The Last Sahelian Elephants

Ranging Behavior, Population Status and Recent History of the Desert Elephants of Mali

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SAVE THE ELEPHANTS

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Contents

Doppit Gromoppit (female)

Her transmitter worked intermittently but showed that she covered the most ground in her search for food (9,368 sq ml).

START and END at *Banzena* May 1, 2000- Apr. 30, 2001

Ahni (female)

Took a loop route like Doppit's, but shorter (7,466 sq ml). Circular migrations are rare in terrestrial mammals.

El Mehedy (male)

His route basically doubled back on itself (4,498 sq ml), which may be a pattern particular to Gourma males.

Map illustrates distance traveled during one year of the 17-month study.

SOURCES: ROUTES BY SAVE THE ELEPHANTS; DISTRIBUTION BY AFRICAN ELEPHANT DATABASE 1998, IUCN/SSC AFRICAN ELEPHANT SPECIALIST GROUP; MODIS IMAGE BY WORLDSAT INTERNATIONAL INC. NATIONAL GEOGRAPHIC MAPS
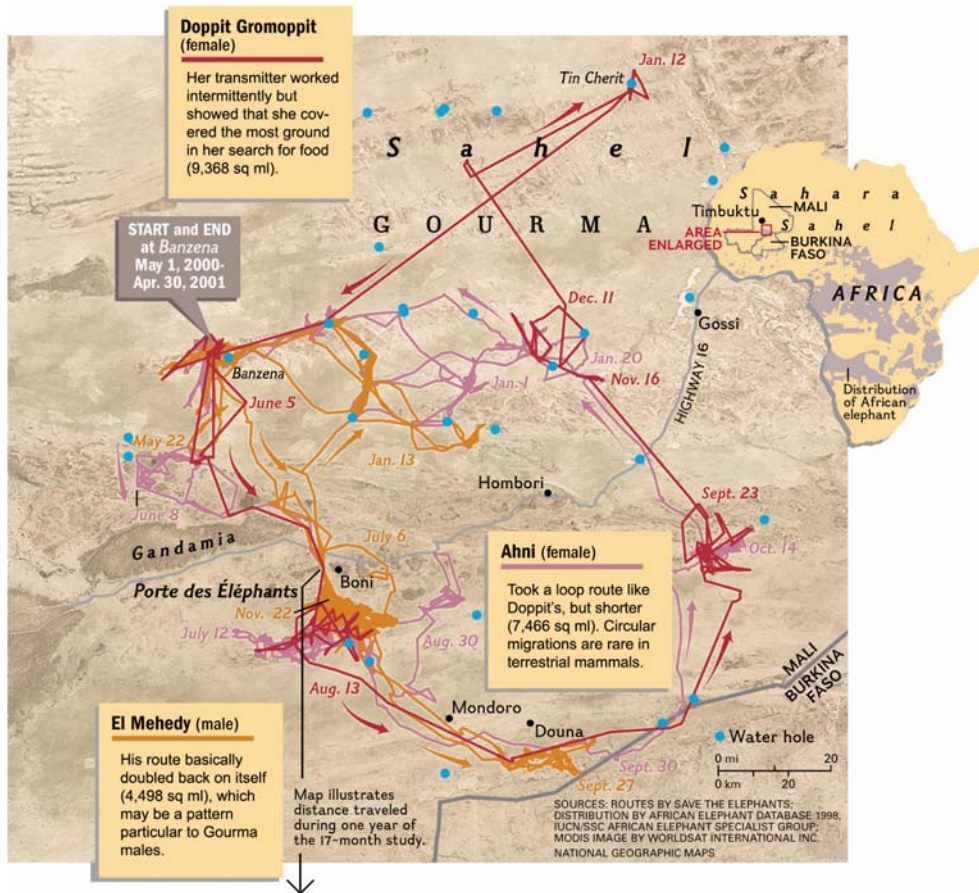
Figure 1 The complete migration route of the Gourma elephants from radio-tracking, between 2000 and 2001, by courtesy of African Elephant Database 1998, IUCN/SSC African Elephant Specialist group, Worldsat International Inc. and National Geographic Maps.

Figure 2 The critical nick point, at the Porte des Elephants, through which all migrating elephants must pass from North to South

Foreword

The Mali elephants live in the Gourma area and constitute the last Sahelian elephants in Africa. The survey of Mali's elephants was made in the context of Save the Elephant's mission to secure a future for elephants. Save the Elephants (STE) is a UK-based charity with field projects in Kenya, South Africa, Congo and Mali. We sponsor studies of elephant movements in savannah, forests and semi-desert, with a view to understanding elephant survival strategies. Since 1995 we have developed high-tech radio tracking using GPS radio collars with an in-built memory that logs data.

In 2000 an opportunity arose to help rare 'desert' elephants living in the Gourma region of the Malian Sahel, to the south of Timbuktu. The research project was drawn up for Save the Elephants by Anne Orlando from the University of California Davis and the results were to be used for her PhD. STE provided radio-tracking equipment. Anne attached nine GPS collars to elephants in the Gourma in early 2000. A two-year battery life meant that these collars needed to be recovered by early 2002

The study of the last Sahelian elephants was made possible through the generosity and collaboration of many parties. Prince Bernhard of the Netherlands was our principal donor. The US Fish and Wildlife Service also supported the project from the very beginning when the collars were first attached to elephants. We are grateful to Dr Billy Karesh from the Wildlife Conservation Society and Sybil Quandt who originally darted the elephants to attach the collars and to the International Fund for Animal Welfare, who donated funds for this operation to Save the Elephants. The Wildlife Conservation Society, Born Free Foundation and UC Davis also made substantial contributions, and Kenya Wildlife Service loaned a dart gun. All vehicle and aeroplane fuel costs were met by Shell International, who also gave a generous cash donation.

Randgold provided us with introductions, facilities, financial and logistical support. Diago provided drinking water. Dr Bertrand Chardonnet provided an anaesthetic dart gun. Henri and Barbara de Dinechin gave us vital logistical support in Bamako. The aerial census was paid for by the MIKE (Monitoring the Illegal Killing of Elephants) programme of CITES (Convention on International Trade in Endangered Species) and organized by Philippe Bouchet, their regional support officer. Nothing would have been possible without the active support and participation of officers of the DNCN (la Direction Nationale de la Conservation de la Nature), and we are particularly grateful to Yaya Tamboura, M. Samake and El Mehedi. The Malian army also provided a liaison officer who was very helpful. The US Ambassador, Michael Ranneburger, gave invaluable support in a number of ways. Finally, we are very grateful to the government of the Republic of Mali for permission to conduct these studies and for such whole-hearted support throughout.

To all the above we are most grateful for a project that, despite a number of challenges along the way, was ultimately successful and produced priceless data on the movements of the desert elephants.

Iain Douglas-Hamilton – August 2003

Introduction

Elephants once occupied a largely continuous range across West Africa, from the coastal forests to the Sahara. The collapse of these once extensive populations, caused by poaching for the ivory trade, human encroachment and the concurrent lack of conservation and scientific attention, has been alarming. Remaining populations are small, highly fragmented and geographically isolated, with over half now containing fewer than 100 individuals (Roth and Douglas-Hamilton 1991; Said et al. 1995; Barnes et al. 1998; Barnes 1999). The population living in the Gourma, which before this survey was estimated to be between 300 and 800, is one of the most important in the West African region and is accorded a high priority in the regional elephant strategy of the IUCN (Worldwide Conservation Union).

The African elephants (*Loxodonta africana*) of Mali's remote Gourma region and extreme northern Burkina Faso are the northernmost in existence since the extinction of the Mauritanian elephants in the Assaba mountains in the 1980s (Douglas-Hamilton 1979, 1992). They are the only remnant of a once-extensive population found across the Sahel. Despite their ecological and conservation importance, these elephants are scientifically poorly known. Estimates of the total population to date have been derived from interviews with local people who have extensive knowledge, from incomplete aerial reconnaissance (Sayer 1977; La Marche 1980; Douglas-Hamilton 1979; Pierre Vernet 2002 pers. comm.; Anne Orlando 2000 pers. comm.), and from extrapolation from a short-term dung count (figure 3)(Jachmann 1991).

Bruno La Marche, a French schoolteacher, made a special study of these elephants throughout the 1970s, and although he never published his results they were used by Sayer (1977) and Douglas-Hamilton (1979). According to La Marche, the elephants lived in relative harmony with nomadic Touareg pastoralists in the 1970s, a coexistence that continued in the 1980s and 1990s (Douglas-Hamilton and Douglas-Hamilton 1992; Olivier 1983; Jachmann 1991; Youssef 2001). However, gradual changes in climate and human land use were thought to be increasing competition between people and elephants, with potentially negative consequences for both. The elephants' behaviour is thought to be highly adapted to conditions of extreme aridity for most of the year. Understanding the movements and ecology of these elephants is critical for land-use planning of the Gourma, if the elephants are to be conserved.

The Gourma elephants share the near-desert habitat with nomadic and transhumant pastoralists and their cattle, goats, sheep, donkeys and camels (Jachmann 1991). Local Tamasheq (Touareg) and Peulh (Fulani, Fulbé) pastoralists, and the more settled Souraih and Dogon view the elephants as symbols of natural well-being, and conflict between humans and elephants has traditionally been low (Y Tamboura 2002, pers. comm.). Humans and elephants have been reported as partitioning their resource use, with elephants often drinking only at night while herdsmen water their stock during the day (Pringle and Diakité 1992). However, we observed elephants and Touareg drinking and sharing the same pastures by day within 200 metres of each other on the first day of our expedition and throughout the last two weeks of April 2000. Poaching by local nomadic peoples has traditionally been very low; however, until the 1980s, illegal hunting by urban Malians from vehicles was a threat to the Gourma elephants (Olivier 1983).
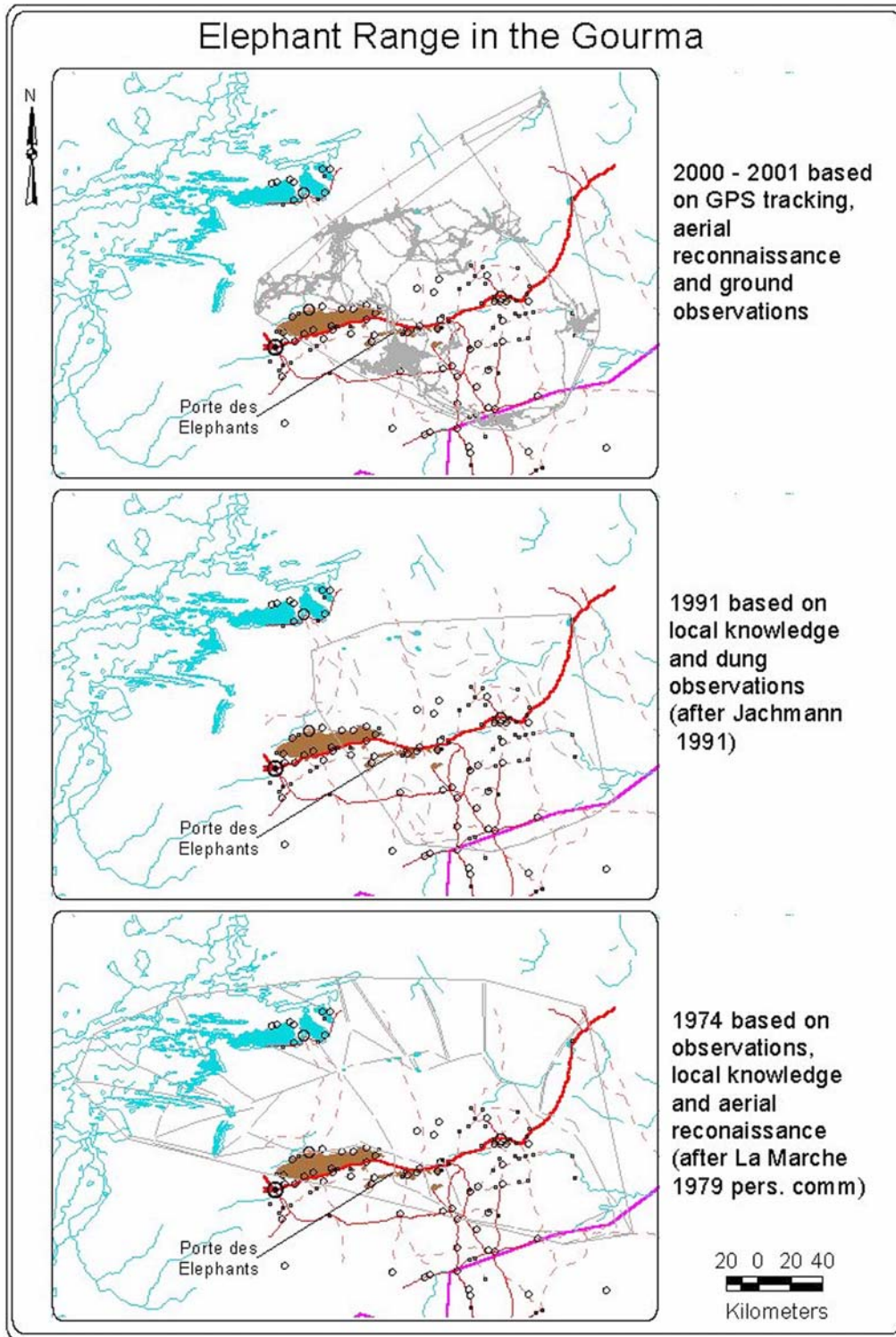
Figure 3 Elephant ranges were first described by La Marche in the 1970s as extending far West to the riverine lakes of the Niger. Later Jachmann described a more restricted range to the East. The current study extends their range Northwards to Tin Cherit. All observers agree that the movements have been counter clockwise traditionally , but it appears that the western range has been lost.

Possibly because of the tolerance of local people, the isolation of the region, and the small, low-quality tusks of the remaining Gourma elephants, the population largely escaped the intense poaching of the 1980s, which extirpated all populations that once existed across the Sahel.

A recent trend of reduced rainfall, agriculture and water development programmes, cessation of ancient patterns of livestock migration and increasingly settled human populations are changing the traditional dynamic, yet stable, relationship between elephants, humans and the Sahelian ecosystem (Jachmann 1991). Humans and elephants are competing more heavily for the same resources (land, crops and water), which is increasing conflict (Olivier 1984; Jachmann 1991; Pringle and Diakité 1992).

The Gourma elephants were reported by La Marche (in Douglas-Hamilton 1979) to make a long counter-clockwise circular migration, which he thought to be a necessary adaptation to the harsh ecological conditions. He and later researchers (Jachmann 1991) and Niagaté 1995), mapped this route with the help of information provided by local inhabitants in the Gourma, and, in the case of Jachmann, from plotting dung recorded on road transects along the elephant routes. The elephants had never been radio-tracked before this study. In January 2000, Save the Elephants and the Wildlife Conservation Society supported an American PhD student, Anne Orlando, from the University of California, Davis, to begin a research project on the remaining elephant population in the Gourma at the invitation of la Direction Nationale de la Conservation de la Nature.

The aim of the study was to examine elephant ranging patterns and survival strategies in the semi-desert. It was intended to integrate data on resource availability from satellite imagery with elephant movements determined by global positioning system (GPS) collars. This information was intended to assist the Malian government to establish a plan for the long-term conservation of elephants in harmony with developing human societies. Between January and March 2000, nine elephants were fitted with GPS collars. These collars (made by the Swedish company Televilt) were designed to log positions every 2 hours and store the information on a memory chip, to be downloaded at a later date (up to 2 years post-deployment). The collars also had radio-transmitter beacons with an expected life of 3–4 years, which made it possible to locate the elephants using conventional radio-tracking.

Following collar deployment, the project experienced several difficulties and Anne Orlando's fieldwork came to an end in September 2000. However the collars continued to accumulate GPS data. In late 2001 the DNCN requested Iain Douglas-Hamilton to organize a team under the auspices of Save the Elephants, to recover the collars and retrieve the data, and this was agreed. At the same time an aerial census of the elephants was organized as part of the MIKE programme. Finally, the African Elephant Specialist Group (AfESG) of IUCN requested an update on the status of Mali's elephants for the *African elephant database*. The objectives of the mission were as follows:

◆ to locate the tagged elephants in the Gourma region of Mali, recover the collars and retrieve the data
◆ to make an aerial census of the elephants in collaboration with MIKE
◆ to review the conservation status of the Malian elephants

Special attention was to be paid to mapping, concentration areas and corridors used by elephants to move from one vital range segment to another This information was to help the

Malian government formulate a national elephant conservation strategy. The GPS data would also be made available to Anne Orlando to complete her PhD programme at the University of California, Davis. Analysis of seasonal ranging patterns was to precede the aerial census and be used in its design.

The country

The Republic of Mali in west Africa, is a land-locked country of 1,241,238 million km^2 bordered by Algeria, Burkina Faso, Guinea, Ivory Coast, Mauritania, Niger and Senegal. Vegetation ranges from extreme desert in the north, through Sahelian and Sudanian savannah, to Sudano-Guinean savannah in the extreme southwest. The climate in the north is arid, becoming sub-tropical in the south. Mean annual rainfall is ca. 1350 mm in the south-west decreasing to negligible levels in the north. A distinct wet season in the south and centre of the country goes from June until October; November to February is dry and mild. The late dry season from February until June is also the hottest period of the year, and mean monthly maximum temperatures reach up to 46°C.

The human population of 11 million is expanding rapidly at an estimated 3.0% per year. Nearly 45% of the population is under 15 years of age. Despite this, the human population density of Mali at 8.9 inhabitants/km^2 remains one of the lowest on earth. Most Malians live in the south of the country, while the north is virtually uninhabited. Climatic conditions mean that primary productivity is highest in the south, and much of the north is too arid for humans and mammalian wildlife to exist. The growing demands of the human population have exacerbated the negative effects of an increasingly dry climate, and desertification, deforestation, erosion and lack of drinking water are major environmental concerns (Kone 2001).

The Gourma region

Gourma elephants range throughout the year broadly within the bend of the Niger River in Mali southward to the border region with Burkina Faso, generally between 14.30°N and 16.50°N, and 0.55°W and 2.55°W. Other large wild mammalian species are rare (listed by Jachmann 1991), and the status of many is unknown. Still commonly seen are Dorcas gazelle (*Gazelle dorcas*), common jackal (*Canis aureus*) and Africa wild cat (*Felis libyca*). The Gourma is an extensive undulating Sahelian landscape with annual grasses, especially *Cenchrus biflorus,* or bare sandy substrate. The area is dominated by dunes that cover 50% of the area, laterite plateaus 25%, plains 19%, and sandstone buttes and escarpments 6% of the region (PIRT 1983). The section of the study area lying north of the only paved road in north and central Mali is characterized by open sandy steppe and savannah with sparse trees (mainly *Balanites aegyptiaca* and *Acacia* spp.), sparsely vegetated dune formations, and shrubby woodland stands occurring in depressions. The section of the study area lying south of the road is dominated by bands of low and relatively thick 'tiger bush' complex, dominated by *Grewia bicolor, B. aegyptiaca* and *Acacia* spp., alternated with dune open steppe and vegetated dune formations (Jachmann 1991). Throughout the study region, trees are small, and their density and height increase from north to south. Isolated woodland stands, usually surrounding waterholes, provide the main elephant

habitat. Erosion by wind and water occurs throughout the study region and is particularly pronounced in areas heavily used by livestock.

The west of the region is delimited by a chain of lakes previously fed by the flood of the Niger River and used by elephants and humans. These lakes had been dry for the past 25 years, but Lake Gakorey partially filled in 1999, a particularly wet year. A series of small semi-permanent lakes runs through the northern half of the region, fed by surface water run-off from local rainfall. Only two of these lakes tend to retain water throughout the entire dry season, and human populations and elephants now heavily rely on them. Even these lakes have dried completely twice during the past 20 years, which has affected the elephant range. Water sources in the southern half of the region tend to be ephemeral, persisting only during the wet and early dry season.
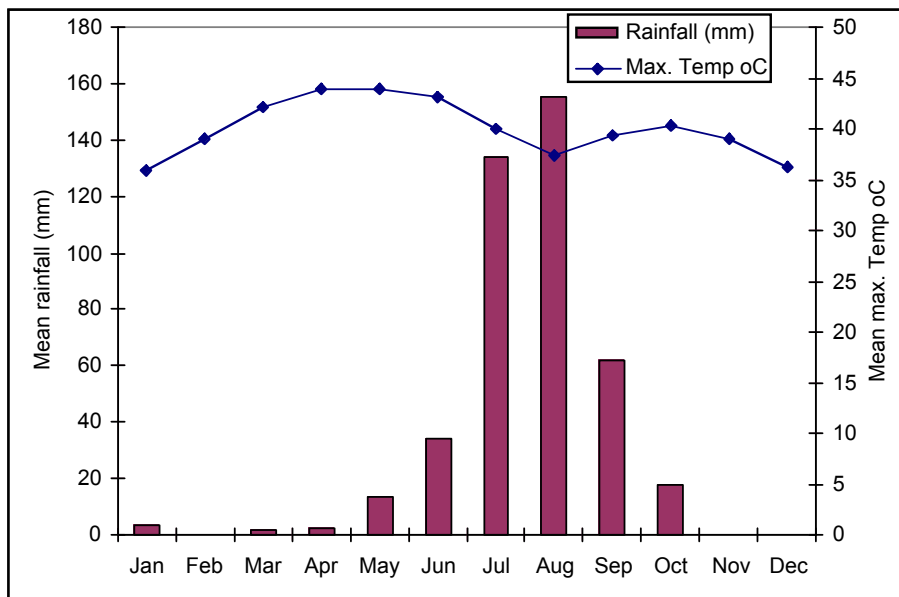

Figure 4 Rainfall and temperature data from the Gourma region showing that temperatures maximize in April and May, the month when all elephants are concentrated at Banzena and Gossi. The rainy season is brief, mainly in July and August.

A marked rainfall gradient spans the Gourma, with average annual rainfall of 450 mm in the extreme southern range, progressively declining to 150 mm in the extreme north. The region experiences a single rainy season with most precipitation falling between late June and late August followed by a dry season lasting from 8 to10 months (figure 4) (PIRT 1983). Rainfall isohyets have shifted to the south in recent years, because of a series of below-average rainfall seasons. Long-term rainfall data for this region that exist from the 1920s reveal droughts and a series of years with above-average rainfall occurring at unpredictable intervals (Leeuw et al. 1993). Whether the current prolonged period of low rainfall is part of normal long-term rainfall cycles, a long-term drying trend, or the result of drought induced by human use or other factors is not known.

The Radio Tracking Study

Methods

Collar recovery

Because of collar design and problems in meeting the schedule of the original project, it was not possible to download the Televilt collars while they were on the elephants. Recovering the collars was therefore the only way to retrieve the data. When the mission began, eight collars were thought to be on elephants, one collar having been removed by Mr El Mehedi in April 2000 from a female elephant that had died immediately after the collar was attached.

Reconnaissance flights

VHF tracking by plane detected only three collars, all within the first day's flight and within 30 km from the base camp at Banzena. On following flights, faint and suggestive signals were picked on a few occasions; however, further flights failed to confirm them, and it was assumed the remaining collars were no longer transmitting. The entire known range of the elephants was thoroughly covered (figure 5). On most days visibility was poor due to the Harmattan.

GPS telemetry

Four collars were retrieved during the mission—the three collars transmitting a signal as well as one collar, retrieved at Inadiatafan during ground operations from a young bull, that consisted of only the webbing belt as both the battery pack and the antenna–memory chip assembly had been pulled off. This individual could therefore not be identified. The remaining three collars, although still containing the vital parts and memory, were all heavily worn.

The memory unit on the collar worn by the elephant Ahni had become completely detached and was hanging loose by one thin wire. It must have been within days of dropping off altogether. The technical fault was that the manufacturer had used corrodible bolts to attach the memory and battery modules to the web belt. It has since rectified this design fault.

The high level of degradation of the recovered collars was further evidence that the remaining four collars not located must have lost vital parts and not been transmitting. Data from collars were downloaded in the field using Televilt software and preliminary analysis was conducted. Collar performance was poor relative to expectations. According to the manufacturer, collars were designed and programmed to collect fixes every 2 hours for a minimal period of 2 years, resulting in at least 8760 GPS locations per collar. The collar with the best performance recorded only 56% of this expected total, and the collar of longest duration lasted for only 512 days, or 70% of the estimated longevity.
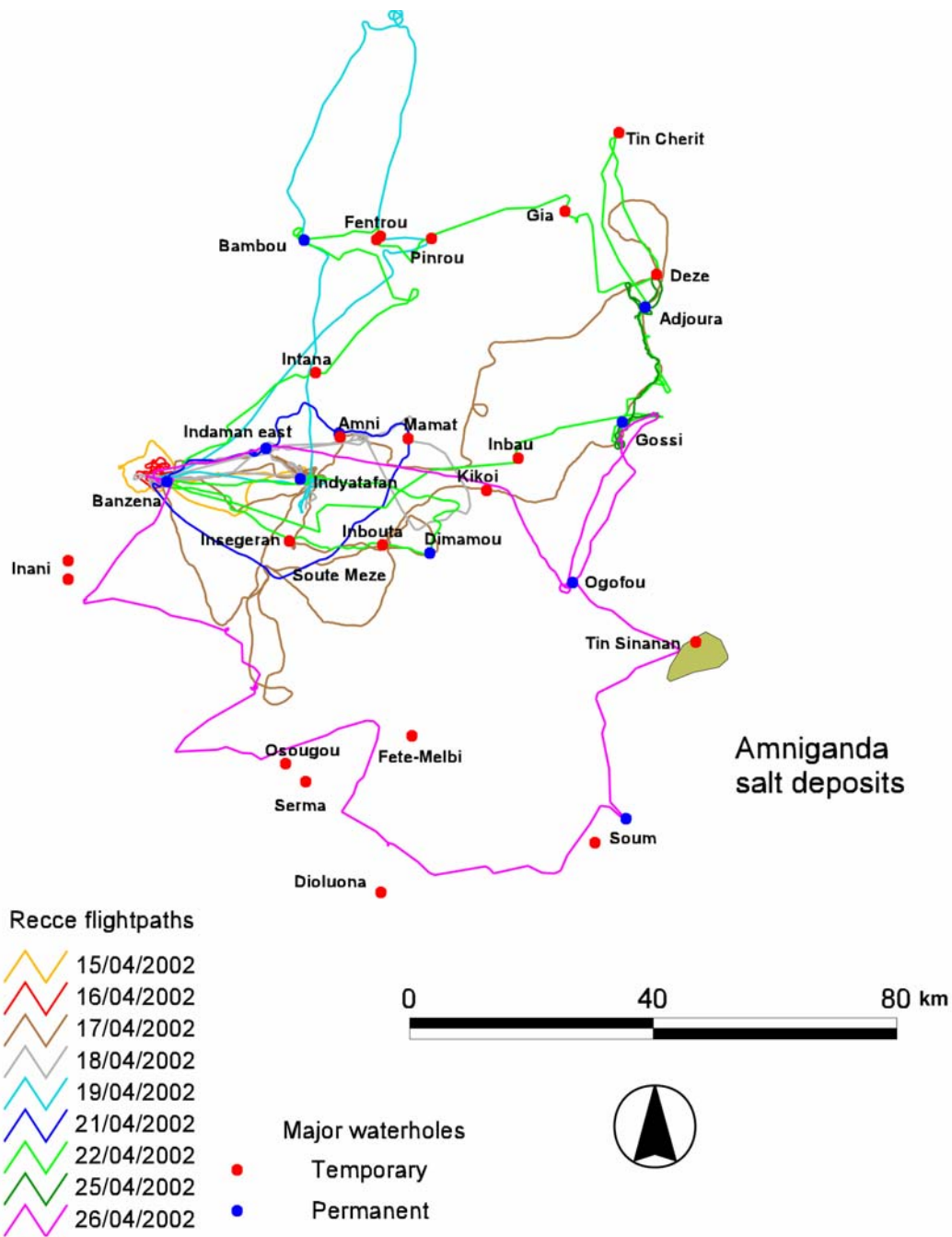
Figure 5 Reconnaissance flight lines made by the team to find the elephants and investigate the migration route, with place names of waterholes. (NB spelling was hard to establish as several variants occurred on maps.)

This performance, however, was better than what we had experienced in East Africa. VHF beacon performance was good for new collars, with a reception distance of up to 95 km; however, during the recovery operation this dropped to about 25 to 30 km. Given the amount of flying time spent searching for collars, we must conclude that the remaining collars either malfunctioned, or were broken by the elephants, or were found by local people on dead elephants and destroyed.

Ground operations

All members of the ground team responsible for stalking, darting and subsequently removing and reviving the collars had experience from previous operations, mainly in Kenya, and were used to operations done on foot with minimal disturbance to the elephants. This is contrasted with operations where the darting is done from a helicopter, putting much stress on the elephants. However, several factors were particular to this operation.

Initial reports from suggested that the Gourma elephants were sensitive to human presence and reacted strongly to the presence of cars or other motor noises. Large numbers of Touareg herders and high densities of livestock are found in areas where the elephants could be expected this time of year. Furthermore, the elephants often occurred within large groups of 120 or more. This made it difficult for the darting team to get close, find the collared individual, and get into position to shoot without being detected by other herd members. Frightening the elephants during operations would not only pose a threat for the darting team but also might panic a herd into stampeding through livestock and herders, creating a very dangerous situation.

The elephants generally occurred in two types of habitat:

1) Away from the few waterholes in areas of large undulating dunes, with sparse vegetation consisting of low bushes 30 to 40 m apart with limited or no grass cover between. In these areas, the darting team was faced with the difficulty of approaching undetected by the elephants to within maximum darting distance (60–70 m). Furthermore, the limited vegetation provided virtually no cover in the case of an elephant attack on the darting team (figure 6).

Figure 6 In the dunes cover was limited as we approached elephant herds to dart the target animal.

2) At or near the existing waterholes in areas of relatively dense bush and tall trees with visibility varying from 50 m down to only a few meters but most often around 30 m. These areas provided good cover for the darting team; however, within these areas the density of Touareg herds and livestock was especially high.

Drugs and dart gun

On all operations, M99 was used as immobilization drug, with between 12 and 15 mg used, depending on size and sex of the elephant. No xylacine was added. All elephants went down between 6 and 10 minutes after the dart hit, and no additional doses were needed. Diprenorphine was used for revival. Two long-range gas driven Dan-inject™ dart guns were used, one capable of extra long range darting up to 70 metres.

Elephant location

Each morning at first light, Iain Douglas-Hamilton found the collared individuals by air from a Cessna 172. At the same time, the ground team went by vehicle to the place where the target elephants had been observed the previous day. As soon as the aerial reconnaissance team had located one or more targets, they communicated by hand-held VHF radios to the ground team precise information on location of the collared individual (GPS position), herd size and terrain condition in the immediate neighbourhood of the individual as well as possible access routes. The ground team was then dispatched to a suitable site downwind from the elephants and used hand-held telemetry tracking equipment to get a precise location of the target. On operations that occurred away from the main base camp Banzena and the airstrip there, the ground team first constructed a temporary airstrip approximately 4 or 5 km away from the elephants. Following a reconnaissance flight with a member of the darting team to assess local conditions, the aeroplane was kept on standby, and the darting team proceeded to within 500–800 m downwind of the target, by vehicle if possible. At all times the aerial and ground teams maintained two-way communication. If elephants became too nervous, the operation was abandoned until the following day.

Usually the vehicle was parked at between 500 and 800 m downwind from the elephants and the darting team would proceed on foot.

Approach and darting

The ground team consisted of Henrik B. Rasmussen (overall in charge of ground operations and darting); Job Githaiga (veterinarian, animal health and darting); Stephen Blake (biopsy samples, data recording), El Mehedi (security, translation) and occasionally Saba Douglas-Hamilton (video and still photography). The team carried two hand-held radios for communication with the plane, the car and among themselves. Furthermore, Mr El Mehedi carried a backup rifle for security. Dan-inject™ guns were prepared before leaving the car (figure7).

Figure 7 Githaiga, the team vet from Kenya showing a modern gas powered dart gun to El Mehedi and two Touaregs.

When closing in on the elephants, the team observed radio silence. In thick bush, both darters proceeded together leaving the rest of the team approximately 50 to 100 m from the elephant group. Working close together, they approached usually between 10 and 30 m from the elephants, staying slightly apart to increase the chance for one of them to have a clear shot. In situations were the target was situated in thick bush or the car was unable to support the darting team, the aeroplane circled on stand-by at a distance of 3 or 4 km—far enough away not to disturb the elephants but close enough to intervene rapidly if necessary. In the event, close aerial support was not required for any of the immobilizations.

After the dart hit the target elephant, the darting team remained still for approximately 5 minutes to minimize disturbance. If visual contact was broken, the team tracked the elephant, keeping back the greatest distance possible to keep both the targeted elephant and the others in the group calm. Usually the elephants spooked when one was darted and moved off quickly about 50 m before calming and slowing down. When the darted elephant went down, the darting team would slowly walk up to it, clapping hands and talking to press any other elephants away. At the same time the car was called in if access was possible. No immobilized individuals were defended to any serious extent by herd or family members. The first person of the team to arrive at the downed elephant would straighten the trunk to make breathing easier and pour water on the ear to cool the animal (figure 8). The vet would tend to animal welfare; another team member would take biopsy samples and other measurements, another would remove the collar, while the last kept a lookout for other elephants. On all operations, the revival drug was injected less than 8 min after the elephant went down. After injecting the revival drug the team would pull back 30 to 40 m while still maintaining visual contact. On all but one occasion, the elephant got up after 3 to 4 min and slowly walked away. On the last occasion, the cow elephant went straight for the darting team and chased the team to cover. When the team returned to the scene most of the equipment left (receivers, antennas, binoculars and water bottles) had been trampled by the apparently highly irate elephant.

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Figure 8 During immobilizations, water was poured over the ears to prevent overheating, and the exposed eye was moistened and covered to prevent it from drying out.

General remarks

High midday temperatures of 45–50 °C in the shade made darting risky for the elephants during the hot hours and almost unbearable for the darting team to be away from shade. Operations were therefore normally cancelled between 1200 and 1600. The reported nervousness of the elephants towards people turned out to be overestimated, and it was the opinion of the ground team that these elephants were not reacting that differently from other elephants; in some instances they were even calmer. Local rumour also held that the elephants were more wary of strangers than of local Touaregs. Initially the team did not believe this; however, on several occasions the elephants reacted more strongly towards us than towards local people when they got our wind but not when their clue was visual. This indicates that the response was linked to olfactory clues and suggests that the elephants felt safe around local Touaregs.

On only one occasion was a vehicle used to drive off elephants from around the downed target. The elephant group gave no reaction whatsoever when the target individual was darted and fell over. Since the habitat did not provide any kind of cover, the darting team did not chase off the remaining elephants until the backup car had arrived from its position 400 m from the herd. The backup car was called in one other time. It arrived shortly after the darting team got to the downed target, but the darting team had had no problems in pressing the family away.

All operations proceeded without seriously frightening the elephants around the target and the target individuals reacted only mildly to the darting, one not reacting at all, one giving a quick jerk then slowly moving away and the rest running for approximately 50 m before settling down.

 We believe several conditions contributed to this success.

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◆ Ample time was allowed for the operations. On average two attempts were made per collar before the right condition prevailed.

◆ We disturbed the elephants as little as possible by keeping absolutely still and quiet after the dart was fired.

◆ The relatively silent Dan-inject™ gun made it difficult for the elephants to determine the direction from where the disturbance came.

◆ Using a relatively small needle on the dart combined with its slow speed reduced the impact trauma compared with that of a powder-driven dart.

It is worth noting, however, that the large but light dart travelling at slow speed was susceptible to cross wind. Even wind speeds around 5 m/sec made a shot over 50 m relatively risky. We allowed for this. Our worst mishap was an accidental darting of the wrong animal, standing right next to the target animal. It went down with minimum disturbance. We took a tissue sample and tail hair, and the animal immediately revived with no further problem.

Results

Seasonal migration patterns of Gourma elephants

Summary data recovered from the three functioning collars recuperated are shown in table 1.

Name	VHF freq.	Sex	Start date (2000)	End date (2001)	Days	Total GPS fixes	Mean Fixes per day	Range* (km^2) (Minimum Convex Polygon)	Max. linear distance across range (km)
Doppit Gromoppit	160.025	F	25 Feb	31 July	512	413	0.8	24,265	203
Ahni	160.124	F	9 Feb	12 May	457	4919	10.8	19,338	180
El Mehedi	160.203	M	11 Feb	28 June	502	4778	9.5	11,651	166

Table 1 Summary data recovered from the three functioning collars recovered

The GPS telemetry data of the collared elephants (figure 9) showed that seasonal and permanent waterholes were the backbone of a migration circuit that took a year to complete. However, there was a considerable divergence between the movements of bulls and cows. In February, the elephants were near the top of their range, with concentration points at Insegeran, Indeman West and Banzena waterholes. In April and May they moved west to occupy the Banzena waterhole and the surrounding area. In June and July, they travelled south, and in August and September, they moved quickly through the southern portion of their range, briefly entering Burkina Faso. In August, the bull reached the most southerly section of his range, where he spent September in a restricted area of ca. 100 km^2, within 10 km of the Burkina Faso border. In October, unlike the females, who continued east, the bull began a return path north-west on a route that very closely followed his earlier route south. By January 2001, he was localized around Insegeran with occasional visits to the Indaman and Banzena waterholes. Between February and May, he was based in the area comprising Banzena, Insegeran and Indaman. In April and May, however, he was most frequently located near the

Banzena waterhole. In April and May 2000, he stayed within 10 km of the waterhole for a full 76% and 73% of fixes, respectively. In 2001, however, during the entire month of April he was never recorded more than 10 km from Banzena, and in May was within 10 km for 73% of fixes. During the remaining time, he made an excursion to the Kikoi waterhole some 90 km to the east of Banzena.

Both females completed a circular migration with a circumference of about 450 km. The monthly distributions of both were closely correlated, being most concentrated at Banzena in April and May, in common with the bull. In June and July, they gradually moved south some 80 km and centred their activities at Osougou, a large seasonal waterhole. Both completed the southern loop of their migration during August and September and arrived at the easterly edge of their range, at the waterhole of Tin Sininan, in October. This area was well known to local people for its salt deposits, found in highest concentrations at Amniganda). Both females left this zone in late October, and travelled north-west, arriving in Inbau and Kikoi in November, where they remained throughout December. At this point they showed some divergence in their distribution.

In late December, the female Doppit Gromoppit (160.025) left Kikoi and travelled north-west some 50 km, where she remained for several days. She then continued on to the waterhole of Gia, where she probably remained until 18 March. However, there was a long period, including all of February, where no GPS data were recorded, and she may have visited Tin Cherit, where our colleagues from DNCN, Samake and El Mehedi, had earlier reported elephant presence. On 18 March, she moved rapidly from Gia to Indaman West, a linear distance of 102 km in a period of 90 hours (3 ¾ days). Exactly one year previously she had also been at Indaman West. In April, she was back in Banzena, with all the other collared elephants.

On the return journey female 160.124 (Ahni) did not go farther north than Indaman East, and during December and January travelled between the waterholes of Kikoi, Inbau, Indaman East, Inadiatafan and Insegeran. In February she continued to use Insegeran and Inadiatafan but pushed further west to Indaman West and on to Banzena late in February. She remained in the area bounded by Banzena, Inadiatafan, Insegeran and Indaman West until May 2001, and the end of GPS data collection. In May 2001, all three animals were based at the Banzena waterhole, as they had been a year previously.
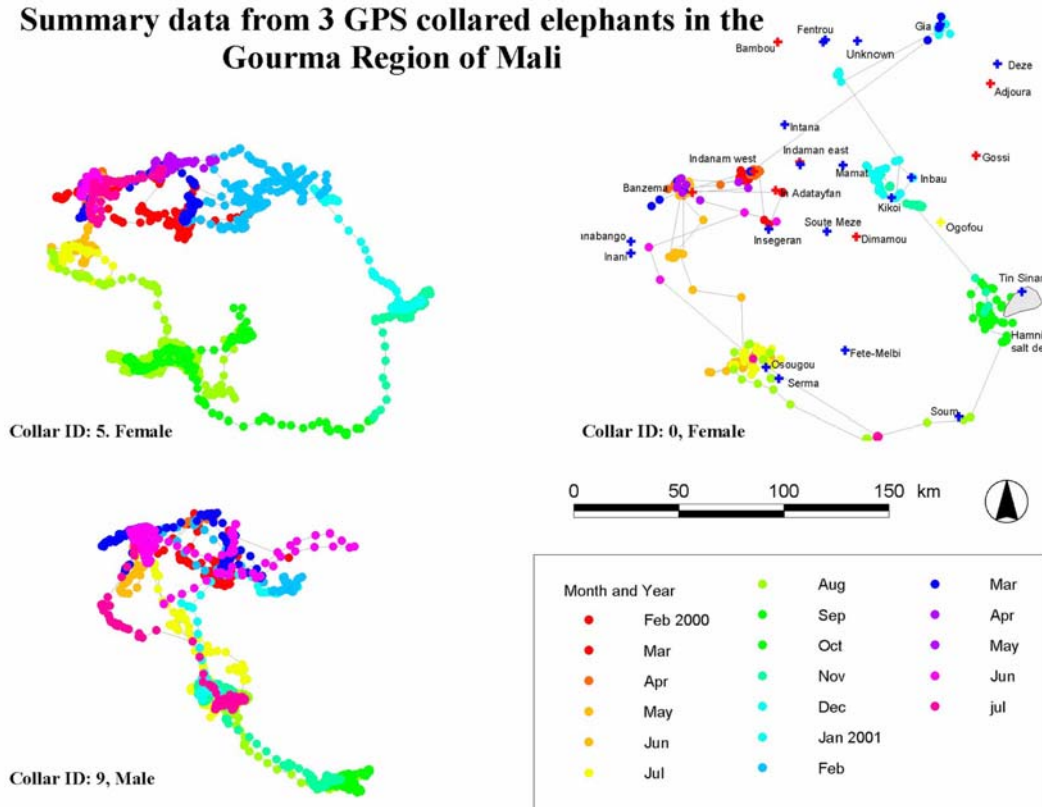
Figure 9 The movements of the three radio-tracked elephants are colour coded to show where they were in each month.

Despite the very different movement patterns of the bull compared with the two cows, in relation to the most reliable and permanent waterhole in the region, Banzena, some striking similarities were evident. These may be at least partially explained by the rainfall pattern and the availability of standing water through the Gourma through the year. During April and May, the three elephants were highly concentrated at the Banzena waterhole, which are the driest and hottest months of the year. Only Banzena, Gossi and Adjora had water at this time, (although in heavy rainfall years, Dimamou, Indaman East, Inadiatafan and Ogofou may also have standing water). As rainfall increased in June, water became available elsewhere, and the elephants moved. Interestingly, it was in September that all elephants reach their farthest mean distance from Banzena, rather than in July and August when mean rainfall was highest (figure 10). Two reasons for this are likely: during the years in which data were collected the peak rainfall period was later than usual (in September), or more likely, there was a lag between the onset of the rains and an increase in primary productivity. Furthermore, the rainfall data do not take into account the extreme rainfall gradient north to south across the Gourma, with which primary productivity must also be correlated.
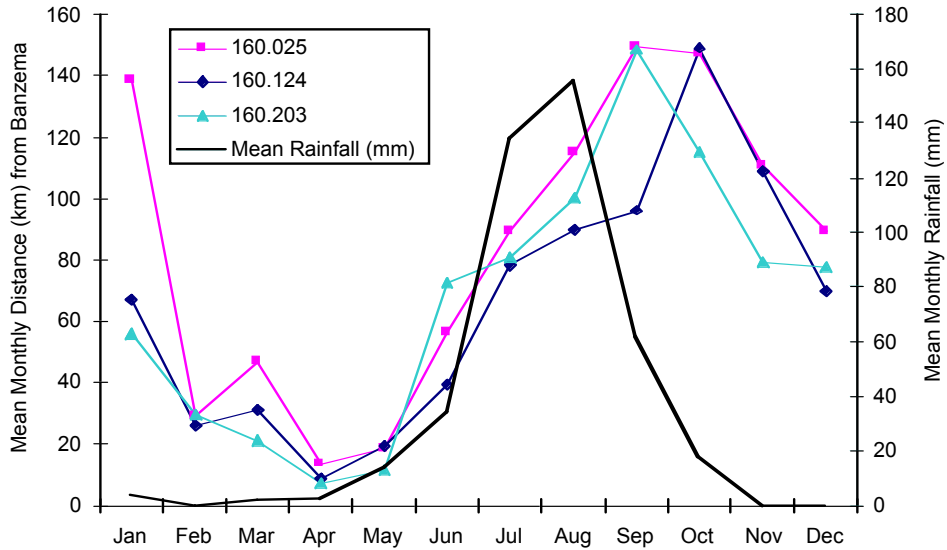
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Figure 10 Mean monthly distance from Banzena of the three collared elephants compared to the mean monthly rainfall.

It was when they were at maximum distance from Banzena (in September and October) that the bull and the cows diverged, with the bull retracing his earlier path northward and the females continuing on their anti-clockwise route to the south-east. However, the mean monthly distances of all three elephants from the farthest water point, Banzena, were remarkably similar. As mean monthly rainfall decreased to low levels in October, all elephants moved north, and as the dry season progressed, they became increasingly concentrated around the waterhole.

Daily and seasonal movement patterns

The daily distances travelled, measured as a cumulative total between the 12 daily fixes, are shown in figure 11. The overall daily average of the bull was 10.05 km/day and 9.4 km/day for both female. Both individuals occasionally travelled long distances of up to 55 km in 24 hours. These long-distance movements most often coincided with general shift in range and were mainly done at night when temperatures were cool.

Day range of the female did not change appreciably with season; however, day range of the bull increased during May–June 2000, January–February 2001 and again during May–June 2001. The bull used three different areas during these periods but also used these areas at other times without an increase in day range. Thus it is unlikely that the increase in daily distance was linked to the area visited. More likely, it was that the bull was sexually active, possibly in musth, during these periods and increased his travel distances when in search of receptive females.
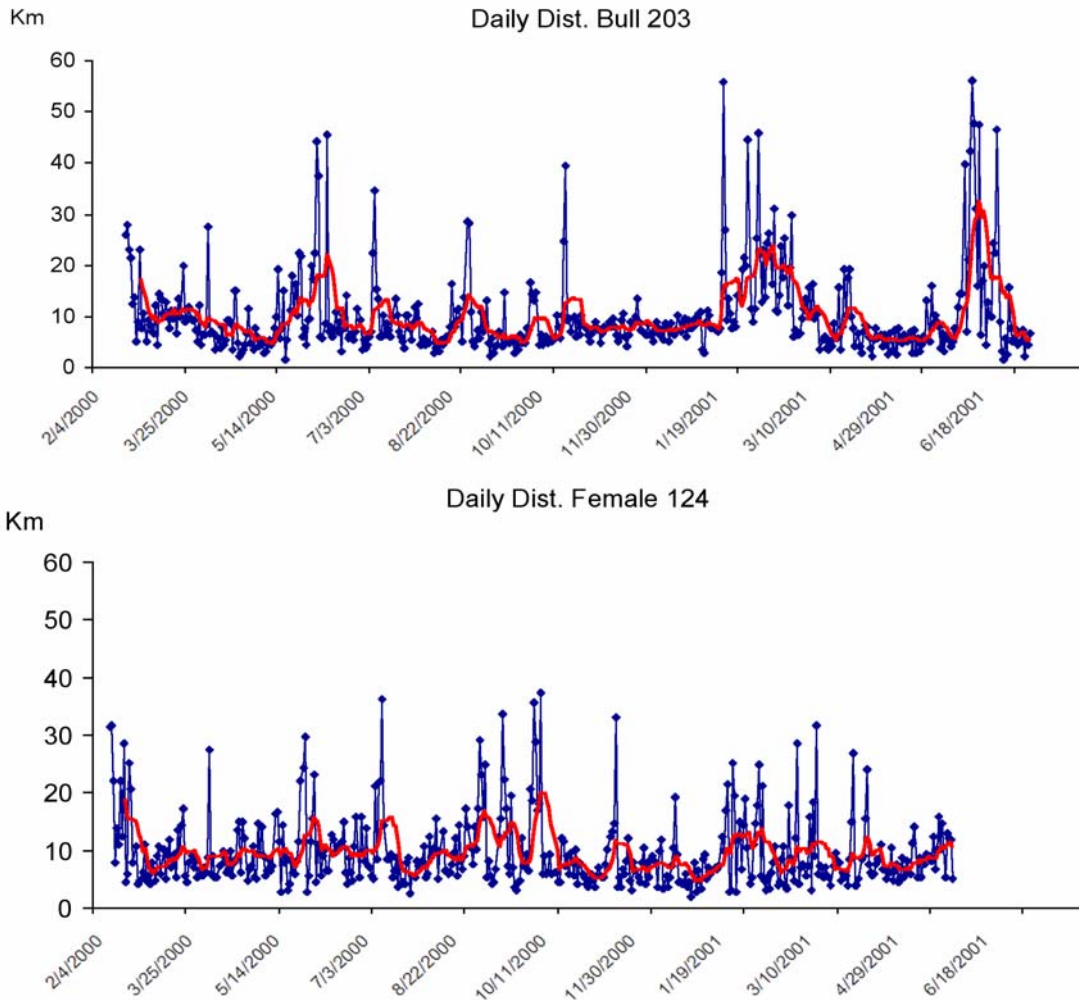
Figure 11 Daily traveling distance of two of the collared individuals. Red line is 10-day flow mean.

Individual interactions

From the three recovered GPS collars, continuous inter-individual distances could be calculated for more than a year (figure 12). The three individuals remained within the same area to the north-western-most part of their range between Banzena and Inadiatafan from when they where collared in mid-February 2000 until the beginning of May 2000. With the onset of the rains in June and July, the three elephants split up, indicating an asynchronous departure from the north. Between August and October, when they were in the southern part of their range, the three elephants were considerable distances apart, female 124 staying around Osougou, the bull 203 along the Burkina Faso border, and the last female around Tin Sinana. During October to November the two females joined in the same area, whereas the bull returned north the same way, staying far from the females. During January to March, all three elephants again returned to the northern part of their range. However, they did not use the same watering points. This may be because waterholes were relatively abundant at that time; thus the elephants could reduce the level of competition for forage by using different water sources. However, as the

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temporary waterholes dried up, the elephants were again forced together and repeated the pattern from the previous year, staying in the same area around Banzena between March and May.
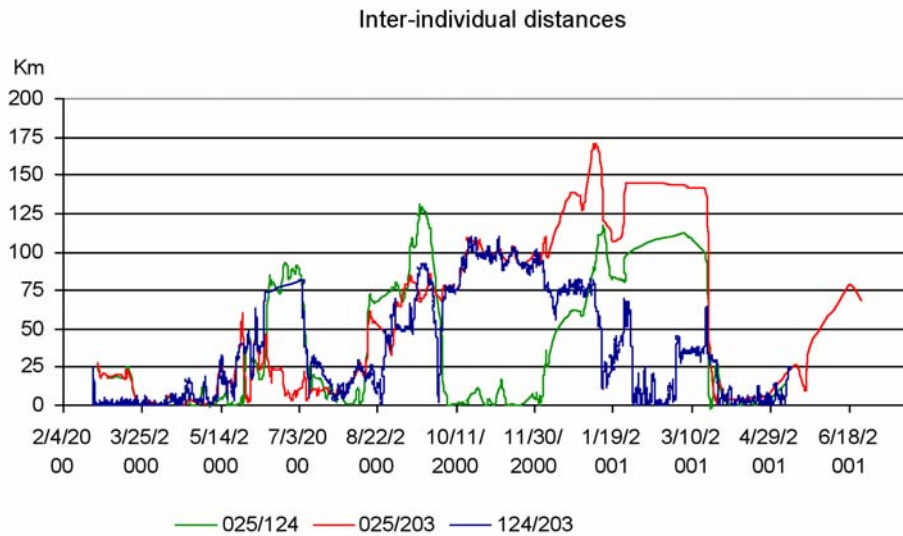

Figure 12 Inter-individual distances between the three GPS-collared individuals, females 025 and 124 and bull 203.

Aerial observations along the migration route

An aerial survey of the entire migration route of the Gourma elephants was completed on 26 April 2002. Summary observations on the distribution of human habitation, permanent villages and temporary settlements, cultivation and livestock are shown in figure 13.

Reference points along the flights are coded from F1 – F16. The most noteworthy observation was the change in the distribution of habitation, from mostly small temporary dwellings in the north to an increase in the abundance of permanent villages in the south. Permanent villages in the north were restricted to natural waterholes, whereas in the south, it appeared that many permanent villages relied on wells and boreholes. The highest concentration of permanent villages and sedentary populations lay immediately to the south of the inselbergs that bisected the southerly migration route of the elephants. There is one spectacular choke point where the elephant migration passes between two huge rocky platforms, known locally as the 'Porte des Elephants' (figure 2).

The distribution of land under cultivation closely followed that of permanent villages, while livestock numbers decreased near permanent villages. The exception to this was the very high livestock numbers at the permanent waterholes, notably Gossi, Inadiatafan and Ogofou, where major human habitations were also present. At Ogofou, however, only a small number of permanent dwellings were seen, although there were many temporary camps, and a large brick-production site indicated that humans are also to some degree sedentary.
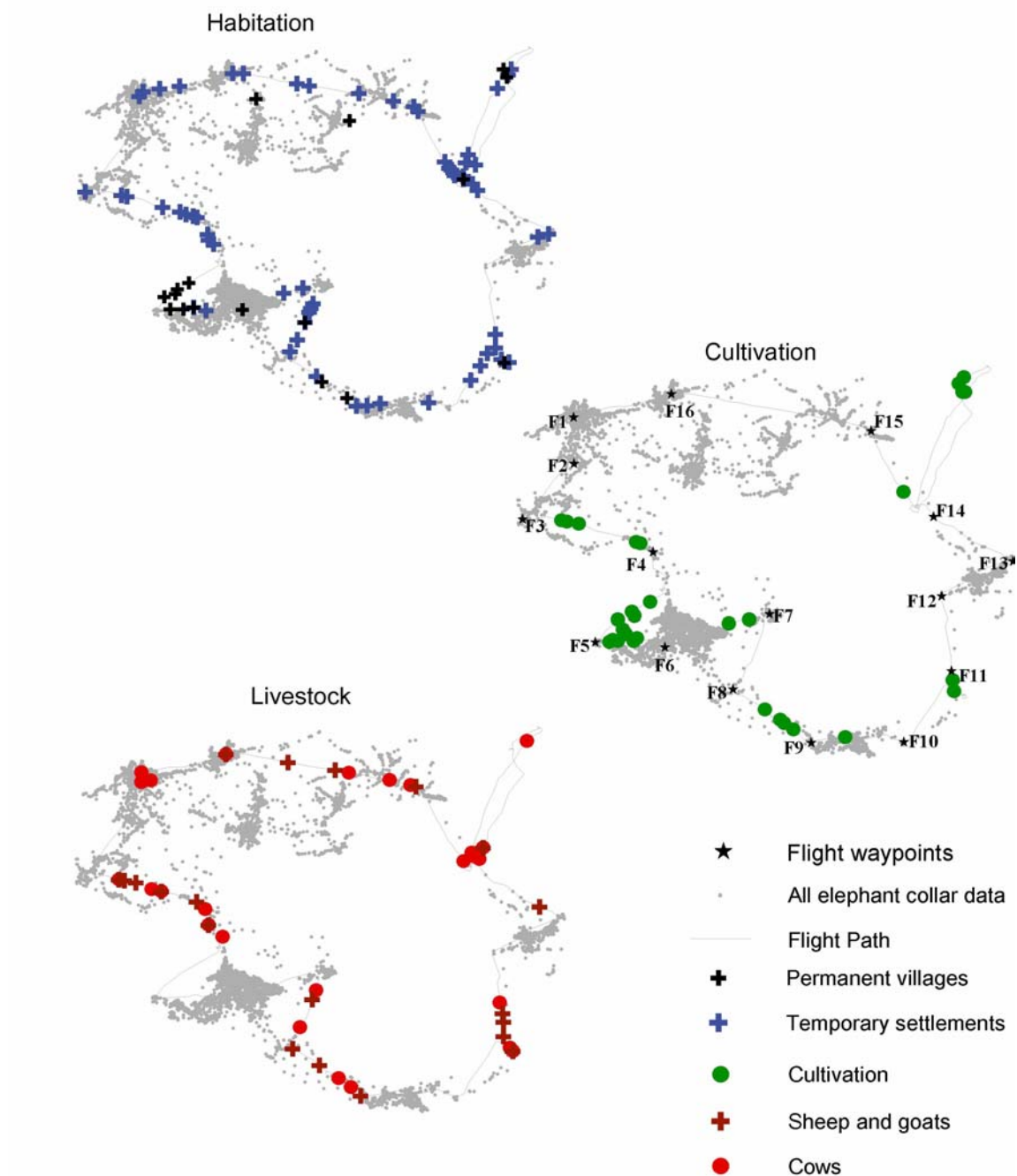
Figure 13 Human influence along the elephant migration route as observed from an aerial reconnaissance flight.

Habitat

Despite generally sparse vegetation cover, there was considerable variation in habitat quality with respect to elephants (and livestock). Forest cover (actually open bush with low tree density) was almost always associated with permanent and temporary waterholes and seasonal rivers. Occasionally patches of trees were found in low-lying areas not associated with water points but where presumably the water table was relatively close to the surface. Forest cover was most

common along the northern half of the migration route in both number of patches and patch size, which is interesting since annual rainfall increases sharply from north to south. Grass cover was also more extensive and of higher quality to the north. The aerial survey verified that throughout the region, grass sward quality increased dramatically with increasing distance from waterholes. The most likely cause of this is that grazing pressure increases with proximity to waterholes, which is a common phenomenon in other arid and semi-arid parts of Africa.

Around the Banzena waterhole, grass cover was sparse or non-existent at a distance of 2–3 km, and in many areas, good-quality sward began at a distance beyond 5 km. Wade (1974, cited in Sinclair and Fryxell 1985) graphically described this phenomenon as created by artificial waterholes in another region of the Sahel, stating that 'each borehole became the centre of its own little desert'. In the north-west of the migration route at distances beyond 10 km from water, the sward was generally of high quality. Habitat quality for elephants around the Inabango waterhole was excellent for elephants—a combination of moderate sward quality and open bush. However beyond 10 km to the east of F3, laterite-dominated plains became more common and by F4 little vegetation remained. Following F4, cultivation increased and non-cultivated lands offered poor elephant habitat, until east of F9, when grass cover and bush density increased once again. The areas of cultivation, however, probably offer elephants an excellent food source in those regions where non-cultivated lands are of poor quality. Immediately north of F12, habitat quality was high; however, the lack of livestock tracks meant that it was too far from water to be easily accessible. Between F14 and to ca. 10 km west of F15, habitat quality was generally poor but then steadily increased toward Indaman East. As at Banzena and the other permanent waterpoints, grass cover decreased to nearly zero close to the water. Extensive beds of water lilies occurred at Indaman East, which must provide a valuable source of food for both elephants and humans. The forest at Indaman East was particularly extensive. Between Indaman and Banzena the habitat was highly variable between good quality grazing and barren sand and laterite pans, with only sparse forest cover.

The aerial survey showed large stands of dead trees in the middle of the water at a number of waterholes, most notably Gossi. Local people said that these trees were of a species that lives in permanently saturated soil or standing water (*Mitrygena* sp. according to El Mehedi), which during periods of heavy drought are the only trees at the waterholes that carry green leaves. During droughts, the Touareg herders are therefore forced to cut the larger branches to feed their goats and sheep, which over time may kill the tree. Additionally, in particularly heavy drought, this species cannot tolerate dry soil. Thus if the waterhole dries up completely, the trees die. Observations of heavily pruned trees in and near the water Banzena confirmed these views.

Vegetation survey at Banzena

Of all the waterholes along the migration route Banzena appeared to be the most heavily used by elephants so we took a few quantitative measures of the feeding pressure on the habitat. Summary data on elephant browsing are shown in table 3. The mean height of vegetation increased with distance to the water, both generally and for species found in both waterhole woodland and scrub woodland habitats. The mean tree height at the dune edge was 234 cm contrasted with 498, or over double, near the water's edge. The most commonly recorded species, *Balanites aegyptiaca*, made up one-fourth of the total sample. It was present in both habitat types, and heavily browsed by elephants in both. This species was usually also heavily pruned by camels, and in some instances it was difficult to distinguish camel-feeding signs from

those of elephants. *Acacia nilotica,* the second most abundant species in the sample, was absent from the dune edge woodland, being found only in close proximity to the water and exclusively on seasonally flooded soils. Of 21 trees recorded, 19 (90%) showed signs of elephant browsing or debarking. *Bauhinia* sp. (19 individuals) and *Boscia* sp. (12 individuals) showed no sign of elephant browsing. Despite these levels of browsing no trees appeared to be killed by elephants. These measurements however may be useful as a rough baseline for future comparisons.

Habitat and species	Elephant feeding sign				Individuals (no.)	Browsed (no.)	Browsed (%)
	None	Low	Moderate	High			
Dune edge							
Acacia tortilis raddiana		1		1	2	2	100.0
Balanites aegyptiaca	2	7	7	1	17	15	88.2
Bauhinia sp.	3				3	0	0.0
Boscia sp.	10	1	1		12	2	16.7
Indigofera sp.					0	0	
Maerua crassifolia	1	1	1	1	4	3	75.0
Ziziphus mauritiana	2	1	4	2	9	7	77.8
Lake edge							
Acacia nilotica	2	9	10		21	19	90.5
Balanites aegyptiaca		2	5	4	11	11	100.0
Bauhinia sp.		6	10		16	16	100.0
Ziziphus mauritiana		1		1	2	2	100.0

Table 3. Feeding signs and index of damage level for trees and shrubs at Lake Banzena

Recent development at Banzena

The Banzena waterhole is well known in Mali for the excellent elephant-viewing opportunities it offers, and it attracts a steady stream of tourists. Several years ago, the resident Touareg at Banzena, on their own initiative according to the elders, built a small compound ca. 250 m from the waterhole to receive tourists. The collar recovery team used this facility as a base of operations. Currently the Touareg charge is 1000 CFA (US$1.70) per person per day for use of the site, which is simply a square brick wall (20 x 20 m) with a small room in one corner. There is no toilet or washing facilities. The Touareg who manage the site, headed by Mr Alhassane Ag Aghaly, live in traditional huts 50 m from the compound. Mr Aghaly said that they usually receive three or four groups of tourists per month. There is no control over tourism, and people are free to do as they please, although the DNCN authorities in Douentza encourage people to hire certified guides.

Local people say that before tourists began visiting in regular numbers, the elephants were calm and relaxed at the waterhole and even in the dunes. However now they are alleged to have become nervous of people and easily frightened by vehicles. This was illustrated by the fresh remains of a baby elephant said to have been killed as a result of an interaction with tourists, shown to the team by local people. The dead baby elephant, estimated to be at most 1 month old, was found less than 200 m from a Touareg camp on the western end of the lake. The Touaregs said that a group of over 100 elephants had been chased by a 4 x 4 vehicle carrying tourists who were trying to get close to the group. The elephants panicked and ran, and were pursued by the tourists. The baby got its feet caught up in a small tree (later inspection showed it to be a *Balanites aegyptiaca*) and became stuck. Presumably it was snared by long sharp thorns

of this species. Two females returned to the baby and attempted to pull it free but failed and eventually panicked and ran off to join the rest of the herd. The local people want to see tourists come to the area to see elephants but they want the tourists to behave appropriately and not approach or disturb the elephants. They thought such behaviour would make the elephants more dangerous.

Three more significant developments have occurred at Banzena in the recent past. First, a concrete well was completed in July 2000, which provides a permanent fresh water supply. Mr Alhassane Ag Aghaly did not know the name of the NGO (non government organization) that funded the well, but since it has made life considerably easier, he said the local population is very happy with it. In 2001 a water pumping station was completed at the lake edge, funded by the Malian government (DNCN) according to Mr Aghaly. The purpose of the station is to pump water from the water table into the lake during severe drought, to help keep elephants and domestic stock alive. Local people, who remember clearly the devastation of the 1984 drought in which Banzena dried up and caused huge losses of livestock and high elephant mortality, welcomed the pump. Thirdly, a 'Centre d'alphabetisation' was under construction, only 30 m from the tourist compound. The building, consisting of a single large room ca. 10 x 6 m and a veranda, is intended to provide basic reading and writing training for Touareg adults; it is supported by the local community.

Dung transects

To obtain a measure for the relative distribution of elephants within the important north-western part of the elephant range around Banzena and Inadiatafan, three dung-counting transects were carried out (figure 14).

The transects were made by driving along the existing car tracks with one observer counting the amount of defecation seen 50 m to one side of the car. Few dung piles were likely to have been missed because the habitat is very open.

The three transects were carried out:

* 30 km south of Banzena to Banzena
* Banzena to Inadiatafan
* Hombori to Inadiatafan

Large variations in density were seen along the transects, with the highest densities occurring close to the permanent and semi-permanent waterholes. The distribution of GPS collar positions and the density of dung piles counted during the transects were similar. This indicates that the overall population uses the area around Banzena and Inadiatafan in much the same manner as the three collared elephants. This furthermore indicates that the distribution in the rest of the range of GPS collar positions probably mimics the overall distribution of elephants and is a good indication for the overall distribution of elephants.
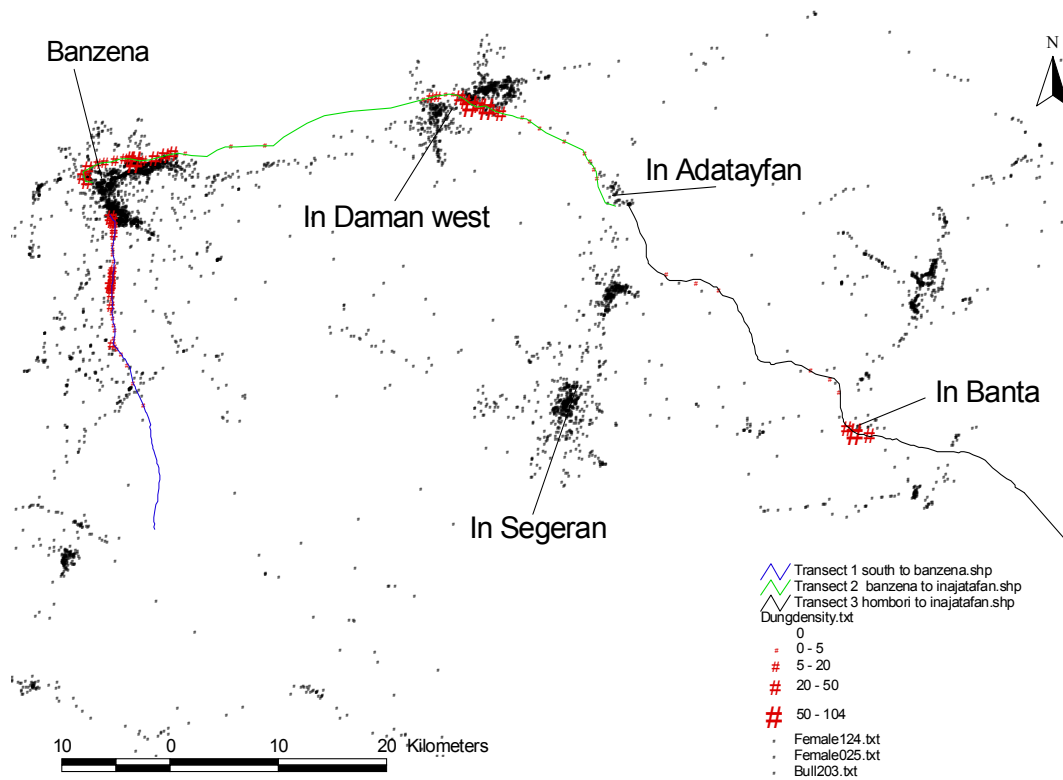
Figure 14 The north-western part of the elephant range. Dung transects are shown as lines with density shown in red (dung piles per km) as well as all GPS collar positions combined.

Aerial Census

Introduction

The Gourma is the last known area of Mali where elephants stay permanently. This elephant range has been also selected as a MIKE site. It represents a sample that should allow the MIKE Programme to monitor the illegal killing of elephants, notably on the basis of the knowledge of their population trends.

No surveys have been undertaken in the Gourma for 11 years. The last survey had been carried out in 1991 (Jachmann, 1991). With the approach of new development projects in the region, it was considered necessary by DNCN to count how many desert elephants remain.

This was the first time an aerial total count has been undertaken in the Gourma. The main goal was to estimate the elephant population accurately, to create a baseline for the future, and to, and compare the result with previous estimates to comment on trends.

Methods

Reconnaissance

In order to maximize our chance to cover the areas used by elephants in April and to do as accurate a count as possible, a pre-reconnaissance was undertaken in several ways:

- A few months before the arrival of the team in the field, Mr Samaké and El Mehedi, Wildlife Officers from DNCN undertook a pre-reconnaissance across the entire Gourma region.

- They met people in 52 localities, mainly to inform them about the survey. Interviews with key informants also helped to determine the areas most likely to contain elephants. This gave us the first picture of elephant distribution in April.

- Extensive flights using VHF tracking in search of the collared elephants in the initial stages of the mission enabled observers to gain a good understanding of the distribution of the major elephant herds, and the location of standing water.

- The data recorded by the recovered collars, helped the team to target the position of elephants herds during the survey period.

More than 30 hours of flight time revealed that the only large concentrations of elephants were in the north of the migration circuit, with visual observations of herds at Banzena, Inadiatafan, Indaman, and Gossi.

Survey

On the basis of local knowledge about the elephants, the first aerial reconnaissance and the data collected from GPS collars, it was obvious that the elephants were mainly concentrated

around the Banzena Lake during the survey period. However, small herds remained in Inadiatafan and in Gossi to the east.

During all the flights detailed counts were made of all elephant herds seen, and digital photographs were taken of the large herds. Photos allowed confirmation of visual observations when elephant herds were in open terrain, but were less useful when herds were encountered in thick bush where they were often obscured by vegetation.

Each picture was next downloaded onto a computer. Using image manipulation software it was possible to enlarge the image on a laptop screen and divide the herds into sub-groups that were easy to count (figure 15).
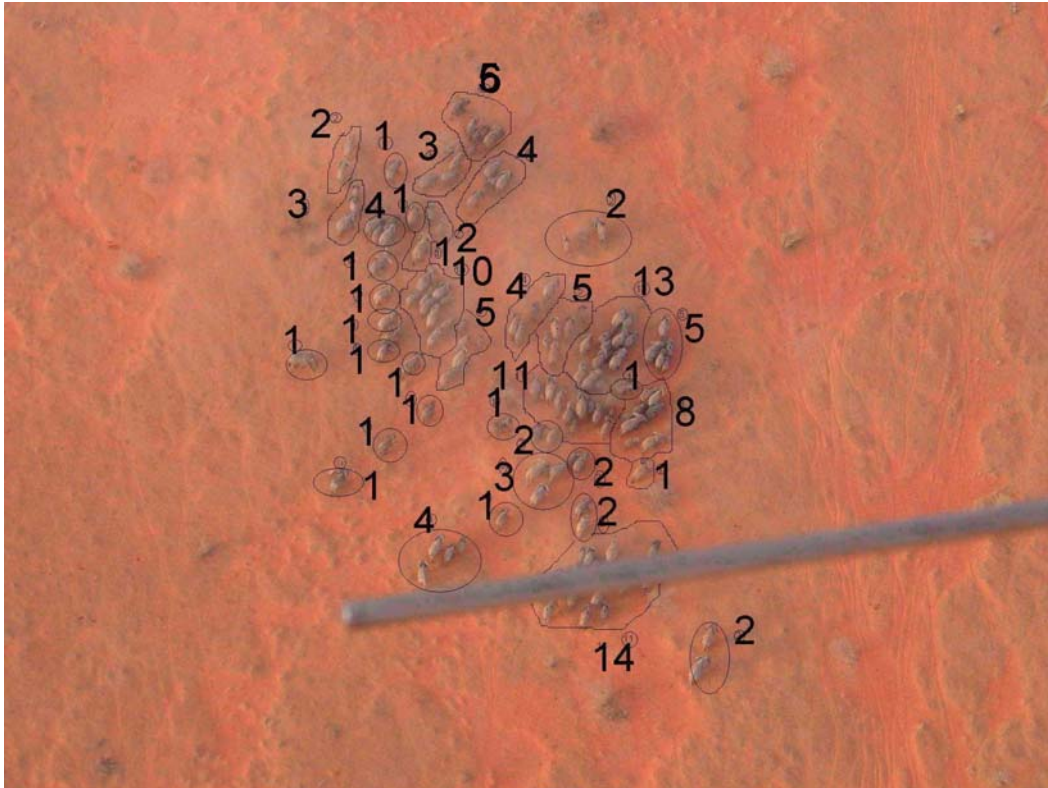

Figure 15 A herd of 134 elephants in the open dunes observed and counted on the 16th of April, 2002.

Some flights were dedicated to travel along the entire elephant migration route. Each elephant concentration areas, always around water holes, was scanned thoroughly using an inward spiral flight pattern. Apart from the big herds at Banzena elephants were also seen several times in Inadiatafan, Indaman and Lake Gossi. Elsewhere the pools were dry or were occupied by cattle. On the basis of the best count around each waterhole frequented by elephants it was possible to provide an accurate estimate of the Gourma elephant population.

Results

Table 5 summarizes the elephant count according to the observation conditions and opportunities. The first two groups seen around Banzena were observed only once in the dunes, a very open habitat that allowed an accurate count.

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Location	Group Number*	N individuals	Location	Date observed	Time observed
Banzena	1	134	N15° 41,50' W 2° 33,12'	16-Apr-02	06:35
	2	125			
	3	17			
	4	20			
Inadiatafan	5	12		17 to 25 Apr-02	
Gossi	6	5	N15° 45,027' W 1° 19,535'	24-Apr-02	15:11
	7	2	N15° 49,764' W 1° 18,370'	24-Apr-02	15:28
	8	7	N15° 51,748' W 1° 18,142'	24-Apr-02	15:34
Total positive count	**322**				

- Groups 1,2 and 4 all within 5 km of group 1. Observed during same flight

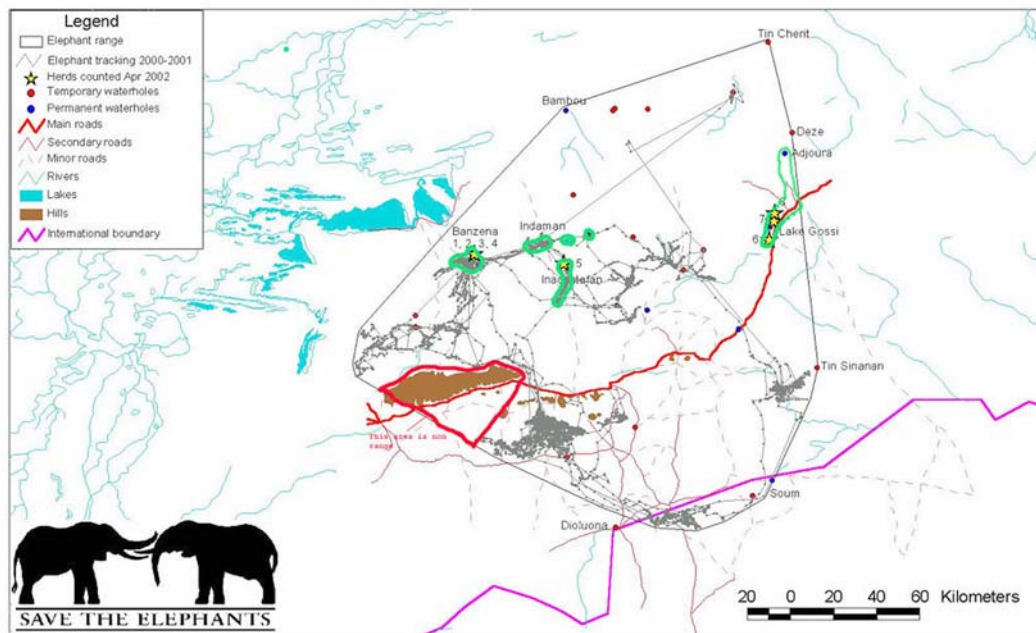Table 5. Summary data from an aerial census of the Gourma elephant population

Figure 16 Green polygons indicate areas in which elephants were counted in aerial survey, and yellow stars the position of actual elephant herds counted, matched by group numbers to the table above. The outer grey line is the minimum convex polygon of the elephants range based on elephant movement data traced in grey. The red zone encloses non-elephant range in the South West.

These two groups were seen almost every day but on other days the dense woodland habitat did not allow a very accurate count.

A minimum estimate of 322 elephants was made from the aerial counts. Two large herds of 134 and 125 individuals seen near the Banzena waterhole on 16 April 2002, made up 92% of the estimate, with only 4 more small herds seen at Gossi and Inadiatafan. It is possible that a small number of elephants was not detected during the aerial surveys; however it is unlikely that a

significant number were missed. First, local knowledge suggested that all the Gourma elephants were highly concentrated at the few remaining waterholes. Second, by the end of the mission over 50 hours of flight time, which included an extensive survey of the entire migration route, had failed to locate any additional herds. Third, the GPS telemetry data support the notion that elephants are centred on the Banzena waterhole in April and May.

The final estimate from this study according Data Categorization of the African Elephant Database are:

	Definite	Probable	Possible
Gourma	322	30	25

Table 6. Final estimate of this study in the format requested by the African Elephant Specialist Group.

Thus we conclude that the elephant population of the Gourma is likely to be between 322-350 and very unlikely to be more than 375 (table 6). The definite count of 322 represents some 12.9% of the verified number of elephants remaining throughout west Africa (some 2489 cited in the 2002 African Elephant database, though a speculative total for west Africa was listed as 3442). Thus the Gourma elephants are an important population not simply for their ecological uniqueness, but also for their considerable contribution to the total number of elephants that remain in West Africa.

Discussion

Source	Year of the estimate	Methodology	Estimate
Douglas-Hamilton 1979	1972-74	Aerial and ground reconnaissance	550
Lamarche 1981	1979-80	Aerial and ground reconnaissance	550
Jachmann 1991	1990-91	Dung count	597-611
This study	2002	Aerial total count	322-375

Table 7. Comparison of the Gourma elephant estimates from several sources.

The estimate provided by this study is lower than previous results for several reasons. The estimates of 550 elephants provided by Douglas-Hamilton (1979) and La Marche (1981) (table 7) come from two sets of aerial reconnaissance and ground surveys done by La Marche in 1972-74 and 1979-80. These results seem to be the most accurate estimate that we have about this period because both aerial reconnaissance and ground surveys had been undertaken at the same time, at five years interval.

Olivier (1983) published another report where the number provided does not come from his own census but from the compilation of various sources notably those of Douglas-Hamilton (1979). In a study by Cobb (1989) an estimate of 840 animals was given for the elephant population but the accuracy of these figure is questionable since census methodology was not reported. There is thus a doubt concerning the reliability of the estimate from this source.

Jachmann (1991) in 1990 and 1991 undertook dung counts (see table 7) and reported a description of the methods he used. However, several biases that could lead to an overestimate have been noticed:

◆ the survey plan was not designed in a random way

◆ the dung counts were only undertaken in a highly frequented part of the elephant range.

In addition the decay of dung piles is slower in a dry climate like the Gourma. This means that the piles can remain in the field for a long time before disappearing. Consequently there may be an overestimate of elephant numbers, especially when the specific dung decay and defecation rates for the Gourma elephants is not known and that decay and defecation rates from other areas are used.

The results presented by the African Elephant Database (Barnes et al 1999) come from questionnaires in reply to the informed guess of people from the Gourma. The African Elephant Database noticed: " The last survey was a dung count by Jachmann (1991). He estimated that there were 611 elephants in the Gourma area. More recently, Niagaté (questionnaire reply, 1998) has provided an informed guess of 950 to 1000 elephants, while les Amis des Eléphants, an NGO, puts the number at 700 (Pavy, pers. comm., 1998). However, neither of the these results were based on systematic census methodology.

For the first time, during this study, an extensive aerial total count was carried out in the whole range of the Gourma elephants. Several flights were undertaken, in the critical concentration areas in a sufficiently short time to avoid the shifting of elephant herds from one side of the home-range to another and thus avoiding the risk of double counting.

The population from this study was also subject to considerable potential sources of error including that the sample was neither random nor systematic, but was concentrated in areas where local people and previous reports said the elephants were concentrated at that time of the year. However, since the migration pattern suggested by these sources was strongly supported by GPS data, and aerial coverage of the region was vast, this population estimate can be considered as a reliable figure.

Taking all the information into account we conclude that at the end of the 1970s and 1980s about 550 elephants lived in the Gourma, but the elephant population decreased to a minimum of 322 individuals. The Gourma elephant population appears to have been reduced by 41% in 22 years.

Current status of the Mali elephants

Conservation and biodiversity

In 1977, Sayer produced an important baseline report on the status of the large mammalian wildlife of Mali, based on observations collected between 1972 and 1974 (Sayer 1977). His elephant observations were mostly derived from observations of Bruno La Marche. At that time, there were two principal areas of wildlife concentration left in Mali, both of which were closely related to the distribution of humans. First, the northern Sahel, where human populations were low because of aridity, and second, the southern Guinea savannahs, where human settlement was limited by disease, with little wildlife left in the heavily populated south-centre of the country. At that time the total human population of Mali was less than half of what it is in 2002.

The protected-area system, which has remained much the same since Sayer's study, consists of six protected areas, including one national park, Boucle de Booulé, covering ca. 350,000 ha. Adjacent to the national park are three wildlife reserves (Badinko, Fina, and Kongossambougou), which are actually controlled hunting reserves, and together with the national park cover a contiguous area of 771,000 ha. Two protected areas dating from the 1970s are found in the Sahel, the Reserve des Elephants in the Gourma, and the Reserve d'Ansango-Menaka to the east.

Recently, three additional reserves (162 ha), also in the Sahel, have been created in Mali under the IUCN Ramsar Wetlands Programme (Kone 2001). According to Sayer, the Baoulé National Park and its complex of reserves were quite well protected

in the early 1970s and contained healthy populations of many large mammals, including elephants. While the conservation and wildlife management policy of Mali was 'comprehensive', the remaining protected areas were poorly managed and wildlife elsewhere was heavily hunted (Sayer 1977). The legislative framework of the Reserve des Elephants in the Gourma in fact puts few restrictions on consumptive use. Today, there is little or no active management in any of Mali's protected areas.

Mali's elephants and the Gourma population

In the early 1970s, elephants were found in all six of Mali's administrative regions (Sayer 1977); however, no reliable population estimates were available. The few population estimates and status reports that do exist show a decline in both numbers and range of elephants in Mali, such that by the early 1990s no elephants remained outside of the Gourma. The elephants of Mali have been reduced from at least four populations found in all administrative regions in 1970 to ca. 350 individuals in 2002, found in a single population with a range of ca. 30,000 km^2 (figure 17).

The factors leading to this decline are well known. In recent years they include declining rainfall and the adverse ecological impact of humans, notably poorly planned development aid leading to increased settlement by humans leading to permanently grazed rangelands by unsustainable densities of livestock. Over much of the former range of Malian elephants,

poaching has also been a source of high mortality. Elephants have been exterminated from those regions of Mali where human density is highest and where human impact on the landscape (where roads and cultivation are present) has been highest. As is the case throughout Africa, elephants continue to exist only in suitable habitats where human population density, and therefore human impact, is low.
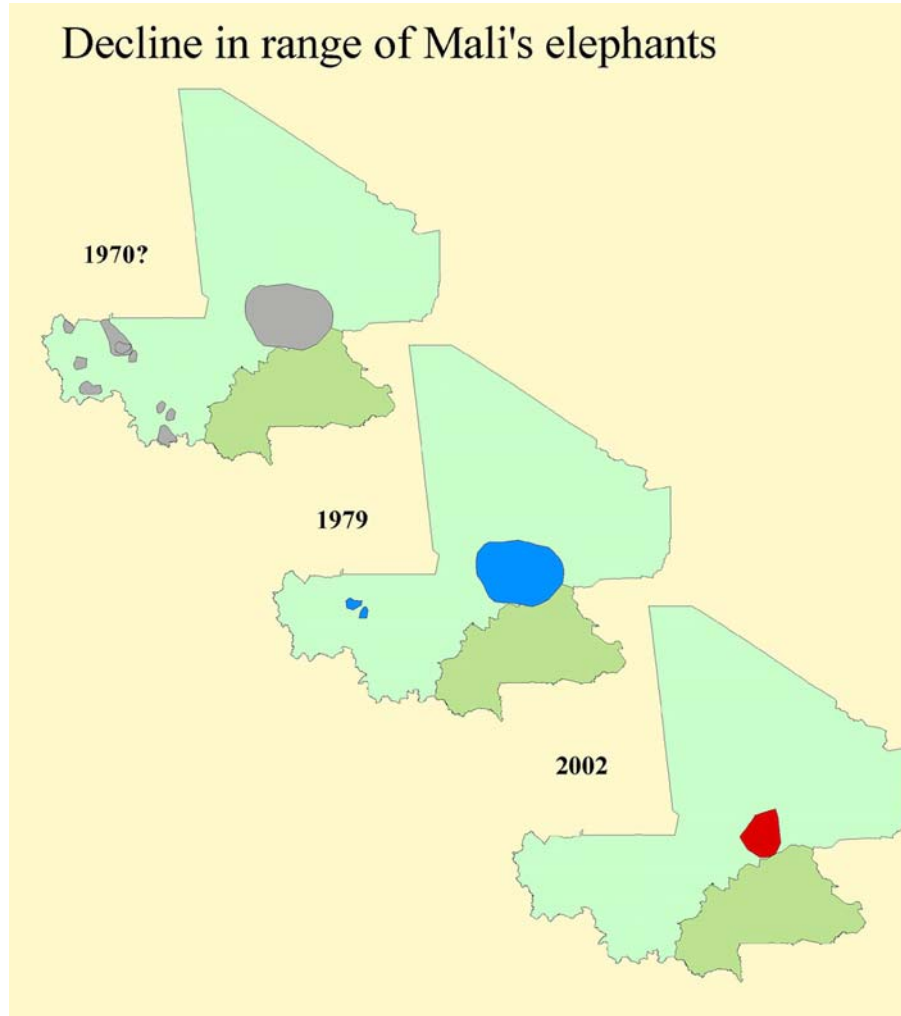

Figure 17 Range change of Mali elephants. Eight population areas were reduced to one between 1975 and 2002.

The Gourma is at the extreme north-eastern edge of human habitation in Mali and in one of the few pockets of low human density in Burkina Faso. It is no accident that here remain the last of Mali's elephants. Also no accident is the circular migration pattern of the Gourma elephants when one considers it in the context of human habitation. The urban area associated with the town of Hombori must surely prevent the elephants from using the interior of their range.

While roads do not exist in much of Mali because of desert conditions with large areas in the north devoid of people, among regions that can support vegetation and therefore herbivorous mammals, the road density of the Gourma is among the lowest in the country. Indeed, there is only a single paved road through the Gourma, although numerous roads have been created in the sandy conditions simply by repeatedly driving over the same route. Jachmann (1991)

suggested that these roads do not influence the movements of elephants; however, local people suggest that elephants avoid even the smallest roads. Finally, most of the agriculture development in Mali has traditionally been in the south of the country where rainfall is moderate. In the Gourma, land-use data suggest that cultivation levels are generally below 5% of the surface area. Close inspection, however, shows that in some areas in the centre and southern portion of the elephant's range, cultivated land may occupy between 30 and 50% of the land surface.

Protected areas within the range of Gourma elephants

There are two legally designated protected areas within the current range of the Gourma elephants: the Reserve des Elephants predominantly to the north-west of the elephants' range, and the Sahel Reserve of Burkina Faso. The reserve boundaries of each are rather ambiguous, and it is difficult to know how much overlap there is between these protected areas and the range of the elephants. Using the WCMC(World Conservation Monitoring Centre)/IUCN GIS coverage of the world's protected areas, the combined areas of these reserves is 28,000 km^2; however, when the WCMC polygons were measured the area calculated was 26,965 km^2 (20,712 km^2 for the Sahel Reserve, and only 6254 km^2 for the Reserve des Elephants). According to a GIS analysis, the actual area of the elephants range within the reserves was just 2587 km^2 (or 10.7% of their range). Thus, according to this analysis, there is no legally mandated land use sensitive to the requirements of the elephants over 89.3% of their geographic range. In any case the Reserve des Elephants does not cover the most critical areas.

Home range of Gourma elephants in comparison with other populations

The difference between the home range size of female Gourma elephants compared with female elephants studied elsewhere in Africa is startling (table 8 and figure 18). The mean MCP (minimum convex polygons) for Gourma females was 3.7 times that of females in the desert conditions of Namibia, and over 9 times that of the next-ranked population (of Tsavo East). Thouless (1996) found that home range for females across Africa increases with decreasing rainfall, presumably as a result of lower vegetation biomass. Given its arid, near desert conditions and sparse vegetation cover, it is not surprising that the home ranges of Gourma elephants are large.

Elephant taxon	Location	Mean annual rainfall	Mean female MCP (km^2)	Reference
Savannah	Gourma	300	21,801	This study
Savannah	Namibia	315	5,860	Lindeque and Lindeque, 1991
Savannah	Tsavo East	300	2,380	Leuthold, 1977
Forest	Ndoki	1,650	1,518	Blake, 2002
Savannah	Kruger Nat'l Park	550	436	Hall-Martin, 1984
Savannah	Tsavo West	550	408	Leuthold, 1977
Savannah	Zambezi Valley	800	156	Dunham, 1986

Savannah	Lake Manyara	1,000	57	Douglas-Hamilton, 1971

Table 8 Adult female home range (MCP) for elephant populations across Africa

What is surprising is the magnitude of the difference with other populations. The Gourma has approximately the same annual rainfall as both the Namibia and the Tsavo sites, yet the difference in elephant range is enormous. Several explanations seem plausible. Rainfall in the Gourma is highly concentrated in a single season, between June and October (figure 4), within which 70% falls in just two months, July and August. This remarkably short rainy season means that widely dispersed waterholes contain water for very limited amounts of time only, and since the distribution of water constrains the elephants' ability to travel to good foraging grounds, they must maximize access to food resources over as wide an area as possible.
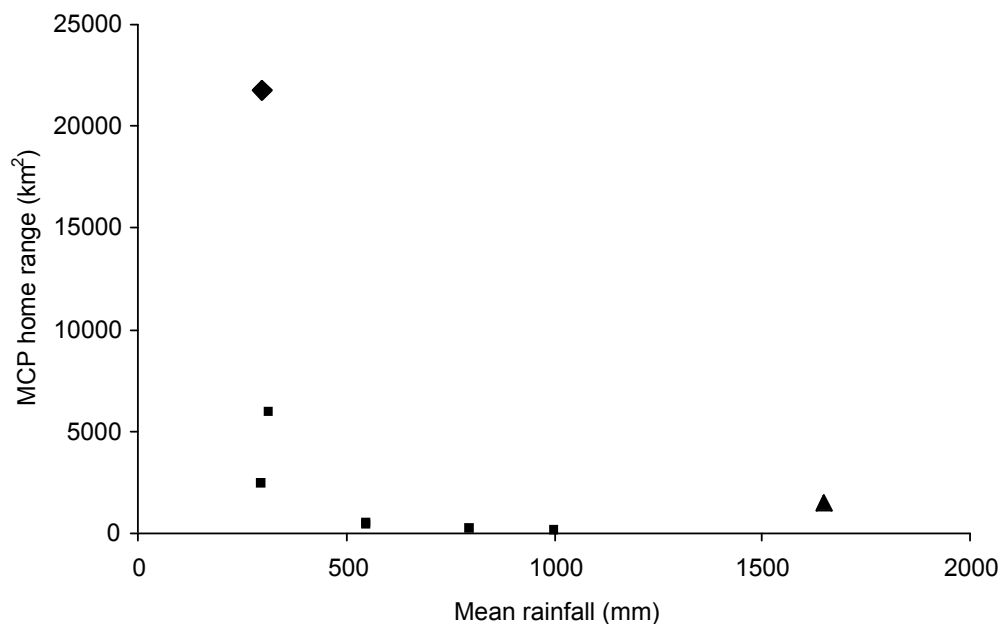

Figure 18 Adult female range, as measured by MCP, compared with mean annual rainfall at the site of elephant populations across Africa (adapted from Thouless 1996). Diamond represents Mali desert elephants, triangle represents Ndoki forest elephants and squares are the remaining data.

The rainfall regime also means that the growing season is short, and forage is generally sparse and of low quality for much of the year. Thus during periods of new growth when leaves of both browse and grass species are most nutritious, the elephants need to maximize forage intake. Because of the distribution of high-quality habitat, this would necessitate long-distance travel. A second explanation is perhaps the widely discussed (Harris et al. 1990), inherent problem of using minimum convex polygons as the basic unit with which to describe home ranges. Some 7410 km^2 (27% of the total MCP) at the centre of the Gourma elephants' range is apparently never visited, thus the area used, according to the MCP, is a considerable over-estimate of the actual range. Nevertheless the area of the 'doughnut' used was still 20,340 km^2, or twice that of the largest elephant home range previously recorded (Lindeque and Lindeque 1991).

Local perceptions of people towards elephants relevant to their conservation

The people of the Gourma region are mainly nomadic pastoralists who move across the region during the year for water and pastures for their cattle. From their knowledge they always known the elephants in the area and their feelings towards them was often of fright and awareness of their weakness in front of these animals.

People generally try to avoid elephants but have no will to kill them even if sometimes humans are killed by them or if their stores are destroyed by elephants. Everybody agrees to say that the pastoralists have lived with elephants for a long time even if some of them don't find their coexistence a good thing.

Figure 19 Banzena is the most reliable remaining waterhole in the Western Gourma in the dry season months of April and May, and forms a refuge for elephants and livestock.

The head of a tribe in Tin Abou, Mohamed Agbilal, who finds that the presence of elephants is positive for the area, summarized the general feeling as this: the bad feeling of some pastoralists towards elephants came from the fact that in recent years the human population and the number of cattle increased in the region and led to the creation of settlements around the lakes (figure 19). The competition between elephants and humans and their cattle for drinking water and for food has led to conflict between them . Agbilal is against the settlements around the lakes because, according to him, high human and cattle concentrations around the lakes will dry them up and create a water supply problem, especially for elephants because in case of

drought, human and cattle will have quit the region a long time before the elephants. He was also worries about the future of elephants if the lakes dry up.

In 1983 the Banzena lake, the major source of water in the region, dried up and the cattle herders left the region. Only elephants remained near the lake and began to die. In reaction to this situation the Government of Mali sent several army trucks to Banzena to provide water to the elephants. Thanks to this initiative the elephants survived this drought.

People of this region wish to conserve the same way of life even if the feeling towards elephants is not the same in the minds of everybody. However Agbilal recommends that elephants should have their own water points and that others should be created for cattle. He also suggests removing all the permanent buildings around the lakes in order to reduce human–elephant conflicts.

Discussion

The results of the radio-tracking show the places important to elephants at different times of the year. In many respects the results have vindicated maps made by La Marche (in Douglas-Hamilton 1979; La Marche pers. comm. 1981, Jachmann 1991). The counter-clockwise circular migration route referred to by all these sources over the last 30 years is confirmed.

Our rapid aerial survey of the migration route suggests an inverse relationship between elephant concentrations villages. We plotted the villages and towns from the 1:200,000 map coverage. It is apparent in the south of the elephants range that the density of villages increases markedly and that the main elephant concentration areas are in the north. A more exact relationship between elephants and land use could be better done by measuring agriculture from satellite images, and it is recommended for future studies.

The priority areas for elephants at present appear to be Banzena, Insegeran, Soute Meze, Inbonta, Dimamou, Kikol, Inbau, Inadiatafan, Indaman east, Bambou, Fentrou, Pinrou, Gla, Tin Cherit, Deze Adjora, Gossi, Ogofou, Tin Sinanan, Soum, Fete-Melbi, Semma and Osougou.

If elephants are to continue surviving in Mali it is essential that they continue to be able to use these areas. In other words, if the elephants are to survive, development in these areas should not make their way of life impossible.

Apart from maintaining the elephants' right to use these areas, the vital corridors that link one segment to another need to be kept open. If present tolerant attitudes are maintained and encouraged and if development does not destroy the elephants' few remaining concentration areas, the elephants should be able to survive.

The remaining five memory modules from the collars are still somewhere out there in the Gourma, some perhaps attached to elephants or lost or fallen on the ground. The memory should last for many years and they should retain their information like time capsules waiting one day to be rediscovered. We still hope that some of these memory units will be found and their data recovered.

The last 30 years has seen a decline in Mali's elephants from at least four extant populations containing probably more than 1000 animals, represented in every region of the nation, to a single population of approximately 350 individuals living at the ecological limits of survival. The reasons, a drying climate and increased pressure from humans, are well known in Mali and have been widely discussed (Olivier 1983; Jachmann 1991; Leeuw et al. 1993).

The ecological degradation that has occurred in the Gourma region of Mali is an excellent example of the 'settlement–overgrazing hypothesis' of (Sinclair and Fryxell 1985), which was extensively discussed by Jachmann (1991). The Gourma elephant range as indicated by GPS is found completely within the Sahelian ecosystem, an environment of low and unpredictable rainfall (Sinclair and Fryxell 1985). The hypothesis postulates that it is settlement of people and subsequent overgrazing of livestock, rather than decreasing rainfall that has caused the rapid desertification of the Sahel. Sinclair and Fryxell (1985) provide compelling evidence that inappropriate development aid, including the provision of water through boreholes and permanent wells, has disrupted the ecological balance that existed when both humans and their

livestock were nomadic. A number of studies have shown that migration by ungulates allows higher populations to exist than if the same animals are sedentary (Fryxell et al. 1988), and the same applies for both wild and domestic species (Sinclair and Fryxell 1985). Thus if once migratory livestock become sedentary, the population density must decline or grass stocks will be depleted and eventually destroyed. Since grass is an important component of the diet of savannah elephants (Laws et al. 1975; Ruggiero 1992), including those in the (Olivier 1983), if sedentary cattle deplete the grass in the Gourma, it will have profound negative consequences for elephants.

It is well agreed that the nomadic lifestyle of the Touareg people has traditionally been compatible with the survival of the Gourma elephants—that elephants still exist bears witness to this. However, this compatibility is possible only when competition between humans, domestic animals and elephants for shared resources is low. As resources essential for livestock, humankind and elephants become limited, competition intensifies—which can only be detrimental for all. Trees around waterholes killed by humans to feed goats and sheep testify to the habitat destruction that is a necessary short-term survival strategy in the face of famine. The Touareg pastoralists, it would seem, are already at or beyond sustainable livestock production. Most of their camps are at the edge of pasture, some 5 or 10 km or more from many waterholes, particularly those offering permanent water. If livestock numbers continue to increase, the remaining good-quality pasture will be pushed still farther from water, until finally a biological limit will be reached, when the energy and time costs involved in walking to and from water can no longer be met by the time available for foraging. Given the large body size of elephants and their water requirements relative to those of cattle, this limit will probably be reached for cattle before elephants, but at enormous environmental and socio-economic cost. Therefore, for pastoralists and elephants to coexist in the Gourma, livestock numbers must not increase beyond the levels that would force an ecological crash. The drying climate means that the carrying capacity of the Gourma in animal biomass will decrease unless considerable effort is put into decreasing the trend toward desertification in the region. As Sinclair and Fryxell (1985) compellingly argue, this would involve maintaining nomadic pastoralists' lifestyles if it remains an objective for the region to support a high capacity of domestic animals.

The southern portion of the Gourma elephants range has seen an increase in agriculture over livestock production, which has inevitably introduced conflict between humans and elephants where it did not exist previously. Elephants find crops such as millet palatable, which inevitably leads to conflict if these crops are grown in areas accessible to them. Farms located within range of the elephants are thus guaranteed to generate conflict, particularly if destruction of natural habitat continues to decrease the natural food resources available to elephants.

Similar problems at the human–elephant interface exist across much of the remaining range of Africa's elephants, and a number of studies have demonstrated that the prognosis for co-existence is often low. Richard Hoare (1999) has demonstrated that when humans and elephants do co-exist, conflict is greatly reduced when the grain of human and elephant distribution is large, that is, when large rather than small blocks of land are divided into human-dominated and elephant-dominated areas. This insight has important consequences for land-use development plans, including conservation, particularly in such an ecologically challenging region as the Gourma.

Recommendations

There is a need for a national elephant strategy. This will give the Wildlife Department influence in dealing with their own and other ministries. IUCN already has a regional planning office in Ouagadougou with support staff who can help draw up this plan. The need for such a document is much greater in the circumstances of West Africa and the francophone system of government than it would be in East Africa, with more entrenched and more powerful wildlife departments linked to thriving wildlife-based tourism. All that is needed now are the funds for a short-term consultant to draw up this plan in discussions with DNCN, which would draw on this report and all previous reports for the facts and convert them into a strategy. With a strategy in hand, environmental threats to the survival of these elephants can be confronted and compromises worked out with development planners that will permit the elephants a future.

Since the human-elephant relationship is very delicate, further analysis needs to be done that relates the elephants' ranging patterns to vegetation, livestock, agriculture, rainfall and habitat type. A study should be made that would help to predict future conflicts and plan to mitigate the conflict and lead to resolution. A more detailed and continuous monitoring of relevant environmental factors should be part of the strategic approach to elephant conservation and the protection of the ecology of the Gourma area.

Currently two large-scale development projects are planned for the Gourma: first, the Mali Arid Rangeland Biodiversity Conservation Project of the Global Environment Facility (GEF), and second a hard-surfaced road from Douentza to Bambara-Mouande, which will provide a direct link to Timbuktu and pass through the western edge of the Gourma elephant range. Both projects may have profound impacts on human distribution and socio-economic development within the Gourma—and therefore on the environment, including elephant ecology and conservation.

The GEF project is tightly linked to the political reforms taking place in Mali, which aim to move from a top-down centralized government to a decentralized administration. A goal of the decentralization programme is to ensure that the rural populations have better access to public services, to socio-economic infrastructures and to productive natural resources, within the framework of which the GEF project aims to ensure that communes of the Gourma can successfully conserve biological diversity in the mainstream in communal and intercommunal development. Clearly, it is a primary goal of any government of a developing nation to provide rural populations with the benefits and services that citizenship brings; however, the manner in which those benefits are introduced may put at risk the environment on which those developments depend and exacerbate the problems, not mitigate them (Sinclair and Fryxell 1985).

Despite the GEF project obviously well-intentioned objectives, from the perspective of elephant and rangeland conservation a number of storm clouds are gathered around the project and its associated planning documents for the Gourma region. The proposed GEF project is part of a broader World Bank initiative—the Country Assistance Strategy (CAS) to Mali. Within the CAS, GEF aims to provide 'support to competitive broad-based growth in the rural sector'. Furthermore, in its Interim Poverty Reduction Strategy Paper (IPRSP), the Bank 'ranks natural disaster as the primary cause of poverty in rural area and relates it to the fragility of the Malian ecosystems. IPRSP supports the rural development strategy whose specific goal is 1) to seek food

security in a manner that integrates the expansion, diversification and optimum development of production in agriculture, livestock, fisheries and forestry, and 2) increases the productivity and protection of the environment, within a sustainable natural resources management framework. IPRSP also supports the environment strategy whose basic challenge is to protect the ecosystem from harm and manage natural resources in such a way as to ensure the survival of populations and boost output.

Given the fragility of the Gourma ecosystem, it is difficult to envisage how the twin goals of expansion, diversification and optimum development of production in agriculture, livestock, fisheries and forestry can be accomplished at the same time as ecosystem restoration and wildlife conservation. The Gourma is being degraded because of over-exploitation and inappropriate exploitation of natural resources, and boosted outputs will simply exacerbate this situation to the detriment of humans and wildlife, including elephants. Thus rather than strive for ever-increasing production from marginal habitats, the recommendations of Sinclair and Fryxell (1985) as modified in the context of the Gourma by Jachmann (1991) would seem the most appropriate strategy to bring sustainable ecosystem management to the region. Verbatim from Jachmann's report, these are as follows:

- Some people must be removed from degraded land to new areas, where they must be educated and helped to establish a rural economy suitable for that land.
- Cattle herds should be severely restricted.
- Once the degraded land has recovered, a modified migration or rotational grazing system should be installed.
- Wells should only be constructed if they do not harm the migration system.

The road link from Douentza to Bambara-Mouande to the west of the elephant range has considerable negative implications for the Gourma elephants and for the Gourma ecosystem. The socio-economic benefits and negative ecological consequences of roads have been widely discussed. In summary, roads create opportunities for trade and commerce, which attract people and improve living standards. Roads link population centres and market economies, which can rapidly transform subsistence-based resource exploitation and economies into market-based systems, which rapidly drive local exploitation to unsustainable levels (large literature reviews in Wilkie et al. 2000; Gucinski et al. 2001). Roads quickly become centres of permanent human population growth, which in rural communities increases sedentary agriculture at the expense of hunter-gatherer or nomadic lifestyles. The Douentza road will be particularly attractive to local peoples as a settlement option since it will have boreholes located regularly along its length. All these factors indicate that permanent road development within the Gourma elephant range will increase the sedentary human population and encourage agriculture at the expense of traditional nomadic lifestyles suitable for the ecosystem, with obvious negative consequences for both. Specifically concerning elephants, not only will this road and its associated developments reduce the habitat available to them, but it will also lead to human–elephant conflict in an area where none exists today.

An obvious, though costly, solution to this problem would be to move the route of the road farther west beyond the ecological limit to elephant movements. With no permanent or seasonal waterholes to sustain elephants to the west, it would seem that moving the proposed road west a distance of ca. 75 km would be sufficient, as it would be impossible for elephants to gain access to it from their seasonal base at Banzena. With no water on a round trip of 150 km,

the Gourma elephants would be unable to reach crops grown along the road and therefore would not come into competition with humans. Thus human development could continue to improve but not at the expense of elephant range and the good will of local people. Large-scale socio-economic development within the Gourma that would result in greater human settlement, crop production and resource use can only have detrimental and potentially catastrophic consequences for elephants. Carefully planned development that separates sedentary people and elephants on a coarse-grained scale will be positive for both, and is likely to be the only option if the last Sahelian elephants are to survive.

In practical terms, if the elephants are to be conserved it is essential to continue monitoring them. Since the population is so small it is recommended that the whole population should be identified, each elephant individually by a researcher who should take photographs of each elephant and organizes a photo file. Equipped with modest resources such a researcher would be able to record all births and deaths and alert the wildlife authorities to any changes in the elephants status. By studying their feeding behaviour and relationships with people such a study would define their essential needs and provide this information to development planners to ensure that the elephants continue to access the minimum requirements for their life.

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Appendix

Data on collar attachments (supplied by Anne Orlando), and recovery of memory modules

Date	Name	Sex	Mean age estimated	Frequency	Longitude dec degrees	Latitude dec degrees	Place name	Comments
Billy Karesh as vet								
12-Feb-00	Ahni	f	33	160.124	1.921	15.549	NW side of Soudomezed	recovered
17-Feb-00	N/A	f	35	160.044	2.317	15.722	In Damane W	died
20-Feb-00	Amali	m	43	160.145	2.577	15.651	Banzena	not recovered*
22-Feb-00	El Mehedi	m	27	160.203	2.573	15.637	Banzena	recovered
24-Feb-00	Amawad	m	15	160.185	N/A	N/A	N/A	not recovered
Sybille Quandt as vet								
20-Mar-00	Lala	f	17	160.065	2.490	15.671	Banzena	not recovered
21-Mar-00	Doppit Gromoppit	f	19	160.025	N/A	N/A	In Segueran	recovered
24-Mar-00	Fatimatah	f	25	160.105	2.575	15.636	Banzena	not recovered
27-Mar-00	Billy Ba	m	33	160.164	N/A	N/A	Gossi	not recovered

N/A – data not available
* This elephant most likely had the blank collar without modules that was recovered.

Abbreviations and acronyms

AfESG   African Elephant Specialist Group

CITES   Convention on International Trade in

      Endangered Species of Wild Fauna and Flora

DNCN   la Direction Nationale de la Conservation de la Nature

GEF   Global Environmental Facility

GPS   global positioning system

IUCN   The Worldwide Conservation Union

MCP   minimum convex polygons

MIKE   Monitoring the Illegal Killing of Elephants

STE   Save the Elephants