Short Note

André Faria Mendonça*, Thaiz Armond, Anna Carla L. Camargo, Priscilla L. Zangrandi and Emerson M. Vieira

Round-pot feeder: low-cost apparatus for field studies on food supplementation for arboreal small mammals

DOI 10.1515/mammalia-2016-0171
Received November 26, 2016; accepted February 24, 2017; previously published online March 30, 2017

Abstract: We describe a newly developed and low-cost feeder designed for use with arboreal small mammals under any climatic condition. As part of a project on bottom-up regulation of small mammal populations in central Brazil, we present the results of 16 months of food supplementation. During the study, more than 118 kg of milled cat food were consumed, out of a total of 207 kg offered. Moreover, we registered a low rate of loss (14.05%) of feeders from falling to the ground or termite/ant colonization. The round-pot feeder described here represents a low-cost method for providing continuous food-supplementation, contraceptives, or poisoned baits to arboreal small mammals.

Keywords: Cerrado; food addition; *Gracilinanus agilis*; population control; population regulation; *Rhipidomys macrurus*; woodland savanna.

Food availability is one of the main factors limiting the population growth and distribution of most terrestrial vertebrates (Lack 1954). Studies on the relationship between food resources and population dynamics frequently rely on supplementary feeding (see reviews by Boutin 1990, Prevedello et al. 2013). This approach permits researchers to identify various types of responses of food-limited species in different hierarchical levels (individual, population, and community). For example, animals can increase their body growth rates, which results in faster maturation and relatively more adults, and may increase their survival or their reproductive effort (Doonan and Slade 1995). Food-supplementation experiments on non-volant small mammals (≤3 kg rodent and marsupial species) were summarized in a detailed review by Prevedello et al. (2013). The authors listed 148 studies, which were conducted using several types of feeders, mainly wooden or plastic boxes, PVC tubes, or aluminum cans. The vast majority (88.5%) of these studies were carried out on rodents in open habitats (e.g. Abramsky 1978, Brown and Munger 1985, Koekemoer and Van Aarde 2000, Orland and Kelt 2007). Therefore, knowledge about the effect of variation in food availability on the mechanisms structuring small mammal communities is still incipient, especially in more structurally complex habitat formations (i.e. forests), despite the fact that these environments harbor the greatest diversity of small mammals (August 1983).

The use of feeders in the field is not restricted to ecological studies. Feeders have been used to provide poison or contraceptives to control or eradicate invasive terrestrial vertebrate species, mainly rodents, in natural areas (Chambers et al. 1999, Orueta and Ramos 2001, Witmer et al. 2007, Pitt et al. 2011). Orueta and Ramos (2001) presented some advantages using feeders to control and eradicate invasive terrestrial vertebrate species: (1) feeders protect poisoned baits from weather; (2) feeders limit the species that can have access to the bait by feeder-size; and (3) feeders reduce the risk of non-target species being affected by management measures. We describe here an efficient and low-cost feeder, which was designed primarily to provide supplementary food to arboreal or scansorial small mammals without interference of social insects or larger vertebrates, and to operate independently of climatic conditions.

***Corresponding author: André Faria Mendonça,** Laboratório de Ecologia de Vertebrados, Departamento de Ecologia, Instituto de Ciências Biológicas, Universidade de Brasilia, Campus Darcy Ribeiro, CP 04457, Brasilia DF, CEP 70919-970, Brazil, e-mail: mendonca.af@gmail.com.
http://orcid.org/0000-0002-8248-0639
Thaiz Armond, Anna Carla L. Camargo, Priscilla L. Zangrandi and Emerson M. Vieira: Laboratório de Ecologia de Vertebrados, Departamento de Ecologia, Instituto de Ciências Biológicas, Universidade de Brasília, Campus Darcy Ribeiro, CP 04457, Brasília DF, CEP 70919-970, Brazil

We developed the round-pot feeder as part of a long-term project on small mammal ecology in the Brazilian savanna (Cerrado), in which our primary goal was to understand the effects of the bottom-up regulation on wild populations in patches of savanna woodland (*cerradão*) located in central Brazil. Details about trapping procedures and site locations are described in Mendonça et al. (2015).

In June 2014, we started food supplementation in half of our four study patches [two manipulated (JB2 and JB4)and two control areas (JB1 and FAL)]. In each of the manipulated patches, we placed 27 feeders in the understory (1.5–2.5 m above ground) evenly distributed along the capture stations inside the 2.72-ha trapping grid. Following Prevedello et al. (2013), we created a buffer around the trapping grid to minimize the artificial crowding effect, where we placed 25–30 feeders in the understory, depending on the availability of space in each patch. All field methods were consistent with the animal care guidelines of the American Society of Mammalogists (Sikes et al. 2011) and were approved by the Ethics Committee on Animal Experiments of the Universidade de Brasília (44259/2012).

We provided milled cat food (Golden Gatos salmon, Grandfood, Dourado, SP, Brazil, 3.91 kcal g^{-1}, 31% crude protein) as the food supplement. We decided to use commercial cat food for the following reasons: (1) it standardizes the nutritional parameters of the food being supplemented; (2) it gives accurate energy and nutrient input values; and (3) it provides a relatively complete dietary supplement for insectivorous-omnivorous species such as *Gracilinanus agilis* Burmeister (Bocchiglieri et al. 2010, Camargo et al. 2013). During the experiment, food was provided *ad libitum* and food was replenished every 2 or 3 weeks, depending on the consumption rate in each area.

The round-pot feeder consists of a round plastic pot (diameter = 150 mm, depth = 130 mm) as the main feeder body, with a plastic plant saucer (195 mm in diameter) used as a cover. On the side of the pot, we drilled a circular opening 40 mm in diameter and attached a polyvinyl chloride (PVC) tube (150 × 40 mm, length × diameter) to restrain the access of larger species and to minimize marauding events by small primates (Figure 1).

On the inner bottom of each feeder, we attached a smaller transparent plastic round pot (110 ml) with high-strength-bonding double-sided tape (Model 4910 VHB™, 3M™) (Figure 2). Inside of this transparent plastic round pot, we placed another transparent round pot of the same model, where the supplementary food was placed. This arrangement of double, small round pots facilitates the inspection and replacement of food.

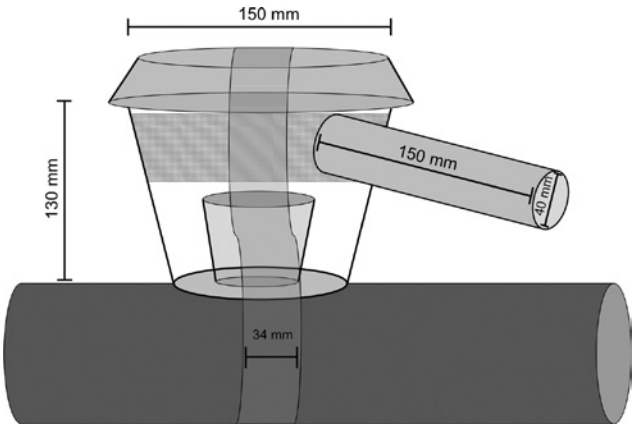

Figure 1: Schematic representation of round-pot feeder placed on a tree branch.
Gray area with diagonal lines represents a layer of entomological glue placed on the internal part of the feeder.

In order to minimize occupation of feeders by termites or other insects, we kept the entrance tube about 5 cm away from the tree branch and applied a layer of entomological glue (Colly Química Ltda., Capivari, SP, Brazil) inside the feeder. To place the feeder in the understory strata, we selected horizontal tree branches (diameter 5–100 cm) and used a polypropylene elastic band 34 mm wide (Zanotti S.A., Jaraguá do Sul, SC, Brazil) to fasten it (Figure 2). The use of this elastic band to attach the feeder to the tree branches facilitated periodic inspections. To identify which species were visiting the feeders, we placed a hair trap in the entrance tube of each feeder. This hair trap consisted of a piece (about 60 mm in length) of double-sided tape (50 mm wide, Adere®, Sumaré, SP, Brazil) on the upper inner portion of the entrance tube. We calculated the visit rate to the feeders as the number of feeders with the feces of small mammals found inside or hair on the hair trap in the entrance. We also placed 20 camera traps (Bushnell NatureView HD, Bushnell, Overland Park, KS, USA) near feeders with higher visit rates for a month in August 2014 (dry season) and in December 2014 (rainy season).

From June 2014 to September 2015, we provided more than 207 kg (about 120.4 kg in JB2 and 86.9 kg in JB4) of food in the manipulated patches and we estimated that 57.0% (about 118.3 kg, 72.5 kg in JB2 and 45.8 kg in JB4) of all food provided was consumed by small mammals. The gracile mouse opossum (*Gracilinanus agilis*) and the long-tailed climbing mouse (*Rhipidomys macrurus* Gervais) were confirmed visitors to the feeders with camera traps (online resources, Supplemental Figure 1) and with hair traps. The Cleber's arboreal rice rat (*Oecomys* cf. *cleberi* Locks) also was a confirmed visitor to the feeders using hair traps. From a total food supplementation effort of

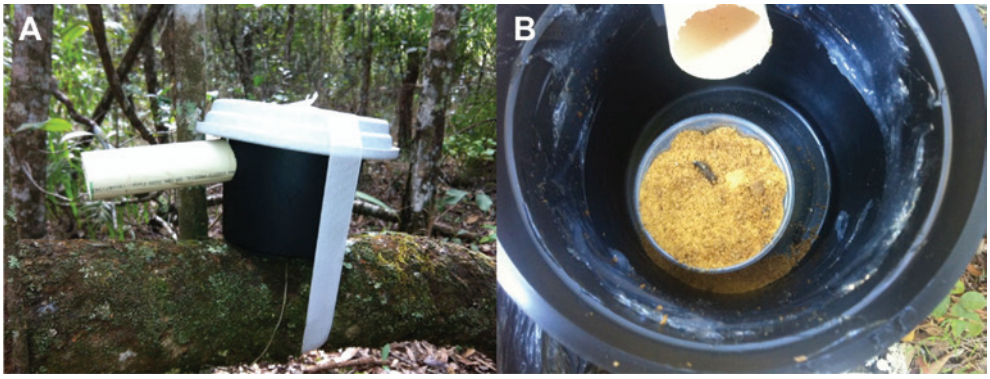

Figure 2: Round-pot feeder placed on a tree branch with an elastic band (A) during food supplementation study in patches of woodland savanna in central Brazil.
The internal arrangement of the feeder with a transparent plastic round pot filled with milled cat food (B).

47,377 feeder nights, we registered a visit rate of 40.0% (about 47.7% in JB2 and 32.6% in JB4) and a loss rate of active feeders of 14.1% (about 12.3% in JB2 and 15.4% in JB4), mainly due to them falling off branches or being colonized by termites. These losses occurred mainly in the early wet season (October–February) due to the increased activity of arboreal termites and climate effects on the elastic bands. We minimized these losses with scheduled maintenance in the late dry season. We observed (<30 occasions) that some feeders were used as nesting places for *G. agilis* and *R. macrurus*, and no other visiting mammal species was recorded using these feeders while the nests were active.

The obtained results demonstrated the efficiency of the round-pot feeder at providing continuous food supplementation, independent of weather conditions, with minimal food loss from looting by social insects and larger vertebrates including larger rodents and marsupials (e.g. white-eared opossums – *Didelphis albiventris* Lund). Two other positive aspects of the round-pot feeder are its low cost and ease of assembly. We used only low-cost components in its assembly, and the final cost of each feeder, including the elastic band, was less than US $5.

Furthermore, the round-pot feeder can potentially be used in management studies with invasive terrestrial vertebrate species to provide a continuous input of poison or contraceptives in natural areas, providing more protection to bait against weather and animal marauding; it can also be used as an artificial shelter where artificial wooden shelters cannot be used due to the presence of termites. Further details on the design and construction of the round-pot feeders can be obtained by contacting the corresponding author.

Acknowledgments: We thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for the postdoctorate scholarship (A.F.M., PNPD/CAPES 3119/10) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico for the research funding (E.M.V., PELD/CNPq 483117/2009-9 and 403845/2012-2) granted during this study. We acknowledge and thank the Botanical Garden of Brasilia and the Ecological and Agricultural Field Station of the University of Brasilia for the permission granted for our fieldwork. Thanks are due to all undergraduate and graduate students who provided valuable help in our fieldwork. We are also grateful to N. Camargo for helpful comments on an earlier draft of this paper.

References

Abramsky, Z. 1978. Small mammal community ecology. Changes in species diversity in response to manipulated productivity. Oecologia 34: 113–123.

August, P. 1983. The role of habitat complexity and heterogeneity in structuring tropical mammal communities. Ecology 64: 1495–1507.

Bocchiglieri, A., A.F. Mendonça and J.B. Campos. 2010. Diet composition of *Gracilinanus agilis* (Didelphimorphia, Didelphidae) in dry woodland areas of Cerrado in central Brazil. Mammalia 74: 225–227.

Boutin, S. 1990. Food supplementation experiments with terrestrial vertebrates: patterns, problems, and the future. Can. J. Zool. 68: 203–220.

Brown, J.H. and J.C. Munger. 1985. Experimental manipulation of a desert rodent community: food addition and species removal. Ecology 66: 1545–1563.

Camargo, N.F., J.F. Ribeiro, A.J.A. Camargo and E.M. Vieira. 2013. Diet of the gracile mouse opossum *Gracilinanus agilis* (Didelphimorphia: Didelphidae) in a neotropical savanna: intraspecific variation and resource selection. Acta Theriol. 59: 183–191.

Chambers, L.K., M.A. Lawson and L.A. Hinds. 1999. Biological control of rodents: the case for fertility control using immunocontraception. In: (G.R. Singleton, L.A. Hinds, H. Leirs and Z. Zhang, eds.) Ecologically-based management of rodent pests.

Australian Centre for International Agricultural Research, Camberra, ACT, Australia. pp. 215–242.

Doonan, T. and N. Slade. 1995. Effects of supplemental food on population dynamics of cotton rats, *Sigmodon hispidus*. Ecology 76: 814–826.

Koekemoer, A.C. and R.J. Van Aarde. 2000. The influence of food supplementation on a coastal dune rodent community. Afr. J. Ecol. 38: 343–351.

Lack, D. 1954. The natural regulation of animal numbers. p. The Natural Regulation of Animal Numbers. Oxford University Press, Oxford, UK.

Mendonça, A.F., T. Armond, A.C.L. Camargo, N.F. Camargo, J.F. Ribeiro, P.L. Zangrandi and E.M. Vieira. 2015. Effects of an extensive fire on arboreal small mammal populations in a neotropical savanna woodland. J. Mammal. 96: 368–379.

Orland, M.C. and D.A. Kelt. 2007. Responses of a heteromyid rodent community to large- and small-scale resource pulses: diversity, abundance, and home-range dynamics. J. Mammal. 88: 1280–1287.

Orueta, J.F. and Y.A. Ramos. 2001. Methods to control and eradicate terrestrial vertebrate species. Nat. Environ. 118: 1–65.

Pitt, W.C., L.C. Driscoll and R.T. Sugihara. 2011. Efficacy of rodenticide baits for the control of three invasive rodent species in Hawaii. Arch. Environ. Contam. Toxicol. 60: 533–542.

Prevedello, J.A., C.R. Dickman, M.V. Vieira and E.M. Vieira. 2013. Population responses of small mammals to food supply and predators: a global meta-analysis. J. Anim. Ecol. 82: 927–936.

Sikes, R.S., W.L. Gannon and Animal Care and Use Commitee of the American Society of Mammalogists. 2011. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. J. Mammal. 92: 235–253.

Witmer, G., P. Burke, W. Pitt and M. Avery. 2007. Management of invasive vertebrates in the United States: an overview. Manag. Vertebr. Invasive Species Proc. an Int. Symp. 56: 127–137.

Supplemental Material: The online version of this article (DOI: 10.1515/mammalia-2016-0171) offers supplementary material.