Numbers, Distribution and Movements of the Nazinga Elephants

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INTRODUCTION

Of fundamental importance to wildlife management are the numbers of animals and their distribution through time. One measure of this is "occupance", which is derived by multiplying the biomass or numbers by time for any unit area. The usual methods for obtaining information on elephant occupance are aerial surveys and ground surveys. in terms of precision, however, both types of survey are unsatisfactory for the following reasons.

Uneven distribution — The sampling error and confidence limits of an estimate are heavily influenced by the distribution of the population being sampled. If the population is clumped, the sampling error is very large. This problem is the most serious limitation in the use of either an aerial or ground survey. Thus, an estimate of elephant numbers will show a large sampling error, because they are so highly clumped. Also, the observations on their distribution may be meaningless if derived - from only one survey.

Limited visibility — The tendency to undercount in any type of vegetative cover is usually much greater than is supposed (Caughley et al., 1976). To allow for this bias, a correction factor should be estimated for every type of cover found in the area to be sampled.

Because of the inaccuracy of the data obtained by both aerial and ground surveys, I used the alternative method of fecal dropping counts to assess elephant occupance on the Nazinga ranch. This method, described by Jachmann and Bell (1979, 1984), has three advantages: it estimates the population size, accurately describes the distribution by season, and identifies possible corridors used by elephants when moving across ranch boundaries.

STUDY AREA

The study area is the 806 km^2 Nazinga Game Ranch in south-central Burkina Faso (Figure 1). The mean annual rainfall is about 1 000 mm. The ranch and its ecology were described by Lungren (1975,1985).

METHODS

Field Procedures

The dry-season survey was carried out from early February to the end of April 1987, and covered the entire ranch. The field method was simply to lay out an imaginary grid consisting of units 2.7 x 2.7 km, using the existing transect lines that were signposted during earlier research (Fig. 2). At each grid intersection or point, a quadrat of 100 x 100 m was examined for elephant droppings. A total of exactly 100 quadrats was sampled (1 sq km), omitting about 10 quadrats on the perimeter of the ranch, where dropping densities were known to be 0. Each quadrat was covered by a team (two labourers, a laboratory-assistant, and the author) walking at 12.5 m intervals from north to south and back. Each person counted the droppings on his left side only, i.e. between himself and the next person. The distance of 100 m was paced out by the author. The wet-season survey was carried out during the first week of September 1987 and, with the exception of the perimeter roads, covered most of the major roads on the ranch. At intervals of 3 km, the

Figure 1.

South-central Burkina Faso, showing Po National Park, Nazinga Game Ranch and Deux Bale Forest Reserves.

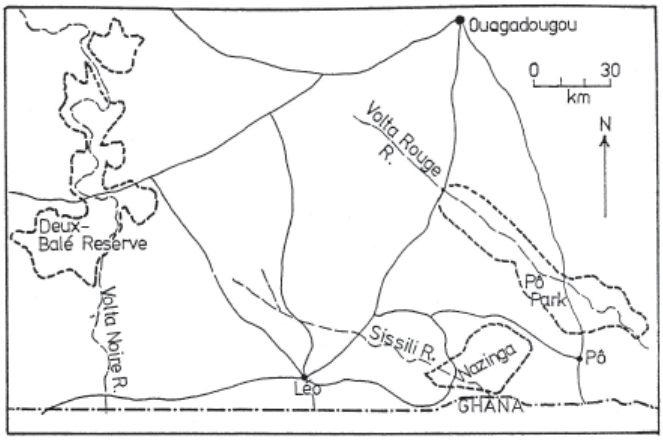
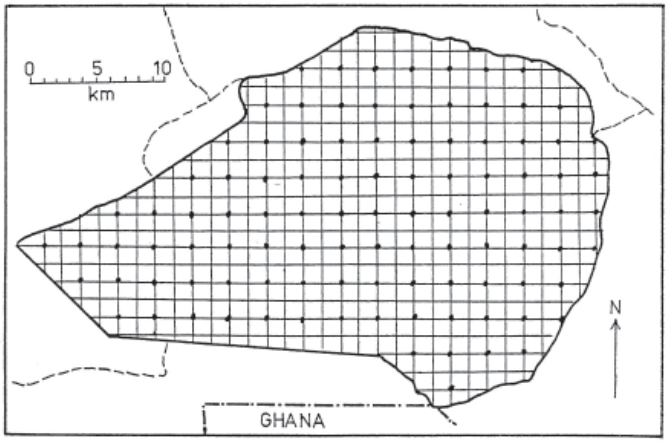


Figure 2.

Location of the Nazinga Game Ranch in south-central Burkina Faso. The imaginary grid consists of units of 2.7 x 2.7 km. The black dot in the middle of each unit shows where a quadrat of 100 x 100 m was examined for elephant droppings.

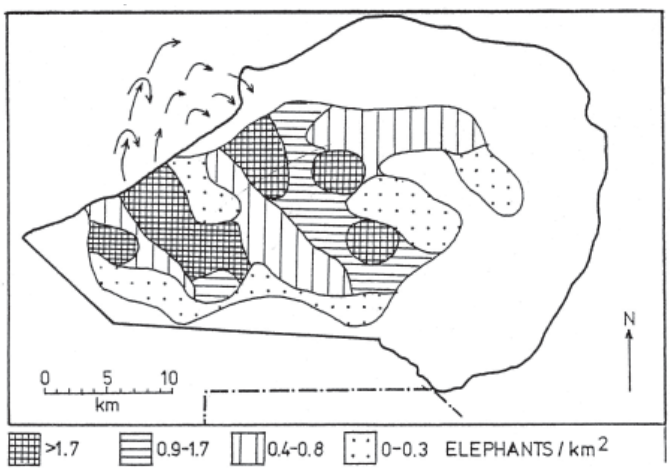


width of the road was measured to the nearest 0.5 m. In this way a stretch of 163 km with a mean width of 3.9 m (0.64 sq km) was examined for elephant droppings. This method assumes that elephants use the road-system on a somewhat similar time-basis as the rest of the ranch (Jachmann, 1984b).

A "dropping" or defecation is defined as one pile of boll. To determine the time period of the accumulation during the dry season, only those droppings that were not scorched by fire were counted. Hence, the period of accumulation began on the day that the particular area was burned. To determine the decomposition rate of elephant droppings at Nazinga, 31 droppings of varying ages from areas from different vegetation characteristics were checked weekly from late January to late March. If more than 90% of the dropping was covered by termite mudcast, it was considered decomposed and was not counted.

Figure 3.

Dry-season elephant distribution at Nazinga Game Ranch. The arrows indicate the nightly excursions outside the ranch. Unshaded portions of the ranch have no elephants.



The dry-season defecation rate of the Nazinga elephants was estimated by following family units and single male elephants on foot for 73 elephant hours. Time of defecation and number of boli per dropping were recorded. In elephants, there appears to be a positive relationship between the amount of grass in the diet (%) and the defecation rate. This phenomenon results from the simple fact that grass consumption is not limited by plant secondary chemicals (Jachmann 1987b) but, to a much lesser' extent, by the rapid rate of throughput, resulting in a decreasing efficiency 'of protein intake. Using the percentages of grass consumed by' elephants during the month preceding the survey (59.4%), in combination with 15.2 elephant observation hours, an estimate of the wet-season defecation rate for the Nazinga elephant population was obtained. Jachmann and Bell (1984) found no significant differences in the defecation rates among the various age classes and between the sexes within a season. Hence we can use mean figures for the Nazinga population.

Elephant movements year-round were studied during both dropping surveys by additional recording of footprints left in the mud (dry season as well as wet season) and by examining the perimeter roads for signs of elephants crossing to areas outside the ranch.

Also four separate trips were made to areas surrounding the ranch, to inquire about recent or former movements of elephants. The first trip was to villages northeast of the ranch, between Nazinga and Po National Park (Ouedraogo Tambi National Park). The second trip was to villages north of the ranch, and the third trip covered the area west of the ranch to the town of Leo. The last trip was to Po National Park, where I both inquired with local rangers and searched a stretch of 12 km of the Volta Rouge River (starting at the main road "N5""and going east) for signs of elephants. Also, on the 1st and 2nd of April, two surveys were flown over the northern area that borders the ranch, to look for signs of elephant movements across ranch boundaries.

Data Analyses

The size of the grid was chosen for practical reasons. A 2.7 x 2.7 km grid enabled us to use the existing transect lines. Decomposition of elephant droppings is caused by three principal factors: termites during the dry season, dung beetles and termites during the wet season, and other disturbances throughout the year (i.e. trampling, fire, rain, insects, insect-eaters). During the dry season, droppings accumulate because 'the rate of deposition by elephants is higher than the rate of decomposition by both termites and mechanical disturbances.

The period during which the droppings accumulate during the dry season (T(n)) was accurately determined as being from the time of fire in that particular area until the day of the survey. To estimate the true number of droppings deposited by elephants a correction factor must be applied to account for droppings that disappeared due to decomposition.

For the Nazinga situation we can proceed as follows. The number of droppings counted in each quadrat (D(a)) was multiplied by 729 to give the number of droppings in each 7.29 sq km grid square. To estimate the true number of droppings deposited per day, we applied a correction factor (L(s)) to account for decomposition. We cannot, however, apply this factor to the number of droppings counted during the survey, because the accumulation of the droppings is a continuous process, starting at 0 (t(0)) the day following the fire. An algebraic progression, not included in the original project proposal by Jachmann (1987a), was used to estimate the number of droppings that disappeared. The number of droppings deposited per day per grid square is given by the following equation:

$$X(a) = \sum_{i=1}^{T(n)} \frac{729.D\ (a)}{((1 - i.\ L(s)) + \ldots (1 - T(n).L(s)))}$$

where: X(a) is the number of droppings per day in the ath grid square (a = 1 to 100),

T(n) is the accumulation period, which varies from 70 to 120 days,

D(a) is the number of droppings counted in the ath quadrat,

L(s) is the correction factor, i.e. fraction of droppings disappearing per day.

The number of elephants represented by the number of droppings deposited per day can now be estimated for each grid square by dividing X(a) by the dry season defecation rate or the number of droppings deposited per day per elephant (R(s)). The final equation is as follows:

$$N = \sum_{a=1}^{n} \sum_{i=1}^{T(n)} \frac{729.D\ (a)}{(((1 - i.L(s)) + .. (1 - T(n).L(s)))).Rs}$$

where, N is the estimated popuation size of elephants.

An alternative solution is to assume an oscillation around a steady state of the actual quantities of fecal droppings. This means that the rate of deposition equals the rate of decomposition halfway through the wet season. The equation is as follows:

$$N = \frac{D(n).\ \left[\log_e 2\right]}{\left[t(1/2)\right]} \Big/ R(s)$$

where, N is the estimated population size of elephants, D(n) is the total number of droppings on the ranch on the day of counting,

t(1/2) is the time at which half of the original dung is unrecognizable (year-round), and R(s) is the defecation rate for that specific season.

RESULTS AND DISCUSSION

Estimation of Elephant Numbers

The late dry-season defecation rate (R(s)) for the Nazinga elephants was estimated as 14.14 droppings per elephant per day, whereas the late wet-season defecation rate was estimated as 27.2 droppings per elephant per day. The mean number of boli per defecation for the dry season was 6.1. In Malawi, Jachmann and Bell (1984) found a dry-season defecation rate of 15.7 droppings per elephant per day, with a mean of 5.6 boli per dropping. Their" observations were based on 147 elephant hours in the miombo woodlands of Kasungu National Park. In Uganda, Wing and Buss (1970) gave an estimate of 17.0 droppings per elephant per day, with an average of 6.3 boli per dropping. Thus, our findings at Nazinga correspond well with observations from other parts of Africa. The dry-season decomposition rate (L(s)) was estimated to be 0.59% per day. Droppings that were more than 90% covered with mudcast were considered decomposed. The t(1/2)) or the time at which half of the droppings is unrecognizable was estimated to be 82.7 days.

A year-round estimate of the decomposition rate must include the wet season rate of decomposition, which was found to be five times faster than that of the dry season (Jachmann and Bell, 1984). Assuming this also applies to Nazinga, we can estimate the year-round t(1/2) as being 49.6 days.

The dropping count method gave three population estimates. The number of elephants present on the ranch during the dry season was estimated by the first solution to be 396 (range 323 - 469). The steady state solution provided an estimate of 353 (range 276 - 430). Also, a preliminary estimate for the wet season gave a figure of 420 (range 0 - 910). See Table 1 for comparison with earlier population estimates.

The wide range of each population estimate from the aerial and ground 'surveys, and a seasonal shift in elephant distribution in combination with different sampling periods,

Table 1. Summary of elephant population estimates at Nazinga Game Ranch from 1980 to 1987.

Year	Estimate	Range[1]	Assessment	Source
1980	40	–	subjective	C. Lungren (pers. comm.)
1982	300	0 — 669	aerial	Bousquet (1982)
1985	32S2	0 — 725	ground	O'Donoghue (1985)
1985	6303	304 — 956	ground	O'Donoghue (1985)
1987	396	323 — 469		dropping (dry season, this ms.)
1987	353	276 — 430		dropping (dry season, this ms.)
1987	420	0 — 910	dropping	(wet season, this ms.)

1. The range is based on the standard deviation
2. Estimate using Fourier series
3. Estimate using modified Haynes

make it difficult to compare the various estimates of elephant numbers. Because of the widely overlapping ranges of the population estimates we cannot describe any trend in elephant numbers from 1982 to 1987. As I will argue in the next section, however, the circumstantial evidence suggests an increasing elephant population, primarily as a result of immigration from areas outside the ranch.

Dry Season Elephant Distribution

The Nazinga elephants have a restricted distribution during the dry season of November to May (Fig. 3). There are several factors contributing to this, of which water availability and poaching seem to be the two most important ones. The small range near permanent water that the Nazinga elephants show during the dry season is similar to the dry-season behaviour of elephants in Kenya and Malawi (Leuthold, 1977; Jachmann, 1983). This can be easily understood in terms of a cost/benefit analysis. During the dry season, food is scarce and of a low quality, If an elephant then has to spend much of its limited energy searching for or commuting to water, it would benefit little or not at all from its extensive range. Therefore, during the dry season, an elephant should expend as little energy as possible, using part or" most of its reserves built up during the former wet season. The elephant should occupy a small area near permanent water. This is the reason why calf mortality is high during the second half of the dry season, which is the nutritional 'bottle-neck' of the year.

In Nazinga permanent water within the Sissili and Dawevele Rivers, where since the early 1980's several dams have been constructed, forms the basic framework for the elephant range. Not all the areas with permanent water, however, are occupied by elephants. Throughout the year, water is available at a dam in the north east as well as along the Sissili River in the extreme south. During the dry season, however; no elephants frequent these areas on a regular basis, most likely due to a high level of illegal activity.

The areas of the ranch where most illegal activity was observed from 1982 to 1986 are mainly in the north, southeast and southwest (Fig. 4). The figures show the number of offences (animals shot, poachers seen or arrested, snares or traps collected) per" sq km. During the dry season, the areas that are frequented by poachers are mostly avoided by elephants, so I postulate a cause and effect relationship. A similar phenomenon was also observed in Kasungu National Park, Malawi (Jachmann, 1983).

As a result of limited waler availability and heavy illegal activity during the'dry season, elephant movements across ranch boundaries are restricted to nightly excursions in the northwestern area only (Fig. 3). During these nightly foraging trips, the elephants usually follow the small stream east of Sia village, passing east of Wiri and Kouna, and returning at Natiedougou. Some elephants continue to Kontioro before returning to the ranch (Fig. 3). This area northwest of the ranch was checked by airplane twice, flying parallel transects 2 km apart. No elephants were observed during the daytime searches.

Wet Season Elephant Distribution

The wet season elephant distribution at Nazinga appears to extend outside the ranch's boundary (Fig. 5). This observation is based on footprints and other signs of elephant presence found during both dropping surveys and in four trips covering the perimeter roads, without paying attention to relative

Figure 4.

Areas in and around the Nazinga Game Ranch, where from1982 to 1986 illegal activity was observed. The figures show the number of offences per km^2.

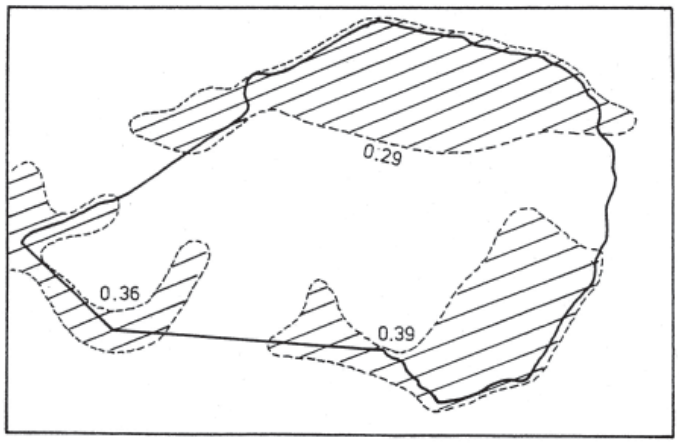
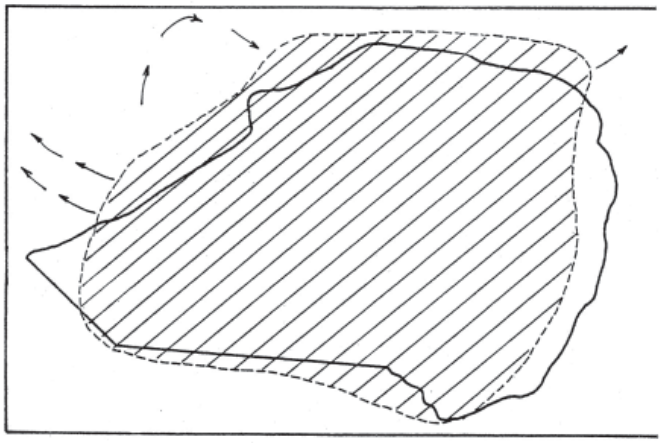


Figure 5.

Wet season elephant distribution (line enclosing crosshatching), including movements across the boundaries of Nazinga Game Ranch. Compare with the dry-season distribution in Figure 3.



abundance. Hence, the figure shows only that some movements outside the ranch occur, but there is no assessment of how much of the elephant population this involves. At the onset of the rains, as soon as water availability and forage plants are no longer a limiting factor, elephants disperse in all directions. They are capable of sensing local rainstorms over considerable distances, moving to and utilizing these areas on an opportunistic basis. At Nazinga, the early wet season dispersion appears to be greatly influenced by poaching activities, because the grass is still short and the visibility is relatively good. Later in the season, when the grass has reached its maximum height and the visibility is poor, elephants can also infiltrate the areas that are regularly frequented by poachers. Dispersion during the wet season, however, is a necessity to cope with nutritional stress and to build up new energy reserves. At the same time the elephants reduce their impact in the areas on which they depend for dry-season survival. Preliminary observations, however, show that the places of highest density remain the same year" round, although the absolute densities decrease in the wet season.

Movements

To fully understand the present seasonal movements of the elephants occupying the Nazinga Game Ranch, we must begin with the early 1970's. The area under consideration is the south-central part of Burkina Faso, between the rivers Volta Rouge in the east and the Volta Noire in the west (Fig. 1). About 1973, Po National Park contained approximately 260 elephants (Heisterberg, 1976), whereas the Nazinga area'contained a few elephants on a seasonal basis only (C.G.'Lungren, pers. comm.). The Po elephants appeared to disperse further to the peripheral areas of the park as the wet season progressed and halfway through the wet season the elephants were noted leaving their usual dry-season areas entirely and not returning for several months (Heisterberg, 1976). According to local people living in the villages not far from the Sissili River (i.e. west of the Nazinga ranch, north of Leo, and east of the Deux Bale Forest Reserves), in the early 1970's many elephants passed by and raided their crops during the second half of the wet season. Elephants appeared to come from the west as well as from the east.

By 1980, fewer elephants passed by the villages northwest of the ranch. Since 1983, only one family unit of 6 was observed (at the end of August 1986) near the Sissili River, just north of the village of Sissili. All along the usual migration route villagers note that they either have not seen elephants for a long time (since the mid-1970's), or that on only a few occasions they saw elephant tracks or the animals themselves. An F.A.O. survey in 1981 to 1982 estimated that 150 elephants still lived in the Deux Bale region (Bousquet, 1982).

Over the past three years (1985 to 1987) no elephants have been observed in Po National Park, with the exception of the tracks of three elephants crossing the Volta Rouge River from south to north halfway through the wet season in 1986 (local rangers, pers. comm.). On the 29th April 1987,! searched a 12 km stretch of the Volta Rouge, starting at the main Po-Ouagadougou road, for signs of elephant presence. Only some footprints were found that seemed to be at least several years old. Permanent water was available at various locations. Considering the information given above, I hypothesize the following. During the dry seasons of the early 1970's, one clan of elephants occupied the Po National Park and another clan occupied the Deux Bale Forest Reserves. In the wet season, the elephants occupying Po Park migrated west along the Nazinga River and continued along the Sissili River, whereas the Deux Bale elephants migrated eastward. Some genetic exchange might have taken place when large aggregations of elephants from both conservation areas met in reproductive arenas. When the grass became less palatable, both clans returned to their dry-season ranges within the conservation areas.

After the period of drought **in** the early 1970's, many Peul (Fulani) herdsmen with their remaining cattle moved southward from the Sahel region, from an annual rainfall area of 200 to 600 mm. Together with the Peul, the Mossi occupying the drier northern parts of the Mossi Plateau migrated to the southern wet savanna (lower Sudan zone and upper Guinea zone) where the rainfall of 700 to 1 100 mm is more reliable. The result was a progressive settlement of the area between the Volta Rouge and Volta Noire Rivers, where land was cleared for cultivation and cattle. In addition, in this southern region, foreign-aid

programmes were started to combat onchocerciasis (river blindness, spread by a black fly **Simulium** sp.) and trypanosomiasis (sleeping sickness, spread by the tsetse fly **Glossina** sp.). The increasing area of land brought under cultivation, the growing numbers of cattle, and the heavier poaching of elephants on their yearly trek resulted in fewer elephants migrating as far as halfway through the region between the Volta Rouge and Volta Noire Rivers. By 1977, elephants still moved from east to west and vice versa, but on a limited scale (Fig. 6). The elephants coming from Po Park each year passed the Nazinga area where, with the continuation of the Nazinga project, the protection from illegal activity was better each year. Also, the construction of the first dams in the early 1980's provided water year-round that is of increasing quantity. This probably resulted in a gradual shift of elephants, formerly occupying Po Park during the dry season, but now remaining in Nazinga on their way east at the end of the wet season. During the F.A.O. survey in 1981-1982, 500 (range 0 to 1 100) elephants were estimated in the Po Park and Nazinga region during the dry season (Fig. 6). This shift in movements continues to the present, and the final outcome is presented in Fig. 6. The Deux Bale elephants still occupy the same area, and most likely only a few elephants make wet season excursions going east. The Po Park elephants apparently all moved to the Nazinga Game Ranch which has become their permanent dry-season base. Very likely, within a few years, the ranch will become their permanent year-round base.

Not all elephant movements towards former" wet-season and dry-season ranges have come to a standstill. The two observations, one of a family unit near the village of Sissili, coming from the east (August, 1986) and the footprints of three elephants crossing the Volta Rouge River going north (August, 1986) are evidence. According to our findings there probably still are some elephants leaving the ranch during the wet season, although their numbers may be few.

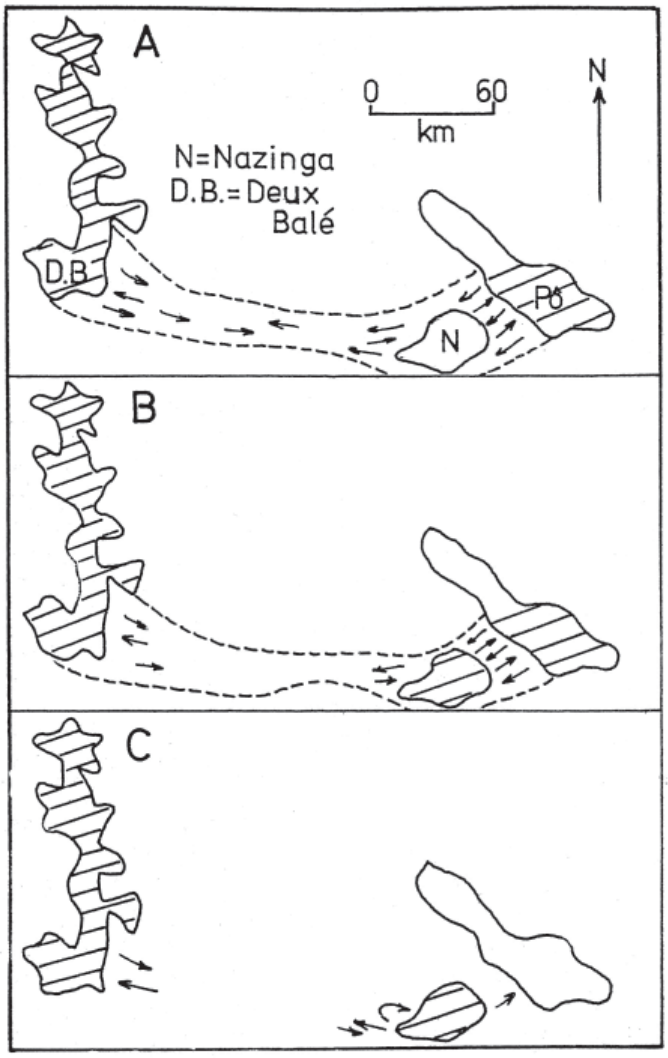
CONCLUSIONS

During the dry season, elephants tend to occupy a limited area near permanent water. At the onset of the rains, and throughout most of the wet season, elephants disperse and use resources that are avail able only temporarily, thereby reducing the impact on the dry-season foraging areas. Water availability and poaching appear to be major factors determining elephant occupance. Because poaching is a serious problem outside as well as along the periphery of the ranch, I hypothesize that most of the elephants occupying the greater" Nazinga area can be found on the ranch during the latter part of the dry season. This period is therefore the most suitable time of year to obtain an accurate estimate of the maximum number of elephants occupying the ranch. Thus, the two estimates of 353 and 396 elephants, suggesting a population of about 350 to 400 elephants must be reasonably accurate accounts for the Greater Nazinga area in early 1987. The wet season population estimate of 420 elephants is a less accurate account than the population estimate for the dry season. The somewhat higher number for the wet season and the small difference between the estimates of both seasons, however, indicate that during the wet season only few elephants may leave the ranch for extended periods.

In future years, elephant movements across ranch boundaries probably will be more and more restricted to safe nightly excursions within a limited area. Over the past 15 years the

Figure 6.

Elephant distribution (crosshatching) and hypothesized pattern of migration (arrows) during the wet season of 1977 (A), 1982(B), and 1987(C). The broken line indicates the limits of the elephant range. For place names see Figure 1.



elephants along the Volta Rouge River have been restricted to a decreasing area, of which the last five years (1 983 to 1987) was the most important period. Population parameters such as the age at reproduction maturity, the calving interval or period between two succeeding oestrus periods, and calf mortality will be influenced accordingly (Jachmann 1980, 1985, 1986). These three population parameters change with the density of the population. The density in turn affects the food availability through food competition amongst the members of a clan (Jachmann 1987b). The age at reproductive maturity or first conception is the slowest changing parameter, changing over the subsequent generations and having a time lag of 10 to 20 years. The calving interval most likely changes within the lifetime of a cow (Jachmann, 1986) and thus has a shorter time lag. Calf mortality is the first fast-acting parameter influencing-population density. My prognosis is an increasing calf-mortality rate over the next five years, after which an increasing age at first conception in combination with a lowered fecundity in older females will partly take over.

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