Shrews (Soricidae) of the lowland forests around Kisangani (DR Congo)

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Abstract

Background

The Congo Basin rainforest is the second largest rainforest in the world and one of the most biodiverse regions on Earth. Nevertheless, the Congo Basin biodiversity remains to be fully mapped, with many species awaiting discovery or official description. In recent years, much effort has been put into research on shrews (Soricidae), particularly in the region around Kisangani (D.R. Congo). Shrews are opportunistic feeders that are able to forage on a large diversity of invertebrate prey and therefore play an important role in the forest ecosystem. Furthermore, as they largely depend on forest habitats and have limited dispersal capacities, shrews form an interesting model group to study biogeographic patterns in the Congo Basin.
New information

This paper collates the efforts on shrew research from the wider region around Kisangani, in the centre of the Congo Basin. Apart from sampling information, the dataset includes morphological measures, DNA sequences and photographs. This dataset is therefore critical in the study of the taxonomy and ecology of Soricidae in the Congo Basin lowland rainforests.

Keywords

pitfall, removal trapping, tropical lowland forest, Democratic Republic Congo, Soricidae

Introduction

The Congo basin rainforest is the second largest in the world and one of the most biodiverse regions on earth (Mittermeier et al. 2003, Lewis 2005). Both the forest and its biodiversity are threatened by forest loss and bushmeat hunting (Malhi et al. 2013). Despite its importance for climate change mitigation and biodiversity conservation, knowledge on the impact of forest loss and degradation and bushmeat hunting on local biodiversity is currently lacking (Gibson et al. 2011, Alroy 2017, Phillips et al. 2017). In fact, the biodiversity of the Congo basin is generally understudied, with several new species being discovered every year (e.g. Colyn et al. 2010, Stanley et al. 2013).

Our knowledge on occurrence, ecology and taxonomy of shrews (Soricidae) in the Congo basin is currently incomplete (Mukinzi et al. 2005, Gambalemoke 2014, Jacquet et al. 2015). Shrews represent critical food web links via their role as predators of small vertebrates and invertebrates and as prey for several vertebrate predators (Churchfield et al. 2004). Apart from their importance in the ecosystem, shrews are also a suitable model taxon for evaluating biogeographic and historical hypotheses (Quérouil et al. 2003). Indeed, the central Congo basin (i.e. the lowland forests south of the Congo river) harbours less terrestrial vertebrate species than the northern part which is due to the smaller habitat area and isolated position of the central Congolian lowland forests (Van de Perre et al. 2019). As richness is limited by habitat area and isolation, this implies that diversity differences amongst Congolian lowland forests are mostly due to forest-associated taxa with limited dispersal capacities, such as shrews.

Therefore, this paper assembles shrew occurrences from three studies in the central Congo Basin (Gambalemoke et al. 2008b, Mukinzi 2014, Van de Perre et al. 2018) and includes the metadata of the captured specimens (morphological measurements, DNA and sampling details) which allows for the advancement of the knowledge on taxonomy and ecology of shrews in the central Congo basin.
General description

Purpose: This paper assembles data collected in the framework of the PhD theses of Jean-Claude Mukinzi Itoka, Sylvestre Gambalemoke Mbalitini and Frederik Van de Perre. These three theses were executed at or in collaboration with the University of Kisangani, the University of Antwerp and the Royal Belgian Institute for Natural Sciences. Although the design and purpose of the three studies differ, the sampling design (the method in which shrews were collected) is equal across studies, which justifies the publication of the dataset as a whole.

Project description

Study area description: We compiled data from three studies in the region around Kisangani (Gambalemoke et al. 2008b, Mukinzi 2014, Van de Perre et al. 2018). The combined data represent 36 sampling sites in which sampling effort was equal and distributed within 6 localities in the Tshopo Province (Fig. 1 and Table 1). Sampling localities are separated by the Congo River and some of its major tributaries (Tshopo, Lindi, Lomami).

Table 1.
List of sampling sites including locality (and initials of collectors), coordinates, forest type (OG-X: Mixed old-growth forest; OG-M: Monodominant old-growth forest; RF: Regrowth forest; FL: Fallow land; OP: abandoned oil palm plantation), number of trapping sessions, start date of trapping and range of field numbers under which specimens are stored.

| Locality   | Latitude | Longitude | Site      | Forest type | Number of trapping sessions | Start date  | Field numbers |
|------------|----------|-----------|-----------|-------------|-----------------------------|-------------|---------------|
| Baliko (SG)| 0.6415   | 26.3639   | Baliko_FP| OG-X        | 1                           | 23/09/2006  | BA77-675      |
|            | 0.6415   | 26.3639   | Baliko_FS| RF          | 1                           | 23/09/2006  |               |
|            | 0.6415   | 26.3639   | Baliko_JC| FL          | 1                           | 23/09/2006  |               |
| Djabir (JCM, SG)| 0.5192   | 24.1736   | Djabir_FP_L1| OG-X      | 1                           | 13/10/2005  | DJ1-567       |
|            | 0.5192   | 24.1736   | Djabir_FP_L2| OG-X      | 1                           | 13/10/2005  |               |
|            | 0.5192   | 24.1736   | Djabir_FS| RF          | 1                           | 13/10/2005  |               |
| Masako (JCM, SG)| 0.6051   | 25.2565   | Masako_FP| OG-X        | 1                           | 2/06/2005   | R27985-28242  |
|            | 0.6051   | 25.2565   | Masako_FS| RF          | 1                           | 2/06/2005   |               |
|            | 0.6051   | 25.2565   | Masako_FS_L1A| RF       | 1                           | 12/03/2011  | CRT3151-3520  |
|            | 0.6051   | 25.2565   | Masako_FS_L1C| RF       | 1                           | 12/03/2011  |               |
|            | 0.6051   | 25.2565   | Masako_Gil_L1A| OG-M    | 1                           | 27/03/2012  | MSK1-362      |
|            | 0.6051   | 25.2565   | Masako_Gil_L1C| OG-M    | 1                           | 27/03/2012  |               |
| Locality | Latitude  | Longitude | Site          | Forest type | Number of trapping sessions | Start date | Field numbers |
|----------|-----------|-----------|---------------|-------------|-----------------------------|------------|---------------|
| Yangambi (FVdP) | 0.8144 | 24.4937 | Yangambi_BRA1 | OG-M        | 1                           | 12/07/2015 | COB2-1390     |
| Yangambi | 0.7966 | 24.4978 | Yangambi_GIL3 | OG-M        | 1                           | 8/05/2014  |               |
| Yangambi | 0.8081 | 24.5281 | Yangambi_GIL4 | OG-M        | 1                           | 21/06/2013 |               |
| Yangambi | 0.7894 | 24.5175 | Yangambi_JEU1 | RF          | 1                           | 20/06/2013 |               |
| Yangambi | 0.7949 | 24.4919 | Yangambi_JEU2 | RF          | 1                           | 7/05/2014  |               |
| Yangambi | 0.7967 | 24.4941 | Yangambi_JEU3 | RF          | 1                           | 13/07/2015 |               |
| Yangambi | 0.7931 | 24.4901 | Yangambi_JEU4 | RF          | 1                           | 16/07/2016 |               |
| Yangambi | 0.7921 | 24.4972 | Yangambi_JEU5 | RF          | 1                           | 17/07/2016 |               |
| Yangambi | 0.8135 | 24.5126 | Yangambi_MIX2 | OG-X        | 1                           | 16/07/2016 |               |
| Yangambi | 0.7805 | 24.5211 | Yangambi_MIX3 | OG-X        | 1                           | 20/06/2013 |               |
| Yangambi | 0.8144 | 24.4931 | Yangambi_MIX5 | OG-X        | 1                           | 12/07/2015 |               |
| Yangambi | 0.8026 | 24.4875 | Yangambi_MIX6 | OG-X        | 1                           | 7/05/2014  |               |
| Yelenge (JCM) | 0.6387 | 25.0780 | Yelenge_FP | OG-X        | 1                           | 6/03/2005  | R27622-27981  |
| Yelenge | 0.6387 | 25.0780 | Yelenge_FS | RF          | 1                           | 6/03/2005  |               |
| Yoko (JCM) | 0.2940 | 25.2881 | Babogombe_FPG_L1 | OG-M      | 5                           | 21/04/2007 | LEGM400-3017 |
| Yoko | 0.2940 | 25.2881 | Babogombe_FPG_L2 | OG-M      | 5                           | 22/02/2007 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_FP_L1 | OG-X      | 8                           | 14/12/2006 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_FP_L2 | OG-X      | 7                           | 14/12/2006 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_FP_L3 | OG-X      | 9                           | 21/04/2007 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_FS_L1 | RF       | 3                           | 14/12/2006 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_FS_L2 | RF       | 3                           | 14/12/2006 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_JJ_L1 | FL       | 3                           | 15/12/2006 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_JV_L1 | FL       | 3                           | 23/02/2007 |               |
| Yoko | 0.2940 | 25.2881 | Babogombe_JV_L2 | FL       | 2                           | 15/12/2006 |               |
| Yoko | 0.3234 | 25.2539 | Kisesa_JJ | FL         | 8                           | 18/10/2007 |               |
| Yoko | 0.3234 | 25.2539 | Kisesa_JV | FL         | 8                           | 18/10/2007 |               |
| Yoko | 0.3234 | 25.2539 | Kisesa_VPS | OP        | 8                           | 18/10/2007 |               |

In the study area, forest disturbance is mainly in the form of slash-and-burn agricultural activities, followed by abandonment and secondary succession. Fallow land, the pioneer stage of forest recolonisation, contains dense thickets with few tall trees. Regrowth forests generally are dominated by *Musanga cecropioides* in the canopy. Old-growth, closed canopy forests represent a range of vegetation, including mixed, semi-deciduous forest, monodominant forest of *Gilbertiodendron dewevrei* (De Wild.) J. Leonard and
monodominant forest of *Brachystegia laurentii* (De Wild.) Hoyle. In some localities, sampling was also conducted in abandoned oil palm plantations. Apart from Yangambi (Van de Perre et al. 2018), quantitative data on tree composition of each sampling site is lacking.

Following the revised Köppen-Geiger classification (Peel et al. 2007), the climate of the region is Af-type tropical rainforest climate. At the Yangambi meteorological station, the annual precipitation is 1839.5 ± 205.7 mm (1980–2012) and average dry season length is 3.3 ± 1.3 months (a month is dry if it receives less than 100 mm of precipitation). Dry seasons occur in December–February and June-August. Temperatures are high and constant throughout the year, with a minimum of 24.2 ± 0.4°C in July and a maximum of 25.5 ± 0.6°C in March (Doetterl et al. 2015).

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**Sampling methods**

**Sampling description:** In all localities, shrews were sampled using the paceline method, which involved placing 20 pitfall traps at 5 m intervals on transects (Nicolas et al. 2003). Pitfall traps consisted of non-baited buckets (10-litre, 30×30×23 cm) that were buried in the ground, with rims even with the ground surface. A plastic drift fence (100 m) was set to increase capture effectiveness by guiding shrews toward traps. Pitfall traps were maintained at their locations for 21 days and were checked daily. Only in Yoko, these pitfall...
lines were set for multiple sessions at the same location. In all other locations, trapping was only conducted once (Table 1).

**Quality control:** Species were identified based on external morphology and cranio-dental characteristics. In addition, species assignments were confirmed for several specimens of each species by molecular analysis (16s rRNA). Taxonomic nomenclature follows Hutterer (2005). Specimens belonging to problematic species complexes that are in need of revision were provisionally labelled with cheironyms, pending formal description.

**Step description:** Field measurements

Sex and sexual condition were noted for each specimen:

- **Males:**
  - testes: abdominal
  - swelling of the epididymis: visible or not
- **Females:**
  - vagina: closed or perforated
  - nipples: small or swollen, lactating
  - pregnant: yes or no

Following measurements were taken from those specimens that were completely intact:

- Weight (in grams)
- Body length (head - tailbone, in mm)
- Length of tail (tail length in mm of the point of curvature (anus) until the tip of the tail)
- Size of the left hind leg (0.1 mm)
- Size of the left ear (0.1 mm)

**Sample collection**

Samples of liver, spleen and kidney were stored in 96% alcohol and RNA-later (only kidney). Blood samples were transferred to filter paper. Ectoparasites were preserved in 70% alcohol. Carcasses of specimens were stored at the Laboratory of Ecology and Animal Resource Management (University of Kisangani) and the Zoologisches Forschungsmuseum Alexander Koenig (Bonn). Tissues samples are stored at the Evolutionary Ecology Lab (University of Antwerp) and at the Royal Belgian Institute of Natural Sciences (Brussels). All specimens are stored under their field number.

For the collection in Yangambi, pictures were taken of each specimen's ventral, dorsal and lateral sides.

**DNA Barcoding**

DNA analysis of 16S-rRNA was conducted for a selection of individuals. For PCR amplification, we used the primer pair 16Sar-L (forward: 5'-CGCCTGTGTATCAAAAACAT-3’, Palumbi et al. 1991) and 16S-Hm (reverse:
5′AGATCACGCTAGGACTTTAAT-3′, Quérouil et al. 2001). PCR amplification was performed in 15-µl reaction mixtures that contained 7.5 µl Qiagen Multiplex, 0.2 µM of each primer, 1.5 µl DNA template and 5.4 µl sterile deionised water. The reaction mixtures were preheated at 95°C for 15 min, followed by 42 amplification cycles (95°C for 30 s, 46°C for 90 s and 72°C for 90 s), with a final 10 min extension at 72°C. The samples were purified and sequenced in both directions at VIB Genetic Service Facility (University of Antwerp). Sequences were aligned using the Geneious software (Drummond et al. 2015).

**Geographic coverage**

**Description:** Lowland forests of the Kisangani, Isangi and Ubundu territories of the Tshopo province (former province Orientale), Democratic Republic of Congo.

**Coordinates:** 0°N and 1°N Latitude; 24°E and 27°E Longitude.

**Taxonomic coverage**

**Description:** All species belong to the family Soricidae, particularly the subfamily Crocidurinae. The dataset contains species from 5 genera: *Crocidura* (14 species), *Paracricidura* (1), *Scutisorex* (2), *Suncus* (1) and *Sylvisorex* (4) (Table 2).

| Species                     | Species Djabir     | Yoko  | Yangambi | Yelenge | Masako | Baliko |
|-----------------------------|--------------------|-------|----------|---------|--------|--------|
| *Crocidura caliginea* Hollister, 1916. | -      | -     | 52       | 3       | 14     | 7      |
| *Crocidura crenata* Brosset, Dubost & Heim de Balsac, 1965. | -      | -     | 9        | 5       | 2      | 0      |
| *Crocidura denti* Dollman, 1915. | -      | -     | 104      | 8       | 25     | 11     |
| *Crocidura dolichura* Peters, 1876. | 13     | 111   | 8        | 6       | 5      | 0      |
| *Crocidura cf. fuscomurina* Heuglin, 1865 | -      | 4     | -        | -       | -      | -      |
| *Crocidura goliath* Thomas, 1906. | 0      | 10    | -        | -       | -      | -      |
| *Crocidura grassei* Brosset, Dubost & Heim de Balsac, 1965. | 0      | 26    | -        | -       | -      | -      |
| *Crocidura latona* Hollister, 1916. | 21     | 168   | 0        | 1       | 26     | 0      |
| *Crocidura littoralis* Heller, 1910. | 27     | 24    | 153      | 44      | 21     | 4      |
| *Crocidura ludia* Hollister, 1916. | 4      | 1013  | 27       | 0       | 34     | 11     |
| *Crocidura cf. maurisca* Thomas, 1904 | 0      | 1     | -        | -       | -      | -      |
| *Crocidura cf. muricauda* Miller, 1900 | -      | -     | 4        | 0       | 1      | 0      |
| *Crocidura olivieri* Lesson, 1827. | 6      | 173   | 43       | 0       | 11     | 10     |

Table 2.
Number of specimens per species caught in each locality.
The dataset contains a number of specimens that likely belong to species new to science. Specimens morphologically resembling known species but found far outside the distribution of the known species have been identified using a cf. statement, others were named using a cheironym.

*Crocidura sp1 yoko* has easily distinguishable characteristics: small size (4-6 g), brownish on the back, greyish-brown on the belly, brownish tail that is completely glabrous, except from the base which is covered with few small vibrissae, the down side of the tail clear, almost white at the base and around the anus and its small paws are equally light coloured (Fig. 2). Its skull resembles that of *Crocidura ludia* but is smaller (Mukinzi-Itoka 2014).
Sylvisorex n.sp. is a small and rare species. Brown greyish on the back and silvery grey on the belly. It has a long tail covered with small hairs that grow longer and are more numerous towards the tip, forming a white brush. The tail is brown-black on top and slightly lighter on the bottom (Fig. 3). The species resembles Crocidura polia Hollister, 1916. However, the new species has little vibrissae on its tail while, in C. polia, half of the tail is covered with vibrissae (Mukinzi 2014).

Scutisorex n. sp. (description in progress, J. Hulselmans pers. comm.) was found in RF Yoko and its distribution seems to be limited to the forest bloc between the Lomami and Lualaba.

**Temporal coverage**

**Notes:** 8 June 2005 (Yelenge) to 7 August 2014 (Yangambi).

**Collection data**

**Collection name:** Carcasses of specimens were stored at the Laboratory of Ecology and Animal Resource Management, University of Kisangani. Tissues samples are stored at the University of Antwerp and at the Royal Belgian Institute of Natural Sciences. For the collection of Yangambi, pictures were taken of each specimen's ventral, dorsal and lateral sides.

**Specimen preservation method:** Samples of liver, spleen and kidney were stored in 96% alcohol and RNA-later (only kidney). Blood samples were transferred to filter paper.
Ectoparasites were preserved in 70% alcohol. Specimen carcasses were stored in 70% alcohol.

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Data resources

Data package title: African Mammalia

Resource link: http://projects.biodiversity.be/africanmammalia

Number of data sets: 3

Data set name: Specimen list

Download URL: http://projects.biodiversity.be/africanmammalia/search

Data format: .csv

Description: The data can be downloaded from the online database, African Mammalia. Shrew specimens can be searched through the 'Search' or 'Taxa' tab.

| Column label             | Column description                                      |
|--------------------------|--------------------------------------------------------|
| Collection number        | Museum collection number                                |
| Order                    | Taxonomic rank                                         |
| Family                   | Taxonomic rank                                         |
| Family author            | Author(s) and publication date of family                |
| Genus                    | Taxonomic rank                                         |
| Genus author             | Author(s) and publication date of genus                 |
| Species                  | Taxonomic rank                                         |
| Species author           | Author(s) and publication date of species               |
| Subspecies               | Taxonomic rank                                         |
| Subspecies author        | Author(s) and publication date of subspecies            |
| Determinator             | Determinator of specimen                                |
| Determination year       | Determination year                                      |
| Accuracy                 | Accuracy of determination                              |
| Field number             | Unique identifier of specimen                           |
| Locality                 | Sampling locality                                       |
| Altitude          | Altitude of sampling location in metres         |
|------------------|-----------------------------------------------|
| Altitude max     | Maximum altitude                              |
| Country iso code | CD                                            |
| Country          | Democratic Republic Congo                     |
| Latitude         | Latitude of sampling locality in decimal degrees |
| Longitude        | Longitude of sampling locality in decimal degrees |
| Collector        | Collector of specimen                          |
| Date collected   | Date of collection                             |
| Date collected end| End of data collection                        |
| Sex              | m, Male - f, Female                            |
| Sexual condition name | Sexual condition, see above                   |
| Sexual condition code | Sexual condition code                          |
| Age              | Age of specimen                                |
| Weight           | Weight in gram                                 |
| Type             | Holotype, paratype or syntype                  |
| Trap             | Type of trap used                              |
| Available        | Whether the specimen is present in the collection |
| Basis of record  | Preserved specimen or observation              |
| Tissues          | Whether tissue samples are available           |
| url              | Link to the specimen information on African Mammalia |

**Data set name:** Sequences

**Download URL:** [http://projects.biodiversity.be/africanmammalia/search](http://projects.biodiversity.be/africanmammalia/search)

**Data format:** .csv

**Description:** Export of DNA sequences and metadata.

| Column label       | Column description                                      |
|--------------------|---------------------------------------------------------|
| Collection number  | Museum collection number                                |
| Field number       | Field number                                            |
| Basis of record    | Preserved specimen or observation                        |
| Family             | Family, Soricidae                                        |
| Genus              | Genus name                                              |
| Species | Species name |
|---------|--------------|
| Subspecies | Subspecies name |
| Accession number | Genbank accession number |
| Sequence number | Unique sequence code |
| Sequence | DNA sequence |
| url | Link to the specimen information on African Mammalia. |

**Data set name:** Measurements

**Download URL:** [http://projects.biodiversity.be/africanmammalia/search](http://projects.biodiversity.be/africanmammalia/search)

**Data format:** .csv

**Description:** Export of morphological measurements and metadata.

| Column label | Column description |
|--------------|--------------------|
| Collection number | Museum collection number |
| Field number | Unique field code |
| Basis of record | Preserved specimen or observation |
| Family | Family, Soricidae |
| Genus | Genus name |
| Species | Species name |
| Subspecies | Subspecies name |
| Sex | Sex (Male or Female) |
| hb | Head-body length |
| tl | Tail length |
| hf | Hind foot length |
| el | Ear length |
| m1-m25 | Craniometric measurement, description available on [http://projects.biodiversity.be/africanmammalia/about/data#measurements](http://projects.biodiversity.be/africanmammalia/about/data#measurements) |
| url | Link to the specimen information on African Mammalia. |
Additional information

Results communication:

Results of diversity analyses have already been published in peer-reviewed journals (in chronological order):

- Mukinzi et al. (2005)
- Gambalemoke et al. (2008a)
- Gambalemoke et al. (2008b)
- Mukinzi et al. (2009)
- Van de Perre et al. (2018)

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Author contributions

Jean-Claude Mukinzi Itoka, Sylvestre Gambalemoke Mbalitini and Frederik Van de Perre are the main collectors of specimens and observations. Frederik Van de Perre sequenced the specimens. Julien Cigar developed the online database. Frederik Van de Perre wrote the first version of the manuscript and all co-authors contributed to the writing.

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