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

8

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27 Abstract:

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

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

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

43

44

45

46 Keywords:

47 *Cryptonanus*; *Holochilus sciureus*, *Sigmodon alstoni*; Coastal savannas; Amazonia

48

49

50 TEXT

51 The analysis of owl pellets contents is a useful tool for providing an inventory of small
52 mammal communities especially in open habitats such as agricultural landscapes or in
53 cerrado-like biotopes (caatinga, savannas, llanos, grassy marshes, ...) in the Neotropics
54 (Rocha et al. 2011; Scheibler and Christoff 2007). The Barn owl (*Tyto alba* (Scopoli, 1769))
55 is a specialized predator and most of its preys are small non-volant mammals weighting from
56 15 to 250 grams. Several recent investigations of Barn owl pellets in Brazil and elsewhere in
57 South America have evidenced the presence of some species of small rodents and opossums
58 which otherwise were very rarely caught by standard trapping methods using live- or snap-
59 traps.

60 For example, Souza et al. (2010) found two rare dwarf opossums (*Gracilinanus agilis*
61 Burmeister, 1854; *Cryptonanus agricolai* (Moojen, 1943)) among 162 pellets collected in the
62 Northeastern Atlantic Forest realm, and those records were new for the coastal region of
63 Pernambuco state. Similarly, Bonvicino and Bezerra (2003) found three rare species (2 small
64 opossums, 1 cerrado mouse) in Barn owl pellets which could not be collected with traps,
65 suggesting that trapping “was either inefficient or was not performed near their specific
66 microhabitats”.

67

68 This study reports on Barn owl pellets which were collected in an old water-tower in
69 downtown Sinnamary, French Guiana (05°23' N; 52°57'W) in march 2011 (120 pellets) and
70 in september 2013 (131 pellets). Sinnamary is a small city (3100 inhabitants in 2013) at ca.
71 100 km north-west from Cayenne; it is located within the coastal northern strip of the country,
72 where non-forested areas, such as agricultural lands, grass and bush savannas, small thickets
73 of trees, grassy swamps and marshes, predominate. The nearest large area of well-drained
74 tropical rainforest starts at 3-4 km south-west from the village, and extends for dozens of km
75 towards the south (the forest locality of Paracou studied by Voss et al. (2001) is only 12 km
76 from the Barn owl breeding site of Sinnamary). Within a radius of 3 km from the Barn owl's

77 nest, swamp areas and pastures with draining canals constitute most of the area to the north-
78 east, whereas grass and bush savannas intermingled with small thickets dominate to the south-
79 east. The western sides of the water-tower are a mixture of highly degraded secondary forests
80 and of agricultural openings for pastures and various abandoned crops.

81

82 The 251 pellets were individually examined for their bony content and a total of 329
83 vertebrate specimens were isolated. Besides birds (46 individuals), bats (3 skulls of
84 Molossidae) and unidentified murids (21 individuals), the pellets yielded 259 small rodents
85 and opossums which could be identified to species level in most cases. For securing the
86 identification, we relied on comparisons with cleaned skulls of reference specimens (vouchers
87 deposited at Paris MNHN and Geneva MHNG museums) and descriptions and drawings
88 found in Husson (1978), Voss et al. (2001), and Voss and Jansa (2009). All skull and
89 mandibles materials from the owl's pellets have been kept and are available for examination
90 upon writing to the senior author. The following craniodental variables were used and are
91 illustrated and/or defined in Voss et al. (2001) and in Carleton and Musser (1989): BR =
92 Breadth of Rostrum; BZP = Breadth of Zygomatic Plate; LBP = Length of Bony Palate; LIB
93 = Least Interorbital Breadth; LIF = Length of Incisive Foramen; M^1 , M^1M^2 , M^1M^3 : lengths of
94 upper molars; ZB = Zygomatic Breadth.

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

99

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

101 - *Cryptonanus* sp Voss et al. 2005: 10 individuals of that very tiny opossum bring an

102 additional taxon to the mammalian fauna of French Guiana. The identification of these

103 remains (mandibles were almost complete, whereas skulls were highly damaged and resumed

104 to the maxillary, palatine and jugal bones) was kindly established by Robert S. Voss (AMNH,
105 New York).

106 The upper molars measurements for 7 adult (all 4 upper molars definitive and erupted)
107 individuals are (mean, minimum, maximum) : M^1 1.5 (1.3 to 1.5); M^1M^2 2.8 (2.8 to 3.0);
108 M^1M^3 4.2 (4.1 to 4.4); M^1M^4 4.8 (4.6 to 4.8); width of M^4 (measured as in Voss and Jansa
109 2009) 1.9 (1.7 to 2.0).

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

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

115

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

119

120 - *Philander opossum* (Linnaeus, 1758): 1 juvenile (only 1. and 2. upper molars erupted) : M^1
121 = 3.8; M^1M^2 = 7.8; *P. opossum* weighs ca. 220 g at that age (unpublished data).

122

123 - *Holochilus sciureus* Wagner, 1842: this large (adult animals of Guyana average 157 g:
124 Twigg 1965) sigmodontine rodent was the most frequent prey of *Tyto alba* at Sinnamary, with
125 106 individuals (41 % of all 259 rodents and opossums), most of them being adults (as
126 defined by having three fully erupted molars). The recognition of skull remains of *Holochilus*
127 *sciureus* from similar-sized *Nectomys rattus* (Pelzeln, 1883) is straightforward if molars are
128 still present, as their dental pattern is quite different (see page “A Sampler of Sigmodontine
129 molars” in Myers et al. 2014). When upper molars are lacking (as was the case in 12 skulls),
130 the recognition of *Holochilus* from *Nectomys* can be easily reached by measuring the Least

131 Interorbital Breadth (LIB), as already shown by Husson (1978) for Surinamese animals. In
132 French Guiana, *Holochilus sciureus* have LIB values smaller than 5.4 mm whereas *Nectomys*
133 *rattus* skulls are larger than 6.1 mm for that measurement (Table 1).

134

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

139

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

147

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

154 The following craniodental measurements characterize the 2 *S. alstoni* from Sinnamary owl's
155 pellets: LIB 5.0 & 5.2; M¹M² 4.1 & 3.9; M¹M³ 6.0 & 5.5; ZB 18.9 & 17.8.

156

157 - *Zygodontomys brevicauda* (J.A. Allen and Chapman, 1893): 38 individuals of this terrestrial
158 sigmodontine were identified by comparison with reference materials of French Guianan
159 vouchers, together with the descriptions and drawings available in Voss (1991).

160 *Zygodontomys* weigh ca 58 g (average for 52 adult specimens caught in French Guiana),
161 therefore this species ranked third by its biomass in the diet of *Tyto alba* at Sinnamary. The
162 following craniodental measurements are derived from 22 skull-remains : LIB 4.9 ± 0.3 (4.4
163 to 5.4) ; LIF 6.4 ± 0.6 (4.7 to 7.1); M^1M^2 3.3 ± 0.1 (3.0 to 3.5); M^1M^3 4.2 ± 0.1 (4.0 to 4.4);

164

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

169

170 - *Rattus norvegicus* (Berkenhout, 1769): 6 individuals were identified through qualitative
171 craniodental characters, and selected measurements confirmed their belonging to *R.*
172 *norvegicus* (see pp. 382-420 in Niethammer and Krapp 1978). Average (N from 4 to 6
173 individuals) and range of values for Sinnamary's materials are: LIB 6.5 (6.2 to 7.2); M^1M^2 5.4
174 (5.3 to 5.5); M^1M^3 7.1 (7.0 to 7.2); BZP 4.5 (4.0 to 4.9). We assume that those *R. norvegicus*
175 were not full grown adults whose weight is too large for *Tyto alba* (Husson (1978) gives ca.
176 420 g for the average of 5 adult *R. norvegicus* from Suriname).

177

178 - *Rattus rattus* (Linnaeus, 1758): 2 individuals were identified by comparison with voucher
179 specimens from French Guiana and by examining the characters currently in use for
180 recognizing *R. rattus* from *R. norvegicus* in owl pellets (Corbet and Harris 1991; Niethammer
181 and Krapp 1978). In French Guiana, *R. rattus* weighs ca. 120 g (average of 35 adult animals:
182 121 ± 33 g – unpublished data).

183

184 - *Proechimys guyannensis* (E. Geoffroy, 1803) : one single damaged skull was identified
185 through its typical dental pattern and by comparison with voucher materials. This was an
186 adult with all molars erupted, corresponding to a weight of ca. 190 g (Catzefflis and Steiner
187 2000).

188

189

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

200 The discovery of *Sigmodon alstoni* in the pellets of the Barn owl from Sinnamary should be
201 no surprise, as the presence in French Guiana of this savanna dweller was suspected by Voss
202 (1992) who wrote that “*alstoni* should occur in the coastal savannas there “ because at that
203 time *S. alstoni* was known from Suriname (Husson 1978; Williams et al. 1983) and Brazilian
204 Amapa (Carvalho 1962). This species was also recently caught in southern Amapa, in grassy
205 savannas near Ferreira Gomes (da Silva et al. 2013). *Sigmodon alstoni* is apparently not
206 common around Sinnamary, as only two skulls were found (less than 1% of all 259 identified
207 small mammals), whereas the similar-sized *Zygodontomys* accounts for 15 % of the preys.

208

209 At Sinnamary, Barn owls have a large range of prey sizes, from the tiny species around 15 g
210 (*Cryptonanus* sp.; *Mus musculus*; *Oligoryzomys fulvescens*) to the larger taxa around 250 g
211 (juvenile of *Philander opossum*; *Proechimys cayennensis*; subadults of *Rattus norvegicus*).
212 Four species comprise 88% of all preys and 90% of the eaten biomass: by decreasing
213 frequency those are *Holochilus* (157 g on average), *Oligoryzomys* (17 g), *Zygodontomys* (58
214 g), and *Nectomys* (177 g) (Table 3). Clearly, the “food value” (the energy) derived from an
215 *Holochilus* is much higher than the one provided by an *Oligoryzomys*, and it is apparently
216 more profitable for owls to select larger prey. With 106 individuals or 41% of all 259 prey
217 items, *Holochilus sciureus* was apparently very common in the hunting area of the Barn owls,
218 and it has been shown elsewhere in the Guianan Region that this rodent species might
219 fluctuate in numbers up to high densities (Twigg, 1965). At Sinnamary, where grassy marshes
220 and savannas are the most abundant places within a 3 to 4 km radius from downtown
221 (unpublished data based on the examination of aerial pictures), the Barn owls secure 78 % of
222 their consumed biomass of non-volant mammals through two species of “large”
223 sigmodontines: *Holochilus sciureus* and *Nectomys rattus* (Table 3). But the selection of larger
224 prey-species is not the rule everywhere, as shown by Scheibler and Christoff (2004) in agro-
225 ecosystems of southern Brazil where *Tyto alba* preyed mostly (82% of 3618 vertebrates) upon
226 *Mus musculus*, despite the fact that much larger rodents (*Akodon*; *Necromys*) were common in
227 their study area.

228

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

235 our knowledge of rodents and opossums living in the non-forested coastal landscapes of
236 French Guiana.

237

238

239

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246 CNRS and of the University Montpellier-2.

247

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321

322 Tables

323

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

326

| | <i>Holochilus sciureus</i> | <i>P-value</i> | <i>Nectomys rattus</i> |
|-------------------------------|----------------------------|----------------|--------------------------|
| 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 ¹ M 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 |

327

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

330 Abbreviations: LIB = Least Interorbital Breadth; M¹, M²: lengths of upper molars; ZB =

331 Zygomatic Breadth; NS = non significant at p = 0.05 level

332

333

334 Table 2: Measurements (mm) of four craniodental variables in *Oligoryzomys fulvescens* skulls

335 from Sinnamary pellets and in adult voucher specimens from French Guiana.

336

| | 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 ¹ M 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 |

337

338 Summary statistics include the sample mean ± one standard deviation, the observed range (in

339 parentheses), and the sample size. P-values for Mann-Whitney tests.

340 Abbreviations: LIB = Least Interorbital Breadth; M¹M³: lengths of upper molars; BR =

341 Breadth of Rostrum; LBP = Length of Bony Palate; NS = non significant at p = 0.05 level

342 Reference specimens examined for *Oligoryzomys fulvescens*: MNHN-1981-183, 1986-174,

343 175, 177, 480, 482, 956 to 959, 962 to 966, 968 to 973, 975; 1998-673; MHNG-1979.04;

344 Catzeflis V-1007, V-1899.

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346

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

350

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

351

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

355