elephants in this national park. Does this concern you?

    Do you know the reasons why elephants are disappearing?

    Do you have some idea to prevent their disappearance?
11. Do you think that elephants are important to the economy of your family or village? In what way?
12. Do you think that the national park is important for this area?

    Would you like to see any changes for better conservation activities?

Appendix 3. List of plant species that elephants frequently feed upon.

FAMILY: FABACEAE:

Tylosema fassoglensis (Schwinf)
Cissus petiolata Hook f.
Panicum maximum Jacq
Dichrostachhys cineres (L.) Wight & Arn.
Ormocarpum trichocar Pum.
Acacia pentagona (Schummach.) Hook f
*A. seng*al (L.) Wild.
A. nilotica (L.) Wild.
A. brevispica Harm
. elatior sub sp. turkanae
A. horrida (L.) Willd.
A. mellifera Benth.
A. seyal Del.
A. tortilis (Forsk.) Hay.
Tamarindus indicus L.

FAMILY: MOACEAE:
Ficus sycamorus L.

FAMILY: PASSIFLORACEAE:
Adenia venenata Forsk.

FAMILY: OLIACEAE:
Ximenia caffra sand.

FAMILY: TILIACEAE:
Grewia bicolor Juss.
G. villosa Willd.
G. tenax (forsk.)Fieri.

FAMILY: SALVADORACEAE:
Salvadora persica L.

FAMILY: CELASTRACEAE:
Maytenus senegalnsis (Lam.) Exell.
Allophyllus abyssinicus.(Hochst.)Radlk

FAMILY; RHAMNACEAE:
Sageretia thea (Osbeck) M.C.
Ziziphus pubescens (mucronata Willd.)

FAMILY: HYDRANGEACEAE:
Piliostigma thonningii (Schum.) Milne-Redh.

FAMILY: BORAGINACEAE:
Urtica simensis Horchst.

FAMILY: POACEAE:
Phragmites sp.
Setaria sp.
S megaphylla (Steud.) Th. Dur & Schur
Panicum maximum Jaq
Digera muricata (L.) Mart.

FAMILY: ACANTHACEAE:
Isoglosomalensis somalensis Lindau

FAMILY: COMMELINACEAE:
Commelina imberbis

FAMILY: CAPPARIDACEAE:
Maerua subcordata (Gilg) DC Wolf
Capparis fascicularis (Gilg) DC.Wolf.
Cadaba farinosa
C. spp.

FAMILY: STERCULIACEAE:
Sterculia africana (Lour.) Fiovi
Dombeya torrida (J.F. Gmel.)

FAMILY: BALANITACEAE:
Balanites agyptica(L) Del.

FAMILY: SAPINDACEAE:
Haplocoelum foliolosum (Hiern.) Bullock
Allophyllus rubifolius L. (Hochst ex.A.Rich.)
A. abyssinicus (Hochst.) Radlk
Allophyllus sp.

FAMILY: ASCLEPIDACEAE:
Leptadenia hastata (Pers.) Decne.
Pergularia damia (Forssk.) Chiov.
Tacazzea spp
Dregea shimpri L

FAMILY: TILIACEAE:
Grewia tenax (Forssk.) Fiori

FAMILY: EUPHORBIACEAE:

Bridelia Scleroneura L.
Phyllanthus Sepialis Muell Arg.
Euphorbia Polycantha Boiss.
Ricinus Communis L.
Acalypha fruticosa Forssk
Margaritaria discoidea (L.)

FAMILY: MELIACEAE:
Trichilin emetica (Forsk.) Chiov.

FAMILY: MYRSINACEAE:
Embellia Shimperi L.

FAMILY: VITACEAE:
Cissus rotundifolia (Forssk) Vahl.
C. Petiolata Hook. f
C. quadrangularies

FAMILY: LAMIACEAE:
Plectranthus ornatus Codd.
Leucas glabrata (Vahl.) Smith
Ocimum urticifolium

FAMILY: RUBIACEAE:
Gardenia lutea Fres.

FAMILY: MALVACEAE:
Hibiscus macranthus A.Rich.

FAMILY: AMARANTHACEAE:
Amaranthus Spinosa L.
Achyranthes aspera .L.

FAMILY: APOCYNACEAE:
Saba comorensis L.
Saba florda

FAMILY: CELASTRACEAE:
Salacia Congolensis DC. wild & Th. Dur
Maytenus senegalensis (Lam.) Exell.

FAMILY: FLACOURTIACEAE:
Dasylepis integra warb

FAMILY: ANACARDIACEAE:
Sclwerocarya sp.

FAMILY: MIMOSIDEAE:
Acacia seyal Del

FAMILY: CUCURBITACEAE:
Diplocyclos palmatus (L.)

FAMILY: BURSERACEAE:
Commiphora fricana (A.Rich.) Engl.
Boswellia resin
commiphora spp.

FAMILY: COMBRETACEAE:
Combretum aculeatum vent.
Terminalia spinosa Engl.

Appendix 4. New records of reptiles and birds, and rare mammal species in the MNP.

Reptiles: Serpents:

Causus resimus	Green night adder
Dendroaspis angusticeps	Green mamba
Agama atricallis	Tree agama
Nucras caesicaudata	Blue-tailed sandveld lizard

Birds:

Family: Caprimulgidae:

Caprimulgus clarus	*Slender-tailed night jar*

Family: Ciconiidae:

Anastomus lamelligerus	African open-billed stork

Family: Upupidae:

Phoeniculus somaliensis	*Black-billed wood-hoopoe*

Mammals:

Species	*English Name*	*Date Observed*	*Abundance*
Erinaceus pruneri	Hedgehog	August 1997	Rare
Erythrocebus ptas	Patas monkey	July 1997 & Febr. 1998	Few
Cercopithecus neglectus	De Brazzas' monkey	September 1997	Few
Otocyon megalotis	Bat-eared fox	January 1998	Few
Lycaon pictus	African hunting dog	March 1998	Very rare
Hayaena hayaena	Striped hayena	February 1998	Very rare
Proteles cristatus	Aardwolf	August 1997	Very rare
Felis libyca	African wild cat	November 1997	Rare
Felis caracal	Caracal	August 1997	Rare
Panthera leo	Lion	August and Nov. 1997	Few
Panthera pardus	Leopard	December 1997	Rare
Acinonyx jubatus	Cheetah	July and Nov. 1997	*Few*
Vivera civetta	Civet	August 1997	Very rare
Oryteropus afer	Aardvark	March 1998	Seen only once
Equus burchelli	Burchell's zebra	November 1997	Rare
Hippopotamus amphibius	Hippopotamus	March	Rare
Potaochoerus porcus	Bush pig	July 1997	Rare
Giraffa camelopardalis	Giraffe	March 1998	Nearly extinct
Tragelaphus atrepsiceros	Greater kudu	February 19	Rare
Oryx beisa Beisa	*oryx*	July 1997	Very rare
Kobus ellipsprynus	Defessa waterbuck		Few
Ridunca fulvorufula	Mountain reedbuck		*Few*
Alcelaphus buselaphus lelwe	Lelwel hartebeest		Few
Gazella granti	Grant's gazelle	July 1997	Rare
Ourebia ourebi	Oribi		Few

THE ASSESSMENT OF ELEPHANT POPULATION SIZE AND DISTRIBUTION PATTERNS IN THE MAGO NATIONAL PARK

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A thesis submitted in Partial fulfillment of the requirements
for the degree of Master of Science in
Biology

September, 1998