



The diurnal primate community of the Tanoé Forest: species composition, relative abundance, distribution, polyspecific associations and conservation status

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ABSTRACT

The Tanoé Forest is located within the original distribution area of the Miss Waldron red colobus (*Piliocolobus badius waldroneae*), the diana rolway (*Cercopithecus diana rolway*) and the white napped mangabey (*Cercocebus atys lunulatus*). These three monkey species are classified by IUCN among the 25 most threatened monkeys of the world. Surveys conducted in their believed distribution area in Côte d'Ivoire from 2004 to 2007 highlighted an advanced degradation of habitats, an intensive hunting activity and a subsequent local extinction of some primate species. Field survey conducted in the Tanoé Swamp Forest shown that there is an exception in this dramatic context since this forest still housing threatened species such as the Diana rolway, the white-napped mangabey, and other monkeys of conservation concern : the Geoffroy's colobus (*Colobus vellerosus*) and the olive colobus (*Procolobus verus*), and probably a viable Miss Waldron monkeys population (*Piliocolobus waldroneae*). In addition, this forest hosts the Lowe's guenon (*Cercopithecus campbelli lowei*) and the lesser spot-nosed guenon (*Cercopithecus petaurista petaurista*), that are widespread in the Tanoé Swamp Forest.

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INTRODUCTION

The coastal forest ecosystems from Guinea to Nigeria have been defined as a hotspot because it contains a high level of species diversity and endemism. It belongs to

the twenty five world's most threatened ecosystem (Myers et al., 2000). Côte d'Ivoire is part of this region and presents one of the highest diversity in primate species in West Africa with twenty three known species. One

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of them is endemic to the country and three others are endemic to both Côte d'Ivoire and Ghana. However, logging, hunting and human population growth have resulted unprecedented forest fragmentation and forest losses. Indeed, in 1957, the forest estate was estimated at 21 million hectares. In 1995, the area covered by forest was less than 2.8 million hectares (Yao et al., 2005). In addition to some environmental problems that this situation creates, we are witnessing the disappearance of many animal and plant species in most parts of the country. These species continue to be threatened even in national parks and reserves by intensive poaching and inappropriate conservation measures. Cowlshaw (1999) studied the potential relationship existing between habitat loss and population extinction. He suggested that this extinction occurred for over 30% of the forest primates in Africa. By considering the rate of deforestation and species loss, Côte d'Ivoire has the highest rates among the top five countries. These countries are predicted to lose 40-50% of their primate species.

The primates have been well studied in the western part of Côte d'Ivoire, particularly in the Taï National Park, where long-term field studies have been going on over years. Indeed, Taï Chimpanzee Project (TCP) and Taï Monkey Project (TMP) contribute to the preservation of the primate species occurring in this part of the country through ecological, ethological and genetic studies. However, in other parts of the country, studies on primates are scarce. Only rapid surveys have been conducted in the eastern part of this country (McGraw et al., 1998; Oates et al., 2000; McGraw, 2005; Gonédélé Bi et al., 2008; McGraw and Oates, 2009; Gonédélé Bi et al., 2010).

The South-central and eastern Côte d'Ivoire in the eastern part of the Upper Guinea forests hotspot are reported to be part of the original range of three critically

endangered primate species: the Diana rolaway (*Cercopithecus diana rolaway*), the white-napped mangabey (*Cercocebus atys lunulatus*) and the Miss Waldron's red colobus (*Piliocolobus badius waldronae*). However, no significant conservation effort has been carried out so far on behalf of these monkeys while by, they are increasingly threatened by human activities. Updates on the current distribution and conservation status of these primates and the identification of sites for primate conservation are urgently needed.

As result of these surveys, the Tanoé Forest has been identified as a priority site for endangered primates conservation in West Africa (Gonédélé Bi et al., 2008), since this forest inhabits several endangered species comprising *Cercopithecus Diana rolaway*, *Cercocebus atys lunulatus*, *Colobus vellerosus*. The Tanoé Swamp Forest may also represent the latest refugee of *Piliocolobus badius waldronae*, since there is strong evidence that the species has survived in this forest (McGraw, 2005). But, only five days were spent in this forest during the first study. The aims of this present survey are to (i) confirm the specific composition of the diurnal primate communities and (ii) determine the relative abundance of these species, (iii) their distribution in this forest, (iv) the poly-specific association in which they involve and identify (v) their conservation status. Thirty days survey period was conducted in this forest for this purpose.

MATERIALS AND METHODS

Survey site

The Tanoé Forest is located in the South-eastern corner of Côte d'Ivoire between latitudes north 5° 05' and 5° 15' and longitudes west 2° 45' and 2° 53' (Figure 1). The average rainfall in the region was 1925 mm per year (Avenard et al., 1971) but it has decreased considerably over the last five

years. It fluctuated between 1400 and 1600 mm per year. The temperatures range from 22° C to 30° C with an average of 26° C (Adou Yao, 2007). The Tanoé Forest is covered by evergreen forest vegetation on swamp ground. The forest is inundated most of the year. Even during the dry season (January, February and March), it is difficult to move through the forest without being trapped into the mud.

This forest is in the rural domain and does not benefit any measure of protection

from the authorities of Côte d'Ivoire. It owes its survival mainly from its swamp state that does not allow the villagers to grow crops, but also from its importance for these populations. Indeed, it constitutes the place of supply of the people in fish, bushmeat and various construction materials. For these reasons, the community has consistently opposed to all industrial institutions (forester, industrial farmers ...) wanting to use the forest

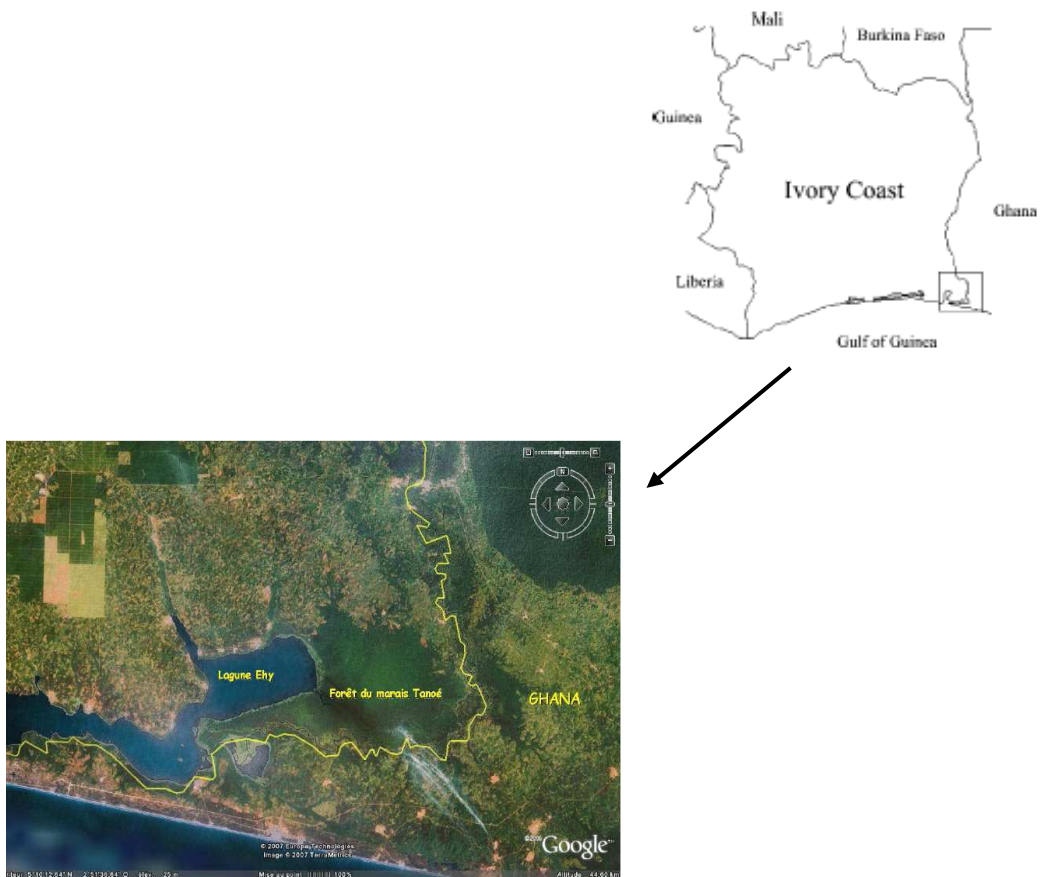


Figure 1: Location of the Tanoé Swamp Forest in South Eastern Côte-d'Ivoire.

Methods

Forest survey was made on foot consisting on walking slowly and quietly along old logging roads and existing paths with 0.8-1 km/hour. The mean distance traveled was about ten kilometers per day and the same walk was repeated twice on the daily basis. Two field works were conducted in the forest in 2007 (13-27th february 2007) and in 2008 (15th february to 25th march 2008) respectively. During the 2007 survey, two camps were established successively with four primatologists and eight guides. During the 2008 survey, a total of eight researchers and 16 guides were mobilized in two different camps simultaneously. Every morning four teams of three persons took different directions from each camp. Guide teams were constituted by former hunters transformed into forest guards by RASAP-CI. Each team changed its camp twice, a total of six camps throughout the forest were established, in order to prospect the majority of the forest. We took note of any visible and audible signs of the presence of primates and determined its position with a GPS. When animals were encountered during the surveys, we determined the species and counted individuals (when possible). We start early in the morning at 6h00 and continue until 1h00 p.m.. After resting for 1 hour we can then continue the exercise till 6h30 p.m.

Data analysis

Apart from the establishment of the distribution maps for different groups of monkeys observed, all other analysis consisted of calculating frequencies using Excel software. Thus, the distribution of groups was determined by recording the geographic coordinates of these groups that were then projected onto a base map of the forest using the software MapInfo Professional. Species identification was made directly on the field as all team members known very well monkey species. We also calculated the frequencies of encounter rate (number of observations per time of observation). Relative abundance was

calculated (number of groups per the distance covered to observe these groups and for the poly-specific association, only frequencies of associations have been calculated.

RESULTS

Specific composition of the primate community of the Tanoé forest

We confirmed the presence of seven diurnal primate species or subspecies in the Tanoé forest:

Three of them are critical endangered (Miss Waldron red colobus, Diana Roloway, White-napped mangabey), two are near threatened (Geoffroy white thighed colobus, Olive colobus) and two are common (Lowe's guenon, Lesser spot-nosed monkey). Except Miss Waldron's red colobus monkeys, several observations of different groups were done during the survey (Table 1).

The Lowe's monkeys (*Cercopithecus campbelli lowei*) are among the most widespread primates living in the Tanoé Swamp Forest. They can be found in all parts of the forest. A total of 123 groups have been identified in 155 observations during the surveys. The most observations were audible signs with 67.64% or visual signs (32.26%) (Table 1).

The Lesser spot-nosed monkey (*Cercopithecus petaurista petaurista*) and the Campbell's monkeys represent the most widespread primate taxa in the Tanoé Swamp Forest. We observed 71 groups of this monkey in 82 signs, N = 52 (63.41%) were visual against N = 30 (35.19%) audible observations (Table 1).

New evidence of the Miss Waldron Red Colobus (*Piliocolobus badius waldronae*) suggests that this species still existing in the Tanoé Swamp Forest. Only few vocalizations were heard by some members of the teams during the surveys in the most wet part of this forest, near the lagoon.

We identified 69 groups of the Diana roloway monkey (*Cercopithecus diana roloway*) in 85 observations. To date, only the Tanoé Swamp Forest still inhabiting several

groups of *C. d. roloway*. We were very happily surprised to encounter so many groups of Diana roloway monkeys in this forest, N = 47 (55.30%) were audible and N = 38 (44.70%) of this evidence were sighted (Table 1). Here, this monkey is widespread (Figure 2a) like the common monkeys (Campbell's lowe and lesser spot-nosed).

In addition, the Tanoé Swamp Forest inhabits an important population of White-napped mangabey (*Cercocebus atys lunulatus*). We observed 45 signs of this species in this forest and allowed to identify 37 groups (figure 2b). Audible observations represent 71.11% against 26.66% for sighted and 02.23% for feeding tracks (Table 1).

The Geoffroy White-thighed Colobus is also confirmed in the Tanoé Swamp Forest. We found 26 groups in this swamp forest in 26 observations (figure 3a) and 65.40% (N = 17) of these observations were visual against 34.60% (N = 9) audible contacts (Table 1).

For the Olive Colobus (*Procolobus verus*) 24 groups were identified (figure 3b) in 29 observations. The observations were mostly visual (55.17%) and audible contacts represent 44.83% of the total observation (Table 1).

Frequency of primate encounters and relative abundance

Over the 423 observations of primate evidences that we made in 748 hours in the Tanoé Forest (0.56 obs./hour), only 0.25% (N= 1) was indirect (feeding tracks of white-napped mangabey). Direct contacts (visual or auditory contact) were the most frequent with 99.75% (N= 422). A total of 496 kilometers have been made by the different teams during the survey time in the Tanoé Forest. By analyzing the encounter rate, three categories can be proposed (Table 2):

“*The most encountered*” species in the Tanoé Forest are the Campbell's Lowe, the Rolloway Diana guenon and the Lesser Spot-nosed monkey. For Campbell's Lowe, N = 155 observations were made during the survey with an Encounter rate E = 0.36 obs/hour. The Rolloway Diana guenon represents the second species in this category with 85 observations

in 748 hours (E = 0.20 obs/hour). For the Lesser Spot-nosed monkey N = 82 observations were made with E = 0.94 obs/hour). When we consider the relative abundance we can note that the Campbell's guenons, the Lesser Spot-nosed monkey and the Rolloway Diana guenon are the most abundant monkey species living in the Tanoé Forest with respectively 0.24 group/km, 0.14 group/km and 0.13 group/km.

The second category is the “*lower encountered*” of monkey species formed by the White-napped mangabey (0.10 obs/hour), the Olive colobus (0.07 obs/hour) and the Geoffroy's colobus (0.06 obs/hour). Comparing the relative abundance, the White napped mangabey (0.07 group/km) is the fourth monkey species of the Tanoé Forest, the Geoffroy white thighed colobus (0.05 group/km) is the fifth and Olive colobus monkey with 0.04 group/km is the sixth.

The Miss Waldron red colobus constitutes alone the third category of monkey with “*rare encounter*” frequency and represents the last monkey species of the Tanoé Forest in abundance level. Indeed, during the total times of observation, only few audible signs were recorded (N = 1) and E = 0.02 obs/hour) with a relative abundance of 0.02 group/km.

Polyspecific associations

During the surveys, these different groups of monkeys have been observed in polyspecific associations. The most encountered associations were made with the Rolloway Diana guenon, the White napped mangabey and the Olive colobus monkeys species. Tables 3 and 4 show the different associations according to the species, the type of observation and the GPS coordinates (Table 3), the number of observation and the frequency of association (Table 4). The dominant polyspecific association is made by Rolloway Diana guenon and White napped mangabey with 45.45% (N = 10), followed by the Rolloway Diana guenon and Olive colobus with 31.82% (N = 7) and the association of Olive colobus and the Geoffroy pied monkey with 09.11% (N = 2).

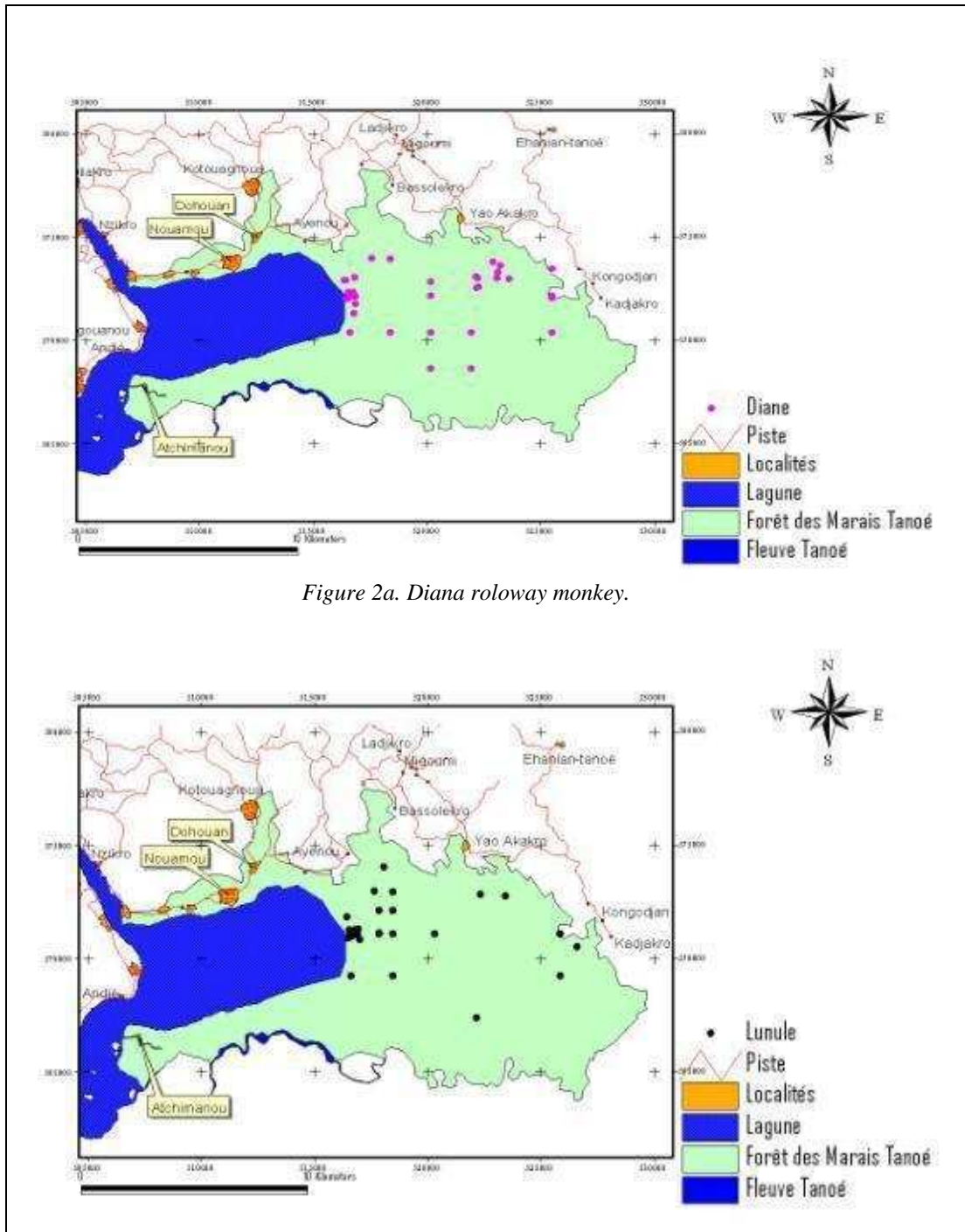


Figure 2: Distribution of two critical endangered primate species in the Tanoé Swamp forest.

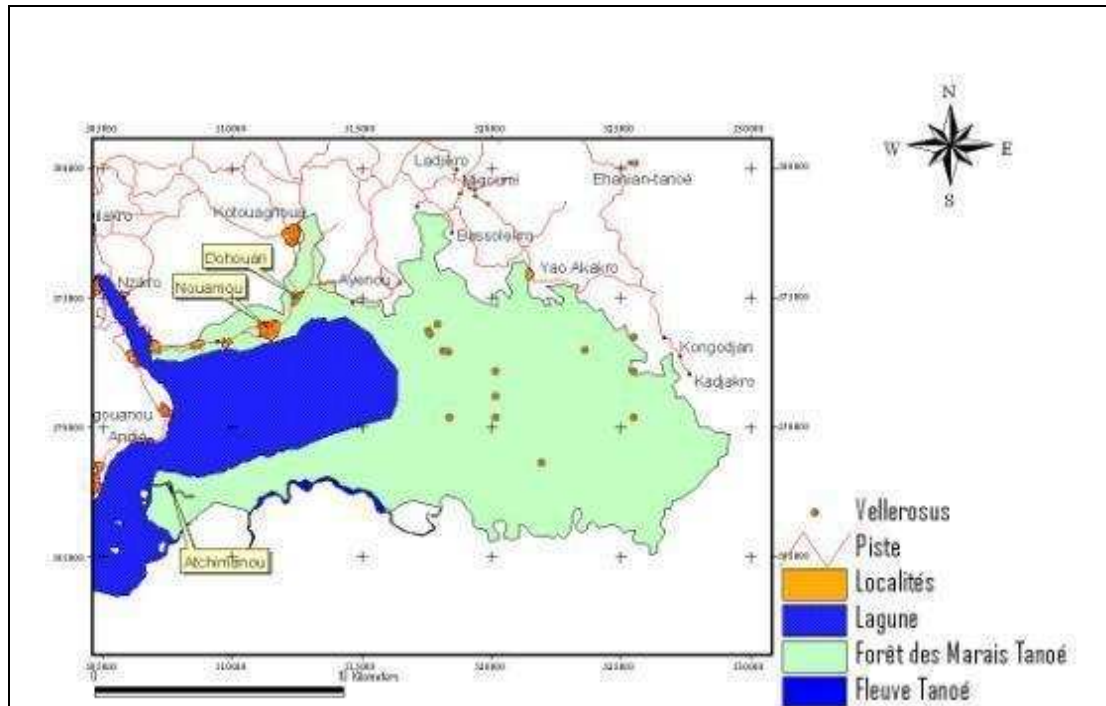


Figure 3a. Geoffroy's Colobus (*Vellerosus*).

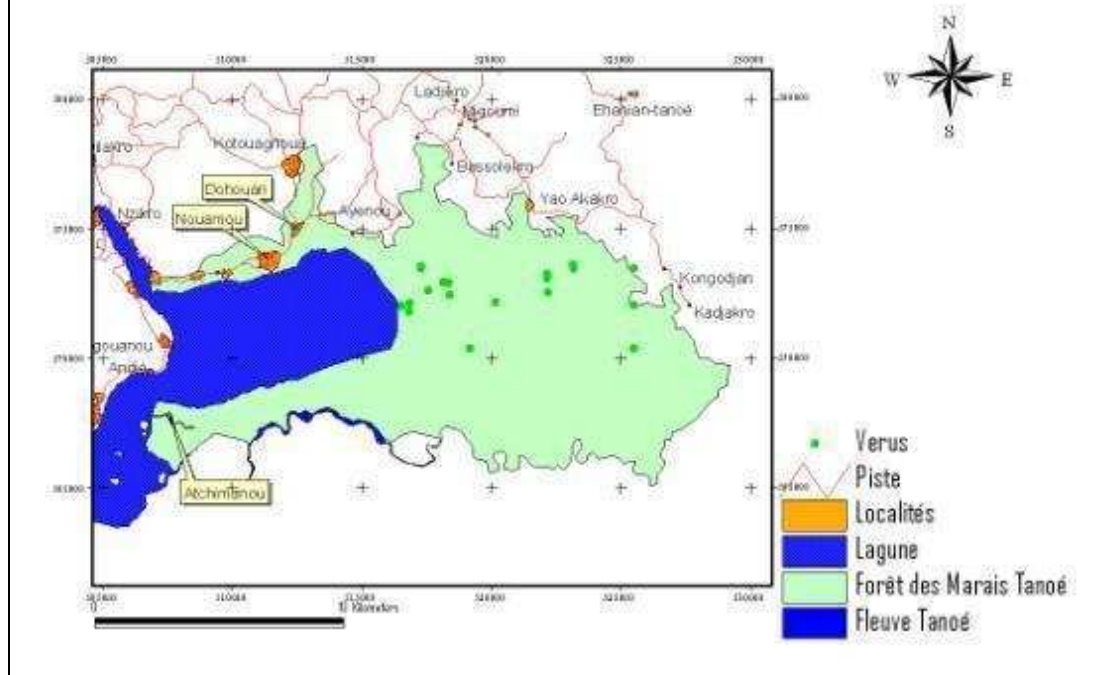


Figure 3b. Olive Colobus (*verus*).

Figure 3: Distribution of two primate species with conservation concern in the Tanoé Swamp forest.

Table 1: Number of observations of primate evidence and number of group in the TSF.

Common name	Scientific name	Number of observations	Number of group	Types of observation		
				visual	audible	tracks
Miss Waldron red colobus	<i>Piliocolobus badius waldronii</i>	1	1	0	1	0
Olive colobus	<i>Procolobus verus</i>	29	24	16	13	0
Geoffroy white thighed colobus	<i>Colobus vellerosus</i>	26	26	17	9	0
Roloway Diana guenon	<i>Cercopithecus diana roloway</i>	85	69	38	47	0
Campbell's Lowe	<i>Cercopithecus campbelli lowei</i>	155	123	50	105	0
Lesser Spot-nosed monkey	<i>Cercopithecus petaurista petaurista</i>	82	71	52	30	0
White napped mangabey	<i>Cercocebus atys lunulatus</i>	45	37	12	32	1

Table 2: Frequency of encounter and relative abundance of the observed primate species in the TSF.

Common name	Scientific name	Observations	Frequency of observation	Number of group	Frequency of group encounter	Relative abundance
Miss Waldron red colobus	<i>Piliocolobus badius waldronii</i>	1	0,002	1	0,001	0,002
Olive colobus	<i>Procolobus verus</i>	29	0,069	24	0,032	0,048
Geoffroy's colobus	<i>Colobus polykomos polykomos</i>	26	0,061	26	0,035	0,052
Roloway Diana guenon	<i>Cercopithecus diana roloway</i>	85	0,201	69	0,092	0,139
Campbell's Lowe	<i>Cercopithecus campbelli lowei</i>	155	0,366	123	0,164	0,248
Lesser Spot-nosed monkey	<i>Cercopithecus petaurista petaurista</i>	82	0,194	71	0,095	0,143
White napped mangabey	<i>Cercocebus atys lunulatus</i>	45	0,107	37	0,049	0,075

Table 3: Frequency of polyspecific associations of monkey in the TSF.

Association	Dia-Lun	Dia-Ver	Ver-Vel	Ver-Lun	Dia-Bad	Dia-Vel	Total
N	10	7	2	1	1	1	22
Frequency	45,45	31,82	9,11	4,54	4,54	4,54	100

Table 4: GPS coordinates of the polyspecific association of TSF monkeys.

Date	Time	Observation type	Species	X	Y
04/March/2008	11 H 22	Heard	dia	516535	571235
04/March/2008	11 H 24	Seen	lun	516535	571235
29/February/2008	16 H 10	Seen	dia	516560	570908
29/February/2008	16 H 10	Seen	ver	516560	570908
11/March/2008	8 H 34	Seen	lun	516584	571070
11/March/2008	8 H 37	Heard	dia	516584	571070
05/March/2008	8 H 35	Heard	dia	516672	571093
05/March/2008	8 H 35	Seen	lun	516672	571093
04/March/2008	16 H 08	Seen	dia	516673	571170
04/March/2008	16 H 08	Seen	lun	516673	571170
05/March/2008	15 H 20	Seen	lun	516682	571053
05/March/2008	15 H 22	Heard	dia	516682	571053
05/March/2008	7 H 26	Heard	lun	516716	571000
05/March/2008	7 H 30	Heard	dia	516716	571000
27/February/2008	9 H 23	Heard	dia	516890	571027
27/February/2008	9 H 23	Heard	ver	516890	571027
28/February/2008	11 H 13	Heard	ver	518222	571849
28/February/2008	11 H 30	Heard	vel	518222	571849
28/February/2008	10 H 55	Heard	ver	518430	571826
28/February/2008	10 H 33	Heard	vel	518430	571826
21/March/2008	8 H 30	Seen	dia	522410	572010
21/March/2008	8 H 30	Heard	ver	522410	572010
24/March/2008	9 H 30	Seen	dia	522448	571465
24/March/2008	9 H 30	Seen	ver	522448	571465
13/March/2008	16 H 02	Heard	lun	516624.51	569210.77
13/March/2008	16 H 02	Heard	dia	516624.51	569210.77
15/March/2008	11 H 35	Seen	dia	518470.72	572895.65

15/March/2008	11 H 45	Heard	lun	518470.72	572895.65
29/February/2008	9 H 05	Heard	ver	520318.33	571053.95
29/February/2008	9 H 05	Heard	lun	520318.33	571053.95
05/March/2008	10 H 24	Heard	dia	520318.33	571053.95
05/March/2008	10 H 24	Heard	wald	520318.33	571053.95
13/March/2008	8 H 23	Heard	dia	522166.62	567370.08
13/March/2008	8 H 23	Heard	lun	522166.62	567370.08
23/March/2008	14 H 30	Seen	dia	525859.77	570932.95
23/March/2008	14 H 30	Seen	ver	525859.77	570932.95
19/March/2008	10 H 40	Seen	dia	525859.23	572406.72
19/March/2008	10 H 40	Seen	vel	525859.23	572406.72
19/March/2008	10 H 40	Seen	ver	525859.23	572406.72
21/March/2008	8 H 29	Heard	lun	525860.40	569213.55
21/March/2008	8 H 29	Heard	dia	525860.40	569213.55
23/March/2008	9 H 55	Seen	ver	525860.40	569213.55
23/March/2008	9 H 55	Seen	dia	525860.40	569213.55
01/March/2008	11 H 30	Seen	dia	610861.15	552713.38
01/March/2008	11 H 30	Seen	ver	610861.15	552713.38

DISCUSSION

South-central and eastern Côte d'Ivoire in the eastern part of the Upper Guinea hotspot are reported to be part of the original range of three critically endangered primate species: the Diana rolway (*Cercopithecus diana rolway*), the white-napped mangabey (*Cercocebus atys lunulatus*) and the Miss Waldron's red colobus (*Piliocolobus badius waldronae*). However, no significant conservation effort has been made so far on the behalf of these monkeys and they are increasingly threatened by human activities. Updates on the current distribution and conservation status of these primates and the identification of sites for primate conservation are urgently needed. Thanks to a collaboration between CEPA (*Conservation des Espèces et Populations Animales*: www.association-

cepa.org) and the CSRS (*Centre Suisse de Recherches Scientifiques en Côte d'Ivoire*: www.csrs.ch), surveys were conducted from 2004 to 2007 14 selected forests of south-central and eastern Côte d'Ivoire to seek evidence for primates of conservation concern.

In this study, seven primate species have been confirmed with three that are classified as Critically Endangered by the IUCN 2008 (*Cercopithecus Diana rolway*, *Cercocebus atys lunulatus* and *Piliocolobus badius waldronae*), two are Near Threatened (*Colobus vellerosus* and *Procolobus verus*) and two are Least Concern (*Cercopithecus campbelli lowei* and *C. petaurista petaurista*). Côte d'Ivoire, with twenty three taxa, presents one of the highest diversity in primate species in West Africa, with some of these species

endemic to this country. Within these species, two colobine taxa are on the verge of extinction: *Procolobus badius waldroneae* and *Colobus polykomos dollmani* (Gonedélé Bi et al., 2006, 2010). After surveying the whole forest area of Côte d'Ivoire for more than a decade, our team concluded that the "Tanoé Swamp Forest" must be considered as a High Conservation Value Forest (Gonedélé Bi et al., 2008). Unfortunately this forest is facing several threats and it is not protected.

This forest represents a unique opportunity for the world scientists and conservationists for the survival of endangered primate species. This forest inhabits at least three of the 25 most threatened primates species in the world (McGraw and Oates, 2009). It is the latest refuge known of the Miss Waldron red colobus monkey (McGraw, 2005). Even if we have heard only vocalizations during our exploration, we believe that there are viable populations in the forest, and so more attention can be paid to the hunters who affirm the presence of viable population. For these hunters, it very difficult to meet the Miss Waldron red colobus monkey because it became very cryptic and noiseless (Koné et al., 2006); Béné and Akpatou, 2007; Béné et al., 2007).

In addition, two other Critical Endangered monkey species have been confirmed: the Diane Roloway monkey and White-napped mangabey are exceptionally abundant in the forest. So far, this is the only forest in Côte d'Ivoire that still housing the Diane Roloway monkey, even if its presence is suspected in some forests like Dassioko FC, Niégré FC and Maby Yaya FC (Koné and Akpatou, 2004). Regarding the White-napped mangabey, its presence was confirmed in another forest (the Dassioko FC) and suspected in other forests.

Furthermore, two monkey species Near Threatened according to INCN 2008 were also met in the Tanoé Forest. Interesting population of Olive colobus has been reported on the non protected islands of the Sanssandra River (Koné et al. 2005), but to date, we can say that the Tanoé Forest is the second forest inhabiting the most population of this monkey species after the Taï National Park. And Geoffroy Black-and-white colobus monkey has been encountered anywhere else during the surveys in different forests of Côte d'Ivoire. For Gonedélé Bi et al., (2006), these two species must be listed as endangered by IUCN.

As it is shown in the distribution maps, the Tanoé Forest is a very important refuge for the monkeys. Indeed, whatever the species of monkey considered, the groups encountered are almost throughout the forest (except for Miss Waldron red colobus monkey for which only few vocalizations have been heard near the lagoon Ehy). However, there is a higher concentration of monkeys on the side of the lagoon. One of the reasons that could explain this situation is the difficulties to access for human because of the inundation of the forest throughout all the year. Even during the dry season, some places in this zone are completely inaccessible. It constitutes a natural barrier of protection for these monkeys.

The different monkeys of the Tanoé Forest have been found sometimes in polyspecific association during the fieldwork. No study has been made on the reasons of this behavior in the forest, but, this strategy is common to all species of monkeys in general, to reduce the risk of predation (Alexander, 1974; Terborgh and Janson, 1986; Dunbar 1988; Bshary and Noë, 1997a, b; Noë and Bshary, 1997). Indeed, several advantages are related to the formation of large groups. While this phenomenon has the disadvantage of

increasing food competition, the risk of being quickly spotted by predators, however, it has advantages to offer a greater possibility of detecting the predator first (Terborgh and Janson, 1986), to increase the chance for individuals to escape an attack by the dilution effect, to confuse the predator by a leak disorderly and the possibility of organizing collective defenses (Boesch and Boesch, 1989; Boesch, 1994).

Conclusion

Our study allowed us to confirm the presence of seven species of monkeys in the forest of Marais Tanoé. Among these monkeys, three are classified as Critical Endangered by IUCN (*Cercopithecus Diana roloway*, *Cercocebus atys lunulatus* and *Ptilocolobus badius waldroneae*), two are Near Threatened (*Colobus vellerosus* and *Procolobus verus*) and two others are Least Concern (*Cercopithecus campbelli lowei* and *C. pataurista pataurista*). These monkeys are encountered everywhere in the forest. Three species (...) are more abundant compared to the others, but in any case they form polyspecific association. Some of these monkeys' species have never been studied in world. Tanoé Forest is a High Conservation Value Forest. It represents a precious asset for research and for the promotion of sustainable development in the region. Feeling concerned by the survival of the unique biodiversity of the Tanoé Forest and by the fate of the human communities, the future of whom is directly or indirectly linked with that of the forest, we urge the Ivorian authorities to consider the conservation of the Tanoé Forest as a top priority.

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