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FOOD HABITS AND CARNIVORY BY A SMALL SIZE OPOSSUM, *Gracilinanus agilis* (DIDELPHIMORPHIA: DIDELPHIDAE)

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ABSTRACT. We investigated the diet of gracile mouse opossum, *Gracilinanus agilis* (Burmeister, 1854), from the analysis of 144 fecal samples collected between November 2009 and October 2011 in an area of savanna riparian forest in the Brazilian Cerrado. Invertebrates were the most frequently consumed food items (96.5%) followed by fruits of pioneer species (29.8%) and flowers (6%). We also observed the presence of fragments of bird vertebrae and downs in samples from 2 adult males, this being the first record of predation on small vertebrates by *G. agilis*. The presence of fragments of birds in the feces of the gracile mouse opossum suggests that despite the small size of this species and its primarily insectivorous habits, small vertebrates may be included in its diet.

RESUMO. Registro de carnivoría pelo pequeno marsupial *Gracilinanus agilis* (Didelphimorphia: Didelphidae). Investigamos a dieta do marsupial *Gracilinanus agilis* (Burmeister, 1854) a partir da análise de 144 amostras fecais coletadas entre novembro de 2009 e outubro de 2011 em uma área de mata ciliar savânica no Cerrado brasileiro. Invertebrados constituíram o item alimentar consumido com maior frequência (96.5%) seguido por frutos de espécies pioneiras (29.8%) e flores (6%). Também observamos a presença de fragmentos de vértebras de aves e plúmulas em amostras de dois machos adultos, este é o primeiro registro da predação de vertebrados pelo *G. agilis*. A presença de fragmentos de aves nas fezes de *G. agilis* sugerem que, apesar de seu pequeno tamanho e de seu hábito alimentar primariamente insetívoro, vertebrados de pequeno porte, podem ser incluídos em sua dieta.

Key words: Cerrado. Didelphimorphia. Diet. Feeding ecology. Marsupials.

Palavras chave: Cerrado. Didelphimorphia. Dieta. Ecologia alimentar. Marsupiais.

Gracile mouse opossum, *Gracilinanus agilis* (Burmeister, 1854), is a small didelphid marsupial with preferably arboreal habits (Paglia et al., 2012) that is occasionally caught on the ground (Eisenberg and Redford, 1999). Adults weigh from 13 to 40 g and males are generally heavier than females (Costa et al.,

2003; Paglia et al., 2012). This species has the widest geographic distribution in the genus, occurring in forest formations of Brazilian Cerrado (riparian forests and dry forests), but also in isolated areas in the Caatinga (Costa et al., 2003; Reis et al., 2010; Geise et al., 2010).

Gracilinanus agilis has been regarded as insectivore-omnivore (Paglia et al., 2012) and its natural diet includes primarily a wide variety of insects (Coleoptera, Hymenoptera and Isoptera), but may also include fruits and even flowers (Bocchiglieri et al., 2010; Lessa et al., 2010; Camargo et al., 2011; Lessa et al., 2013). On the other hand, laboratory feeding preference experiments suggest that small didelphids such as *G. agilis* incorporate into their diet a higher proportion of fruits than indicated by field studies (Astúa de Moraes et al., 2003; Santori et al., 2012). To date, detailed information on the dietary habits of this species is still scarce (Lessa and Geise, 2010; Santori et al., 2012). Didelphids with wide geographic distribution in different biomes or habitats may differ in their diet in response to exogenous factors such as the local variation in resource availability (Ceotto et al., 2009; Lessa and Geise, 2010; Lessa and Geise, 2014). Therefore, it is reasonable to assume that, throughout its wide geographical distribution, *G. agilis* could present a more varied diet than is currently known. In this study, we report the first record of carnivory by this small didelphid marsupial aiming to extend the existing knowledge on its feeding habits and, consequently, on its ecology.

We conducted the study in an area of savanna riparian forest in Parque Estadual do Rio Preto (PERP: 18°05'20" S; 43°20'25" W), located in the municipality of São Gonçalo do Rio Preto, in the state of Minas Gerais, Brazil. With an area of 12 000 hectares, the PERP is located in the southern portion of the Espinhaço range with a mosaic of vegetation physiognomies, which includes campos rupestres (dry, rocky grasslands), cerrado (stricto sensu), cerradão (woodland savanna) and riparian woodlands along the banks of the Rio Preto River. The climate is type Cwb (mesothermal) according to the Köppen climatic classification, with mild and wet summers (October to March) and dry winters (April to September; Lessa et al., 2013).

Opossums were monthly captured from November 2009 to October 2011, through the capture-mark-recapture method. A total of 96 galvanized wire traps (300 x 160 x 160 mm) arranged in 180 m-long parallel transects separated by 50 m were used. In each transect,

12 capture stations were installed and spaced apart by 15 m. Orange or pineapple pieces, cotton wool soaked in Scotch® emulsion and bacon bits were used as baits. Captured animals were identified, marked with numbered ear tags (Zootech®) and released at the same location. Feces were collected directly from each specimen during manipulation or inside the trap. The samples were stored in paper envelopes and preserved at -10°C to avoid fungi infestation. One fecal sample was considered as being all feces produced by a single captured animal in a nighttime period. In laboratory, feces were examined under a stereoscopic microscope and food items were identified to the lowest taxonomic level. We used the relative frequency of occurrence expressed as the number of samples where an item was found (n), divided by the total number of samples and multiplied by 100, in order to determine the contribution of each item in the diet of *G. agilis* (Korschgen, 1987).

During 9216 trap nights and a capture success of 3.9%, we obtained 144 fecal samples. The diet of *G. agilis* showed a high frequency of arthropods (mainly Isoptera, Hymenoptera and Blattodea) present in 96.5% of the samples. Fruits were identified in 29.8% of the samples and flowers in 6% of the samples, indicating a diversified diet, but marked by a high frequency of insects throughout the year (**Table 1**). A predominantly insectivorous diet had been already recorded for *G. agilis* (Bocchiglieri et al., 2010; Lessa and Costa, 2010) and the same trend was observed for the congener *G. microtarsus* (Martins and Bonato, 2004). Patterns of prey selection by mammals appear to be related to both consumption preferences and prey availability in the environment (Leiner and Silva, 2007; Pinotti et al., 2011). The high frequency of arthropods in the samples of *G. agilis* was mainly related to the high consumption of Isoptera and Hymenoptera (Formicidae), abundant resources in the study area (Lessa, 2012) and in the Cerrado biome, even in the driest periods (Pinheiro et al., 2002). Furthermore, the high frequency of litter arthropods in the diet of *G. agilis*, especially Blattodea, indicates a foraging tendency on the ground, as suggested by Eisenberg and Redford (1999).

Table 1Food items found in 144 samples of *Gracilinanus agilis* at Parque Estadual do Rio Preto, Minas Gerais, Brazil.

Food items	N	Frequency of occurrence (%)
SEEDS		
Melastomataceae		
<i>Clidemia urceolata</i>	21	14.6
<i>Miconia holosericea</i>	2	1.4
<i>Miconia pepericarpa</i>	3	2.0
<i>Miconia stenostachia</i>	2	1.4
<i>Miconia</i> sp.	2	1.4
Myrtaceae		
Unidentified seeds	1	0.7
Rubiaceae		
<i>Psychotria capitata</i>	8	5.6
Santalaceae		
<i>Phoradendron crassifolium</i>	7	4.9
Seeds total	43	29.8
FLOWERS		
Lauraceae	2	1.4
Malpigiaceae	1	0.7
Poligonaceae	1	0.7
Eudicotiledonea	1	0.7
Unidentified flowers	5	3.5
Flowers total	10	6.0
ARTHROPODS		
Arachnida	7	4.9
Blattodea	27	18.8
Coleoptera	19	13.2
Dermaptera	13	9.0
Diptera	6	4.1
Hemiptera	1	0.7
Hymenoptera	55	38.2
Isoptera	98	68.0
Lepdoptera	1	0.7
Orthoptera	10	6.0
Unidentified arthropods	20	13.9
Arthropods total	139	96.5
VERTEBRATES		
Birds	2	1.4
Vertebrates total	2	1.4

In the study area, in addition to the high frequency of arthropods in the diet of *G. agilis*, we also recorded the consumption of small vertebrates (birds) by this small sized marsupial, which was confirmed by the identification of fragments of heterocelic vertebral bodies

(characteristic of birds; Hildebrand and Goslow, 2006) and downs in two samples from adult males. Small vertebrates can be preyed alive or consumed as carrion, a distinction hard to make when dealing with fecal content (Ceotto et al., 2009). The consumption of carrion is usually

associated with the presence of dipteran pupae in the feces (Santori et al., 1997) and it has been already observed in studies on the diet of larger didelphids such as *Philander frenatus*, *Lutreolina crassicaudata* and *Didelphis* spp. (Santori et al., 1997; Ceotto et al., 2009; Macedo et al., 2010; Facure and Ramos, 2011; Santori et al., 2012). The consumption of carrion by didelphids can be an important source for the attainment of animal protein with a low energy cost (Santori et al., 1997; Macedo et al., 2010). However, we did not record the presence of dipteran pupae in the analyzed samples suggesting the predation, possibly of nestlings, by adult males of *G. agilis*. A similar pattern, with the consumption of small vertebrates (birds and small mammals) at low frequencies was also observed for other small didelphids such as *Marmosops paulensis* (Leiner and Silva, 2007) and *Micoureus paraguayanus* (Pires et al., 2010).

In Brazil, Didelphidae includes at least 56 species (Rossi et al., 2012); among them, there are many with different degrees of specializations towards carnivory/insectivory (see Vieira and Astúa de Moraes, 2003). Although no species of Neotropical marsupial feeds exclusively on plant matter, the relative importance of animals (vertebrates and invertebrates) in the composition of their diet may vary (Vieira and Astúa de Moraes, 2003). This is the first study to provide evidence of predation on vertebrates (birds) by *G. agilis* expanding the knowledge on the diet of this small sized didelphid marsupial. The record of birds in the diet shows that, although *G. agilis* has an opportunistic behavior primarily preying on arthropods, an abundant resource in the Cerrado biome (Pinheiro et al., 2002; Lessa and Costa, 2010), small vertebrates may be included in their diet. Thus, this study included *G. agilis* as a potential didelphid predator of small vertebrates.

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LITERATURE CITED

- ASTÚA DE MORAES D, RT SANTORI, R FINOTTI, and R CERQUEIRA. 2003. Nutritional and fiber contents of laboratory-established diets of neotropical opossums (Didelphidae). Pp. 229-237, in: Predators with pouches (M Jones, C Dickman, and M Archer, eds.). CSIRO Publishing, Melbourne.
- BOCCHIGLIERI A, AF MENDONÇA, and JB CAMPOS. 2010. Diet composition of *Gracilinanus agilis* (Didelphimorphia: Didelphidae) in dry woodland areas of Cerrado in central Brazil. *Mammalia* 74:225-227.
- CAMARGO NF, RMS CRUZ, JF RIBEIRO, and EM VIEIRA. 2011. Frugivoria e potencial dispersão de sementes pelo marsupial *Gracilinanus agilis* (Didelphidae: Didelphimorphia) em áreas de Cerrado no Brasil Central. *Acta Botanica Brasílica* 25:646-656.
- CEOTTO P, R FINOTTI, R SANTORI, and R CERQUEIRA. 2009. Diet variation of the marsupials *Didelphis aurita* and *Philander frenatus* (Didelphimorphia, Didelphidae) in a rural area of Rio de Janeiro state, Brazil. *Mastozoologia Neotropical* 16:49-58.
- COSTA LP, YLR LEITE, and JL PATTON. 2003. Phylogeography and systematic notes on two species of gracile-mouse opossums, genus *Gracilinanus* (Marsupialia: Didelphidae) from Brazil. *Proceedings Biological Society of Washington* 116:275-292.
- EISENBERG JF and KH REDFORD. 1999. *Mammals of the Neotropics: The central Neotropics, Ecuador, Peru, Bolivia, Brazil*. University of Chicago Press, Chicago.
- FACURE KG and VN RAMOS. 2011. Food habits of the thick-tailed opossum *Lutreolina crassicaudata* (Didelphimorphia, Didelphidae) in two urban areas of southeastern Brazil. *Mammalian Biology* 76:234-236.
- GEISE L, R PARESQUE, H SEBASTIÃO, LT SHIRAI, D ASTÚA DE MORAES, and G MARROIG. 2010. Non-volant mammals, Parque Nacional do Catimbu, vale do Catimbu, Buique, state of Pernambuco, Brazil, with karyologic data. *Check List* 6:180-186.
- HILDEBRAND M and JGE GOSLOW. 2006. *Análise da estrutura dos vertebrados*. Atheneu, São Paulo.
- KORSCHGEN JL. 1987. *Procedimientos para el análisis de los hábitos alimentarios. Manual de técnicas de gestión de vida silvestre*. The Wildlife Society, Washington, DC.
- LEINER NO and WR SILVA. 2007. Seasonal variation in the diet of the Brazilian slender opossum (*Marmosops paulensis*) in a montane Atlantic forest area, southeastern Brazil. *Journal of Mammalogy* 88:158-164.
- LESSA LG. 2012. *Ecologia alimentar e estratégias de germinação de sementes consumidas por marsupiais (Didelphimorphia: Didelphidae) em uma área de Cerrado no sudeste do Brasil*. PhD Thesis, State University of Rio de Janeiro, Brazil.

- LESSA LG and FN COSTA. 2010. Diet and seed dispersal by five marsupials (Didelphimorphia, Didelphidae) in a Brazilian cerrado reserve. *Mammalian Biology* 75:2-16.
- LESSA LG and L GEISE. 2010. Hábitos alimentares de marsupiais didelfídeos brasileiros: análise do estado de conhecimento atual. *Oecologia Australis* 14:918-927.
- LESSA LG and GEISE L. 2014. Food habits of *Metachirus nudicaudatus* (Didelphimorphia, Didelphidae) in a Brazilian Cerrado: diet composition and dietary seasonality. *Studies on Neotropical Fauna and Environment*, in press.
- LESSA LG, L GEISE, and FN COSTA. 2013. Effects of gut passage on the germination of seeds ingested by didelphid marsupials in a Neotropical savanna. *Acta Botanica Brasílica* 27:519-525.
- MACEDO L, F FERNANDEZ, and JL NESSSIMIAN. 2010. Feeding ecology of the marsupial *Philander frenatus* in a fragmented landscape in Southeastern Brazil. *Mammalian Biology* 75:363-369.
- MARTINS EG and V BONATO. 2004. On the diet of *Gracilinanus microtarsus* (Marsupialia, Didelphidae) in an Atlantic Rainforest fragment in southeastern Brazil. *Mammalian Biology* 69:58-60.
- PAGLIA AP et al. 2011. Lista Anotada dos Mamíferos do Brasil. 2ª Ed. Occasional Papers in Conservation Biology, Number 6, Conservation International, Arlington, VA.
- PINHEIRO F, IR DINIZ, D COELHO, and MPS BANDEIRA. 2002. Seasonal pattern of insect abundance in the Brazilian cerrado. *Austral Ecology* 27:132-136.
- PINOTTI BT, L NAXARA, and R PARDINI. 2011. Diet and food selection by small mammals in an old-growth Atlantic Forest of southern Brazil. *Studies on Neotropical Fauna and Environment* 46:2-9.
- PIRES MM, EG MARTINS, LD CRUZ, FR FERNANDES, RBG CLEMENTE-CARVALHO, MNF SILVA, and SF DOS REIS. 2010. Young didelphid consumption by *Micoureus paraguayanus* (Didelphimorphia, Didelphidae) in southeastern Brazil. *Mastozoología Neotropical* 17:183-187.
- REIS RR, AL PERACCHI, MN FREGONEZI, and BK ROSSANEIS. 2010. Mamíferos do Brasil: guia de identificação. Ed. Technical Books, Rio de Janeiro.
- ROSSI RV, MV BRANDÃO, AP CARMIGNOTO, CL MIRANDA, and JJ CHEREM. 2012. Diversidade morfológica e taxonômica de marsupiais didelfídeos, com ênfase nas espécies brasileiras. Pp. 23-72, in: Os marsupiais do Brasil: biologia, ecologia e conservação (NC Cáceres, ed.). Ed. UFMS. Campo Grande.
- SANTORI RT, D ASTÚA DE MORAES, CEV GRELE, and R CERQUEIRA. 1997. Natural diet at a Restinga forest and laboratory food preferences of the opossum *Philander frenatus* in Brazil. *Studies on Neotropical Fauna and Environment* 32:12-16.
- SANTORI RT, LG LESSA, and D ASTÚA DE MORAES. 2012. Alimentação, nutrição e adaptações alimentares de marsupiais brasileiros. Pp. 385-406, in: Os marsupiais do Brasil: biologia, ecologia e conservação (NC Cáceres, ed.). Ed. UFMS. Campo Grande.
- VIEIRA EM and D ASTÚA DE MORAES. 2003. Carnivory and insectivory in Neotropical marsupials. Pp. 271-284, in: Predators with pouches: The biology of carnivorous marsupials (M Jones, C Dickman, and M Archers, eds.). Ed. Collingwood: CSIRO Publishing.