STUDYING FOREST ELEPHANTS BY DIRECT OBSERVATION:

PRELIMINARY RESULTS FROM THE DZANGA CLEARING, CENTRAL AFRICAN REPUBLIC

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INTRODUCTION

For a considerable number of years researchers have been studying forest mammals in the western areas of central Africa. For the forest elephant *(Loxodonta africana cyclotis)* and the western lowland gorilla *(Gorilla gorilla gorilla),* most studies in the forest environment have been based on tracks, dung and remote cameras for census, feeding site inspection for dung analysis to determine feeding ecology, and satellite tracking to study ranging. Some researchers are even using genetic fingerprinting of hair left in gorilla nests to identify individuals (C. Tutin, pers.comm.). There is a simple reason for using these remote methodologies: direct observations have proven extremely difficult in the tropical lowland forests of central Africa. If a researcher tracks an animal and gets close enough to see it (usually a maximum of ten metres), in most cases the individual soon senses the observer and flees, hardly providing opportune conditions for identification of individuals, observations of behaviour, or habituation.

Since 1986 we have been working in the forests of southwestern Central African Republic and northeastern Republic of Congo in the contiguous Dzanga-Sangha Reserves and the newly created Nouabale-Ndoki National Park (DSNN) (Figure 1). Much of that time has been spent studying gorillas and elephants using secondary evidence, and trying to habituate gorillas. In 1990 we decided that a change of strategy was in order.

An interpreted satellite image of the DSNN area produced by NASA (1993) shows that the terrain is homogeneous and flat. Closer inspection reveals a series of little spots

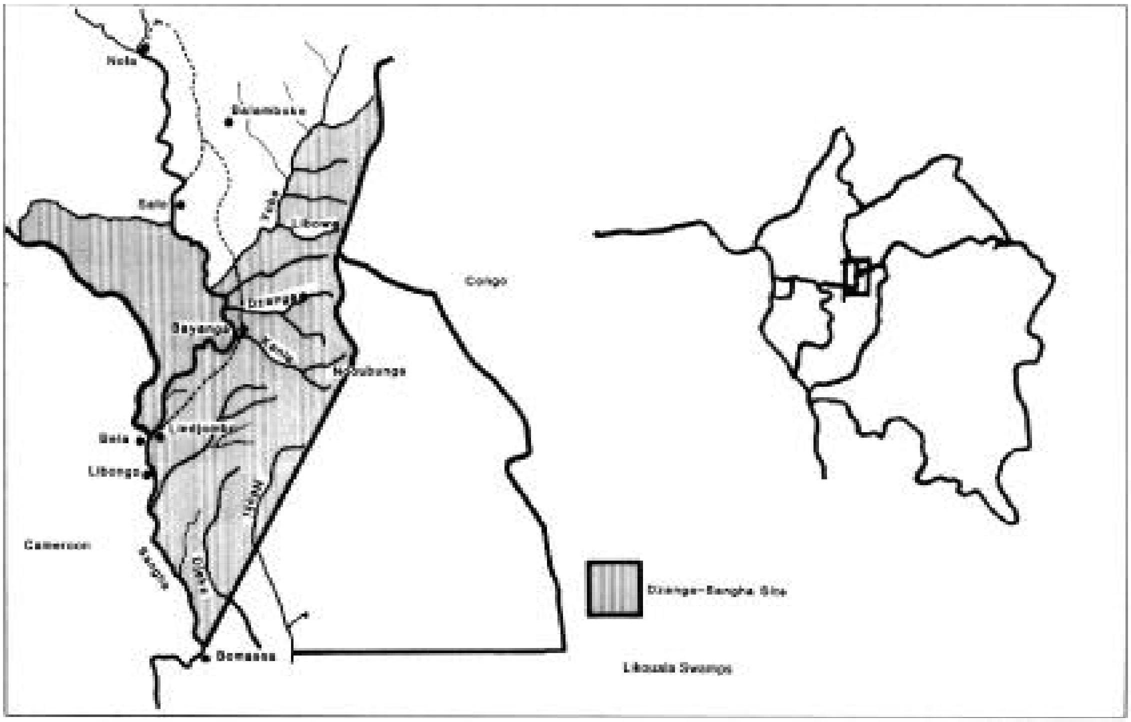

Figure 1. Map of the Dzanga-Sangha and Nouabalé-Ndokl Reserves and the location of the Dzanga clearing.

on the image which are in fact clearings in the forest. The local Bambenjele Pygmies group these clearings into two broad categories: *bai*, a clearing with a water outlet, and *yanga*, a clearing with no outlet. We further subdivided the *bais* into swampy bais, those with permanently saturated soils and inundated in the wet season, and elephant *bais*, those with seasonally saturated sandy substrates. All three types usually have a very low tree density, with a terrestrial vegetation that consists of various species of herbs in the families Cyperaceae, Poaceae, Hydrochartiaceae, Melastomataceae and Onagraceae. Similar clearings exist in Nigeria, Cameroon, Gabon and Zaire.

The origin of these clearings varies. There is no doubt that large mammals, because they are attracted in high numbers to exploit food resources and mineral salts, contribute to their maintenance and may even be responsible for creating forest clearings (Ruggiero & Fay, 1994). It is the concentration of large mammals in these clearings, including forest elephants, gorillas, forest buffalo *(Syncerus caffer nanus)*, bongo *(Tragelaphus euryceros)*, sitatunga *(T spekei)* and giant forest hogs *(Hylochoerus meinertzhageni)*, which provides unique opportunities to study forest mammals using direct, sustained observations.

We have initiated two studies exploiting this opportunity, the "Dzanga Bai Forest Elephant Study" in the Central African Republic and the "Mbeli Bai Gorilla Study" in the Republic of Congo. Both have proved to be successful. In over 1,800 hours of observation at Dzanga, elephants have been present in the clearing over 99% of the time. Over 1,000 hours of observation in the Mbeli clearing have revealed that gorillas are present more than 25% of daylight time both in the wet and dry seasons.

Dzanga has been well known to the local Pygmy population for a very long time as a *bai* favoured by elephants. With the onset of commercial elephant hunting around 1900, Dzanga undoubtedly suffered several depredations for a sustained period of time (Fay & Agnagna, 1993). With the advent of logging in the area in 1970 hunting pressure greatly increased at the *bai*, but elephants continued to visit Dzanga, at least in small numbers, up to 1987 when conservation efforts were initiated in the area. Since that time elephants have enjoyed a high level of protection in the clearing. Consequently the number of elephants visiting Dzanga has increased dramatically.

In 1990 we undertook a pilot study to investigate the possibility of identifying individual elephants at Dzanga. Methodologies similar to those used in East Africa (Douglas-Hamilton, 1972; Moss, 1988) were employed. Using a simple index card system, in which elephants were classed by sex and inferred age, with schematic drawings of tusk morphology, rip, hole, break, and scar patterns on ears, tails and sides, it was discovered that most mature adults could be readily identified and re-identified. The confirmation of this methodology led to a full-time study which began in January 1991. In this paper we present preliminary results and describe how a study in a single location can be used to elucidate population characteristics.

METHODS

Data are being collected on the size, demographics, morphometrics, social structure, social behaviour and genetics of the Dzanga elephant population. The project has been designed in two phases: the primary objective of Phase I was to identify the majority of elephants that come into the clearing and in Phase H data collection has been tailored to answer some of the more complex questions about this forest elephant population.

Since the beginning of the study, the identification of individuals has been based on morphological characteristics as described above. A card has been opened for each individual, which is classed by its sex and morphology. Each identified elephant is given a name. Dependants are given the name of the mother with a Roman numeral H for the oldest offspring, and m, IV, etc. for the younger siblings. This classification system, even with a large number of elephants, has proved to be effective.

Observations are made solely by Andrea Turkalo and one Pygmy spotter using a Bushnell Elite zoom spotting scope and binoculars, from a centrally located platform that is seven metres above the ground at the edge of the clearing. Observations begin in the early afternoon because the majority of elephant visits occur during late afternoon and night. This also permits initial daily observations to be made on a relatively small number of elephants. Upon arrival at the clearing, a total count of elephants is made and identification of the elephants present proceeds for about 30 minutes. Subsequently all elephants entering the clearing during the observation period are recorded and if possible identified. If an elephant is not identifiable by name, its sex is determined and its age estimated. Records are also kept of group composition as elephants enter the clearing. Information on time, group (even if single), names of individuals (or sex and age of each), and location from which they enter, is recorded. Each entrance event serves as a sampling unit. Observation is halted at 17:00 hours when positive identification becomes difficult due to low light levels. In addition, total counts of elephant and other large mammals in the clearing are made at 30 minute intervals. This permits an estimate of not only the number of elephants entering the clearing, but also the total number of elephants, on average, present in the clearing during the observation period.

The study of social structure within elephant groups requires competent identification and re-identification of all individuals and groups. In order to identify primary groupings it is necessary to identify aggregations as they enter the *bai* from the forest, because they disperse once in the clearing. Each group is identified by locating known individuals and observing group composition. Relationships between individuals are inferred from affiliated behaviour. We are confident about the identification of mother-offspring relationships based on association, especially if we observe the same grouping at least twice over several months, and, for example, by suckling behaviour. For secondary associations, assumptions about filiation have been taken one step further. If groups of adult females with young enter the *bai* at least twice together, on different days, they are then classified as secondary groupings. As group data accrue with records of repeated, yet sporadic, affiliations, the identification of secondary associations becomes more definite. Greeting behaviour is not frequently observed in the Dzanga elephants and is not useful in the identification of complex relationships between groups.

Demographic information is based entirely on data obtained from groups. Births to known individuals are recorded, as are absences from groups. The absence of a very young individual is recorded as a death while that of a more mature individual as a separation or death. Height measurements are taken of known individuals to monitor growth. Additional data are collected on behaviour, such as musth, injury, dominance hierarchy and interspecies interactions.

Phase II methodology includes data collection on group composition, with identification, if possible, of all groups and individuals entering the clearing, even those previously recorded during the session. This gives a more quantitative estimate of the percentage of unknown and “clean” elephants in the population. A clean elephant has no readily identifiable characteristics.

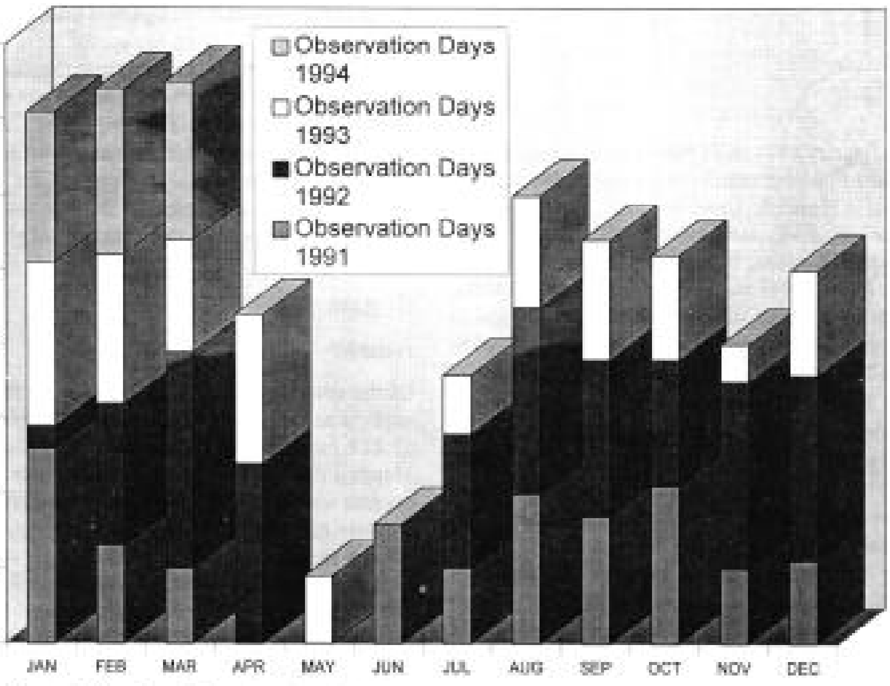

Figure 2. Number of observation days in the Dzanga clearing from 1 January 1991 to 1 March 1994.

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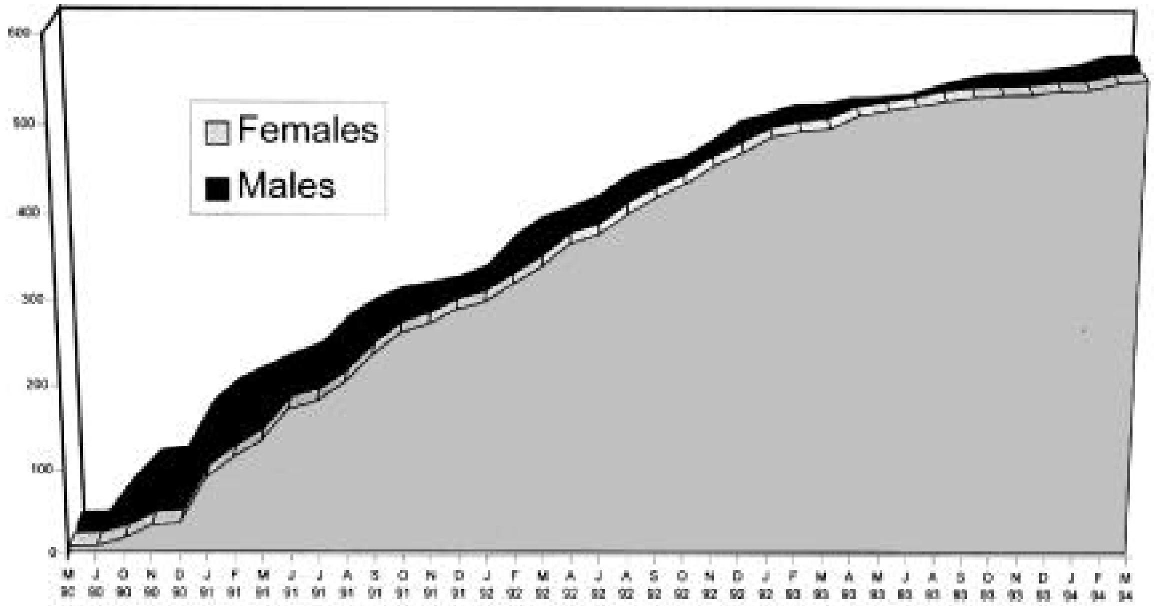

Figure 3. Cumulative number of male and female elephants identified at Dzanga from March 1990 to March 1994.

RESULTS

Individuals

From 1 January 1991 to 31 March 1994 a total of 602 days and 1,806 hours had been logged in the clearing, as shown in Figure 2. Up to this date, 1,705 elephants had been identified, named and catalogued. Of these, 509 are adult females, 50 are independent, subadult or juvenile females, 448 are adult males, 103 independent, subadult or juvenile males, and 495 are classed as offspring (non-adults) which are dependents within groups. Figure 3 shows the number of identified males versus females over the study period. Of the individuals which have been sighted, 81.3% have been seen on more than one day. Since the start of the study the number of elephants identified per day, expressed as a percentage of the maximum half-hour count, has increased. During a period of 17 observation days in March 1994, the average number of elephants identified, expressed as a percentage of the maximum 30 minute count, was 80.5%. Since the start of Phase II, an average of 80% of the elephants entering the clearing can be identified. The number of identified elephants has begun to reach an asymptote, i.e. the number of new elephants identified has begun to approach zero (Figure 3). Based on the estimate that 80% of individuals have been identified, we can calculate that the minimum population visiting the clearing consists of about 2,100 elephants. While new identifications are becoming more infrequent, it is believed that the total number will continue to increase to a minimum of about 2,500.

Groups

Females

Of the adult females, 438 (88.7%) were recorded as mothers accompanied by at least one offspring. A total of 422 mother-calf groups had been identified by March 1994. Stable groups vary in size from two (mother with one offspring) to nine (three adult females with six offspring). The mean group size including solitary individuals is 2.3, and 2.7 if the solitary are excluded. The mean number of offspring/female with offspring is 1.3. The table shows the frequency distribution of different group compositions. The number of old females that are apparently no longer reproductive is 52, of which 6 are associated with groups.

Table. Frequency distribution of female-cal/group compositions including solitary adult (old) females.

GROUP	FREQUENCY
Old Solitary	46
1 Adult 1 Offspring	211
1 Adult 2 Offspring	169
1 Adult 3 Offspring	19
2 Adult 1 Offspring	5
2 Adult 2 Offspring	4
2 Adult 3 Offspring	6
2 Adult 4 Offspring	3
2 Adult 5 Offspring	1
3 Adult 0 Offspring	1
3 Adult 2 Offspring	1
3 Adult 6 Offspring	2

Dzanga groups consist primarily of mother-calf groups often with non-reproductive females. Groups with more than one reproductive female are rare. Most multi-mother groups have been seen on numerous occasions. It should be noted, however, that there is observer bias involved in the identification of these groups. The majority of groups have been seen between one and five times. Known multi-mother groups often enter the clearing as single-mother groups. Conversely, single-mother calf units often enter with other groups, but they have not been seen frequently enough to say whether they represent a cohesive group or not.

More complex (tertiary) relationships have not yet been clearly observed in Dzanga, but there are indications that they do exist. For example, the association between a group of six (Second Broken-Tail with two offspring and Mandy with two offspring), a group of four (Fourth Tuskless with her three offspring), and a group of three (Maureen with two offspring). Fourth Tuskless frequently enters the clearing with Second Broken-Tail and they are almost always present in the clearing together. Maureen is also very often in the clearing with both of the other groups and Maureen's newborn is seen associating with Fourth Tuskless's subadult female offspring. While these relationships are subtle, we believe that if they were common, many more would have been evident.

Males

There is no indication that males associate in groups in the Dzanga clearing. Certain young males rejoin their maternal groups occasionally, but do not remain consistently in any group. Independent males associate loosely while in the clearing, but their associations appear to be temporary, lasting from a few minutes to possibly a day.

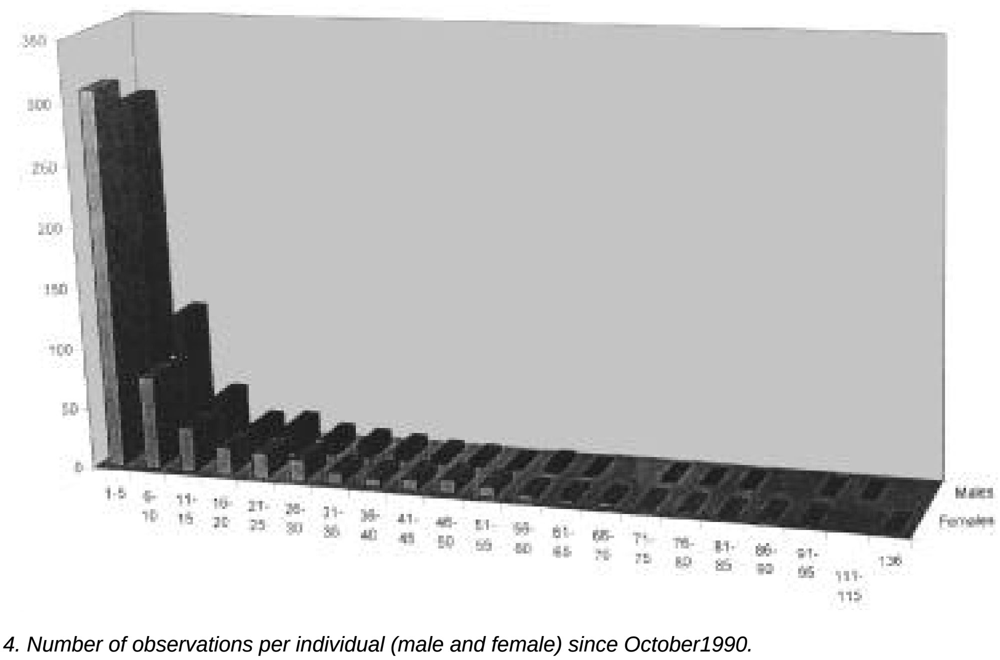

Figure 4. Number of observations per individual (male and female) since October1990.

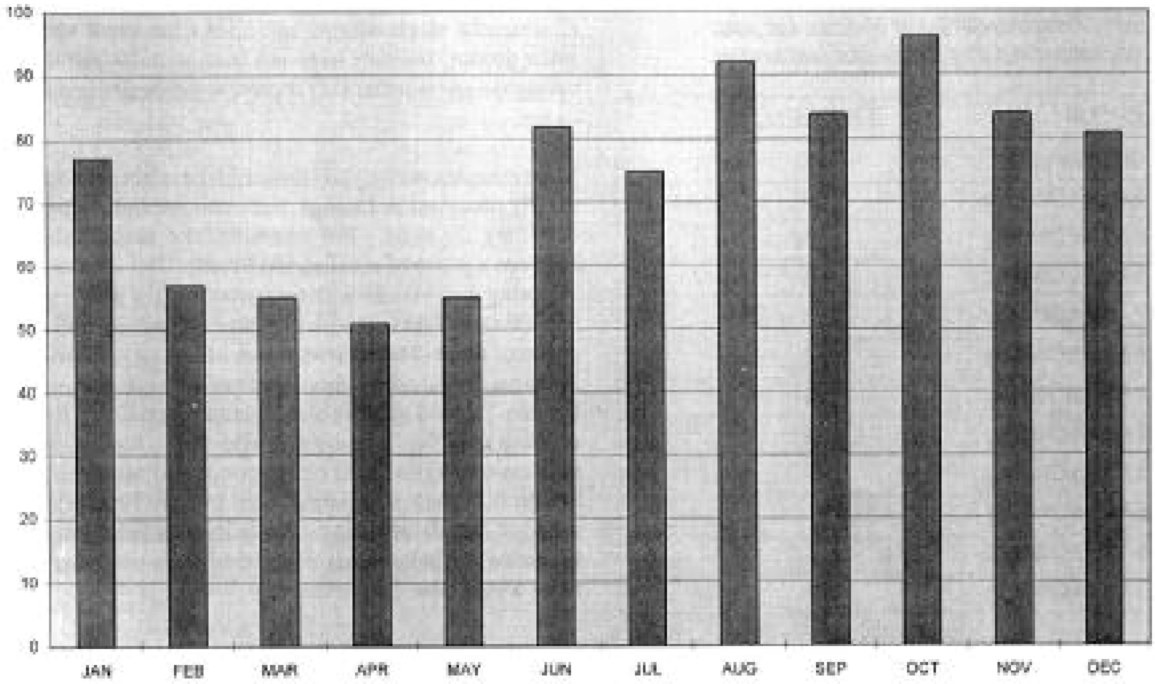

Figure 5 Maximum number 0/elephants observed on one complete count in Dzanga over the study period.

Visitation by males and females

Figure 4 illustrates the visitation rate to the clearing over the study period. Figure 5 shows the maximum number of elephants recorded in one half-hour count in Dzanga for all months over the study period.

Reproduction

Up to 31 March 1994, 72 newborns of known females had been recorded. Second births to individual females have yet to be recorded. The first birth recorded was in January 1991 to an individual named Fourth Tuskless. This individual was last seen on 8 February 1994, still without a second infant. There are many cases of individuals that have not given birth in three years.

Behavioural observations

The majority of elephant behaviour observed in the clearing consists of jockeying in an endless series of dominance bouts for a place at a particular water hole, some of which are obviously preferred. In the dry season the clearing is marked by a series of some twenty to thirty holes in the sandy substrate where elephants pump water out of the sub-stratum. The holes are about one metre deep, beneath which is a layer of gravel. It is common for an individual to wait hours for the chance to drink from a particular hole. Conversely, however, it is not unusual for a single individual, usually a male, to monopolise a waterhole for several hours.

The hierarchy of most individuals in the population seems to be known by other elephants. Hierarchy is often tested at the waterholes. In all cases adult males take precedence and displace adult females and smaller males at a particular hole. Depending on the size and "robustness" of a particular male, the more imposing usually wins, but not always. Amongst the larger males competitive bouts can last for over an hour. The males continuously jockey for position. In very close matches, an elephant's position on the slopes leading down into the clearing can provide the height and momentum needed to defeat an opponent, with dominance often switching from one individual to another. As more data are gathered, specific relationships between individuals will become evident. We believe that the Dzanga clearing is a testing ground for the establishment of dominance hierarchy in the population.

Musth males which visit the saline rarely drink mineral water but instead circulate in the clearing, probably in search of receptive females. Usually they are unsuccessful and leave the clearing after a relatively short time.

DISCUSSION

One striking result of the Dzanga study is the large number of elephants that visit the clearing. Seventeen hundred elephants are more than expected. This is in contrast to the forest buffalo, for example, which visit the clearing on approximately one-third of observation days and comprise only one group of about 18 individuals. Even if the elephant population density in the Dzanga area is one elephant per square kilometre, which is considerably higher than previous dung count surveys would indicate, this would mean that every elephant over the entire Dzanga-Ndoki National Park visits the clearing.

Why do so many elephants visit the clearing? Water is not a limiting factor in this area and therefore cannot be the reason. Minerals may provide the key. Preliminary water analysis from the waterholes indicates that calcium and other cations are found in high concentrations in comparison to those of stream water in the clearing and of the soils surrounding the *bai*.

While we believe that the minerals attract elephants, there may be other reasons why they spend hours at the holes. As in most other waterhole or mineral lick areas frequented by the large mammals, social activity is intense at Dzanga. Perhaps the possibility of social interaction in large numbers is a major attraction for elephants at Dzanga. In this setting, young elephants can learn a great deal from interactions, females have a better chance of being inseminated by prime bulls, and males can establish dominance hierarchy.

Groups

Data presented here suggest that the group size found in the Dzanga clearing is similar to other forest data sets (Merz, 1986; Dudley *et al.*, 1992; White *et al.*, 1993). White (1993) found the average group size (excluding solitary individuals) to be 2.8 compared to 2.7 at Dzanga. In general forest elephant group sizes are considerably smaller than those of documented savanna populations (Douglas-Hamilton, 1972; Moss, 1988, 1990; Ruggiero, 1989).

There are three factors cited as being important in the formation of elephant groups and aggregates: predation, the distribution and abundance of food, and social interaction (Western & Lindsay, 1984; Moss, 1988; Ruggiero 1989).

The predominant predator of the African elephant throughout its range is man. Even in cases where predation by lions on elephants is high, the underlying cause may be man (Ruggiero, 1989). Intense killing of elephants for ivory removes older individuals from groups and may cause aggregation (Laws *et al.*, 1975; Western & Lindsay, 1984), because orphans seek to group with other elephants (Ruggiero, 1989) and there is safety in numbers (Moss; 1988). Increased pressure by secondary predators such as lions and hyaenas may reinforce the tendency to aggregate (Ruggiero, 1991). In the forest environment, man is the only predator of elephants. In historical times many populations of forest elephants were subjected to considerable predation by man. It is unlikely however, that this pressure has ever been as intense in the forest environment as in the savanna. In the Dzanga population, group structure consists of either solitary males or intact single mother families. From an evolutionary point of view, selection for large group size in the forest elephant, through predation, has not occurred. In heavily hunted areas it is possible that elephant groups would band together for safety, but there is no evidence for this in the forest environment. We suggest that small group size in forest elephants, in particular in the Dzanga elephants, may be due to relatively low predation.

Forest elephants are highly frugivorous (Alexander, 1977; Merz, 1981; Short, 1981; Dudley *et al.*, 1992). White *et al.* (1993) suggest that small family units are better able to exploit a patchily available resource, such as ripe fruit, than larger groups. This is in contrast to savanna elephants, for which grass, a more abundant and ubiquitous resource, forms the bulk of the diet. While fruits are important in the diet of the forest elephant, it is doubtful that they could be of sufficient selective significance to determine group size. Tchamba (1993) found that forest elephants in western Cameroon feed extensively on grass in a mixed forest-savanna habitat. White *et al.* (1993) suggest that forest elephants in Lopé, Gabon, do not graze extensively on grass, but their diet consists of a wide diversity of bark, leaves, roots and fruits including the rhizomes of many species of herbaceous monocotyledons in the families Marantaceae or Zingiberaceae. Analysis of over 1,000 dung samples at the Dzanga site indicate that the dietary pattern found at Lopé is similar to that in the Dzanga population. We agree with Dudley *et al's.* (1992) suggestion that it is the patchy nature of food resources in the forest, not just the presence of fruits, that accounts for small primary group size in the forest elephant.

In savanna environments elephants tend to aggregate when fresh grass is abundant (Western & Lindsay, 1984; Moss, 1988; Ruggiero, 1989), unlike forest elephants which do not appear to aggregate even when seasonally abundant and preferred food stuffs are available, such as *Raphia* spp. stems in the Likouala aux Herbes swamps (see below), or grass at Lopé. Moss (1988) suggests that where the resource base permits, such as during a flush of green grass on the open plains of Tsavo or Amboseli in Kenya, these aggregations may serve to establish and re-establish social relationships, and to provide breeding opportunities, social stimulation and a setting for elephants to learn a variety of social and practical skills. The physical constraints brought about by dense vegetation in the forest environment may discourage forest elephants from forming large groups, though this does not explain the lack of aggregations among the Lopé elephants. Forest elephants may generally shun large, open areas. In the gallery forest areas of the Central African Republic, forest elephants were found only in very thin bands of forest along creeks and at the savanna forest ecotone (Fay, pers.obs.), while savanna elephants were abundant just beyond the galleries but never frequented the forests. It is possible, too, that some aggregations of forest elephants pass unobserved because they are hidden by the forest environment.

A high percentage of the total population from a large area visits the Dzanga clearing. Forest elephants apparently prefer the physical conditions of clearings, rather than forests or swamps, for social interaction. The opportunities for social interaction between elephants visiting Dzanga may be similar to those of the Amboseli and other savanna populations. The physical environment of forest clearings encourages intense social activity, often identical to roving savanna aggregations.

Males versus females

The almost equal number of males and females in the clearing is striking. Most populations of elephants in Africa show a much higher percentage of adult females than males, probably due to a high level of selective hunting by humans in the majority of cases. The number of adult males in the Dzanga population is very high compared to populations with a long history of being selectively poached for ivory. Furthermore, the age curve of Dzanga elephants is not significantly different from what one would expect in a population without poaching. Large-tusked old males account for about 7% of the Dzanga population (i.e. about 100 out of 448 males). A thorough analysis of age structure from data on height measurements will provide a powerful data set with which to compare other elephant populations in Africa.

Do the Dzanga elephants represent a population which is not poached or at least not selectively poached? In order to address this question we must first look at the possible sources of bias which come from observing elephants in the clearing.

In general, males leave groups at an earlier age than females. Once an individual is independent of its mother it is given a name if it can be identified. While a large number of independent juvenile males are nameless, because they possess no distinguishing features, juveniles and sub-adult males which have been named account for about about 6% of the population. Named, independent sub-adult and juvenile females account for about 3% of the population. Naming bias therefore may interject about a 3% bias in favour of males.

A second source of bias may arise because adult males possess more distinct and conspicuous features than females, so that one tends to name males preferentially both overall and on a daily basis. The data showed that males were identified more frequently in most months, even though their overall number almost equals the females. This may either indicate a bias towards the identification of large males, or that males visit the clearing more often, the latter being true for mature bulls which probably come to engage in competitive bouts with other males and to find oestrous females.

Visitation by large males to the clearing has certainly increased since the inception of the study. Any observer bias should tend to disappear with time as the elephants become more familiar to the observer.

If males travel further to visit the clearing seasonally and/or on a daily basis, then probably there are lower densities of males being drawn from a larger area. The overall frequency data concur that on an individual basis, males have been recorded more frequently than females and there are more males in the clearing than females in all months of the year except April, May and June. These data, while inconclusive, indicate that there is male dominance for most of the wet season and female dominance in the late dry season-early wet season. A systematic analysis of the data on individual visitation will help to determine if visitation by males and females is clumped, random or regular. Visitation by large males appears to be clumped and seasonal, mostly being noted in two months of the year.

Migration

Reconnaissance surveys in the Nouabale-Ndoki National Park have shown that most elephant trails in the area are orientated from north-west to south-east. Over a seven-year period (since 1987), in areas south of the Dzanga clearing, both in the Ndoki National Park in the Central African Republic and the Nouabale-Ndoki National Park in adjacent Congo, we have noted that elephants migrate in and out of these areas. Based on observations and anecdotal information from hunters and others, it would seem that elephants in the Dzanga Sangha-Nouabale-Ndoki complex migrate from the north-west to the south-east in an annual cycle. This migration appears to be correlated with diet. In the dry season elephants travel to the Likouala swamps to the south-east of the two parks where there is an abundance of *Raphia* spp. stands. During the wet season they migrate north to feed on the fruit that ripens as the season advances from south to north.

Strong evidence for this migration pattern has emerged from the Dzanga data, with distinct differences between males and females. Based on half-hour counts, there is a period during the dry season, February to April, when there are fewer elephants in the clearing. When more data from the late dry season are collected, this trend may become more marked. The total number of individuals identified daily, divided by the number of observation days and tallied per month, drops sharply in the short, wet season from May to July. By examining male and female daily sightings separately, the data reveal that males, which range further than females, probably form the migratory segment of the population. For nine months of the year, the number of males is larger than females but during three months, April to June, the number of females is greater. However, while the number of males drops considerably during this period, the female numbers stay relatively constant. These data indicate that there is indeed migration which may be accentuated in males; they may be more mobile and migrate from greater distances.

In conclusion we stress that these results are preliminary and thus our hypotheses should be regarded as tentative. Continued data collection will help to elucidate patterns. For a clear understanding of social organisation of the Dzanga elephants, long-term observations, combined with a thorough knowledge of most individuals in the population, are absolute necessities. Our aim in this article has been to show the wealth of information that can be obtained on a wide variety of aspects of the forest elephant using data collected from a single point.

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