Changes in forest fragment sizes and primate population trends along the River Tana floodplain, Kenya

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Abstract

The Tana River forest patches significantly decreased in total area by 1875 ha (34.5%), from 5439 to 3564 ha between 1979 and 2000. The area covered by forests outside the Tana River Primate National Reserve declined by 1246 ha (38%) from 3283 to 2037 ha. This loss was higher than that inside the reserve, where total forest area reduced by 629 ha (29%) from 2156 to 1527 ha. The numbers of Tana River red colobus (*Procolobus rufomitratus*) and Tana crested mangabey (*Cercocebus galeritus galeritus*) groups were significantly correlated with forest sizes suggesting that both red colobus and crested mangabeys are likely to be affected by forest loss and fragmentation. However, comparison of the 1974/75 and 2001 census data did not reveal any significant change in the number of groups of either the red colobus or crested mangabey. The two endangered primates may have developed strategies to cope with a shrinking habitat.

Key words: forest sizes, primate population trends

Résumé

Entre 1979 et 2000, la taille des parcelles de forêt du fleuve Tana diminua de 1875 ha (34.5%), passant de 5439 ha à 3564 ha au total. La superficie forestière en dehors de la réserve naturelle Tana River diminua de 1246 hectares (38%), descendant de 3283 à 2037 hectares. Cette perte fut plus élevée que celle au sein de la réserve, où la superficie forestière diminua de 629 ha (29%), passant de 2153 à 1527 hectares. Le nombre de groupes de singes rouges colobus de la Tana (*Procolobus rufomitratus*) et de mangabeys de la Tana (*Cercocebus galeritus galeritus*) furent en rapport étroit avec la taille forestière, ce qui laisse supposer que les deux espèces seront très probablement atteints par les pertes forestières et la fragmentation. Néanmoins, une comparaison des données des recensements de 1974/75 et 2001 ne montre aucun changement important dans le nombre de groupes de singes rouge colobus, ni mangabeys. Il se peut que ces deux primates menacés aient développé des nouvelles stratégies pour faire face au rétrécissement de leur habitat.

Introduction

The gallery forest patches along the lower reaches of the river Tana in the coastal region of Kenya are home to several primate species: the Tana river red colobus (*Procolobus rufomitratus*), the Tana crested mangabey (*Cercocebus galeritus galeritus*), yellow baboon (*Papio cynocephalus*), lowland sykes monkey (*Cercopithecus mitis albotorquatus*), vervet monkey (*Cercopithecus aethiops*), Garnets galago (*Otolemur garnettii*), Zanzibar galago (*Galago zanzibaricus*) and Senegal galago (*Galago senegalensis*) (Butynski & Mwangi, 1994). The Tana river red colobus and crested mangabey are both endemic to these forest patches and are endangered (Marsh, 1978; Lee, Thornback & Bennet, 1988).

The occurrence of remnant forest patches surrounded by agricultural or grazing land is a common form of humanized landscape that is increasing with increase in human population densities (Onderdonk & Chapman, 2000), and this phenomena can be observed in the forests along the lower Tana (Butynski & Mwangi, 1994). The forests are currently threatened by increasing levels of fragmentation as a result of three major activities; overexploitation by the increasing human population, irrigation and a highly dynamic rivercourse (Butynski & Mwangi, 1994; Suleman *et al.*, 2001). The forests are being converted to cropland at an alarming rate by the resident Pokomo people who are changing from shifting subsistence cultivators to a more sedentary farming life-

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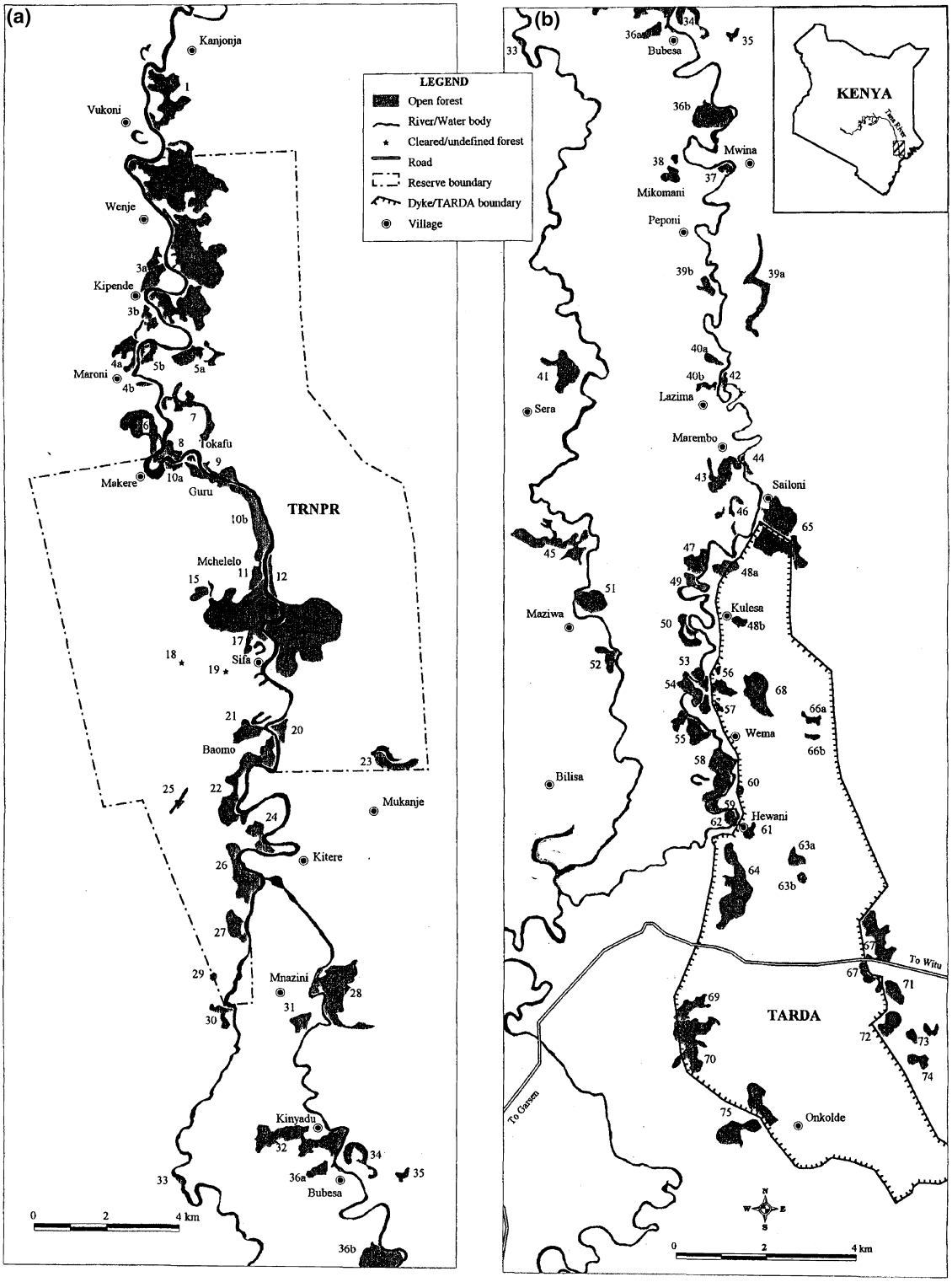

Fig 1 The distribution of Tana River forest fragments in which primate censuses were conducted. (a) TRNPR, Tana River National Primate Reserve; (b) TARDA, Tana and Athi River Development Authority's Tana Delta Irrigation Project (TDIP)

Fig 1 Continued

Forest name	Reference no.
Nkanjonja*	1
Wenje 1†	2a
Wenje 2†	2b
Wenje 3†	2c
Kipendi 1*	3a
Kipendi 2*	3b
Maroni west 1*	4a
Maroni west 2*	4b
Maroni east 1†	5a
Maroni east 2†	5b
Makere west*	6
Kwechi†	7
Makere east†	8
Guru east†	9
Guru north†	10a
Guru south & central†	10b
Mchelelo Complex†,‡	11, 13, 14, 17
Mchelelo east†	12
Unnamed woodland†	15
Sifa east†	16
Maridadi†	18
Hadribu†	19
Baomo east†	20
Baomo north†	21
Baomo south†	22
Lemu†	23
Kitere†	24
Kombeni†	25
Mnazini north†	26
Mnazini south†	27
Mnazini east*	28
Mnazini west*	29
Matalani north*	30
Munguveni*	31
Kiyandu west*	32
Matalani south*	33
Kinyandu east*	34
Bubesa east*	35
Bubesa west 1*	36a
Bubesa west 2*	36b
Mwina west*	37
Mikameni*	38
Peponi east*	39a
Peponi west*	39b
Lazima north*	40a
Lazima south*	40b

Fig 1 Continued

Forest name	Reference no.
Sera*	41
Lazima east*	42
Marembo west*	43
Marembo east*	44
Giritu woodland*	45
Sailoni 1*	46
Sailoni 2*	47
Kulesa east 1§	48a
Kulesa east 2§	48b
Kulesa west 1*	49
Kulesa west 2*	50
Maziwa north*	51
Maziwa south*	52
Wema west 1*	53
Wema west 2*	54
Wema west 3*	55
Wema east 1§	56
Wema east 2§	57
Hewani west 1*	58
Hewani east 1*	59
Hewani east 2§	60
Hewani east 3§	61
Hewani west 2*	62
Hewani south 1a§	63a
Hewani south 1b§	63b
Hewani south 2§	64
Bvumbwe north§	65
Bvumbwe south 1§	66a
Bvumbwe south 2§	66b
Lango la Simba§	67
Wema east 4§	68
Mitapani 1§	69
Mitapani 2§	70
Daruka Karicho 1§	71
Daruka Karicho 2§	72
Daruka Karicho 3§	73
Daruka Karicho 4§	74
Onkolde§	75

*Other forests in lower Tana River.
†Forests within TRNPR.
‡The forest complex comprised of Mchelelo west, Congolani central, Congolani west and Sifa west forests.
§Forest within (Tana and Athi River Development Authority) TARDA region.

style. Many of the tree species, e.g. *Ficus* sp, that are important to the endangered primates found within the reserve are also vital to the local communities for construction of canoes, poles and other wood products (Medley, 1990; Kahumbu, 1992). The River is also characterized by an ever-changing river course. Its seasonal flooding regime and the shifting channels result

in the formation of isolated inland ox-bow lakes (Hughes, 1990). Forests along the old riverbed dry up and become senescent while new forests are established along the new river bank. Sometimes forests are flooded for extended periods and most canopy trees fall or die off resulting in open canopy forests (Wahungu, 2001). The River has changed its course five times between Hola and Garsen (Butynski & Mwangi, 1994), producing a dynamic mosaic of forest patches in various stages of succession.

Moreover, dyke construction for irrigation in the lower course of the Tana River by the Tana and Athi River Development Authority (TARDA) has had a profound impact on the forests in the region (Butynski & Mwangi, 1994). Medley (1993) reported that forest loss, fragmentation, and subsequent reductions in the area-to-perimeter ratio are partially responsible for the decline in primate populations in the Tana River area.

Although primate censuses have been conducted in the lower Tana forests since 1972 (Groves, Andrews & Horne, 1974), in which 27 forests were visited, Marsh's 1975 census (Marsh, 1978, 1986) were the first detailed census covering 59 (77%) of the 77 known forest fragments. This survey has been used in later censuses as the baseline against which to assess population trends in these two primates. Butynski & Mwangi (1994), using the same census method covered 60 (78%) of the forests fragments.

Primates are valuable subjects for examining the effects of fragmentation, because they have specific responses to fragmentation (Estrada & Coates-Estrada, 1996; Tutin, White & Mackanga-Amissandzou, 1997). Many are endangered or threatened, making it critical that the threats to their survival be better understood (Onderdonk & Chapman, 2000). In this paper, we use results of a primate census conducted in 2001 (Suleman *et al.*, 2001), using the same method and covering 73 forests (Fig. 1). We estimated changes in forest sizes between 1979 and 2000 and compared that with population trends of both red colobus and crested mangabeys within that period. It was not possible to collect reliable data on group sizes and composition under the circumstances of the census and therefore all data analysed and discussed in this paper is on group counts.

Methods

A primate census was conducted using the quadrat census method (Struhsaker, 1981; Butynski & Mwangi, 1994) between January and March 2001 in 73 forest fragments along the lower River Tana, Kenya. The census team consisted of among others three primatologists who had also carried out the 1994 census (see Butynski & Mwangi, 1994). The team was divided into several observer units. The number of units per forest varied with the size of the forest. Each observer unit consisted of at least three people; one primate spotter/recorder, a guide and a third member taking records on plants. Primate censuses were conducted in the morning between 06.30 and 10.00 hours. and late in the afternoon between 15.00 and 18.30 hours.

Before the census started, the planning phase involved using existing maps, information from local guides and familiarity with a given forest fragment by members of the research team to determine forest sizes and shapes. This information was then used to plan census routes. At the start of the census, all observer units synchronized their watches, agreed on a start time, and arranged themselves along the forest edge in a straight line perpendicular to the length of the forest. All units would then, after start time walk parallel to one another at a preset inter-observer distance of either 50 or 100 m, depending on shape and size of forest, along predetermined census routes (see Struhsaker, 1981). The observers moved at an average speed of 1 km/h, making frequent stops to look and listen for primates.

When primates were encountered, records were made of the species, time at the beginning and end of encounter, minimum number of monkeys clearly seen, age and sex of monkeys clearly seen, tree species in which monkeys were first observed, the general direction of movement of monkeys and time at the end of the census.

Immediately after every morning or afternoon census, the census team discussed the results and summarized the data for each forest. Counts within forests were repeated whenever the census team felt that a particular forest was not adequately censused especially if observer teams lost direction and coordination. Forest fragments that were joined or close to one another such that primates were likely to move between them were censused the same morning or afternoon.

Satellite imagery covering the lower Tana forests for the year 2000 were digitized at the National Museums of Kenya GIS laboratory to estimate the current forest sizes. Ground truthing was conducted during the primate census using GPS receivers (Garmin Corporation, 1998), and walking around the forest, marking points along the edge that were later downloaded to produce the true forest shapes and sizes. Topographic maps (Ref No. 168/3, 179/

Table 1 Changes in forest sizes between 1979 and 2000

Forest reference no.	Forest area (ha) 1979	2000	Percentage decrease
1	168.8	84.2	50.1
2a,b,c	683.6	534.0	21.9
3a	55.9	37.4	33.1
3b	34.5	14.8	57.2
4a	69.1	30.9	55.3
4b	27.4	4.1	84.9
5a/b	133.6	54.3	50.1
6	135.9	68.2	49.8
7	85.3	48.4	43.3
8	49.3	19.2	61.1
9	33.6	17.1	49.1
10a	16.9	6.9	59.0
10b	74.4	90.7	−22.0
11,13,14,17	258.7	207.8	19.7
12	10.0	11.2	−12.0
15	12.0	12.3	−3.0
16	187.6	262.8	−40.1
18	7.1	0.0	100.0
19	16.4	0.0	100.0
20	73.7	14.2	80.7
21	46.1	30.2	34.6
22	261.4	99.0	62.1
23	29.3	27.8	5.3
24	35.7	25.2	29.4
25	11.5	1.9	83.8
26	61.3	60.3	1.5
27	68.2	27.7	59.4
28	127.9	115.0	10.1
29	61.2	3.4	94.5
30	72.5	15.5	78.6
31	7.1	18.5	−159.5
32	78.1	106.7	−36.7
33	240.3	2.3	99.0
34	9.1	28.7	−216.3
35	12.4	7.0	43.4
36a	57.8	15.2	73.7
36b	123.5	61.0	50.6
37	5.3	7.8	−46.7
38	19.4	20.7	−7.2
39a	145.0	55.0	62.1
39b	14.0	13.9	0.7
40a/b	40.1	15.0	62.7
41	204.1	59.0	71.1
42	15.5	8.9	42.6
43	48.6	49.2	−1.3
44	29.4	5.3	82.0
45	327.5	79.2	75.8
48a	68.1	19.3	71.7
49	24.0	11.1	53.8
51	61.2	43.5	28.9
52	40.0	21.3	46.8
53	9.6	7.6	20.4
54	20.5	18.5	9.6
56	30.0	28.1	6.4
60	7.9	4.2	46.7
62	9.3	10.1	−8.2
63	20.1	15.6	22.3
64	105.0	116.4	−10.9
65	260.6	136.5	47.6
66	8.9	9.5	−7.2
67a	86.4	79.2	8.3
68	58.1	63.2	−8.9
70	105.3	76.7	27.2
71	38.4	22.9	40.5
72	12.6	28.6	−127.6
73	3.6	28.6	50.1
74	4.8	16.1	−232.2
75	31.3	100.6	−221.1

The following forests have been excluded from the analysis because of lack of reliable estimates of forest sizes for either 1979 or 2000: 46, 47, 48b, 50, 55, 57, 58, 59, 61, 69.

1,179/3) (Survey of Kenya, 1981a,b, 1981c), covering the study area were also digitized at the GIS laboratory and used to estimate the forest sizes in 1979.

Changes in forest sizes were analysed using paired sample *t*-test (Zar, 1996). Spearman rank correlation (Zar, 1996) was used to investigate the relationship between forest size and number of primate groups for each of red colobus and crested mangabey, while the Kruskal–Wallis test (Zar, 1996) was used to examine differences in the number of groups per forest for forests covered by all censuses conducted between 1974/75 and 2001 (Fig. 1). We analysed for the difference in the populations between 1974/75 and 2001 using Mann–Whitney test (Zar, 1996).

Results

Changes in forest sizes and primates

A total of 73 forests and forest patches were covered during the census (Fig. 1). Table 1 shows forest fragments' individually estimated sizes in 1979 and 2000. Total forest

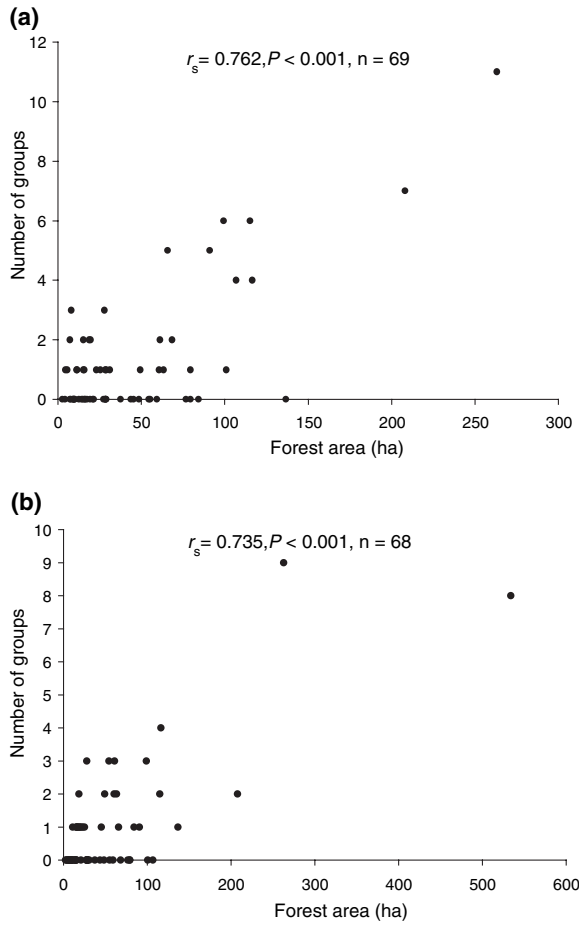

Fig 2 The relationship between forest size (ha) and the number of red colobus (a) and crested mangabey (b) groups

sizes significantly decreased by 1875 ha (34.5%) from 5439 to 3564 ha (Paired sample *t*-test, $P < 0.001$; n = 69). Forest sizes inside the reserve decreased by 629 ha (29.2%) (from 2156 to 1527 ha, $P = 0.02$; n = 21), whereas that outside the reserve lost 1246 ha (38%) (from 3283 to 2037 ha, $P = 0.005$; n = 48). Ten forests were excluded from the analysis because after ground truthing, it was discovered that the estimates for either 1979 or 2000 sizes were wrong.

The number of primate groups in a given forest was significantly correlated with the forest sizes estimated using data from 2000 (Spearman rank correlation: red colobus: $r_s = 0.762$, $P < 0.001$, n = 69; crested mangabey: $r_s = 0.735$, $P < 0.001$, n = 68) (Fig. 2), suggesting that both red colobus and crested mangabeys are likely to be affected by forest loss and fragmentation.

Distribution of primate groups within forests between 1972/74 and 2001

Trends in the number of groups of Tana River red colobus. There was a significant difference in the number of groups recorded per forest for all forests covered by all censuses between 1974 and 2001 (Kruskal–Wallis test: $P = 0.004$, d.f. = 5; Table 2). However, there was no significant difference in the total number of groups counted in 1974/75 and 2001 (Mann–Whitney test: $U = 112.5$, $P > 0.05$), although there was an apparent decline between 1985 and 1987 (Table 2). New sightings of twelve groups of colobus groups were recorded in ten forests. Of these, seven were forests where censuses had been carried out at least once since 1972/74, and in which we recorded nine groups. Three forests, 71, 72 and 75 had never been censused before and each contained one group of red colobus (Fig. 1).

We compared trends on groups counted in each forest between 1972/74 and 2001, in order to determine if some groups may have actually been lost from some forests. We assumed that groups of colobus might have been lost from a particular forest fragment if these groups had not been observed or reportedly seen during the last three censuses. Using this criterion, we estimate that at least six groups have been lost in the said period. Of these, two groups were lost from forests inside the reserve (Maroni East and Guru East), labelled 5a and 9 respectively on Fig. 1, and at least three from inside TARDA managed land (Wema East 1, 56; Hewani East 3, 61 and Mitapani 1, 69), (Fig. 1; Table 3).

Trends in the number of groups of Tana River crested mangabey. There was no significant difference in the number of groups of crested mangabeys recorded per forest between 1974 and 2001 (Kruskal–Wallis test: $P > 0.05$, d.f. = 5; Table 2). There was also no significant difference in the total number of groups counted in 1974/75 and 2001 (Mann–Whitney test: $U = 107$, $P > 0.05$). We reported six new mangabey groups distributed within five forests, all outside the TRNPR, two of which (Daruka Karicho 1, 71 and Daruka Karicho 4, 74; Fig. 1) had never been covered in previous censuses. Two others, Bvumbwe North (65) and Wema East 4 (63a) are on TARDA managed land while Lazima North (40a) and Lazima South (40b) are on communal land (Fig. 1).

Between four and seven groups appear to have been lost from seven forests between 1975 and 1989 (Table 3). All

Table 2 Distribution of red colobus and crested mangabey groups in selected forests in the lower Tana between 1974 and 2001

	Census year											
	2001		1994		1987		1986		1985		1974/75	
Forest	Col	Mag	Col	Mag	Col	Mag	Col	Mag	Col	Mag	Col	Mag
Kipendi W.	0	0	1	0	1	0	1	0	1	0	1	0
Maroni W.	1	0	2	0	1	0	0	0	0	0	2	0
Makere W.	2	0	2	0	1	0	1	0	1	0	1	0
Guru N.	2	0	1	0	1	0	Nc	Nc	Nc	Nc	Nc	Nc
Guru S.	5	2	3	3	1	2	1	2	1	2	7	4
Mchelelo comp.	7	2	4	3	2	3	2	3	2	2	8	6
Maridadi	Nc	Nc	0	0	0	0	0	0	0	0	0	1
Hadribu	Nc	Nc	1	0	0	0	0	0	0	0	1	0
Baomo N.	Nc	Nc	1	1	0	1	0	1	0	1	3	2
Baomo S.	6	3	7	4	4	5	3	5	4	6	7	6
Kitere W.	1	1	1	0	0	1	0	1	Nc	Nc	2	0
Mnazini N.	1	2	4	1	2	2	2	2	1	2	3	2
Mnazini S.	3	3	3	1	1	1	2	1	2	1	3	2
Wema E. 1	0	0	0	0	0	1	1	2	0	–	0	2
Hewani W. 1	5	1	3	1	1	0	–	–	0	1	2	2
Hewani E. 1	1	0	1	0	1	0	1	–	0	0	0	0
Hewani E. 2	1	0	1	0	2	0	1	0	1	0	1	0
Hewani S. 1	1	0	1	0	1	0	0	0	1	0	1	0
Hewani S. 2	4	4	10	4	2	1	2	2	0	2	3	2
Total	40	18	46	18	20	17	17	19	14	17	45	29

Source: 2001 – this report.
1994 – Butynski & Mwangi, 1994.
1974 to 1987 – adopted from Decker & Kinnaird, 1992.
Col, colobus; Mag; mangabey; Nc, not counted, – groups not seen but known to be present; Mchelelo comp, Mchelelo complex.

Table 3 Forests that have lost at least one group of the two primates between 1975 and 1990

Primate specie/ Forest name	No.	1974	1975	1985	1986	1987	1989	1992	1993	1994	2001
Red colobus											
Matalani South	33	–	**1**	–	–	–	–	–	–	–	0
Maroni East 1 &2	5a/b	–	**1**	0	–	–	0	–	0	0	0
Guru East	9	–	**1**	**1**	–	–	–	–	0	0	0
Wema East 1	56	**0**	**1**	**0**	**1**	**0**	**2**	**0**	–	0	0
Hewani East 3	61	–	**1**	**1**	**0**	**1**	**1**	**1**	–	1	0
Mitapani 1	69	–	–	–	–	–	–	–	–	[(1)]	0
Crested mangabey											
Maziwa North	51	( )	–	–	–	–	–	–	–	–	0
Hewani East 1	59	( )	0	0	0	0	0	0	–	0	0
Hewani East 2	60	( )	0	0	0	0	0	0	–	0	0
Bubesa East	35	**0**	**1**	–	–	–	0	–	–	0	0
Bubesa West 1	36a	–	**1**	–	–	–	0	–	–	0	0
Matalani South	33	**0**	–	–	–	–	1	–		0	0
Wema East 1	56	**0**	**1**	**1**	**1–2**	**1**	**1**	**0**	–	0	0

Numbers in bold show the number of groups before they were lost; – indicate years when censuses were not carried out in the given forests; ( ) show reported group(s); Legend; [(1)] indicates reported solitary.

these groups have been lost from forests outside the reserve, three of which (Wema East 1, Hewani East 1, and Hewani East 2, 60; Fig. 1) are on TARDA managed land.

Discussion

Forest fragmentation isolates floral and faunal populations and impedes or prevents gene flow between forest patches (Marsh, 1978). Isolation may lead to local extinction especially in species that are represented by small populations such as colobus and mangabeys (See Lee *et al.*, 1988). Isolation of contiguous forest patches along the Tana river results from a number of factors, the most serious one being forest clearing for farming. A number of studies carried out on primates or forest habitat along the river Tana have highlighted the impact of subsistence farming on forest sizes and condition and its possible effects on the red colobus and crested mangabey (Marsh, 1978; Kahumbu, 1992; Medley, 1993; Decker, 1994; Suleman *et al.*, 2001). Our study shows that significant reductions in forest sizes have occurred between 1979 and 2000. Forest blocks are also increasingly becoming fragmented and primates isolated from contiguous populations.

Decker (1994) estimated that 56% of the forest within the reserve was lost and five large forests fragmented into fifteen small forest patches between 1960 and 1985. We estimated that 29% of forest was lost within the protected Tana River Primate National Reserve between 1979 and 2000. Decker (1994) also estimated that 69% of forests within the colobus' geographical range was lost between 1960 and 1969. Our estimate for this range between 1979 and 2000 is 35%.

Human and natural induced impacts on the forests along the lower Tana River vary from slash and burn to complete clearing of forests by man and from death of trees by senescence because of the effects of the dynamic rivercourse. Suleman *et al.* (2001) reported that of the human activities affecting the forests, tree cutting for building poles contributed to 22% of forest destruction compared with 16% for slash and burn type of clearing, and 12% for thatch (affecting *Phoenix* spp. and *Hyphaene* spp.). The other 50% destructive activities included light extraction and low level impact harvesting of forest products. Of the seventeen forests affected by changes in the rivercourse, eleven were affected by natural dieback as a result of drought and six were affected by flooding (Suleman *et al.*, 2001).

This study showed that the numbers of primate groups were significantly related to forest sizes implying that the two primate species are potentially affected by the fragmentation and reduction in forest sizes. The highest risk is in the unprotected forests outside the Tana River National Primate Reserve, where 54 and 44% of red colobus and crested mangabey groups were found by Suleman *et al.* (2001) and where 38% of the forest has been lost between 1979 and 2000.

Reduced forest sizes and fragmentation have far-reaching consequences for primate populations. Decker (1994) showed that demographic parameters such as group membership instability, high infant mortality, more multimale groups, extra groups, smaller home ranges, use of a large proportion of their range per day, and the higher proportion of mature leaves in the diet of red colobus at Mchelelo in Tana Primate Reserve may all be related to high population density as a result of reduction in forest size. Elsewhere, effects of habitat change on primate abundance or behavioural patterns have been documented by Struhsaker (1976).

To be able to live in fragments, perhaps a primate must have either a small home range or, if they have a large home range, the ability to move between patches (Onderdonk & Chapman, 2000). Survival in patches may be related to an ability to live on the edge of forest. As forests have a much higher ratio of edge to area than contiguous forest, ability to live on edges is a logical requirement for living in patches (Onderdonk & Chapman, 2000). Tana River colobus have small home ranges and no recorded ability of moving between patches (see Decker, 1994). Therefore the persistence of the colobus population in small fragments may be explained by several factors: evidence shows that the ability of colobines to live on edges may be related to a dietary preference for secondary growth (Onderdonk & Chapman, 2000). However, Decker (1994) observes that the extreme arboreal nature of the Tana red colobus inhibits their capacity to disperse from disturbed to less disturbed patches. In other studies (e.g. Rudran, 1973; Dunbar & Dunbar, 1974) compressed ranges have been found to relate highly to population density in colobines.

The results of this study are also consistent with those of Medley (1993) who examined the relationship between the abundance of red colobus and crested mangabey and the habitat conditions of ten forest patches within the Tana Primate Reserve. The findings of her study indicated that the abundances of both colobus and mangabeys were

highly correlated with the spatial characteristics of the forests. There were negative correlations between abundance and intra-forest disturbance, while abundance correlated positively with forest area and with area-to-perimeter ratio suggesting that changes in these attributes may have a significant impact on primate populations. Medley (1993) explains that although the two species are adapted to a dynamic riverine environment, they prefer interior forest patches and are susceptible to disturbance that reduces forest area or that increases forest edge and intra-forest disturbance.

Results from our census indicate a northern extension of the colobus range to Wenje on the east bank of river Tana from the former range at Maroni east forest (Andrews, Groves & Horne, 1975). Currently, the forest has been heavily affected by deforestation, losing 22% of forest cover after 1979 (Table 1), with a considerable portion of forest next to the river having been reclaimed for farmland.

Mangabey persistence in patches may in part be explained by the observation that frequent crop raiding constitutes a significant proportion of their foraging (Suleman *et al.*, 2001). The observation that primates living in forest patches probably do not subsist on food from trees alone and probably supplement by crop raiding is also reported by Naughton-Treves *et al.* (1998). We observed mangabeys crop raiding in at least four forests and recorded complaints from five different forest patches. Although home range size and a highly frugivorous diet are cited as factors limiting the ability of primates to live in forest fragments (e.g. Estrada & Coates-Estrada, 1996), some species are flexible in these parameters. Although mangabeys have a highly frugivorous diet and large home ranges, they have been reported to move between different forest patches (Wahungu, 1998).

We conclude that although the numbers of red colobus and crested mangabey groups were significantly correlated with forest sizes, suggesting that they were likely to be affected by forest loss and fragmentation, the two endangered primates may have developed strategies to cope with a shrinking habitat.

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