

# The bats of the Kianjavato-Vatovavy region, lowland eastern central Madagascar

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## Abstract

In early 2014, we conducted a survey of the bats of the Kianjavato-Vatovavy region of lowland eastern central Madagascar. In general, few faunal surveys have been published on the bats of this part of the island. The Kianjavato-Vatovavy region is a zone where the chiropteran fauna has been surveyed on several occasions over the past 25 years and certain species, specifically *Myzopoda aurita*, have been the focus of ecological studies. The general area is composed of some relatively intact natural forests, secondary forests, mixed forest-agricultural areas, gallery forests, and open degraded marshlands modified for rice paddy and savannah (*savoka*). Some important areas of exposed bedrock hold caves and rock-shelters of varying size. Field techniques during the early 2014 surveys involved visits to diurnal roost sites (buildings, caves, and rock shelters) and extensive nocturnal capture with mist nets and harp traps. In total, 14 species are known from the site, based on different collections and recent fieldwork. Compared to other sites in the eastern lowland portion of the island, the Kianjavato-Vatovavy region has a relatively high species richness. The present study provides new distributional information for several species: *Pteropus rufus*, *Eidolon dupreanum*, *Myotis goudoti*, *Neoromicia matroka*, and *Chaerephon*

*atsinanana*. The most important finding is evidence of female *Myzopoda aurita* in the region; this species was previously locally known only by the capture of close to 100 males.

**Key words:** Madagascar, Kianjavato, Vatovavy, bats, inventories, species richness

## Résumé détaillé

La connaissance de la faune chiroptérologique malgache ne cesse de s'améliorer grâce aux travaux d'inventaires récemment entrepris. En effet, de nombreux sites auparavant peu connus ont pu être inventoriés dans la partie orientale de l'île, par exemple, les stations forestières d'Ivoloina et de Tampolo, la région de Tolagnaro, notamment Sainte-Luce et Mandena ou encore l'île Sainte-Marie. Pour étoffer les informations sur la distribution et l'écologie des chauves-souris, un inventaire a été fait dans la région de Kianjavato-Vatovavy du mois de janvier au mois de février 2014. Cette zone présente une topographie assez complexe avec une succession de nombreuses collines séparées par des vallées hébergeant des petits ruisseaux et des rivières. Outre les vestiges de formation autochtone, la végétation y est dominée par des formations secondaires ou « *savoka* » avec une prépondérance des *Ravenala madagascariensis*, des bambous et des plantations.

Les travaux d'échantillonnage ont été divisés en deux parties. Pendant le jour, des prospections de gîtes, aussi bien les grottes et les abris sous-roches que les constructions synanthropiques, ont été faites. Les chauves-souris y ont été capturées à l'aide d'un filet à papillons. Pendant la nuit, plusieurs sites ont été échantillonnés en utilisant des filets japonais et un piège harpe afin de capturer les chauves-souris pendant la phase de la recherche de leur nourriture.

Afin de présenter des informations fiables, les résultats des travaux antérieurs non publiés entrepris dans la région ont été inclus dans ce manuscrit, notamment ceux de Louise Emmons et G. Ken Creighton en 1987, de G. Ken Creighton et Jim Ryan en 1988, de F. H. Rattrimomanarivo et E. N. Rakotonandrasana en 2005, et de F. H. Rattrimomanarivo et S. M. Goodman en 2005. Au total, 14 espèces de chauves-souris ont été répertoriées dans la région de Kianjavato-Vatovavy

dont trois espèces frugivores : *Pteropus rufus*, *Eidolon dupreanum* et *Rousettus madagascariensis* et 11 espèces insectivores : *Hipposideros commersoni*, *Paremballonura atrata*, *Myzopoda aurita*, *Chaerephon atsinanana*, *Mops leucostigma*, *Mormopterus jugularis*, *Pipistrellus raceyi*, *Neoromicia matroka*, *Myotis goudoti*, *Scotophilus robustus* et *Miniopterus egeri*. Le présent travail a permis de constater que la région de Kianjavato-Vatovavy présente une diversité chiroptérologique plus importante par rapport aux divers sites de la région orientale de basse altitude. En outre, de nouvelles distributions ont été également définies pour *Pteropus rufus*, *Eidolon dupreanum*, *Myotis goudoti* et *Neoromicia matroka*. Pendant ce travail, deux individus femelles de *Myzopoda aurita* ont été également capturés à proximité des zones de recherches antérieures. Davantage de recherches seraient encore nécessaires pour mieux apprécier la biologie et l'écologie des chauves-souris de la région de Kianjavato-Vatovavy.

**Mots clés** : Madagascar, Kianjavato, Vatovavy, chauves-souris, inventaire, richesse spécifique

## Introduction

Over the past decade, a considerable amount of new information has been gathered on the bats of Madagascar. These advances include the description of a number of new species and even genera to science (Goodman, 2011; Goodman *et al.*, 2012), and different ecological aspects of a previously poorly known fauna. While there has been a notable concentration of work in the sedimentary rock areas of the western half of the island, associated with concentrations of bats in caves (Goodman *et al.*, 2005; Cardiff, 2006; Andriafidison *et al.*, 2007; Rakotoarivelo *et al.*, 2007), little has been published on the chiropteran fauna occurring at sites in the lowland humid forest zones of the east. There are a few exceptions, such as the littoral and lowland forest near Tolagnaro in the extreme southeast (Jenkins *et al.*, 2007; Goodman, 1999); the Ivoloïna Forestry Station, north of Toamasina (Ramasindrazana, 2008, 2009); the Tampolo Forestry Station, north of Fénériver-Est (Ifticène *et al.*, 2005); and the bats of the offshore island of Ile Sainte-Marie (Rakotonandrasana & Goodman, 2007). One site that has been previously surveyed, but certain faunistic data unpublished is the region of Kianjavato, to the west of Manankara-Mananjary, specifically the zone

around the local forestry station and the Vatovavy Massif (Figure 1).

The Kianjavato Forestry Station, which is under the direction of FOFIFA ("Foibe Fihofanana momba ny Fambolena" or The National Center for Applied Research on Rural Development), has been the site of considerable work on the local chiropteran fauna, ranging from several different collection surveys from 1987, 1988, and 2005, as well as ecological studies specifically focusing on the sucker-footed bat *Myzopoda aurita* (Andriamboavonjy, 2009; Ralisata *et al.*, 2010; Riskin & Racey, 2010). Different systematic revisions concerning Malagasy bats and recently described species have also been published including specimens obtained from this zone (Bates *et al.*, 2006; Goodman *et al.*, 2011). The purpose of this paper is to summarize information on the bat fauna of Kianjavato and neighboring areas including portions of the Vatovavy Massif, based on previous studies, different museum collections as well as new fieldwork, and to document certain ecological aspects of the locally occurring species.

## Material and Methods

### Previously made museum collections

From 9 to 12 August 1987, Louise Emmons and G. Ken Creighton visited the Kianjavato-Vatovavy area and collected bats at a site "0.5 km N Kianjavato", 47.8667°E, 21.3833°S. The following year G. Ken Creighton returned to the same general zone accompanied by Jim Ryan and collected bats on 28 to 31 July 1988 at "Vatovavy, 9 km ESE Kianjavato", 47.95°E, 21.40°S and on 3 August 1988 at "4 km by road, E Kianjavato," 47.90°E, 21.38°S. These specimens are housed in The National Museum of Natural History (USNM), Washington, D.C.

Additional collections were made by Fanja H. Ratrimomanarivo and Eddy Rakotonandrasana from 22 to 24 May 2005 at different sites around Kianjavato, including animals using synanthropic day roosts within the village, as well as in local caves and rock shelters. Fanja H. Ratrimomanarivo returned to the area on 25 September 2005 with Steven M. Goodman for a night of bat netting at the Kianjavato Forestry Station. Specimens from these field surveys are housed in the Département de Biologie Animale (UADBA), Université d'Antananarivo, Antananarivo, and The Field Museum of Natural History (FMNH), Chicago.

From 10 January to 5 February 2014, a field team composed of Beza Ramasindrazana, Mercia Rasoanoro, and Steven M. Goodman conducted

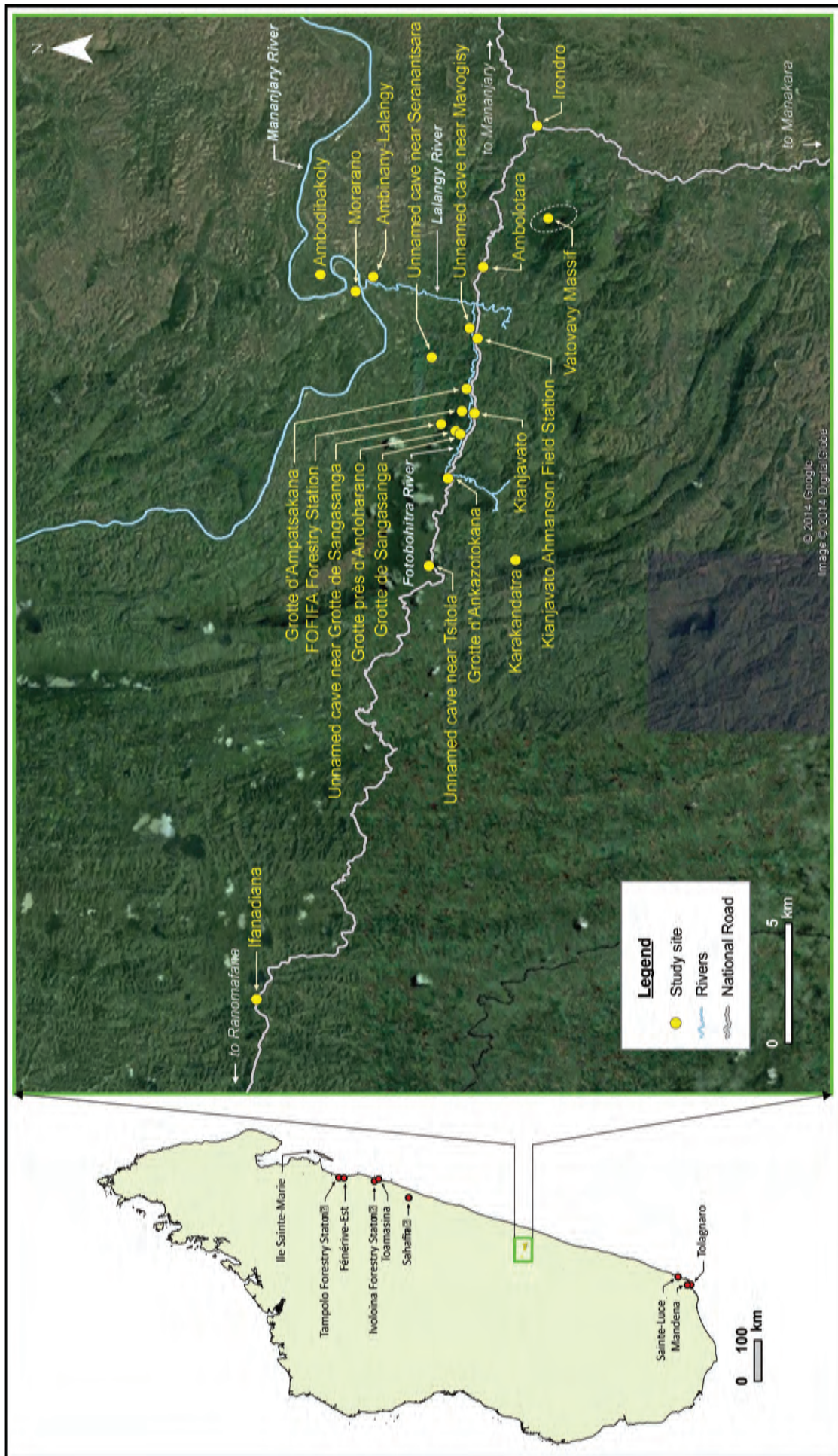


Figure 1. Map of the general Kianjavato-Vatovavy region, with the principal national road, rivers and sites mentioned in the text.

fieldwork on the bats of the Kianjavato-Vatovavy area. The techniques used by this group are discussed in the next section, but associated specimens are housed in the UADBA and FMNH collections.

### Fieldwork in 2014

Intensive bat surveys were conducted from 10 January to 5 February 2014 in the Kianjavato-Vatovavy area. During the day, different buildings, caves or rock-shelters were visited to document the species and roosting associations of bats and during the night a series of sites were sampled. In general, bats were captured at day roost sites with a long handled butterfly net and during the night sampled with 6 m (short) or 12 m (long) mist nets in a variety of set positions in different types of forested areas, gallery habitat, and open agricultural or degraded zones. Further, at a few sites during night surveys, a harp trap was employed along narrow trails in closed native or secondary forest habitats. More detailed information on the ecology of the local bat communities and aspects of prey availability and prey consumption will be presented in the forthcoming DEA mémoire of Mercia Rasoanoro.

In some cases, voucher specimens were saved and standard external measurements and information on reproductive condition were noted. Blood samples from bats will be used for a study of bat hematoparasites, as well as ectoparasites in systematic studies of bat flies and associated zoonoses. The specimens collected in 2014 were divided between the FMNH and UADBA and have yet to be catalogued at these institutions; hence, we use the museum acronym and field number when referring to specific specimens.

### Description of local habitats

The natural vegetation of the Kianjavato-Vatovavy region is lowland eastern humid forest. The zone has been notably disturbed by human activities and little relatively intact native vegetation exists. The majority of the immediate area has been the subject of extensive forest clearing and slash-and-burn agriculture, with the resulting habitat being mixed grasses and woody vegetation, often composed of introduced and invasive species, referred to in Malagasy as “*savoka*” (Manjaribe *et al.*, 2013). With repeated burning, *savoka* is transformed into a grassland formation with some scattered short-growing woody plants known as “*roranga*”. In natural forests of the Kianjavato-Vatovavy region, *Ravenala*

*madagascariensis* is relatively common and these trees are distinctly more abundant in degraded habitats and outside the forest, particularly in low-lying areas.

The zone is topographically complex with numerous deep valleys, often serving as drainages for streams and rivers of different size. The elevational range of the zone varies from approximately 50 to 600 m above sea level. Annual rainfall at Kianjavato is about 1800 mm, with the majority falling between December and March (Manjaribe *et al.*, 2013). In some years, strong cyclonic systems pass through the area, bringing considerable rainfall during short periods and on occasion with devastating winds. The mean annual temperature is 23.4°C, with monthly means ranging from 16.1°C in June to 30.7°C in January (FOFIFA weather station, 2011, published in Manjaribe *et al.*, 2013).

In close proximity to the village of Kianjavato is the previously mentioned Kianjavato Forestry Station, which maintains a plantation of a wide variety of different species and varieties of coffee (Andrianasolo *et al.*, 2013). The habitats within the station are diverse and vary from blocks of relatively intact native forest, often heavily fragmented, to secondary forests mixed with plantations of coffee and different introduced fruiting trees, dense zones of bamboo and degraded *savoka* and *roranga*. The station is bordered on the Kianjavato (village) side by the Fotobohitra River.

## Species accounts

### Family Pteropodidae

#### *Pteropus rufus* E. Geoffroy, 1803

**General distribution** – *Pteropus rufus* is broadly distributed in the eastern humid forest, dry deciduous forest formations of northwestern and western Madagascar, and southwest spiny bush; it occurs across an elevational range from near sea level to about 1400 m (Goodman & Ramasindrazana, 2013). It is recorded at numerous eastern lowland sites, including Ivoloina Forestry Station, littoral forests near Tolagnaro and Ile Sainte-Marie (Jenkins *et al.*, 2007; Rakotonandrasana & Goodman, 2007; Ramasindrazana, 2008).

**Previous specimens** – We are unaware of any specimen record of this taxon from the Kianjavato-Vatovavy area. Although details are lacking, it was previously noted as occurring near Kianjavato (Andriambovonjy, 2009).

**Records from 2014 field season** – This species was documented in the Kianjavato-Vatovavy area. Near Ambodibakoly (Figure 1), about 20 individuals were found roosting singly from *Ravenala* petioles and directly under the shade of leaves (Figure 2). Approximately 1 km from this site, a *P. rufus* group of unknown size was roosting in trees. Animals at these roost sites are exploited by local people for bush meat.

***Eidolon dupreanum* (Pollen, 1866)**

**General distribution** – *Eidolon dupreanum* is broadly distributed in the eastern humid forest, dry deciduous forest formations of northwestern and western Madagascar, and southwest spiny bush; it occurs across an elevational range from near sea level to about 1800 m (Goodman & Ramasindrazana, 2013). It has been recorded in lowland forests near Tolagnaro (Jenkins *et al.*, 2007).

**Previous specimens** – We are unaware of any previous specimen record of this taxon from the Kianjavato-Vatovavy area before early 2014. Although details are lacking, this species was previously noted

as occurring near Kianjavato (Andriamboavonjy, 2009).

**Records from 2014 field season** – A small roosting colony of *Eidolon dupreanum* was located on a rock cliff near Karakandatra (Figures 1 & 3). Approximately



**Figure 2.** *Pteropus rufus* was found in the vicinity of Ambodibakoly, where about 20 individuals were found roosting singly in *Ravenala* trees. (Photograph taken by Mercia Rasoanoro.)



**Figure 3.** A roost site of about 100 *Eidolon dupreanum* was located on a rock cliff near Karakandatra and was surrounded by dense areas of *Ravenala* and agricultural fields. (Photograph taken by Mercia Rasoanoro.)

100 individuals occurred at the roost site, which was surrounded by dense areas of *Ravenala* and agricultural fields. These animals are exploited by local people for bush meat.

***Rousettus madagascariensis* G. Grandidier, 1928**

**General distribution** – *Rousettus madagascariensis* is broadly distributed in the eastern humid forest and the dry deciduous forest formations of northwestern and western Madagascar across an elevational range from near sea level to about 1150 m (Goodman & Ramasindrazana, 2013). It is recorded at numerous eastern lowland sites, including Tampolo Forestry Station, Mandena (Tolagnaro), and Ile Sainte-Marie (Ifticène *et al.*, 2005; Jenkins *et al.*, 2007; Rakotonandrasana & Goodman, 2007).

**Previous specimens** – A number of specimens have been obtained in the Kianjavato-Vatovavy region, these include: 4 km by road, E Kianjavato, 3 August 1988, “mistnet over stream in secondary forest beside coffee and banana plantation” (USNM 449206-209, 449272-278); 0.5 km N Kianjavato, 9-12 August 1987, “mistnet across river between town & banana plantation”, “garden”, “forest edge”, and “over small river between coffee plantation and village” (USNM 448880-882, 448919, 448921-928); and FOFIFA Forestry Station, 24 May 2005, “piste à côté des arbres fruitiers, formation savoka et des touffes de bambou” (FMNH 185223).

**Records from 2014 field season** – This species was frequently captured in mist nets set across water. There is presumably a day roost site relatively close to the village of Kianjavato, within a relatively deep rock shelter or cave, which was not located during the 2014 survey of the area or disclosed to us by local guides. However, given that individuals of *R. madagascariensis* were captured near the forestry station in mist nets within 20 minutes after sunset, the roosting site must be in relatively close proximity to this site.

In January and February 2014, most captured *Rousettus* were not in breeding condition and included numerous subadults. One exception was a female collected on 10 January 2014, which was carrying an embryo of 40 mm crown-rump length, indicating notably late breeding for this species. A number of females handled during this period showed signs of recent lactation, almost certainly associated with the considerable number of subadults captured.

**Family Hipposideridae**

***Hipposideros commersoni* (E. Geoffroy, 1803)**

**General distribution** – *Hipposideros commersoni* is broadly distributed in the eastern humid forest, dry deciduous forest formations of northwestern and western Madagascar, and southwest spiny bush; it occurs across an elevational range from near sea level to about 1325 m (Goodman & Ramasindrazana, 2013). It was been documented at several the central eastern lowland sites of Tampolo Forestry Station, littoral forests near Tolagnaro, and Ivoloina Forestry Station (Ifticène *et al.*, 2005; Jenkins *et al.*, 2007; Raharinantenaina *et al.*, 2008; Ramasindrazana, 2008, 2009).

**Previous specimens** – We are unaware of any specimen of this species from the Kianjavato-Vatovavy region. This species was previously noted as being captured on several occasions near Kianjavato (Andriamboavonjy, 2009) and include during the different field seasons of Mahefatiana Ralisata at the FOFIFA Forestry Station: eight individuals in 2008 and two in 2010 (Figure 4).

**Records from 2014 field season** – Not captured or noted.



**Figure 4.** A roosting individual of *Hipposideros commersoni* found on 26 November 2010 within the FOFIFA Forestry Station. (Photograph taken by Mahefatiana Ralisata.)

**Family Emballonuridae**

***Paremballonura atrata* (Peters, 1874)**

**General distribution** – This species is broadly distributed in the eastern humid forest across an elevational range from near sea level to about 1100

m (Goodman & Ramasindrazana, 2013). Previously recorded at the central eastern lowland site of Ile Sainte-Marie (Rakotonandrasana & Goodman, 2007).

**Previous specimens** – Previous collections from the Kianjavato-Vatovavy region include three individuals collected on 25 May 2005 at a site near Kianjavato known locally as “Grotte à Kianjavato Taloha”, 47.860°E, 21.374°S, “dans la forêt” (FMNH 185224-226). Tissue samples from these individuals were used in a phylogeographical study of this species (Goodman *et al.*, 2006).

**Records from 2014 field season** – In the different areas of exposed rock in the Kianjavato-Vatovavy area, this species makes its day roosts in shallow caves or rock shelters. During the 2014 survey, a number of such sites were visited (see Figure 1) that held active day roost sites of this species (number in parentheses is estimate of roosting individuals and succinct information on local habitat[s]):

- 1) Grotte près d’Andoharano (circa 50 individuals, secondary natural forest with some introduced plants);
- 2) Grotte d’Ankazotokana (circa 50 individuals, secondary natural forest with some introduced plants and fruit trees);
- 3) Grotte d’Ampatsakana (circa 20 individuals, in forested zone dominated by native vegetation);
- 4) Grotte de Sangasanga (circa 10 individuals, in forested zone dominated by native vegetation);
- 5) Unnamed cave in close proximity to Grotte de Sangasanga (circa five individuals, in forested zone dominated by native vegetation);
- 6) Unnamed cave near Mavogisy (circa 10 individuals, in close proximity to human habitation and surrounded by introduced fruit trees);
- 7) Unnamed cave near Tsitola (circa four individuals, in a zone of secondary vegetation dominated by *Ravenala*, banana, and *Afromomum*);
- 8) Unnamed cave near Seranantsara (a few individuals, in close vicinity to rice field);
- 9) Morarano (circa 10 individuals, in excavated 10-15 m deep tunnel and surrounded by open zone with areas of bamboo and a small river.

In general, the caves or rock shelters where *P. atrata* was found were not occupied by other bat species. The one exception was an unnamed tunnel shaped rock shelter near the Grotte de Sangasanga, where a single *Myotis goudoti* was found roosting with a small number of *P. atrata*. As has been documented for another member of this genus elsewhere on

Madagascar (Rakotonandrasana & Goodman, 2007), an individual was trapped in a synanthropic setting, specifically an abandoned building within the forestry station.

In January 2014, a significant proportion (more than 50%) of the captured individuals were juveniles or subadults, and several females showed signs of recent lactation. Only single placental scars were found in females that had recently bred.

## Family Myzopodidae

### *Myzopoda aurita* Milne Edwards & A. Grandidier, 1878

**General distribution** – *Myzopoda aurita* is broadly distributed in the eastern humid forest across an elevational range from near sea level to about 1000 m (Goodman & Ramasindrazana, 2013). It was been documented at several the central eastern lowland sites of Tampolo Forestry Station, Sainte-Luce near Tolagnaro, and Ivoloïna Forestry Station (Ifticène *et al.*, 2005; Jenkins *et al.*, 2007; Ramasindrazana, 2008, 2009).

**Previous specimens** – On the basis of bat collections made in the Kianjavato area by Louise Emmons, G. Ken Creighton, and Jim Ryan in 1987 and 1988, the forestry station became known as a site where this species could be easily captured (Schliemann & Goodman, 2003). Subsequently, the zone surrounding the station was used for different studies on the ecology of this species (Andriamboavonjy, 2009; Ralisata *et al.*, 2010; Riskin & Racey, 2010).

Earlier specimen records from this site and elsewhere in the Kianjavato-Vatovavy area include: Vatovavy, 9 km ESE Kianjavato, 28 and 31 July 1988, “mist net across forest trail”, “streamside net”, and “along path between tomb and highway” (USNM 449283-284); 0.5 km N Kianjavato, 9 and 12 August 1987, with individuals taken in a variety of different mist net sets including “net across river between town and banana plantation”, and “coffee plantation” (USNM 448883-886, 448929-932); 4 km by road, E Kianjavato, 3 August 1988, “mist net over stream in secondary forest beside banana & coffee plantation” (USNM 449285); Kianjavato, FOFIFA Station, 24 May 2005 and 25 September 2005, “piste à côté des arbres fruitiers, formation *savoka* et des touffes de bamboo”, “in disturbed mixed native and introduced forest” (FMNH 185227, 187621-622). Tissue samples saved from some of the Kianjavato specimens

were used in a phylogeographical study of *M. aurita* (Russell *et al.*, 2008).

**Records from 2014 field season** – During the course of the early 2014 fieldwork, the majority of captured individuals were obtained in nets set across streams and rivers, such as the Fotobohitra River below the FOFIFA Forestry Station.

In a detailed study of *M. aurita* in and around the Kianjavato Forestry Station conducted by Ralisata *et al.* (2010), 98 unique individuals were captured, all of which were male, including a notable percentage of juveniles. The lack of any females being captured during the course of this study, conducted across different seasons and years (October–November 2007, February–March 2008, July–August 2008, and October–November 2008) is difficult to explain, but may be related to some differential dispersal between the sexes. Despite the intensive work of Ralisata and colleagues, there are indeed some records of females near Kianjavato:

- 1) 31 July 1988, Vatovavy, 9 km ESE Kianjavato by G. Ken Creighton and Jim Ryan, animal captured in a mist net (USNM 449284),
- 2) 17 January 2014, 4 km below the village of Kianjavato, in a 12 m mist net traversing the Fotobohitra River, in an agricultural zone with fruit trees (bananas), some native vegetation, and areas of bamboo (FMNH RB-266),
- 3) 22 January 2014, in the immediate vicinity of the site where FMNH RB-266 was netted, another female was captured in a 6 m net blocking an exit passage in a zone of dense bamboo and native vegetation (UADBA MR-21).

Both females netted in 2014 showed signs of recent lactation. The later female was captured in the same net a few minutes before an adult male of this species.

On the basis of these records, female *M. aurita* do occur in the vicinity of Kianjavato. Moreover, a few kilometers below Kianjavato there is evidence of breeding females. In their review of possible explanations of the pronounced sexual separation in *M. aurita*, Ralisata *et al.* (2010) reviewed cases of differential movements within non-Malagasy Vespertilionidae bats, with males moving to higher elevations than females. This might be an explanation for the unisexual captures of *Myzopoda* by these researchers in and around the Kianjavato Forestry Station. The fact that two of the female records are from a month that Ralisata and colleagues did not net bats at Kianjavato and from elevations below that of

the Kianjavato Forestry Station, approximately 80 m elevation, might indicate some subtle difference in the elevational range of the sexes. Further inventories above and below Kianjavato should help to verify this hypothesis.

Few details are available on the period of reproduction in *M. aurita*, which is a key element combined with information on the condition of reproductive organs, to determine potential seasonal displacements of non-breeding males. The observation from the latter half of January 2014 of females that had recently lactated gives an indication that reproduction takes place in the latter portion of the calendar year. At other localities on Madagascar both sexes have been captured at the same site and during the same period: Bemangidy, north of Tolagnaro, 25 December 1948 (two females and one male; FMNH 85237, 92832-833); Ivoloina Forestry Station, north of Toamasina, 19 November to 5 December (two females and three males; UADBA 43236-240), and also at the Ivoloina Forestry Station, 25 and 27 April 2007 (one female and 4 males; FMNH 194176-180). The first two cases fall during the presumed breeding period of this species and last case during the post-breeding period. Males captured near Kianjavato in mid-January 2014 had externally visible testes in the uropatagium, but in no case did collected males show enlarged epididymes; it can be assumed they were not in reproductive condition.

#### Family Molossidae

##### ***Chaerephon atsinanana* Goodman, Buccas, Naidoo, Ratrimomanarivo, Taylor & Lamb, 2010**

**General distribution** – This species is broadly distributed in the eastern humid forest across an elevational range from near sea level to about 1000 m (Goodman & Ramasindrazana, 2013). It has been recorded at the central eastern lowland site of Ivoloina Forestry Station (Ramasindrazana, 2009); this record was assigned to *C. pumilus*.

**Previous specimens** – We are unaware of any previous specimen of this taxon collected in the Kianjavato-Vatovavy area before early 2014, but it is known from numerous east coast localities, including near Manankara (Goodman *et al.*, 2010).

**Records from 2014 field season** – This species was found at two different locations in the Kianjavato-Vatovavy area -- both cases in synanthropic settings. At the first roost, a single animal was captured from a small colony (ca. 10 individuals) found in an attic of a school at Ambolotara (Figure 1). The second



roost was composed of more than 20 individuals and located in an abandoned barrack near Ambinany-Lalangy, which was being used as a pigsty, and roosted in spaces between cracks in the concrete walls within the building. At the same site, individuals of *Neoromicia matroka* were also found and they roosted within the attic space in vertical positions attached to roof joists. Female *C. atsinanana* collected on 4 February 2014 showed active signs of breeding with embryos measuring between 27 and 30 mm crown-rump length and several others actively lactating.

### ***Mops leucostigma* G. M. Allen, 1918**

**General distribution** – *Mops leucostigma* is broadly distributed in the eastern humid forest, dry deciduous forest formations of northwestern and western Madagascar, and southwest spiny bush; it occurs across an elevational range from near sea level to about 1350 m (Goodman & Ramasindrazana, 2013). This species has been previously recorded at the central eastern lowland site of Ivoloïna Forestry Station (Ramasindrazana, 2008, 2009), as well as in a number of synanthropic settings across this portion of Madagascar (Ratrimomanarivo *et al.*, 2008).

**Previous specimens** – In previous studies of the region, a number of specimens of *Mops leucostigma* have been collected. These include at 0.5 km N Kianjavato, 12 August 1987, “over river between coffee plantation, banana grove & village” (USNM 448890-891, 448942-943); Kianjavato ville, Eglise catholique (47.63789°E, 21.30373°S), 22 May 2005, “maison près des formations savoka”.

**Records from 2014 field season** – This species is known to occupy synanthropic day roost sites (Ratrimomanarivo *et al.*, 2008), which was the case for individuals found during our work in the Kianjavato-Vatovavy area. A roost of at least seven individuals of this species was found in an abandoned military barrack near Ambinany-Lalangy (Figure 1), which was being used for a pigsty. In one case three individuals and in another four individuals were found together in crevices within the cement walls of the structure. This building was different from the one with the *C. atsinanana* and *N. matroka* roost (see above). One female collected on 3 February 2014 had a single embryo in the uterus measuring 24 mm crown-rump length.

### ***Mormopterus jugularis* (Peters, 1865)**

**General distribution** – *Mormopterus jugularis* is broadly distributed in the eastern humid forest, dry deciduous forest formations of northwestern and western Madagascar, and southwest spiny bush; it occurs across an elevational range from near sea level to about 1700 m (Goodman & Ramasindrazana, 2013). It was been documented at Mandena near Tolagnaro (Jenkins *et al.*, 2007) as well as in a number of synanthropic settings across this portion of Madagascar (Ratrimomanarivo *et al.*, 2009).

**Previous specimens** – We are unaware of any specimens of this species from the Kianjavato-Vatovavy region. Although details are lacking, this species was previously noted as being captured near Kianjavato (Andriamboavonjy, 2009).

**Records from 2014 field season** – Not captured or noted.

### **Family Vespertilionidae**

#### ***Pipistrellus raceyi* Bates, Ratrimomanarivo, Harrison & Goodman, 2006**

**General distribution** – *Pipistrellus raceyi* is broadly distributed in the eastern humid forest and a few sites in the dry deciduous forest formations of western Madagascar. It has been found across an elevational range from 10 to 300 m (Goodman & Ramasindrazana, 2013). This species has been recorded at the central eastern lowland forestry stations of Tampolo and Ivoloïna (Ifticène *et al.*, 2005; Ramasindrazana, 2009).

**Previous specimens** – A number of specimens referable to this species have been collected in the Kianjavato-Vatovavy region: 0.5 km N Kianjavato, 11 August 1987, netted in “garden of house in coffee plantation” (USNM 448887); Kianjavato, CSB II [=Centre de Santé Base Niveau II], 47.866°E, 21.381°S, 22 May 2005, “Maison près des formations savoka” (FMNH 185562-571). The latter group of specimens forms a portion of the type series associated with the description of *P. raceyi* and FMNH 185567 is the holotype (Bates *et al.*, 2006).

**Records from 2014 field season** – During the early 2014 fieldwork, a male and a female were captured in a 12 m mist net spanning the Fotobohitra River just below the FOFIFA Forestry Station. At Ambalahosy (Figure 1), this species was found roosting in the same building as *Neoromicia matroka* and *Myotis goudoti*, but each of the species was found in different positions between the ceiling joists and roofing.

***Neoromicia matroka* (Thomas & Schwann, 1905)**

**General distribution** – *Neoromicia matroka* is broadly distributed in the eastern humid forest across an elevational range from near sea level to about 1450 m (Goodman & Ramasindrazana, 2013).

**Previous specimens** – Previous specimens collected in the Kianjavato-Vatovavy area and referable to this species include: 0.5 km N Kianjavato, 11 August 1987, “garden of house in coffee plantation” (USNM 448936-937).

**Records from 2014 field season** – In early 2014, one roosting individual of *N. matroka* were found in a church at Ambalahosy (Figure 1) that was also occupied by *Pipistrellus raceyi* and *Myotis goudoti*. Another individual was captured in a synanthropic setting at Ambinany-Lalangy in close proximity to individuals of *Chaerephon atsinanana* (see above). Both captured *N. matroka* were males and showed no sign of being in breeding condition.

***Myotis goudoti* (A. Smith, 1834)**

**General distribution** – This species is broadly distributed in the eastern humid forest, dry deciduous forest formations of northwestern and western Madagascar, and southwest spiny bush across an elevational range from near sea level to about 1450 m (Goodman & Ramasindrazana, 2013). *Myotis goudoti* was recorded at eastern lowland sites of Ivoloïna Forestry Station (Ramasindrazana, 2009) and Sainte-Luce and Mandena near Tolagnaro (Jenkins *et al.*, 2007).

**Previous specimens** – In earlier field surveys in the Kianjavato-Vatovavy area specimens have been collected of this species and include: Vatovavy, 9 km ESE Kianjavato, 29-30 July 1988, “along forest trail” (USNM 449200-201, 449280); 0.5 km N Kianjavato, 12 August 1987, “coffee plantation” (USNM 448934); 4 km by road, E Kianjavato, 3 August 1988, “mist net over stream in secondary forest beside banana and coffee plantations” (USNM 449279).

**Records from 2014 field season** – During the early 2014 field season, a female was netted over an open rice field and in close proximity to a zone of *Raphia* palms. Two roost sites of this species were located. The first was in an unnamed tunnel shape rock shelter near the Grotte de Sangasanga (Figure 1), where one individual was found roosting and attached in a vertical position to the rock walls. About five individuals of *Paremballonura atrata* were

found in the same cave in close vicinity of *M. goudoti*. The second roost site was at Ambalahosy, where the species co-occurred with *P. raceyi* and *N. matroka*.

***Scotophilus robustus* Milne Edwards, 1881**

**General distribution** – This species is broadly distributed in the eastern humid forest and dry deciduous forest formations of northwestern and western Madagascar across an elevational range from near sea level to about 1400 m (Goodman & Ramasindrazana, 2013). It has been recorded at the eastern lowland site of Mandena near Tolagnaro (Jenkins *et al.*, 2007).

**Previous specimens** – We are unaware of any previous specimen of this taxon collected in the Kianjavato-Vatovavy area before early 2014. Although details are lacking, *Scotophilus robustus* and *Scotophilus* sp. were noted as having been netted near Kianjavato (Andriamboavonjy, 2009).

**Records from 2014 field season** – In January and February 2014, three individuals of *Scotophilus robustus* were obtained: an adult female not in reproductive condition trapped in a 6 m net installed across a road in a secondary forest surrounded by mixed native and introduced plants within the Kianjavato Forestry Station; and an adult male with non-developed testes and a female not in reproductive condition were trapped in a net crossing the Fotobohitra River in close proximity to the FOFIFA Forestry Station.

**Family Miniopteridae*****Miniopterus egeri* Goodman, Ramasindrazana, Maminirina, Schoeman & Appleton, 2011**

**General distribution** – *Miniopterus egeri* occurs across the eastern humid forest from the Maroantsetra area south to Andrambovato and across an elevational range from near sea level to about 1300 m (Goodman *et al.*, 2011; Goodman & Ramasindrazana, 2013). It was recorded at the eastern lowland site of Sahafina (Goodman *et al.*, 2011). Echolocation calls of *Miniopterus* recorded at the Ivoloïna Forestry Station were most likely of this species (Ramasindrazana, 2009). Previous records of *M. manavi* at Kianjavato (Andriamboavonjy, 2009) are presumably referable to *M. egeri*.

**Previous specimens** – During early bat surveys, a number of *M. egeri* were collected in the Kianjavato-Vatovavy area: Vatovavy, 9 km ESE Kianjavato, 29 and 30 July 1988, “along forest trail” (USNM

449202-203, 449286-287); 0.5 km N Kianjavato, 12 August 1987, “coffee plantation” (USNM 488888-889, 448938-940); 4 km by road, E Kianjavato, 3 August 1988, “mist net over stream in secondary forest beside coffee and banana plantations, 7-9 p.m.” (USNM 449288); Kianjavato, FOFIFA station, 25 September 2005, “in disturbed mixed native and introduced forest” (FMNH 187663-664). Several of these specimens were used in the description of this species (Goodman *et al.*, 2011).

**Records from 2014 field season** – During the early 2014 field visit to the Kianjavato-Vatovavy area, this species was relatively uncommon and only two individuals were captured. One was netted along the Fotobohitra River in close proximity of the FOFIFA Forestry Station and the other captured in a harp trap placed along a narrow road in secondary forest surrounded by mixed native and introduced plants. The female captured on 11 January showed signs of recent lactation.

## Discussion

Two decades after the publication of a monograph on Malagasy bats (Peterson *et al.*, 1995), information on the diversity and ecology of these animals is a long ways from being complete. In some cases, considerable data remains unpublished, such as the specimen records presented herein from Kianjavato-Vatovavy dating from 1987, 1988, and 2005. In the present study, using a combination of museum specimens, published information, and new field studies, we were able to document and summarize bat diversity in the Kianjavato-Vatovavy region. In total, 14 species have been documented in this region, which is more than any other lowland eastern site on the island (Table 1).

A number of additional species were added to the regional list. These include, for example, the local occurrence of three species of frugivorous bats belonging to the family Pteropodidae. Members of this family are well-known for their capacity to disperse seeds and for pollination of different plants, helping to assure the dissemination of native plant formations across considerable distances (Shilton *et al.*, 1999; Singaravelan & Marimuthu, 2004; Raheriarisena, 2005). Some species, including *Scotophilus robustus* and *Neoromicia matroka*, were not previously reported from the Vatovavy-Kianjavato region. Because of similarities in morphology, *N. matroka* can be easily confused with *Pipistrellus raceyi*. The

records presented herein for both of these taxa are based on morphological and molecular characters.

Some useful information was gathered on the roosting ecology of certain species, particularly for those for which little information is available in the lowland east. *Myotis goudoti* was found roosting in a small cave and in another case in a synanthropic setting. This latter roost site is seemingly uncommon for this species, which generally occurs in caves and rock shelters (Goodman, 2011) and perhaps constitute a temporary roost site. Two other species of vesper bats, *Pipistrellus raceyi* and *Neoromicia matroka* were also found roosting in the same building with *M. goudoti*.

One of the more interesting findings during the early 2014 fieldwork, was the capture of two female *Myzopoda aurita*, as well as earlier documentation of a female in the region in 1988 based on previous museum collections. During a multi-year and multi-season intensive study of this species in the Kianjavato-Vatovavy region, Ralisata *et al.* (2010) only captured males and presented a very strong case for differential sexual dispersal. During our survey, females were captured approximately 4 km below Kianjavato village and in one of these cases a male was also obtained in the same net set a few minutes after the female. A hypothesis can be advanced to explain this observation. In certain portions of the study area, both sexes of *M. aurita* presumably roost and forage in close proximity. In contrast, in the immediate vicinity of the FOFIFA Forestry Station, where Ralisata *et al.* (2010) worked, only adult and juvenile males were captured. While rather subtle, the area below Kianjavato may represent a zone where both sexes occur and in and around Kianjavato restricted to only males. During the mating season males presumably join females for at least a short period and then return to the bachelor roosts. Further, after independence from females, subadult males join the bachelor groups at slightly higher elevations.

In the literature, bat diversity from the eastern lowland areas of Madagascar is considered relatively low to lowland sites in the west (Eger & Mitchell, 2003). This is at least associated with complex cave systems and exposed rocks in the west, providing a diversity of roosting sites and certain sites hold at least 19 species (Goodman, 2011; Goodman & Ramasindrazana, 2013). In the eastern lowland portion of the island, such rock formations are not common. This was not the case in the Kianjavato-Vatovavy area, where considerable exposed rock

Table 1. Species diversity of bats at some localities in the eastern lowland of Madagascar.

Family	Genus and species	Ile Sainte Marie	Tampolo Forestry Station	Ivoloina Forestry Station	Kianjavato-Vatovavy	Tolagnaro
<b>Pteropodidae</b>	<i>Eidolon dupreanum</i>	-	-	-	+	+
	<i>Pteropus rufus</i>	+	-	+	+	+
	<i>Rousettus madagascariensis</i>	+	+	-	+	+
<b>Hipposideridae</b>	<i>Hipposideros commersoni</i>	-	+	+	+	+
<b>Emballonuridae</b>	<i>Paremballonura atrata</i>	+	-	-	+	-
	<i>Taphozous mauritianus</i>	-	+	-	-	-
<b>Myzopodidae</b>	<i>Myzopoda aurita</i>	-	+	+	+	+
<b>Molossidae</b>	<i>Chaerephon atsinanana</i>	-	-	+	+	-
	<i>Mops leucostigma</i>	-	+	+	+	-
	<i>Mormopterus jugularis</i>	-	-	-	+	+
	<i>Tadarida fulminans</i>	-	-	-	-	+
<b>Vespertilionidae</b>	<i>Pipistrellus raceyi</i>	-	+	+	+	-
	<i>Neoromicia matroka</i>	-	-	-	+	-
	<i>Myotis goudoti</i>	-	-	+	+	+
	<i>Scotophilus robustus</i>	-	-	-	+	+
<b>Miniopteridae</b>	<i>Miniopterus egeri</i>	-	-	-	+	-
	<i>Miniopterus gleni</i>	+	-	-	-	+
	<i>Miniopterus majori</i>	-	-	-	-	+
	<i>Miniopterus petersoni</i>	-	-	-	-	+
<b>Total number of species</b>		<b>4</b>	<b>6</b>	<b>7</b>	<b>14<sup>1</sup></b>	<b>12</b>
<b>References</b>		Rakotonandrasana & Goodman (2007)	Iflicène <i>et al.</i> (2005), Raharinantenaina <i>et al.</i> (2008)	Ramasindrazana (2009)	This study; Andriamboavonjy (2009)	Jenkins <i>et al.</i> (2007); Maminirina <i>et al.</i> (2009); Peterson <i>et al.</i> (1995)

<sup>1</sup> Andriamboavonjy (2009, annex 1) noted several species present in the Kianjavato area that are not treated herein and currently not accepted for the local bat species list: *Emballonura* [= *Paraemballonura*] *tiavato*, *Taphozous mauritianus*, *Traienops* [= *Paratrienops*] *furculus*, *T. rufus* [= *menamena*], *Pipistrellus nanus*, *Scotophilus tandrefana*, *Miniopterus gleni*, *M. majori*, *Chaerephon leucogaster*, *C. jobimena*, and *Otomops madagascariensis*.

and associated small caves and rock shelters can be found. This is probably the best explanation for the elevated local species diversity. With further fieldwork, it is certain that additional taxa will be added to the local list, as a number of bats are known from the lowland east, but yet not recorded in the Kianjavato-Vatovavy area.

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