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Elephant movements and home range determinations using GPS/ARGOS satellites and GIS programme: Implication to conservation in southern Tanzania.

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Abstract

Satellite tracking of elephants was carried out in order to determine their home ranges and movements in southern Tanzania in view of incorporating such information in a wider conservation programme, which is carried out in the Selous-Niassa Corridor (SNWC). Ten elephants (2 cows and 8 bulls) from different areas of the SNWC were radio-collared and tracked for periods varying from 8 to 24 months. One radio-collar attached to the cow did not function. Home range sizes varied between 328 and 6,905 km^2. Observed home range sizes fell into three categories: Small home ranges (328 to 576 km^2, n=3), medium home ranges (1494 to 3,135 km^2, n=3) and large home ranges (from 4,421 to 6,905 km^2, n=3). Elephants with small home ranges spent their time mostly in areas between the Selous Game Reserve and the adjoining buffer zone at the northern end of the study site. Elephants with medium sized home ranges stayed in the central areas of the study site and occasionally visited Sasawara Forestry Reserve. Elephants with large home ranges moved across the central and southern sections of the study area, with cross-border movements between Tanzania and Mozambique, and within Mozambique. This study confirms important elephant habitats outside Selous and Niassa Game reserves and confirms cross border movements of elephants between Tanzania and Mozambique. These data support the importance of protecting the area as an important elephant range and corridor, linking two of the largest protected areas in Africa, the Selous and Niassa Game Reserves in Tanzania and Mozambique, respectively.

Key words: elephant, home range, and migration corridor.

1: Introduction

In many African countries, the current threat to the survival of elephant populations is loss of suitable habitats. The increase in human population and expansion of human related activities has drastically decreased the available habitats to the extent that the elephants are forced in small isolated pockets of protected areas. Usually, dense human populations surround the remaining habitats making frequent contacts between people and elephant common (Campbell and Hofer, 1995, Runyoro, 2000). Because of this association, many forms of human wildlife conflicts are at large. It is therefore likely that the small habitats remaining as protected area may not have sufficient resources necessary to support elephant population year round or during the period of scarcity, such as drought. The shrinkage and fragmentation of habitats creates smaller and more isolated animal population, which are more vulnerable to local extinction due to stochastic events (Soule and Gilpin, 1991). Isolated animal groups may have trouble to maintain their genetic diversity and likely to experience in breeding depression (Fahig and Merriam, 1994). In breeding in mammals has been found to cause reduction of fecundity and survival, especially for infants. Such situation is likely to happen when there are no corridors of appropriate habitat for the migratory mammalian species to move through (Fiedler and Jain, 1992). This is because barrier to dispersal limits species potential to colonization and foraging ability for food resources.

Recent studies on population dynamics and population genetic model in stochastic environments show that animals of isolated wildlife populations may not be able to mate freely. This can lead to decrease in fitness, rapid genetic erosion, population decline and loss of biodiversity. This scenario explains the role of wildlife corridors and dispersal areas in protected area paradigm. The use of effective system of wildlife corridors is therefore useful in providing ecosystem connectivity, which is essential in avoiding the loss of species both within and outside protected areas (Soule, 1987). In recent times, maintaining connectivity of several habitat patches by corridors is believed to decrease the deleterious consequences of habitat fragmentation (Saunders and Hobbs, 1991). Corridors are essential in the survival of wild animals as they migrate from one ecosystem to another in search of food, water, shelter and space (WPT, 1998). The major challenge to the corridor concept lies on sustaining both increasing wildlife and human population.

In Tanzania, wildlife corridors have been vulnerable due to land use changes adjacent to them. The increase of human activities such as settlement and farms in areas previously used by wild animals for migrations has led to more and more traditional migration routes being cut off. Protected areas in Tanzania are therefore in danger of becoming isolated islands (Borner, 1985, Mwalyosi, 1991, Newmark, 1996, Kamenya, 2000, Noe, 2003). This study was carried in order to determine the elephant home range and movement patterns The data obtained were used to define an area that required protection as a wildlife corridor in particular with respect to elephant movements, in order to assist the preservation of the genetic viability and persistence of two of the largest elephant populations in Africa and the implementation of attempts to minimize conflicts between wildlife and local communities.

2: Material and Methods

2.1: Description of the study site

The Selous-Niassa Wildlife Corridor (SNWC) lies in southern Tanzania and is located north of Niassa Game Reserve in Mozambique. The Ruvuma River, the international boundary between Tanzania and Mozambique, separates the corridor from the Niassa Game Reserve. The corridor lies within the administrative unit of Ruvuma Region in the two Districts of Songea Rural, now renamed Namtumbo (major western section of SNWC) and Tunduru (smaller eastern section of SNWC). In total the SNWC covers approximately 6,000 – 8,000 km^2 and extends approximately 160-200 km in north-south direction (Figure 1). The area is mostly covered by miombo woodland and wooded grassland, and there are substantial areas of open savannah, seasonal and permanent wetlands and riverine forests along numerous rivers and streams. The Corridor receives rain during a single period from late November to April and May with an average of 800 – 1,100 mm per year. The Songea-Tunduru road via Namtumbo and Kilimasera forms the watershed between the northern and southern sections of the Corridor. The Mbarangandu River and its tributaries drain towards the north into the Selous Game Reserve towards Kilombero and the Rufiji River system. In the southern section, rivers such as Sasawara, Lukimwa, Nampungu and Msangesi drain into the Ruvuma River. The landscape consists of plains, valleys, undulating topography and Inselberg Mountains at altitudes between 400 m at the Ruvuma River and 1,283 m in the Mtungwe Mountains. The most important ranges are Mtungwe (1,283 m), Changalanga (901 m) and Kisungule (688 m) mountains; other prominent ranges occur in the southern section of the Corridor. There are 17 villages in the northern section of the SNWC of which 9 villages are directly linked with the corridor and the rest forms a continuous buffer with the SGR. Most of their land is currently managed by a series of Wildlife Management Areas run by the local people as part of the SGR buffer zone project guided by the Wildlife Division and the Community Based Conservation programme. In the southern section of the SNWC are 12 sparsely populated villages where Wildlife Management Areas do not currently exist and (with the exception of the Sasawara Forest Reserve) other forms of protection are currently not available.

2.2: Study methods

In order to track movements of elephants in the corridor, 10 elephants were collared with GPS/ARGOS satellite telemetry system devices (Telonics, Arizona USA) as described in details by Mpanduji et al. (2003). The fitted electronic devices included: A GPS receiver for highly accurate records of the latitude and longitude of the elephant's location at pre-set intervals to an accuracy of better than 100m; An ARGOS satellite communication unit that broadcasted the GPS records to the low-orbit ARGOS satellite at regular, pre-set intervals, and thus enabled the remote downloading of location data; A VHF component that permitted elephants to be located using conventional radio-tracking techniques (over distances of 3-4 km on the ground or up to 40km using aircraft).

The ARGOS satellite received information broadcasted by the elephant collar and passed all information to the ARGOS ground station in France. The ARGOS satellite system was in this case was used as a system to relay information in addition to providing an estimate of the current location of the transmitter. ARGOS ground station then transferred the information by e-mail to the receiving computer where the data were processed. The extracted locations were used for analysis of animal movements and home ranges determination. Home range sizes were calculated using a special module available for Arc View (Hooge and Eichenlaub, 2000

3: Results

3.1: Elephant home ranges

Nine elephants were tracked for periods varying between 8 and 24 months, covering several natural seasons. One radio-collar did not function at all. The estimated home range sizes the nine elephants are summarized in Table 1

Home range sizes as calculated by the MCP method (Table 1) varied from 328 to 6,905 km^2. Elephants that were radio-collared in the northern section of the Selous-Niassa wildlife corridor (the Mbarangandu-B and D, and the Likuyu-F) had smaller home ranges than the elephants radio-collared in the central and southern sections of the Corridor. The Msanjesi-J bull (radio-collared in the central area), the Ndalala-H and the Mkasha-G bulls (radio-collared in the southern section) along the Ruvuma River had the largest home ranges. Figure 1 shows the distribution of the home ranges as defined by the MCP method in relation to the location of villages, previously recorded elephant migration routes and all the protected areas in the vicinity of or within the Selous-Niassa Wildlife Corridor.

Several information was derived from the results on the location and size of elephant home ranges in the Corridor:-

(i) Some elephants (both males and females) maintained small or small to medium-sized home ranges throughout the year and should be classified as truly resident, non-migratory animals.

(ii) Home ranges were oriented in both north-southerly direction, expected if animals use the Corridor principally as a transit area or simply follow the main drainage patterns, and in east-westerly direction, more compatible with the idea of a resident existence.

(iii) Some individual home ranges cover a large section of the corridor, covering an area from the Songea-Tunduru road that divides the Corridor into the smaller northern and larger southern section to areas south of the Ruvuma River.

(iv) Several animals spent time regularly inside the Corridor and the adjacent Game Reserve, the Selous in the north and the Niassa in the south.

(v) Large breeding bulls frequently switched between the southern sections of the Corridor and large parts of the Niassa Game Reserve inside Mozambique.

(vi) During the wet season, home range sizes as calculated by the MCP method varied from 181 to 4,562 km^2 ($n = 8$). Home range sizes for the dry season varied from 312.5 to 6,784 km^2 ($n = 8$). There were no apparent significant differences between wet and dry season home range sizes. One bull was tracked across two full wet seasons, the inclusion of locations from the second wet season led to a modest increase of total home range size by 2.2%, suggesting that the animal was truly resident and that there was little change in home range use between subsequent wet seasons.

4: Discussion

4.1: Elephant movements and home range

Previous status survey of African elephants by Said et al. (1995) and Barnes et al. (1998) mentioned the possibility of cross-border movements of elephants between Tanzania and Mozambique. The ground observations study by Mpanduji et al (2002) and this study confirmed nine such crossing points at which elephants from either side were observed to cross the Ruvuma River.

The three groups of elephants radio-collared in the northern, central and southern sections of the corridor showed distinct and different home range characteristics. The northern individuals had predominantly small home ranges, showed substantial degree of home range overlap and a modest overlap of their home range core areas. The central group had medium-sized home ranges, overlapped substantially but showed no overlap of the core areas of their home ranges. None of the four bulls radio-collared in the central section of the SNWC had its core area within the Sasawara Forest Reserve. The southern individuals had the largest home ranges, and yet showed the greatest overlap of their core areas.

Previously recorded home range sizes of African elephants varied from 15 to 8,700 km^2, a 600-fold difference, recorded in a wide variety of habitats by several methods across a range of African countries **(Table 2).** Discussions on explaining such variation considered differences in methodology, the absence or presence of what were considered migratory movements as a consequence of marked seasonal environmental changes, differences in the productivity of habitats, and the protected status of some of the areas where elephants were tracked. For instance, all elephants previously reported to have small home ranges were only found in protected areas. In comparison, the results from this study demonstrate substantial range variation within the same study population, namely a 20-fold variation in range size, from fairly small (328 km^2) to large ranges (6,905 km^2), in one habitat, and that was a habitat – miombo woodland – not previously studied. Whether such variation in one study area was a consequence of improved technology, studying elephants in a novel habitat type or an increased sample size remains presently unclear. Alternatively, it may reflect differences in space use strategies between individuals that by the standards of other studies would be classified as resident and migratory, respectively.

In terms of movement patterns, elephants in the present study might be classified as residents (in the northern and central sections of the SNWC), and partially migratory in the case of individuals moving extensively between Tanzania and Mozambique in the southern section. The results from satellite-based telemetry demonstrated extensive movement of elephants towards the end of dry season and limited mobility during the wet season. During this time, elephants appeared to stay at specific locations.

The extensive movements of elephants during the late dry season have previously been associated with a search for new growth and fruiting plants (Haltenorth and Diller 1986). During interview and village meetings (Mpanduji et al., 2002), elephants were reported to proceed from south to north between March and April and from north to south between June and December. However, this idea did not conform to the results from the present study where southward movements of one radio collared individual was observed earlier from January and continued until April, during which the elephant reached the Tanzania-Mozambique border but did not cross the Ruvuma river. The lack of ground based observations of specific radio-collared individuals during these times is likely to have contributed to the missing of the predicted large-scale movements of elephant herds previously reported by the villagers (Mpanduji et al., 2002).

4.2: Implication to conservation and challenges

At least some elephants in the Corridor, both males and females, are truly resident, non-migratory animals. The Corridor is therefore not just an area of transit for elephants between the two Game Reserves in the north and in the south but it also sustains its own sizable resident population. There are at least 2,400 elephants that are resident or use the Corridor part-time (CIMU, 2001), and the population appears to be currently expanding, with a healthy calf: female ratio and excellent values in terms of the reproductive quality of semen of breeding bulls (Hofer et al., 2004).

As the details of radio-tracked movements of individuals particularly in the centre of the Corridor indicated, the biological corridor stretches further in east-westerly direction than initially expected. The resultant bulges are useful in providing sufficient habitat to allow successful breeding, which may further act as sub-population. Bulges may also provide additional recruitment to the patches linked by the corridor (Lynch and Saunders 1991).

Some elephants make use of large sections of the Corridor by virtue of maintaining very large home ranges. The fact that there are conspicuous and well-established major elephant movement routes that cross the entire Corridor (Mpanduji et al, 2002). This suggests that some elephants may be entirely transient and use the Corridor to move between the adjacent Game Reserves. Hence, any fragmentation of elephant habitat in the Corridor would be a grave disadvantage.

Regular movements of animals between the Corridor and the adjacent Game Reserves, the Selous in the north and the Niassa in the south, emphasise the contiguousness of the habitat in terms of its conservation value, and underscores the value of the Corridor for the adjacent Game Reserves.

Large breeding bulls frequently move between the southern sections of the Corridor in Tanzania and large parts of the Niassa Game Reserve inside Mozambique. Not only does this emphasise the status of the Corridor as a true trans-boundary ecosystem, it also pinpoints the value of the Corridor as a link between the Selous and the Niassa elephant populations in terms of breeding and genetic exchange.

The major challenges facing the conservation of the Corridor is the development activities in the corridor and the human wildlife conflicts. At present, one prominent settlement (Semeni) has been established along the crucial animal migration route of the Selous-Niassa Wildlife Corridor across the Ruvuma River. The residents of this settlement are engaged in agriculture and other human activities that are threatening the continued existence of the corridor. Negotiations are carried out between the District and the Semeni inhabitants for the possibility of relocation to another area.

It has been shown that, the number of elephants and other wild animals are increasing in the corridor because of conservation efforts. It is expected that, the conflict between wild animals and people will increase. This may in the long run impart a negative attitude towards conservation especially if wild animals damage much of the cultivated crops and other human properties.

4.3: Way forwards:

The land use plan which is to be implemented with the assistance of the SNWC project and other development partners will use the results of the elephant home range and movement data in order to identify the key habitats and important migration routes, which will be avoided for human settlement and development activities.

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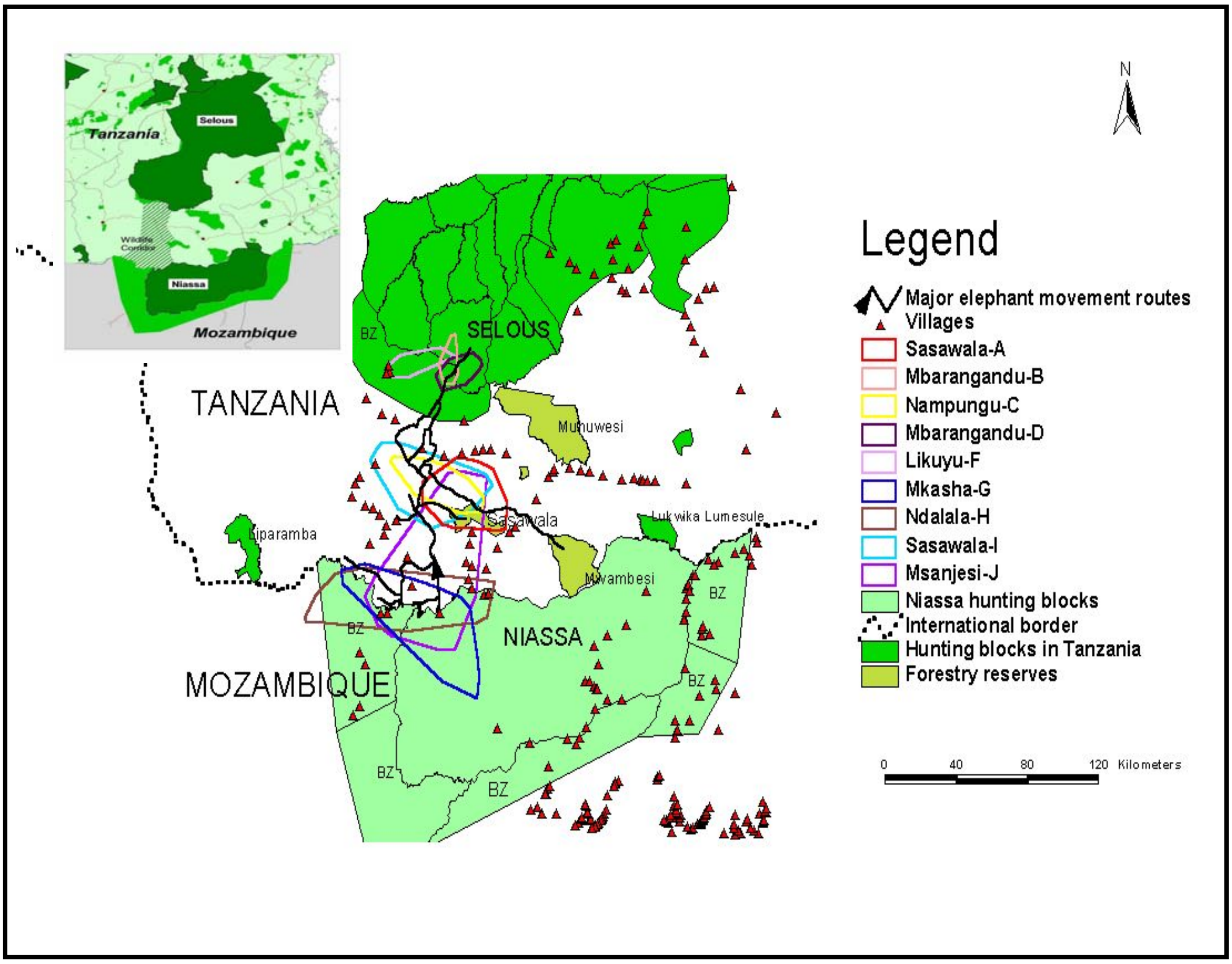

Figure 1: Home ranges polygons of nine radio-tracked elephants in relation to previously recorded elephant migration routes, the locations of villages and protected area in the Selous-Niassa Wildlife Corridor. BZ: buffer zones around Selous are separate from the Game Reserve, around Niassa are part of the Game Reserves. The small map insert shows the position of the SNWC in relation to the Selous Ecosystem.

Table 1: Home range sizes of radio-tracked elephants in the Selous-Niassa Wildlife Corridor, as calculated with the minimum convex polygon, kernel and Jennrich-Turner methods.

Elephant Identification	Total home range by various estimation methods (size in km^2)				
	MCP	Kernel Home Range			Jennrich-Turner
	100%	95%	75%	50%	95% ellipse
Sasawala-A	2369.4	1485.3	390.3	81.5	2495.9
Mbarangandu-B	328.0	238.5	99.6	35.6	309.9
Nampungu-C	1493.8	1098.0	277.3	106.3	1889.9
Mbarangandu-D	548.8	201.1	54.5	20.8	316.6
Likuyu-F*	576.3	1197.6	591.1	290.2	1192.8
Mkasha-G	4420.8	2449.4	750.0	165.3	3985.1
Ndalala-H	4610.1	4057.0	1427.2	698.6	5610.1
Sasawala-I	3134.9	1553.2	333.3	79.6	3773.3
Msanjesi-J	6905.1	2663.2	419.4	180.7	7728.8
Means ± SE	2709.5±753	1660.4±410	482.5±138	184.3±70	3033.6±833

*The home range estimate for this animal should be treated with caution because of the small sample size (n= 25). Both MCP and KHR are sensitive to sample sizes (Arthur and Schwartz, 1999, Seaman et al., 1999).

Table4: Home range sizes of African elephants

Study area	Country	Study method	Home range size (km^2)	Reference
Lake Manyara NP	Tanzania	Individual recognition	15-52	Douglas-Hamilton (1971, 1973)
Tarangire NP	Tanzania	Individual recognition	330	Douglas-Hamilton (1971)
Serengeti NP	Tanzania	Individual recognition	> 330	Douglas-Hamilton (1971)
Tsavo West NP	Kenya	Individual recognition	350	Leuthold & Sale (1973)
Kruger NP	South Africa	Individual recognition	436	Hall-Martin (1984)
Tsavo NP	Kenya	Individual recognition	1,532	Leuthold (1977)
Tsavo East NP	Kenya	Individual recognition	1,580	Leuthold & Sale (1973)
Northern Namib Desert	Namibia	Individual recognition	1,763-2,944	Viljoen (1989)
Laikipia Samburu	Kenya	VHF radio collars	102 – 5,527	Thouless (1996)
Amboseli NP	Kenya	VHF radio collars, aerial surveys	2,756; 3042; combined 3,588	Western & Lindsay (1984)
Waza NP	Cameroon	Argos satellite collars, VHF radio and visual observations	785-2,534	Tchamba et al. (1994)
Etosha NP	Namibia	Argos satellite collars	5,800-8,700	Lindeque & Lindeque (1991)
Tarangire NP	Tanzania	GPS satellite collars	159-660 (N) 2,104-3,314 (S)	Galanti et al. (2000), TMCP (2002)
Selous-Niassa Wildlife Corridor	Tanzania	GPS/ARGOS satellite collars	328 – 6905	This study

NP – National Park; N – north; S – south