Short Note

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

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 that 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*. Although *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: Amazonia; coastal savannas; *Cryptonanus*; *Holochilus sciureus*; *Sigmodon alstoni*.

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, etc.) in the Neotropics (Scheibler and Christoff 2007, Rocha et al. 2011). 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 g. 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, and *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. Similarily, Bonvicino and Bezerra (2003) found three rare species (two small opossums and one cerrado mouse) in barn owl pellets that 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 that 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 northwest 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 southwest from the village and extends for dozens of kilometers toward 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 northeast, whereas grass and bush savannas intermingled with small thickets dominate to the southeast. The western sides of the water tower are a

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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 (three skulls of Molossidae) and unidentified murids (21 individuals), the pellets yielded 259 small rodents and opossums that 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 mandible 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; M^1, M^1M^2, M^1M^3, lengths of upper molars; ZB, zygomatic breadth.

Craniodental measurements were taken with digital calipers 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): Ten 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 seven adults (all four upper molars definitive and erupted) individuals are (mean and range): M^1, 1.5 (1.3–1.5); M^1M^2, 2.8 (2.8–3.0); M^1M^3, 4.2 (4.1–4.4); M^1M^4, 4.8 (4.6–4.8); width of M^4 (measured as in Voss and Jansa 2009), 1.9 (1.7–2.0).

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

We refrain from naming to species level our pellet-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): Seven individuals, whose upper molars measurements are as follows: M^1M^2, 3.7 (3.5–4.0); M^1M^3, 5.6 (5.1–6.0); M^1M^4, 6.6 (6.3–7.1). Adult *M. murina* weigh ca. 41 g (average of 39 individuals caught in French Guiana – unpublished materials).

Philander opossum (Linnaeus, 1758): One juvenile (only one and two upper molars erupted): M^1, 3.8; M^1M^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 *H. 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 LIB, as already shown by Husson (1978) for Surinamese animals. In French Guiana, *H. 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 <4% of the total biomass, as this terrestrial oryzomyine weighs ca.

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

	H. sciureus	p-Value	*N. rattus*
LIB	4.8±0.3 (4.0–5.4) 91	<0.001	6.7±0.4 (6.1–7.7) 25
M^1	3.0±0.1 (2.6–3.3) 90	NS	3.0±0.1 (2.8–3.2) 10
M^1M^2	4.9±0.2 (4.4–5.3) 92	NS	4.9±0.2 (4.5–5.3) 11
ZB	20.1±1.3 (17.9–22.8) 39	NS	21.0±2.1 (17.1–24.1) 8

Summary statistics include the sample mean±1 SD, the observed range (in parentheses), and the sample size. p-Values for Mann-Whitney tests.

NS, non-significant at p=0.05 level.

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 two *Sigmodon alstoni* from Sinnamary owl's pellets: LIB, 5.0 and 5.2; M^1M^2, 4.1 and 3.9; M^1M^3, 6.0 and 5.5; ZB 18.9 and 17.8.

Zygodontomys brevicauda (J. A. Allen and Chapman, 1893): Thirty-eight 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 (4.4–5.4); LIF, 6.4±0.6 (4.7–7.1); M^1M^2, 3.3±0.1 (3.0–3.5); M^1M^3, 4.2±0.1 (4.0–4.4).

Table 2 Measurements (mm) of four craniodental variables in *Oligoryzomys fulvescens* skulls from Sinnamary pellets and in adult voucher specimens from French Guiana.

	Sinnamary owl's pellets	p-Value	Reference specimens
LIB	3.6±0.2 (3.3–4.1) 35	NS	3.6±0.2 (3.3–4.2) 29
M^1M^3	3.0±0.1 (2.7–3.1) 38	NS	3.0±0.1 (2.8–3.2) 29
BR	4.3±0.3 (3.9–5.1) 26	NS	4.3±0.3 (3.8–5.1) 26
LBP	3.9±0.1 (3.6–4.2) 23	NS	3.8±0.2 (3.0–4.1) 25

Summary statistics include the sample mean±1 SD, the observed range (in parentheses), and the sample size. p-Values for Mann-Whitney tests.
NS, non-significant at p=0.05 level.
Reference specimens examined for *O. fulvescens*: MNHN-1981-183, 1986-174, 175, 177, 480, 482, 956–959, 962–966, 968–973, 975; 1998-673; MHNG-1979.04; Catzeflis V-1007, V-1899.

Mus musculus Linnaeus, 1758: One single damaged skull was identified through the unique murine pattern of the upper molars and had the following measurements: LIB, 3.4; M^1M^2, 2.7; M^1M^3, 3.2; LIF, 5.0. *M. musculus* caught in French Guiana have an average weight of 14.0 g (average for 23 adults; unpublished data).

Rattus norvegicus (Berkenhout, 1769): Six 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=4–6 individuals) and range of values for Sinnamary's materials: LIB, 6.5 (6.2–7.2); M^1M^2, 5.4 (5.3–5.5); M^1M^3, 7.1 (7.0–7.2); BZP, 4.5 (4.0–4.9). 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): Two 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 (Niethammer and Krapp 1978, Corbet and Harris 1991). 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 the Brazilian Ceara state, for the species *C. agricolai* (Voss et al. 2005), which is ca. 2000 km southeast from Sinnamary. da Silva et al. (2013) mention the capture of one specimen of *Cryptonanus* sp. in a grassy savanna landscape from southeast Amapa, in a locality along Higway BR-156 (0°05′S; 51°10′W) near the Maraca River, which is still a distance of ca. 650 km southeast 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 (de Carvalho 1962). This species was also recently caught in southern Amapa, in grassy savannas near Ferreira Gomes (da Silva et al. 2013). *S. alstoni* is apparently not common around Sinnamary, as only two skulls were found (<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): *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: *H. sciureus* and *Nectomys rattus* (Table 3). However, 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, Scheibler and Christoff 2007, Magrini and Facure 2008, Rocha et al. 2011). Thus, our results cannot 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.

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.

	Weight (ref.)	Individuals		% Energy
		n	%	
Cryptonanus sp.	15[a]	10	3.9	0.5
Marmosa murina	41[a]	7	2.7	1.0
Philander opossum	220[a]	1	0.4	0.8
Holochilus sciureus	157[b]	106	40.9	60.6
Nectomys rattus	177[c]	26	10.0	16.7
Oligoryzomys fulvescens	17[a]	59	22.8	3.7
Sigmodon alstoni	61.5[d]	2	0.8	0.4
Zygodontomys brevicauda	58[a]	38	14.7	8.0
Mus musculus	14[a]	1	0.4	0.1
Rattus norvegicus	300[a]	6	2.3	6.6
Rattus rattus	120[a]	2	0.8	0.9
Proechimys cayennensis	190[e]	1	0.4	0.7

[a]Unpublished data from wild-caught animals in French Guiana.
[b]Twigg (1965). [c]Catzeflis (2012). [d]Vivas (1986). [e]Catzeflis and Steiner (2000).
The total weight of all 259 ingested preys is 27,475 g, and energy intake is represented by the weight.
(ref.), reference for the average weight.

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