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Barn owl pellets collected in coastal savannas yield two additional species of small mammals for French Guiana.

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Small non-volant mammals in French Guianan savannas

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Abstract:
A sample of 251 pellets regurgitated by the Barn owl in an old building located in Sinnamary (French Guiana) provided a rare opportunity to get a preliminary inventory of small rodents and opossums living in grassy savannas along the coastal non-forested landscapes of this Guianan region.

From a total of 329 specimens of vertebrate remains, we focused on 259 small rodents and opossums which could be positively identified. Two species previously unknown in French Guiana were evidenced: a very small opossum of the genus Cryptonanus and the medium-sized terrestrial rodent Sigmodon alstoni. Whereas Cryptonanus was an unexpected finding so far away from its Amazonian distribution area, the presence of Sigmodon in French Guiana fills a gap between Suriname and Brazilian Amapa where this species is typical of grassy savannas.

The species of small mammals most commonly preyed upon by the Barn owls of Sinnamary was a large semi-aquatic rodent, Holochilus sciureus, followed in decreasing order by two sigmodontines typical of non-forested ecosystems: Oligoryzomys fulvescens and Zygodontomys brevicauda.

Keywords: Cryptonanus, Holochilus sciureus, Sigmodon alstoni; Coastal savannas; Amazonia
The analysis of owl pellets contents is a useful tool for providing an inventory of small mammal communities especially in open habitats such as agricultural landscapes or in cerrado-like biotopes (caatinga, savannas, llanos, grassy marshes, …) in the Neotropics (Rocha et al. 2011; Scheibler and Christoff 2007). The Barn owl (Tyto alba (Scopoli, 1769)) is a specialized predator and most of its preys are small non-volant mammals weighting from 15 to 250 grams. Several recent investigations of Barn owl pellets in Brazil and elsewhere in South America have evidenced the presence of some species of small rodents and opossums which otherwise were very rarely caught by standard trapping methods using live- or snap-traps. For example, Souza et al. (2010) found two rare dwarf opossums (Gracilinanus agilis Burmeister, 1854; Cryptonanus agricolai (Moojen, 1943)) among 162 pellets collected in the Northeastern Atlantic Forest realm, and those records were new for the coastal region of Pernambuco state. Similarly, Bonvicino and Bezerra (2003) found three rare species (2 small opossums, 1 cerrado mouse) in Barn owl pellets which could not be collected with traps, suggesting that trapping “was either inefficient or was not performed near their specific microhabitats”.

This study reports on Barn owl pellets which were collected in an old water-tower in downtown Sinnamary, French Guiana (05°23’ N; 52°57’W) in march 2011 (120 pellets) and in september 2013 (131 pellets). Sinnamary is a small city (3100 inhabitants in 2013) at ca. 100 km north-west from Cayenne; it is located within the coastal northern strip of the country, where non-forested areas, such as agricultural lands, grass and bush savannas, small thickets of trees, grassy swamps and marshes, predominate. The nearest large area of well-drained tropical rainforest starts at 3-4 km south-west from the village, and extends for dozens of km towards the south (the forest locality of Paracou studied by Voss et al. (2001) is only 12 km from the Barn owl breeding site of Sinnamary). Within a radius of 3 km from the Barn owl’s
nest, swamp areas and pastures with draining canals constitute most of the area to the north- 
east, whereas grass and bush savannas intermingled with small thickets dominate to the south-
east. The western sides of the water-tower are a mixture of highly degraded secondary forests 
and of agricultural openings for pastures and various abandoned crops.

The 251 pellets were individually examined for their bony content and a total of 329 
vertebrate specimens were isolated. Besides birds (46 individuals), bats (3 skulls of 
Molossidae) and unidentified murids (21 individuals), the pellets yielded 259 small rodents 
and opossums which could be identified to species level in most cases. For securing the 
identification, we relied on comparisons with cleaned skulls of reference specimens (vouchers 
deposited at Paris MNHN and Geneva MHNG museums) and descriptions and drawings 
found in Husson (1978), Voss et al. (2001), and Voss and Jansa (2009). All skull and 
mandibles materials from the owl’s pellets have been kept and are available for examination 
upon writing to the senior author. The following craniodental variables were used and are 
illustrated and/or defined in Voss et al. (2001) and in Carleton and Musser (1989): BR = 
Breadth of Rostrum; BZP = Breadth of Zygomatic Plate; LBP = Length of Bony Palate; LIB 
= Least Interorbital Breadth; LIF = Length of Incisive Foramen; M1, M1M2, M1M3 : lengths of 
upper molars; ZB = Zygomatic Breadth.

Craniodental measurements were taken with digital callipers and recorded to the nearest 0.01 
mm, but values reported herein are rounded to the nearest 0.1 mm. Univariate statistical tests 
for comparing measurements between groups included Mann–Whitney nonparametric test, as 
implemented by the software PAleontological STatistics (PAST: Hammer et al. 2011).

The following taxa were found in the pellets collected at Sinnamary:

- Cryptonanus sp Voss et al. 2005: 10 individuals of that very tiny opossum bring an 
additional taxon to the mammalian fauna of French Guiana. The identification of these 
remains (mandibles were almost complete, whereas skulls were highly damaged and resumed
to the maxillary, palatine and jugal bones) was kindly established by Robert S. Voss (AMNH, New York).

The upper molars measurements for 7 adult (all 4 upper molars definitive and erupted) individuals are (mean, minimum, maximum): M\(^1\) 1.5 (1.3 to 1.5); M\(^1\)M\(^2\) 2.8 (2.8 to 3.0); M\(^1\)M\(^3\) 4.2 (4.1 to 4.4); M\(^1\)M\(^4\) 4.8 (4.6 to 4.8); width of M\(^4\) (measured as in Voss and Jansa 2009) 1.9 (1.7 to 2.0).

The Sinnamary specimens of Cryptonanus appear smaller than C. agricolai, as judged by comparing M\(^1\)M\(^3\) and M\(^1\)M\(^4\) lengths values detailed in Voss et al. (2005: Table 5).

We refrain from naming to species level our pellets-derived materials of Cryptonanus sp., pending future analysis on complete vouchered animals that has been recently acquired (two adults weighing 14.5 and 15.5 g: unpublished data).

- Marmosa murina (Linnaeus, 1758): 7 individuals, whose upper molars measurements are as follows: M\(^1\)M\(^2\) 3.7 (3.5 to 4.0); M\(^1\)M\(^3\) 5.6 (5.1 to 6.0); M\(^1\)M\(^4\) 6.6 (6.3 to 7.1). Adult M. murina weigh ca 41 g (average of 39 individuals caught in French Guiana – unpublished materials).

- Philander opossum (Linnaeus, 1758): 1 juvenile (only 1. and 2. upper molars erupted): M\(^1\) = 3.8; M\(^1\)M\(^2\) = 7.8; P. opossum weighs ca. 220 g at that age (unpublished data).

- Holochilus sciureus Wagner, 1842: this large (adult animals of Guyana average 157 g: Twigg 1965) sigmodontine rodent was the most frequent prey of Tyto alba at Sinnamary, with 106 individuals (41 % of all 259 rodents and opossums), most of them being adults (as defined by having three fully erupted molars). The recognition of skull remains of Holochilus sciureus from similar-sized Nectomys rattus (Pelzeln, 1883) is straightforward if molars are still present, as their dental pattern is quite different (see page “A Sampler of Sigmodontine molars” in Myers et al. 2014). When upper molars are lacking (as was the case in 12 skulls), the recognition of Holochilus from Nectomys can be easily reached by measuring the Least
Interorbital Breadth (LIB), as already shown by Husson (1978) for Surinamese animals. In French Guiana, *Holochilus sciureus* have LIB values smaller than 5.4 mm whereas *Nectomys rattus* skulls are larger than 6.1 mm for that measurement (Table 1).

- *Nectomys rattus*: this large (average weight of 177 g for 23 adults in French Guiana: Catzeflis 2012) terrestrial rodent was represented by 26 individuals (10 %) and was ranked second after *Holochilus* when biomass was considered. See above for *Holochilus* concerning the identification of *Nectomys*.

- *Oligoryzomys fulvescens* (Saussure, 1860) was ranked second for its occurrence (59 individuals, or 23 %) but its contribution to the diet of *Tyto alba* was less than 4% of the total biomass, as this terrestrial oryzomyine weighs ca 17 g (average for 7 adults caught in French Guiana). The identification of this taxon was based upon dental and skull characters described and illustrated in Carleton and Musser (1989). We also compared the values of some selected craniodental measurements (Table 2) in Sinnamary pellets with those measured in vouchered specimens from French Guiana (housed at MNHN and MHNG museums).

- *Sigmodon alstoni* (Thomas, 1881): two individuals of this terrestrial sigmodontine bring an additional taxon to the mammalian fauna of French Guiana. The identification of this medium-sized (average weight is 61.5 g in Venezuela: Vivas 1986) species is straightforward due to its peculiar upper incisives which are broad and deeply grooved. Voss (1992) provides an excellent description together with detailed figures for the different species of *Sigmodon*, of which *S. alstoni* is the one already known in Suriname and Brazilian Amapa.

The following craniodental measurements characterize the 2 *S. alstoni* from Sinnamary owl’s pellets: LIB 5.0 & 5.2; M¹M² 4.1 & 3.9; M¹M³ 6.0 & 5.5; ZB 18.9 & 17.8.
Zygodontomys brevicauda (J.A. Allen and Chapman, 1893): 38 individuals of this terrestrial sigmodontine were identified by comparison with reference materials of French Guianan vouchers, together with the descriptions and drawings available in Voss (1991). *Zygodontomys* weigh ca 58 g (average for 52 adult specimens caught in French Guiana), therefore this species ranked third by its biomass in the diet of *Tyto alba* at Sinnamary. The following craniodental measurements are derived from 22 skull-remains: LIB 4.9 ± 0.3 (4.4 to 5.4); LIF 6.4 ± 0.6 (4.7 to 7.1); M1M2 3.3 ± 0.1 (3.0 to 3.5); M1M3 4.2 ± 0.1 (4.0 to 4.4);

- *Mus musculus* Linnaeus, 1758: one single damaged skull was identified through the unique murine pattern of the upper molars, and had the following measures: LIB 3.4; M1M2 2.7; M1M3 3.2; LIF 5.0. *Mus musculus* caught in French Guiana have an average weight of 14.0 g (average for 23 adults: unpublished data).

- *Rattus norvegicus* (Berkenhout, 1769): 6 individuals were identified through qualitative craniodental characters, and selected measurements confirmed their belonging to *R. norvegicus* (see pp. 382-420 in Niethammer and Krapp 1978). Average (N from 4 to 6 individuals) and range of values for Sinnamary’s materials are: LIB 6.5 (6.2 to 7.2); M1M2 5.4 (5.3 to 5.5); M1M3 7.1 (7.0 to 7.2); BZP 4.5 (4.0 to 4.9). We assume that those *R. norvegicus* were not full grown adults whose weight is too large for *Tyto alba* (Husson (1978) gives ca. 420 g for the average of 5 adult *R. norvegicus* from Suriname).

- *Rattus rattus* (Linnaeus, 1758): 2 individuals were identified by comparison with voucher specimens from French Guiana and by examining the characters currently in use for recognizing *R. rattus* from *R. norvegicus* in owl pellets (Corbet and Harris 1991; Niethammer and Krapp 1978). In French Guiana, *R. rattus* weighs ca. 120 g (average of 35 adult animals: 121 ± 33 g – unpublished data).
- *Proechimys guyannensis* (E. Geoffroy, 1803): one single damaged skull was identified through its typical dental pattern and by comparison with voucher materials. This was an adult with all molars erupted, corresponding to a weight of ca. 190 g (Catzeflis and Steiner 2000).

Two taxa are new for French Guiana (Catzeflis 2010; Lim 2012): *Cryptonanus* sp. and *Sigmodon alstoni*. Before the recent discovery of *Cryptonanus* in Brazilian Amapa (da Silva et al. 2013), the nearest locality for that diminutive opossum was Crato (07°14’S; 39°23’W) in Brazilian Ceara state for the species *C. agricolai* (Voss et al. 2005), that is ca. 2000 km south-east from Sinnamary. Da Silva et al. (2013) mention the capture of one specimen of *Cryptonanus* sp. in a grassy savanna landscape from south-east Amapa, in a locality along Highway BR-156 (0°05’ S; 51°10’ W ) near the Maraca River, that is still a distance of ca. 650 km south-east from Sinnamary. In September 2013 two adult *Cryptonanus* were caught in pitfalls at Sinnamary (unpublished data of F. Catzeflis and B. de Thoisy), and those preserved animals are under study for their identification to species level.

The discovery of *Sigmodon alstoni* in the pellets of the Barn owl from Sinnamary should be no surprise, as the presence in French Guiana of this savanna dweller was suspected by Voss (1992) who wrote that “*alstoni* should occur in the coastal savannas there “ because at that time *S. alstoni* was known from Suriname (Husson 1978; Williams et al. 1983) and Brazilian Amapa (Carvalho 1962). This species was also recently caught in southern Amapa, in grassy savannas near Ferreira Gomes (da Silva et al. 2013). *Sigmodon alstoni* is apparently not common around Sinnamary, as only two skulls were found (less than 1% of all 259 identified small mammals), whereas the similar-sized *Zygodontomys* accounts for 15 % of the preys.
At Sinnamary, Barn owls have a large range of prey sizes, from the tiny species around 15 g (Cryptonanus sp.; Mus musculus; Oligoryzomys fulvescens) to the larger taxa around 250 g (juvenile of Philander opossum; Proechimys cayennensis; subadults of Rattus norvegicus). Four species comprise 88% of all preys and 90% of the eaten biomass: by decreasing frequency those are Holochilus (157 g on average), Oligoryzomys (17 g), Zygodontomys (58 g), and Nectomys (177 g) (Table 3). Clearly, the “food value” (the energy) derived from an Holochilus is much higher than the one provided by an Oligoryzomys, and it is apparently more profitable for owls to select larger prey. With 106 individuals or 41% of all 259 prey items, Holochilus sciureus was apparently very common in the hunting area of the Barn owls, and it has been shown elsewhere in the Guianan Region that this rodent species might fluctuate in numbers up to high densities (Twigg, 1965). At Sinnamary, where grassy marshes and savannas are the most abundant places within a 3 to 4 km radius from downtown (unpublished data based on the examination of aerial pictures), the Barn owls secure 78 % of their consumed biomass of non-volant mammals through two species of “large” sigmodontines: Holochilus sciureus and Nectomys rattus (Table 3). But the selection of larger prey-species is not the rule everywhere, as shown by Scheibler and Christoff (2004) in agro-ecosystems of southern Brazil where Tyto alba preyed mostly (82% of 3618 vertebrates) upon Mus musculus, despite the fact that much larger rodents (Akodon; Necromys) were common in their study area.

Most authors who have compared inventories of small mammals through pellets analysis and through conventional trapping have concluded that those methods were complementary (Bonvicino and Bezerra 2003; Magrini and Facure 2008; Rocha et al. 2011; Scheibler and Christoff 2007). Thus our results can not be taken as an inventory of the non-volant small mammals living in the grassy savannas, marshes and shrublands around Sinnamary. Future research in these areas there should use conventional trapping as well as pitfalls for improving
our knowledge of rodents and opossums living in the non-forested coastal landscapes of French Guiana.

Acknowledgements: we thank Elisabeth Cabirou for her technical skills at sorting skulls and bones remains from the Sinnamary owl pellets. Our colleague and friend Robert S. Voss (AMNH, New York) was kind enough to examine and identify the skull remains of Cryptonanus sp. AB thanks the SEPANGUY association for allowing him to work on this project. We thank the environmental services of the municipality of Sinnamary for access to the water-tower building. That research was funded by institutional support of the French CNRS and of the University Montpellier-2.


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Table 1: Measurements (mm) of four craniodental variables in adult *Holochilus sciureus* and *Nectomys rattus*

<table>
<thead>
<tr>
<th>Variable</th>
<th><em>Holochilus sciureus</em></th>
<th><em>P-value</em></th>
<th><em>Nectomys rattus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>LIB</td>
<td>4.8 ± 0.3 (4.0-5.4) 91</td>
<td>&lt; 0.001</td>
<td>6.7 ± 0.4 (6.1-7.7) 25</td>
</tr>
<tr>
<td>M¹</td>
<td>3.0 ± 0.1 (2.6-3.3) 90</td>
<td>NS</td>
<td>3.0 ± 0.1 (2.8-3.2) 10</td>
</tr>
<tr>
<td>M¹M²</td>
<td>4.9 ± 0.2 (4.4-5.3) 92</td>
<td>NS</td>
<td>4.9 ± 0.2 (4.5-5.3) 11</td>
</tr>
<tr>
<td>ZB</td>
<td>20.1 ± 1.3 (17.9-22.8) 39</td>
<td>NS</td>
<td>21.0 ± 2.1 (17.1-24.1) 8</td>
</tr>
</tbody>
</table>

Summary statistics include the sample mean ± one standard deviation, the observed range (in parentheses), and the sample size. P-values for Mann-Whitney tests.

Abbreviations: LIB = Least Interorbital Breadth; M¹, M²: lengths of upper molars; ZB = Zygomatic Breadth; NS = non significant at p = 0.05 level
Table 2: Measurements (mm) of four craniodental variables in *Oligoryzomys fulvescens* skulls from Sinnamary pellets and in adult voucher specimens from French Guiana.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sinnamary owl's pellets</th>
<th>P-value</th>
<th>Reference specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIB</td>
<td>3.6 ± 0.2 (3.3-4.1)</td>
<td>NS</td>
<td>3.6 ± 0.2 (3.3-4.2)</td>
</tr>
<tr>
<td>M1,M3</td>
<td>3.0 ± 0.1 (2.7-3.1)</td>
<td>NS</td>
<td>3.0 ± 0.1 (2.8-3.2)</td>
</tr>
<tr>
<td>BR</td>
<td>4.3 ± 0.3 (3.9-5.1)</td>
<td>NS</td>
<td>4.3 ± 0.3 (3.8-5.1)</td>
</tr>
<tr>
<td>LBP</td>
<td>3.9 ± 0.1 (3.6-4.2)</td>
<td>NS</td>
<td>3.8 ± 0.2 (3.0-4.1)</td>
</tr>
</tbody>
</table>

Summary statistics include the sample mean ± one standard deviation, the observed range (in parentheses), and the sample size. P-values for Mann-Whitney tests.

Abbreviations: LIB = Least Interorbital Breadth; M1,M3: lengths of upper molars; BR = Breadth of Rostrum; LBP = Length of Bony Palate; NS = non significant at p = 0.05 level

Table 3: Relative contribution of each prey species to energy intake of the Barn owl, as expressed by the product of the sample size by the average weight of an individual. The total weight of all 259 ingested preys is 27'475 g, and energy intake is represented by the weight.

<table>
<thead>
<tr>
<th>Species</th>
<th>Weight (ref.)</th>
<th>N ind.</th>
<th>% ind.</th>
<th>% energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptonanus sp.</td>
<td>15 (a)</td>
<td>10</td>
<td>3,9</td>
<td>0,5</td>
</tr>
<tr>
<td>Marmosa murina</td>
<td>41 (a)</td>
<td>7</td>
<td>2,7</td>
<td>1,0</td>
</tr>
<tr>
<td>Philander opossum</td>
<td>220 (a)</td>
<td>1</td>
<td>0,4</td>
<td>0,8</td>
</tr>
<tr>
<td>Holochilus sciureus</td>
<td>157 (b)</td>
<td>106</td>
<td>40,9</td>
<td>60,6</td>
</tr>
<tr>
<td>Nectomys rattus</td>
<td>177 (c)</td>
<td>26</td>
<td>10,0</td>
<td>16,7</td>
</tr>
<tr>
<td>Oligoryzomys fulvescens</td>
<td>17 (a)</td>
<td>59</td>
<td>22,8</td>
<td>3,7</td>
</tr>
<tr>
<td>Sigmodon alstoni</td>
<td>61,5 (d)</td>
<td>2</td>
<td>0,8</td>
<td>0,4</td>
</tr>
<tr>
<td>Zygodontomys brevicauda</td>
<td>58 (a)</td>
<td>38</td>
<td>14,7</td>
<td>8,0</td>
</tr>
<tr>
<td>Mus musculus</td>
<td>14 (a)</td>
<td>1</td>
<td>0,4</td>
<td>0,1</td>
</tr>
<tr>
<td>Rattus norvegicus</td>
<td>300 (a)</td>
<td>6</td>
<td>2,3</td>
<td>6,6</td>
</tr>
<tr>
<td>Rattus rattus</td>
<td>120 (a)</td>
<td>2</td>
<td>0,8</td>
<td>0,9</td>
</tr>
<tr>
<td>Proechimys cayennensis</td>
<td>190 (e)</td>
<td>1</td>
<td>0,4</td>
<td>0,7</td>
</tr>
</tbody>
</table>

Abbreviations: (ref.) = reference for the average weight. a = unpublished data from wild-caught animals in French Guiana; b = Twigg (1965); c = Catzeflis (2012); d = Vivas (1986); e = Catzeflis and Steiner (2000).