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## LOCAL DISTRIBUTION AND DENSITY ESTIMATES OF PRIMATES IN THE TRANSBOUNDARY RESERVE OF THE MONO RIVER, TOGO (WEST AFRICA)

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**RÉSUMÉ.**— *Distribution locale et estimation des densités des primates dans la réserve transfrontalière du fleuve Mono, Togo (Afrique de l'Ouest).*— La réserve de biosphère de Mono est située dans le « Dahomey Gap » qui sépare la ceinture des forêts denses humides ouest-africaines en deux blocs forestiers : guinéen (occidental) et congolais (oriental). Cette discontinuité climatique dahoméenne est caractérisée par des mosaïques de forêts denses semi-décidues, des savanes guinéennes, des prairies marécageuses, des marais, des mangroves et des plans d'eau, des mosaïques d'agroforêts, champs et jachères. Dans cette réserve centrée sur la vallée du Mono entre le Togo et le Bénin, d'une superficie de 2042,18 km<sup>2</sup>, nous nous évalué le statut des populations des espèces de primates. Au total, 9 espèces ont été recensées : *Galago senegalensis*, *Galagoides demidoff*, *Perodicticus potto*, *Papio anubis*, *Colobus vellerosus*, *Cercopithecus erythrogaster erythrogaster*, *Cercopithecus mona*, *Erythrocebus patas* et *Chlorocebus tantalus*. Les populations de ces espèces sont distribuées dans quatre unités fondamentales de la réserve : la forêt d'Asrama, le complexe d'aires protégées de Togodo, la forêt sacrée de Godjé-Godjin et la forêt sacrée d'Akissa. Les travaux ont clairement établi un déplacement saisonnier et régulier des populations de ces espèces de primates dans ces différentes unités écologiques. Le complexe d'aires protégées de Togodo constitue le sanctuaire pour les populations de primates dans le Sud du Togo et du Bénin et principalement celle du Hocheur à ventre roux (*Cercopithecus erythrogaster erythrogaster*) considéré comme espèce en danger critique sur la liste rouge de l'UICN.

**SUMMARY.** – The reserve of biosphere of Mono river is located in the Dahomey Gap, which is the relatively arid interruption in the West African forest belt that stretches from the Accra Plains in Ghana across the Volta River through Togo to the eastern border of Benin. This West African climate discontinuity is characterized by mosaics of dense semi-deciduous forests, Guinean savannahs, swampy meadows, marshes, mangroves and bodies of water, mosaics of agroforest, farms and fallow land. In this reserve, centered on the Mono valley between Togo and Benin, with 2042.18 km<sup>2</sup> area, we assessed the status of populations of primate species. Overall, 9 species were recorded: *Galago senegalensis*, *Galagoides demidoff*, *Perodicticus potto*, *Papio anubis*, *Colobus vellerosus*, *Cercopithecus erythrogaster erythrogaster*, *Cercopithecus mona*, *Erythrocebus patas* and *Chlorocebus tantalus*. The populations of these species are distributed in four basic units of the reserve: the Asmara forest, the Togodo protected area complex, the Godjé-Godjin sacred forest and the Akissa sacred forest. Our works clearly established a seasonal and regular displacement of primate species populations among different ecological units. The Togodo protected areas complex is the sanctuary for primate populations in southern Togo and Benin, and mainly for the Red-bellied Monkey (*Cercopithecus erythrogaster erythrogaster*), which is considered a Critically Endangered species on the IUCN Red List.

The Dahomey Gap is a relatively dry interruption of the West African forest belt (Jenik, 1984, 1994; Maley, 1996) extending from the plains of Accra (Ghana), crosses the Volta and Togo escapes and ends in northern Benin. This Dahomeyan bioclimatic discontinuity is characterized by mosaics of dense semi-deciduous forests, Guinean savannahs, swampy meadows, marshes, mangroves and waterbodies, agroforest mosaics, fields and fallow land. Many studies have shown the zoogeographic role of the Dahomey Gap for the speciation processes of small mammals (Robbins, 1978; Booth, 1958), primates (Booth, 1958; Campbell *et al.*, 2008; Hounbedji *et al.*, 2012), amphibians (Hillers *et al.*, 2009; Schiøtz, 1967; Rödel & Agyei, 2003; Leaché *et al.*, 2006), fishes (Clausen, 1964) and butterflies (Larsen, 2008). Because of its special ecological characteristics, the Dahomey Gap is a true conservation refuge. For example, the Togodo forests in southwestern Togo remain among the few refuges of Forest buffaloes (*Syncerus brachyceros*) in the Dahomey Gap where these ungulates are still common (Segniabeto *et al.*, unpublished observations), with the only other high-density area for this species in Togo being Fazao-Malfakassa National Park (Atsri *et al.*, 2013; Amori *et al.*, 2016).

The Mono Transboundary Biosphere Reserve (hereby MTBR) is located in the Dahomey Gap at the border between Togo and Benin. MTBR is characterized by a suite of natural habitats of conservation concern, including three Ramsar sites such as the Togodo Reserve, the coastline of southern Togo and the Gbaga Channel. All these sites have a very rich biological diversity, including primates (Segniabeto *et al.*, 2017), antelopes (Amori *et al.*, 2016), hippopotamuses (Amori *et al.*, 2016), and manatees (Segniabeto *et al.*, 2007) just to cite a few.

As mentioned above, the MTBR is also an important area for the conservation of primates (Segniabeto *et al.*, 2017). Recent work on the primates of Togo also presented data collected from the MTBR, including Oates (1988), Campbell *et al.* (2008), Hounbedji *et al.* (2012), Agbessi *et al.* (2017) and Segniabeto *et al.* (2017), and a summary of the distribution records collected so far is available in Segniabeto *et al.* (2016). Segniabeto *et al.* (2017) provided data on the abundance (estimated as Kilometric Index of Abundance) for the primates of only the Togodo Forest reserve (and other Togolese sites outside the study area of the present contribution), whereas there were no comprehensive data for the MTBR different sectors in terms of either density or even local distribution.

The present paper fills the documentation gaps of Segniabeto *et al.* (2017), thus completing the primate data for the MTBR. In particular, we address the following key questions: (1) What are the primate species actually present in the MTBR? (2) What is their distribution in the reserve? (3) What are the similarities and differences among the various sectors of the MTBR in terms of primate community composition?

## MATERIALS AND METHODS

### STUDY AREA

The MTBR (Fig. 1) is located along the Mono River and occupies an area of 2042.18 km<sup>2</sup>. The MTBR has an equatorial transition type climate. Rainfall ranges from 1000 to 1300 mm on average per year and is generally higher during the first rainy season (between March and July), but heavy rains also occur during the second rainy season (between September and October). Temperatures are fairly constant throughout the year with the average annual thermal amplitude rarely exceeding 5° C, and the monthly temperatures oscillating between 25° C and 29° C.

The MTBR includes many rivers: the main watercourse is the Mono, with a length of 500 km, it drains with its tributaries a total area of 25 400 km<sup>2</sup>. Besides the Mono, the reserve is drained by some perennial rivers (Hondoulé, Afan and Asrama rivers which are tributaries of Mono) as well as by non-perennial watercourses (Dogotohui and Blado).

Surveys were performed in all the ecological units of the MTBR, as presented in the proposal of the designation of the reserve of biosphere (MERF, 2016 and Segniabeto *et al.*, 2017), including:

(a) The Togodo Protected Areas Complex: It is the largest ecological unit in the entire biosphere reserve. It currently covers a total area of 25 500 ha and is composed of two entities: the forest reserve of South Togodo (15 000 ha) and the forest of North Togodo (10 500 ha). The vegetation is a mosaic of forest and savannah characteristic of the Dahomey Gap. There are forest formations composed of semi-deciduous forests with dry facies dominated by *Drypetes floribunda*, *Monodora tenuifolia*, *Terminalia superba*, *Dispyros mespiliformis*, *Milicia excelsa*, *Antiaris africana*, *Ceiba*

*pentandra* and *Triplochiton scleroxylon*. Dry dense forests, clear forests, forest galleries, wooded and shrub savannahs. In the peripheral areas of the park, there are forest plantations (teak, *Gmelina* and oil palm) and fallow-crop mosaics.

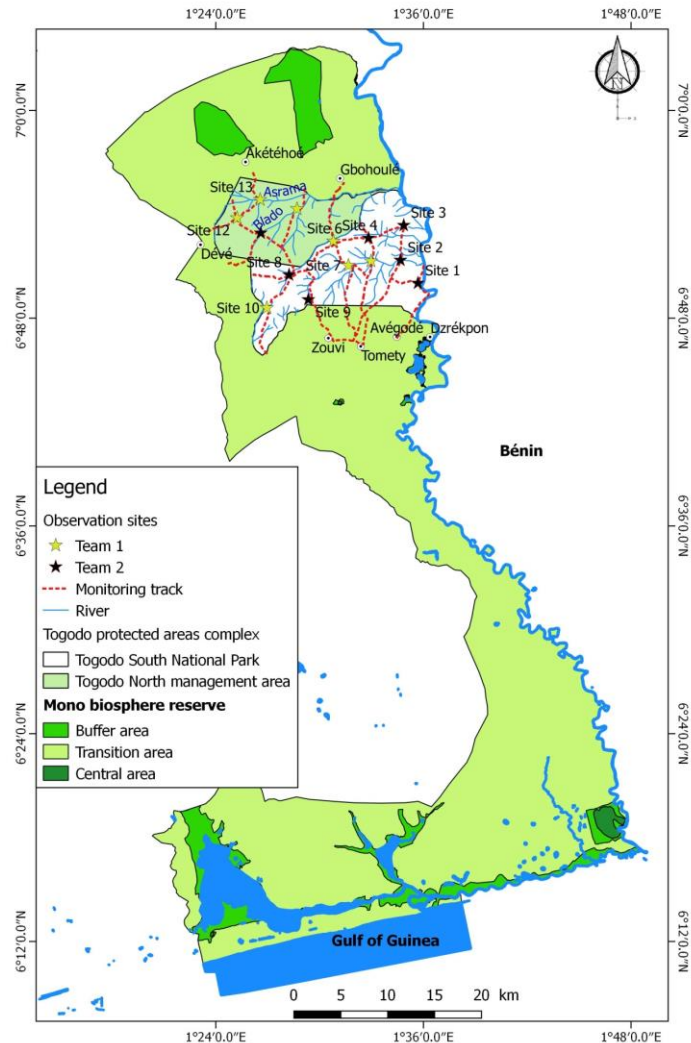


Figure 1.— Map of the Mono Transboundary Biosphere Reserve, including the main vegetation zones and rivers, and the transects used to survey primates.

(b) The forest of Asrama, about 2255.18 ha, is constituted along the access roads of an artificial *Terminalia superba* forest. Inside, there is a savannah-dry forest mosaic with dense forest patches dominated by *Antiaris africana* and *Cola* spp. and associated with a savannah raised with *Pterocarpus erinaceus* and *Lonchocarpus sericeus*.

(c) The sacred forest of Godjè-Godjin, 93 ha surface, is characterized by a mosaic of dry dense forest of *Antiaris africana*, *Cola* spp. associated with a savannah dominated by *Pterocarpus erinaceus* and *Lonchocarpus sericeus*. The forest islets are dominated by species such as *Antiaris africana*, *Cola gigantea*, *Cola millenii*, *Ceiba pentandra*, *Celtis zenkeri*, *Cleistopholis patens*, *Cynometra megalophylla*, and *Triplochiton scleroxylon*.

(d) The sacred forest of Akissa and the forest of Avégé, with an area of 627.62 ha and 1500 ha respectively, are dominated by flood savannahs with *Mitragyna inermis* and *Andropogon gayanus*. There are also forests of *Dialium guineense* and *Treculia africana*.

(e) The Afito pools, covering an area of 491.55 ha, are flooded and mainly composed of *Mitragyna inermis* and *Lonchocarpus sericeus*. The back of this vegetation is characterized by plantations of oil palms.

(f) Hadjivi Island, is a forested area of about 80 ha surface.

(g) Lake Togo includes some of the most important forest fragments, such as Assévé (or Amédéhoévé, 40.5 ha), Togoville (22.5 ha), Lébé (2 ha), Sévagan (8 ha), etc. All these forest fragments are dominated by *Antiaris africana*, *Dialium guineense* and *Millettia thonningii*.

## FIELD PROTOCOL

Our surveys were carried out between September 2014 and August 2017.

The data collection methodology was based on direct observations of primate individuals or groups during the surveys (both Visual-Encounter-Surveys along line transects and observation points; see below for more details) across the potential habitats of primates both in the inner and in the peripheral sites of the MTBR. In addition, semistructured interviews were performed with local hunters and with the managers of the wildlife export farms (Mare and Toganim, Lomé) in order to collect more information on the local distribution of primates and on the relationships between humans and primates.

In Togodo area, primate observations were performed essentially along access paths that were made previously for management reasons by the protected area authorities (see Fig. 1 for the map of the transects used to survey primates during the present study). For the other sites of the MTBR, namely Afito pools, Asrama forest, sacred forests of Godjé-Godjin and Akissa, along the Mono and the sacred forests around Lake Togo, we established some observation points in each of the potential primate habitats by following the indication of experienced persons from local villages. Reconnaissance surveys were also carried out using Southwick & Cadigan's (1972) and Lawes' (1991) methods. The field team was always composed of three scientists (G. H. Segniagbeto and two other researchers being coauthors of the present contribution) supported by two trackers (usually two local hunters). The protocol approach consisted in moving at a speed of 1 or 2 km/h to minimize disturbance of the animals. Surveys were done at 04h to 11h and/or at 15h to 19h (Lomé Standard Time). We recorded the starting time and the ending time of the censuses, as well the GPS coordinates of the starting point and of the ending points, in order to calculate the observation effort as well as the number of kilometers traveled. When a primate was encountered, the following information was recorded: species, time, GPS location (taken by Garmin GPSmap 62s), group size (i.e. number of individuals), group structure (i.e. females, males, juveniles) and the type of habitat. The distance of the primate individuals from the position of the observers as well as the maximum observation band at the site (all in m) were also noted. Since group size may be difficult to estimate with precision with relatively large groups, when the group size exceeded 10 individuals, we reported the approximate number of individuals (but some minor errors in the counts cannot be excluded). In Asrama, Godjé-Godjin, Afito, Akissa along the Mono and the sacred forests around Lake Togo, a total of 14 observation points were established with the support of local guides.

Threats and the different types of human-made pressures on primates by various practices were identified during field surveys simultaneously to primate searches. The GPS coordinates of the anthropogenic disturbance sites on the various habitats (agriculture, timber exploitation, pollution, etc.) were recorded.

Overall, a total of 255.1 km were walked during our surveys. The average width of the observation band was 65 m on each side of the paths (= 130 m); hence, the area sampled throughout the protected territory was: 255.1 km x 0.13 km = 33.163 km<sup>2</sup>. This area corresponds to  $\approx$  13% of the total study areas. The average density of each species in the study area was therefore calculated by dividing the number of observed individuals in each site by this area estimate.

## STATISTICAL ANALYSES

A cluster analysis (UPGMA method with Euclidean distances as dissimilarity measure) was used for clustering (i) the various primate species in terms of their presence/absence and density across the study areas, and (ii) the study areas in terms of the relative density of the various primate species within each study area. In the text, the means are presented  $\pm$  1 Standard Deviation.

## RESULTS AND DISCUSSION

### LIST OF SPECIES AND SPECIES-SPECIFIC ESTIMATES OF THEIR LOCAL DENSITY

Details of the various encounters with primates, including locality, date, time of observation, and geographic coordinates of the sighting place, are given in Appendix. Nine species of primates were recorded in the whole of the MTBR. These include seven species that were directly observed in the wild, i.e. *Galago senegalensis*, *Cercopithecus erythrogaster erythrogaster*, *Cercopithecus mona*, *Chlorocebus tantalus*, *Colobus vellerosus*, *Erythrocebus patas*, *Papio anubis*, and two species that were found only as dead specimens or that were indirectly reported by interviewed hunters, i.e. *Galagoides demidoff* and *Perodicticus potto juju*.

### *Directly-observed species*

The Senegal galago (*Galago senegalensis*, Least Concern according to IUCN, 2017) was observed in Siyimé forest, where two large groups were found in two distinct localities (Appendix). Two other individuals were directly observed in Mambui (Avévé) (Appendix). Mean group size was  $27.33 \pm 24.1$  ( $n = 3$  observed groups). *Galago senegalensis* presence was also reported by local hunters in the protected area complex of Togodo, Godjé-Godjin and Akissa. This species was widely exported from Togo between 1980 and 2009 (at least 1672 exported individuals). According to interviewees' opinion (local hunters and managers of the wildlife export farms Mare and Toganim), all the sites on the reserve constituted the hunting grounds of the exported individuals.

Red-bellied monkey (*Cercopithecus erythrogaster erythrogaster*, Vulnerable): The density of the population in Togodo forest was estimated at 5.07 individuals per km<sup>2</sup>. Five groups (consisting of 7 up to  $\approx 50$  individuals; mean group size =  $23.4 \pm 20.1$ ) were observed in different places of the protected area, including Atchankeli, Tomety-Kondji and Kpotivé. Apart from the sites of direct observation (Appendix 1), this species was reported by local guides to occur also at Gboto-Zouvi in Togodo. The species was reported to be also seasonally present in the sacred forest of Godjé-Godjin and along the River Mono, including the small islets around the Afito pools. The southern limit of the distribution of the species in the reserve was Gogo-Kondji where 15 individuals were observed. The typical habitat of this species consists of forest fragments dominated by tall trees and vines. Our results provided more data on *Cercopithecus e. erythrogaster* in Togodo Protected Areas Complex than those provided by Hougbedji *et al.* (2012). Indeed, Hougbedji *et al.* (2012) just conducted their surveys in riparian forest by canoe along the Mono River, with a total of 12 km of transect walked in the park. Their survey effort was very low when compared to ours and they did not cover the two protected areas of Togodo (North and South) as we did. The results of Hougbedji *et al.* (2012) indicated that only 9 individuals of this species were observed, whereas during our study, a total of 168 individuals were observed.

The Mona monkey (*Cercopithecus mona*, Least Concern) was found in all the ecological units of the MTBR, i.e. from the forest of Asrama to the sacred forest of Akissa. Its presence in the sacred forests around Lake Togo (sacred forests of Togoville, Assévé and Lébé) was also regularly noted by us as well as by experienced interviewees. Overall, 534 individuals were observed throughout this study. The mean group size was  $16.98 \pm 16.8$  individuals ( $n = 37$  groups), with a estimated density of 8.17 individuals per km<sup>2</sup>. The largest groups consisted of about 50-60 individuals (Appendix).

The Tantalus monkey (*Chlorocebus tantalus*, Least Concern) is also common, and was directly observed in all the ecological units of the reserve. Its density was estimated to be at 4.10 individuals per km<sup>2</sup>. A total of 23 distinct observations events were made throughout the reserve, and 345 individuals were recorded (Appendix). Mean group size was  $13.53 \pm 13.7$  individuals, with a range of 1 to  $\approx 60$  individuals).

White-thighed black-and-white colobus (*Colobus vellerosus*, Vulnerable): a total of five individuals were observed during the present surveys (Appendix). During our surveys, three observations were made in the forest of Aketé-Atchankli, in the Gbowlé forest and in the Siyimé forest. Mean group size was  $1.75 \pm 0.5$  individuals, with a range of 1-2 individuals per group. In addition, the skin of a recently killed specimen was observed at Dévé, and another individual was hunted on 12 August 2017 in Gbowlé. This species was for long time supposed to be present only in the forest of the two Béna, Assoukoko and Fazao-Malfakassa in southwestern Togo (Amori *et al.*, 2016), thus the present findings considerably extended its known distribution in the country. The presence of this species in Togodo, which can be predicted on the basis of the map available in Oates (2011, page 393), was first reported by Segniagbeto *et al.* (2017), but several hunters reported its regular occurrence in the area. The presence of the species in Dévé and Siyimé is probably linked to forest fragments in this part of the park. Considering the current threatened

status of this species (VU by IUCN, 2017), its presence in the study area has a considerable importance in terms of conservation and management policies.

The Patas monkey (*Erythrocebus patas*, Near Threatened) is the most abundant species in the MTBR, with an estimated density of 13.96 individuals per km<sup>2</sup>. A total of 28 distinct observations were made for this species, corresponding to 522 individuals recorded mainly in the Togodo complex and in the Godjé-Godjin sacred forest. Mean group size was  $20.78 \pm 18$  individuals (range 2 to  $\approx 60$ ). This species was observed in all the ecological units of the MTBR except in the sacred forests around Lake Togo. Individuals that were regularly observed in forest islets south of the Resad (Hadjivi, Avévé and Akissa) should not be permanent dwellers of these islets according to the reports of local hunters. According to these persons, the Patas move seasonally from the protected area complex of Togodo to feed on these forest islands.

Olive baboon (*Papio anubis*, Least Concern): seven groups of baboons were recorded in the protected area complex of Togodo. Density was 0.81 individuals per km<sup>2</sup>. Mean group size was  $3.86 \pm 1.8$  individuals, with a range of 2-6 individuals. In general, we observed a very small size of baboon groups in the study area compared to other studies (for example, Higham *et al.*, 2009). Indeed, these primates are known to live in large groups of over 100 individuals in East Africa, whereas their groups are generally much smaller in West Africa (Oates, 2011). Nonetheless, even in West Africa their groups are usually larger than in our study area: 14-28 individuals were observed in Gashaka (Nigeria, see Warren, 2003) and 12 in Comoé, Côte d' Ivoire (Kunz & Linsenmair, 2008).

#### *Indirectly-observed species*

Two additional species were observed only with dead specimens found in villages or just indirectly recorded from interviewed hunters: *Galagoides demidoff* and *Perodicticus potto juju*.

Demidoff's Galago (*Galagoides demidoff*, Least Concern) was never observed by us in the wild. However, a specimen was hunted in the forest of Hadjivi during the fieldwork, and another dead individual was recorded in the village of Avévé. Local hunters stated the regular presence of this species in the ecological units south of the Reserve, including Hadjivi, Avévé and Akissa. This species was also heavily exported for the pet trade: between 1980 and 2010, 934 specimens of this species were exported from Togo to the USA, Japan, the Netherlands, France, and other European countries (see CITES trade dataset at: [https://trade.cites.org/en/cites\\_trade](https://trade.cites.org/en/cites_trade) accessed on 16<sup>th</sup> February 2018). According to the information provided by the managers of the wildlife export farms (Mare and Toganim), the specimens exported came from the Agomé Glozou zone, which corresponds to the forests of Hadjivi, Assévé, Avévé and Akissa.

The Benin potto (*Perodicticus potto juju*, Least Concern) was never encountered during our field surveys; however, local hunters suggest that it is present in their forests, but that it is increasingly rare in Akissa forest but still common in Hadjivi Island. This species was a heavily traded species in Togo: between 1990 and 2010, more than 600 live specimens of this species were exported from Togo according to the data available on the WCMC / UNEP website (see CITES trade dataset, accessed on 16<sup>th</sup> February 2018 at: [https://trade.cites.org/en/cites\\_trade](https://trade.cites.org/en/cites_trade)). The area of Akissa, Avévé and Hadjivi islands are the main catch areas for the traded individuals according to the operators of the Lomé-based wildlife farms.

#### ESTIMATES OF DENSITY AT THE ASSEMBLAGE-SCALE

The density of the various species, in the distinct sites of the MTBR, is given in Tab. I. A dissimilarity dendrogram showed that the various primate species are clustered in three groups in terms of their presence/absence and density across the study areas (Fig. 2), whereas the various sites clustered in two groups in terms of primate presence and density (Fig. 3). Interestingly, both in terms of number of species and their relative density estimates, two sites (Godjé-Godjin sacred

forest and Hadjivi forest) clustered together and appeared to be particularly suitable for primates to reach high densities (Fig. 3). In particular, there was a high density for species like *Cercopithecus e. erythrogaster*, *Cercopithecus mona*, *Chlorocebus tantalus* and *Erythrocebus patas*. These two sites are very small, with a total area of respectively 93 ha and 80 ha. As they are ‘sacred’ forests, the vegetation is traditionally preserved and hunting is strictly avoided. As a consequence, it is very easy to observe primates in these study areas.

TABLE I

*Density of the various primate species in the ecological units of the Mono Transboundary Biosphere Reserve.*

Species	Density per km <sup>2</sup>							
	Togodo	Asrama	Godjé-Godjin	Afito	Akissa	Avévé	Hadjivi	Lake Togo
<i>Colobus vellerosus</i>	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Cercopithecus e. erythrogaster</i>	5.07	0.00	40.82	0.00	0.00	0.00	0.00	0.00
<i>Cercopithecus mona</i>	8.17	5.56	81.63	0.00	0.00	5.93	138.75	1.34
<i>Chlorocebus tantalus</i>	4.16	5.01	61.22	2.76	0.21	5.47	75.00	4.53
<i>Erythrocebus patas</i>	13.96	9.23	61.22	0.00	0.00	0.00	0.00	0.00
<i>Papio anubis</i>	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>Galago senegalensis</i>	2.41	0.00	0.00	0.00	0.00	0.07	1.25	0.00

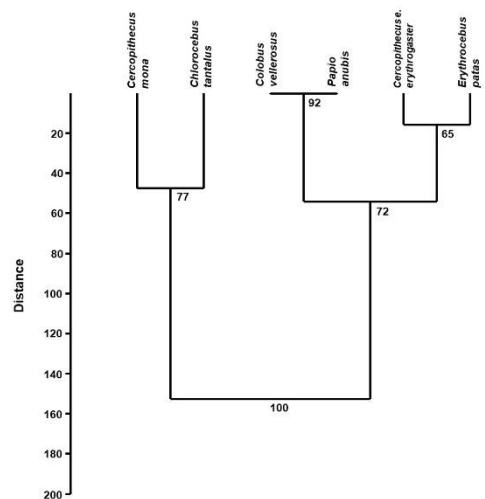


Figure 2.— Dendrogram (Ward’s method with 40 bootstraps as branching measurements) showing dissimilarities among primate species in the study area in terms of presence/absence and density per km<sup>2</sup>.

In general, the importance of primate diversity in the Togodo Protected Areas Complex and in a few other sites (Fontan, Togoville and Amedehévé Forest (Assévé Forest)) has already been stressed by Campbell *et al.* (2008), Hounbedji *et al.* (2012), Agbessi *et al.* (2017) and Segniagbeto *et al.* (2017). However, these studies did not take into account all the forest sites available in the MTBR as our present study did, but provided data on the density of primates in Togodo that can be tentatively compared with our own results. Hounbedji *et al.* (2012) indicated a lower total density of primates (2.7 individuals per km<sup>2</sup>) in Togodo South National Park than that recorded by us (5.07 individuals per km<sup>2</sup>). It is still unknown whether these density differences are attributable to population fluctuations or observer’s biases, as, overall, the employed methodologies were similar.



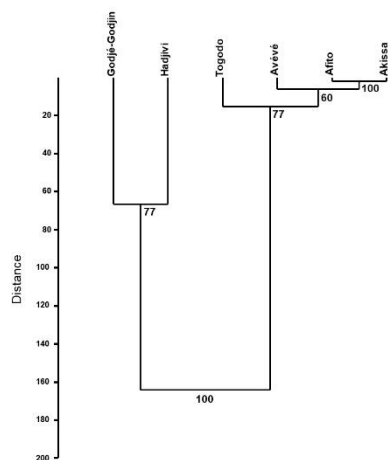


Figure 3.— Dendrogram (Ward's method with 40 bootstraps as branching measurements) showing dissimilarities among study sites in terms of the primate presence/absence and density per km<sup>2</sup>.

#### ECOLOGICAL UNITS OF PRIMATE RELEVANCE IN THE MTBR

Overall, in terms of species distribution (Fig. 4), data collected in the field allowed to define three large sets of ecological units of primate relevance within the reserve:

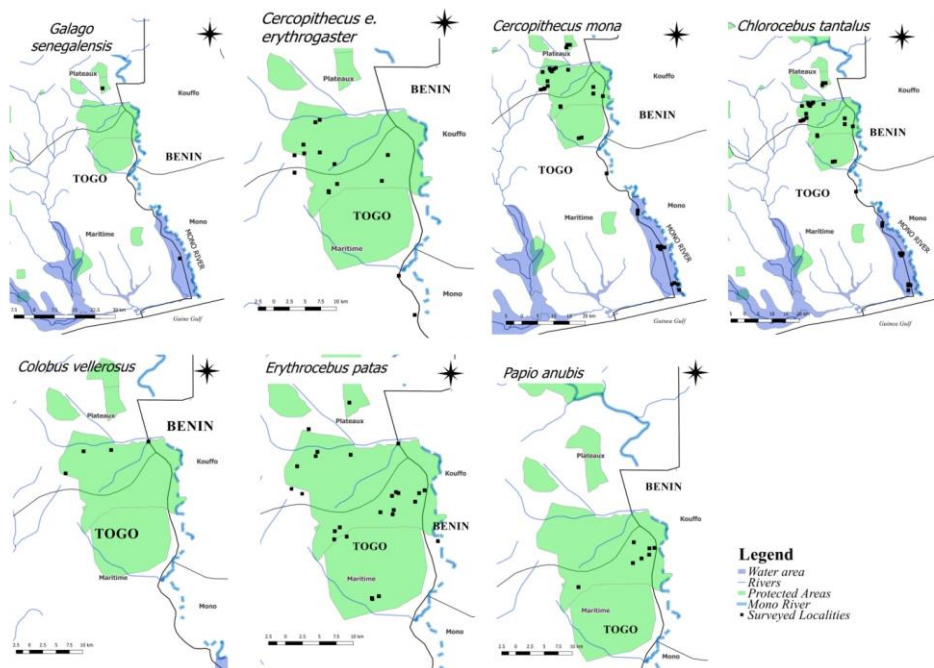


Figure 4.— Distribution of the primate species throughout the study area.

(i) The northern ecological units of the reserve include the protected area complex of Togodo, Asrama and Tetetou forest, but also the sacred forest of Godjé-Godjin and the Afito pools. They may also include the Gogo-Kondji site and the Zekete pond of Tokpli. These units constitute an

ecologically functional set of habitats suited to populations of *Colobus vellerosus*, *Cercopithecus. e. erythrogaster* and *Cercopithecus mona*.

(ii) The ecological units south of the reserve: This set consists of the forests of Akissas, Avévé, Hadjivi and Lake Elia. This unit is important for the preservation of the populations of *Cercopithecus mona*, *Galagoides demidoff* and *Perodicticus potto*.

(iii) Ecological units around Lake Togo: These forest units are very fragmented and remote from one another. However, groups of *Erythrocebus patas* and *Chlorocebus tantalus* are still found in these forest fragments, especially at Assévé, Lébé and Abobo.

These three ecological units are actually functional even if the one around Lake Togo appears very fragmented. No previous study has dealt with this characterization of river and lagoon terrestrial ecosystems in southern Togo. It seems that, until the 1980s, animal species, especially large mammals such as hippos and manatees, could exploit all of these units as a refuge corridor. This could also be the case for primate species. What might be of interest in the current biosphere reserve project would be to consolidate and strengthen the corridors that would be eventually used by wildlife as dispersal routes for recolonizing depauperate forest sites. Indeed, as a conservation strategy, it is urgent to secure forests galleries along the Mono river, as these habitats are currently disturbed by the poachers often coming out from Benin.

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## APPENDIX

*List of the various encounters (direct observations and heard calls) with primates done during the surveys at the study areas*

Abbreviations: No. = number of individuals (approximative when No. > 10). Dist. = Distance from the observer's. VOB = visibility of the observation band.

Locality	Date	Species	Presence sign	No	Time	Dist.	VOB	Longitude /East	Latitude /North
Dévé (Tovégoé)	07/03/2015	<i>Cercopithecus e. erythrogaster</i>	Observed	10	07h01	15m	30m	1.43047	6.87588
Atchenkéli	08/03/2015	<i>Cercopithecus e. erythrogaster</i>	Observed	7	07h22	18m	40m	1.44752	6.90936
Atchenkéli	08/03/2015	<i>Cercopithecus e. erythrogaster</i>	Observed	4	08h10	18m	50m	1.45383	6.91275
Gboto-Zouvi	23/03/2015	<i>Cercopithecus e. erythrogaster</i>	Observed	8	15h56	30m	140m	1.45383	6.864
Tométy-kondji	26/03/2015	<i>Cercopithecus e. erythrogaster</i>	Observed	10	14h33	25m	150m	1.55147	6.86031
Dévé (Tovégoé)	06/03/2015	<i>Cercopithecus e. erythrogaster</i>	Observed	50	09h25	50m	60m	1.41763	6.85977
Tométy-kondji	04/12/2014	<i>Cercopithecus e. erythrogaster</i>	Observed	2	09h40	20m	20m	1.41763	6.83397
Tométy-kondji	05/12/2014	<i>Cercopithecus e. erythrogaster</i>	Observed	1	08h23	15m	20m	1.54288	6.82141
Gboto-Zouvi	06/12/2014	<i>Cercopithecus e. erythrogaster</i>	Observed	1	05h32	10m	20m	1.46688	6.80448
Gboto-Zouvi	06/12/2014	<i>Cercopithecus e. erythrogaster</i>	Observed	2	06h07	12m	20m	1.46647	6.80605
Kpotivé Forest	29/07/2017	<i>Cercopithecus e. erythrogaster</i>	Observed	40	12h54	30m	50m	1.47488	6.84661
Entré Bethé	29/07/2017	<i>Cercopithecus e. erythrogaster</i>	Observed	3	13h47	100m	100m	1.47866	6.81708
Gogo Kondji	15/06/2017	<i>Cercopithecus e. erythrogaster</i>	Observed	15		70m	500m	1.59	6.62097
Dévé (Tovégoé) Forest	14/08/2017	<i>Cercopithecus e. erythrogaster</i>	Observed	15	18h20	15m	15m	1.4315	6.86255
Dévé (Tovégoé)	07/03/2015	<i>Cercopithecus mona</i>	Observed	5	07h01	20m	30m	1.43047	6.87588
Atchenkéli	08/03/2015	<i>Cercopithecus mona</i>	Observed	6	07h22	20m	40m	1.44752	6.90936
Atchenkéli	08/03/2015	<i>Cercopithecus mona</i>	Observed	5	08h10	15m	50m	1.45383	6.91275
Tométy-kondji	04/12/2014	<i>Cercopithecus mona</i>	Observed	1	13h00	15m	20m	1.55744	6.84222
Gboto-Zouvi	06/12/2014	<i>Cercopithecus mona</i>	Observed	2	05h32	7m	20m	1.46688	6.80461
Gboto-Zouvi	06/12/2014	<i>Cercopithecus mona</i>	Observed	9	06h07	10m	20m	1.46647	6.80605
Godjinmè	31/07/2017	<i>Cercopithecus mona</i>	Observed	20	7h47	100m	100m	1.51691	6.71816
Houndoulé Forest	26/07/2017	<i>Cercopithecus mona</i>	Observed	60	08h38	100m	100m	1.58370	6.83458
Godjinmè-Tchawoè	25/07/2017	<i>Cercopithecus mona</i>	Observed	10	10h53	30m	30m	1.52516	6.71988
Godjinmè-Tchawoè	25/07/2017	<i>Cercopithecus mona</i>	Observed	10	10h45	100m	100m	1.52516	6.71961
Amévo Forest	10/06/2017	<i>Cercopithecus mona</i>	Observed	50	16h35	50m	70m	1.7455	6.41863
Avévé(Mambui) Forest	11/06/2017	<i>Cercopithecus mona</i>	Observed	2	07h30	50m	55m	1.74447	6.41847
Hadivi	13/06/2017	<i>Cercopithecus mona</i>	Observed	40	08h50			1.68056	6.51774
Hadivi	13/06/2017	<i>Cercopithecus mona</i>	Observed	40	09h45			1.67993	6.51135
Hadivi	13/06/2017	<i>Cercopithecus mona</i>	Observed	1	10h30			1.67988	6.51004
Hadivi	13/06/2017	<i>Cercopithecus mona</i>	Observed	30	10h50	70m	70m	1.67988	6.51
Gogo Kondji	15/06/2017	<i>Cercopithecus mona</i>	Observed	60		70m	500m	1.59422	6.62097
Aketé-Atchankli Forest	11/08/2017	<i>Cercopithecus mona</i>	Observed	5	09h14	40m	80m	1.43933	6.90561
Aketé-Atchankli Forest	11/08/2017	<i>Cercopithecus mona</i>	Observed	5	09h35			1.43619	6.91086
Aketé-Atchankli Forest	11/08/2017	<i>Cercopithecus mona</i>	Observed	30	09h47			1.44130	6.90541
Aketé-Atchankli Forest	11/08/2017	<i>Cercopithecus mona</i>	Observed	35	09h54	30m	50m	1.41725	6.9015
Gbowlé Forest	13/08/2017	<i>Cercopithecus mona</i>	Observed	15	12h15			1.48752	6.90741
Site Kpétumé (siyimé)	13/08/2017	<i>Cercopithecus mona</i>	Observed	15	11h08			1.48586	6.97641
Site Kpétumé (siyimé)	13/08/2017	<i>Cercopithecus mona</i>	Observed	10	09h47			1.49294	6.97647
Site Kpétumé (siyimé)	14/08/2017	<i>Cercopithecus mona</i>	Observed	4	07h45	30m	100m	1.48347	6.96922
Dévé (Tovégoé)	14/08/2017	<i>Cercopithecus mona</i>	Observed	40	18h20	15m	15m	1.4315	6.86255
Dévé (Tovégoé)	14/08/2017	<i>Cercopithecus mona</i>	Observed	2	17h20			1.42280	6.85636
Dévé (Tovégoé)	14/08/2017	<i>Cercopithecus mona</i>	Observed	2	17h25			1.41963	6.85436
Dévé (Tovégoé)	15/08/2017	<i>Cercopithecus mona</i>	Observed	20	07h00		100m	1.41180	6.85258
Akissa	03/04/2016	<i>Cercopithecus mona</i>	Observed	20	09h15	20 m	20 m	1.7655	6.31727
Takpome	03/04/2016	<i>Cercopithecus mona</i>	Observed	25	08h10	30 m	60 m	1.7726	6.31369
Akissa	03/04/2016	<i>Cercopithecus mona</i>	Call		12h48		15 m	1.7658	6.31352
Takpome	04/04/2016	<i>Cercopithecus mona</i>	Observed	3	05h30	40 m	50 m	1.7658	6.29786
Amévo (Avévé)	14/04/2016	<i>Cercopithecus mona</i>	Observed	10	12h00		12 m	1.74211	6.41338
Amévo (Avévé)	14/04/2016	<i>Cercopithecus mona</i>	Observed	6	12h00		10 m	1.7435	6.41311
Amévo (Avévé)	14/04/2016	<i>Cercopithecus mona</i>	Observed	15	15h00		12 m	1.73716	6.41861
Mambui (Avévé)	14/04/2016	<i>Cercopithecus mona</i>	Call				50 m	1.74111	6.41516
Fontan	14/04/2016	<i>Cercopithecus mona</i>	Observed	5	15h30	50 m	60 m	1.74610	6.41566
Dévé (Tovégoé)	07/03/2015	<i>Chlorocebus tantalus</i>	Observed	15	07h01	18m	30m	1.43047	6.87588
Godjinmè	21/03/2015	<i>Chlorocebus tantalus</i>	Observed	15	16h08	40m	40m	1.51911	6.72072
Godjinmè	22/03/2015	<i>Chlorocebus tantalus</i>	Observed	10	07h20	30m	40m	1.52052	6.71930
Tométy-kondji	26/03/2015	<i>Chlorocebus tantalus</i>	Observed	15	10h19	20m	30m	1.54324	6.82847
Dévé (Tovégoé)	05/06/2015	<i>Chlorocebus tantalus</i>	Observed	9	06h16	30m	50m	1.40558	6.86275
Tométy-kondji	04/12/2014	<i>Chlorocebus tantalus</i>	Observed	15	10h37	15m	20m	1.55675	6.84333
Tométy-kondji	04/12/2014	<i>Chlorocebus tantalus</i>	Observed	11	13h00	20m	20m	1.55744	6.84222
Tométy-kondji	04/12/2014	<i>Chlorocebus tantalus</i>	Observed	7	15h45	18m	20m	1.551	6.85675
Tométy-kondji	04/12/2014	<i>Chlorocebus tantalus</i>	Observed	15	16h20	15m	15m	1.54783	6.85780
Tométy-kondji	05/12/2014	<i>Chlorocebus tantalus</i>	Observed	10	08h23	20m	20m	1.54288	6.82141
Gboto-Zouvi	06/12/2014	<i>Chlorocebus tantalus</i>	Observed	6	08h06	14m	20m	1.46574	6.79508
Dévé (Tovégoé)	08/12/2014	<i>Chlorocebus tantalus</i>	Observed	3	06h43	15m	15m	1.40808	6.85763
Dévé (Tovégoé)	08/12/2014	<i>Chlorocebus tantalus</i>	Observed	10	10h45	10m	15m	1.41191	6.87447
Afito	30/07/2017	<i>Chlorocebus tantalus</i>	Observed	15	7h44	90m	90m	1.58177	6.79238
Godjinmè-Tchawoè	25/07/2017	<i>Chlorocebus tantalus</i>	Observed	5	10h53	30m	30m	1.52516	6.71988
Amévo Forest	10/06/2017	<i>Chlorocebus tantalus</i>	Observed	20	16h35	50m	70m	1.7455	6.41863
Avévé ( Mambui )	11/06/2017	<i>Chlorocebus tantalus</i>	Observed	50	07h32	40m		1.73669	6.4195
Hadivi	13/06/2017	<i>Chlorocebus tantalus</i>	Observed	60	08h50			1.6728	6.50805

Awatsè Forest	13/06/2017	<i>Chlorocebus tantalus</i>	Observed	20	17h05	60m	60m	1.65513	6.49986
Gogo Kondji	15/06/2017	<i>Chlorocebus tantalus</i>	Observed	20		70m	500m	1.58677	6.62097
Aketé-Atchankli Forest	11/08/2017	<i>Chlorocebus tantalus</i>	Observed	2	16h05	20m	20m	1.45161	6.93980
Fontan	14/04/2016	<i>Chlorocebus tantalus</i>	Observed	12	15h30	50 m	60 m	1.74594	6.41566
Dévé (Tovégoé)	10/09/2014	<i>Colobus vellerosus</i>	Observed	1	11h00		30m	1.41102	6.86805
Aketé-Atchankli Forest	11/08/2017	<i>Colobus vellerosus</i>	Observed	2	09h47			1.44130	6.90541
Gbowlé Forest	13/08/2017	<i>Colobus vellerosus</i>	Observed	2	10h15			1.55044	6.92191
Siyimé Forest	13/08/2017	<i>Colobus vellerosus</i>	Observed	2	12h15			1.4875	6.90741
Tométy-kondji	26/03/2015	<i>Erythrocebus patas</i>	Observed	20	10h19	30m	30m	1.54324	6.82847
Tométy-kondji	04/12/2014	<i>Erythrocebus patas</i>	Observed	10	09h40	20m	20m	1.54494	6.83397
Tométy-kondji	04/12/2014	<i>Erythrocebus patas</i>	Observed	5	15h45	12m	20m	1.551	6.85675
Tométy-kondji	04/12/2014	<i>Erythrocebus patas</i>	Observed	10	16h20	10m	15m	1.54783	6.85780
Gboto-Zouvi	06/12/2014	<i>Erythrocebus patas</i>	Observed	20	06h07	15m	20m	1.46647	6.80605
Gboto-Zouvi	06/12/2014	<i>Erythrocebus patas</i>	Observed	15	08h06	15m	20m	1.46574	6.79508
Dévé (Tovégoé)	08/12/2014	<i>Erythrocebus patas</i>	Observed	2	08h30	15m	15m	1.40916	6.86197
Godjinmè	31/07/2017	<i>Erythrocebus patas</i>	Observed	30	7h45	100m	100m	1.51572	6.71725
Godjinmè	31/07/2017	<i>Erythrocebus patas</i>	Observed	2	8h07	30m	100m	1.51616	6.71591
Sédome-Mono	30/07/2017	<i>Erythrocebus patas</i>	Observed	40	7h07	70m	70m	1.518	6.79286
Kpotivé Forest	29/07/2017	<i>Erythrocebus patas</i>	Observed	30	10h00	50m	100m	1.47327	6.81086
Entrance Tovigan	28/07/2017	<i>Erythrocebus patas</i>	Observed	25	08h57	30m	30m	1.52691	6.83094
Tovigan River	28/07/2017	<i>Erythrocebus patas</i>	Observed	2	09h28	10m	10m	1.54222	6.85286
Near Houndoulè	26/07/2017	<i>Erythrocebus patas</i>	Observed	2	12h22	80m	80m	1.58572	6.86027
Houndoulè Trail	26/07/2017	<i>Erythrocebus patas</i>	Observed	60	09h46	50m	200m	1.57280	6.84508
Houndoulè River	26/07/2017	<i>Erythrocebus patas</i>	Observed	60	14h22	40m	300m	1.57816	6.85625
Godjinmè-Tchawoè	25/07/2017	<i>Erythrocebus patas</i>	Observed	25	10h45		100m	1.52516	6.71961
Godjinmè	31/07/2017	<i>Erythrocebus patas</i>	Observed	2	08h20	35m	35m	1.51616	6.71591
Aketé-Atchankli Forest	11/08/2017	<i>Erythrocebus patas</i>	Observed	40	09h47			1.44130	6.90541
Aketé-Atchankli Forest	11/08/2017	<i>Erythrocebus patas</i>	Observed	5	10h12			1.43191	6.94105
Aketé-Atchankli Forest	11/08/2017	<i>Erythrocebus patas</i>	Observed	10	11h02			1.43194	6.94125
Gbowlé Forest	13/08/2017	<i>Erythrocebus patas</i>	Observed	15	10h15			1.55044	6.92191
Siyimé Forest	13/08/2017	<i>Erythrocebus patas</i>	Observed	20	12h15			1.48752	6.90741
Site Kpétumé (siyimé)	13/08/2017	<i>Erythrocebus patas</i>	Observed	25	11h08			1.48586	6.97641
Dévé 1 Forest	15/08/2017	<i>Erythrocebus patas</i>	Observed	30	08h00	8m	50m	1.42330	6.8555
Dévé 1 Atchankli Forêt	15/08/2017	<i>Erythrocebus patas</i>	Observed	2	08h03	10m	50m	1.41655	6.89208
Gboto-Zouvi	24/03/2015	<i>Erythrocebus patas</i>	Observed	15	09h12	20m	30m	1.48227	6.79875
Site Kpétumé(siyimé)	13/08/2017	<i>Galago senegalensis</i>	Observed	50	07h54	02m	02m	1.48613	6.97611
Site Kpétumé(siyimé)	13/08/2017	<i>Galago senegalensis</i>	Observed	30	09h10			1.48594	6.97602
Mambui (Avévé)	14/04/2016	<i>Galago senegalensis</i>	Observed	2	13h30	05 m	05 m	1.74266	6.41069
Tométy-kondji	26/03/2015	<i>Papio anubis</i>	Observed	5	16h56	20m	30m	1.56602	6.85177
Gboto-Zouvi	06/12/2014	<i>Papio anubis</i>	Observed	5	06h07	10m	20m	1.46647	6.80605
Kpédaba Lane	27/07/2017	<i>Papio anubis</i>	Observed	6	09h34	20m	20m	1.55372	6.87719
Kpédaba Lane	27/07/2017	<i>Papio anubis</i>	Observed	5	09h02	20m	20m	1.55258	6.84427
Awloe	26/07/2017	<i>Papio anubis</i>	Observed	2	11h12	50m	50m	1.5865	6.86825
Houndoulè-Adrala	26/07/2017	<i>Papio anubis</i>	Observed	2	11h12	75m	75m	1.57822	6.8575
Houndoulè	26/07/2017	<i>Papio anubis</i>	Observed	2	10h24	60m	200m	1.57855	6.86763