Can Baited Pitfall Traps for Sampling Dung Beetles Replace Conventional Traps for Sampling Ants?

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Abstract
Ants and dung beetles are widely used in monitoring biodiversity and are considered excellent environmental indicators. Although the pitfall trap is the most commonly used method to sample dung beetles and ants in ecological studies, beetles are usually sampled using dung-baited pitfall traps while ants are sampled using un-baited pitfalls. In the protocol for collecting the beetles it is necessary to have attractive baits in pitfalls. In order to minimize collection effort and costs and to facilitate logistics, it is necessary to determine if there is an effect of the baits on the biodiversity of ants collected in the same traps. Therefore, the objective of this work was to find out whether baited pitfalls could replace conventional pitfalls for the capture of ants. In a total of 42 areas of native habitat, three baited pitfall traps and three without bait were installed, all in the same transect, equidistant ten meters and in activity for 48 hours. In total, 150 species were collected, of which 131 were recorded in non-baited pitfalls and 107 in baited pitfalls. Traps without bait contributed to 28% of the total number of species captured in this study, whereas pitfalls with bait contributed only to 12% of the total species caught. However, 60% of the total species were captured regardless of the method. In addition to the loss of species among the types of traps, the effect of the method modifies the species composition. We concluded that depending on the type of study, a small decrease in the number of species and change in the composition can influence the results. Thus, we recommend that baited pitfalls should not replace conventional pitfalls.

Introduction
In biodiversity monitoring programs, insects are generally used as ecological and biodiversity indicators to highlight areas maximum diversity and the degree of disturbance of the areas (McGeogh, 2007). Among the insects with potential for use in such monitoring programs, the orders Coleoptera and Hymenoptera stand out, particularly dung beetles (Coleoptera: Scarabaeinae) and ants (Hymenoptera: Formicidae) (Barthi et al., 2016; Louzada et al., 2010). Both taxonomic groups are extremely abundant and play extremely important roles in the ecosystems where they live, such as nutrient cycling, decomposition, pollination, predation and seed dispersal (Nichols et al., 2008; Del Toro et al., 2012).
Although these groups are well studied in terms of taxonomy and ecology, the taxonomy identification and natural history of a large proportion of the species is still unknown (Nunes et al., 2014; Prado et al., 2016; Silveira et al., 2016). Dung beetles, more than their outstanding diversity of species, play important roles in ecosystems and are sensitive to environmental changes, which affect the group’s richness, distribution and abundance (Marsh et al., 2013). Ants are also diverse and act in ecosystems as predators, herbivores, saprophages, seed dispersers, directly affecting the structure and composition of vegetation (Underwood & Fisher, 2006; Del Toro et al., 2012).

An advantage for using dung beetles and ants in environmental and biodiversity monitoring is the fact that both are sampled quickly and relatively cheaply, both groups being frequently employed (Gardner et al., 2008; Ribas et al., 2012). The methods of collecting ants and dung beetles differ in the published collection protocols, and can vary according to the objective of each study (Lobo et al., 1988; Delabie et al., 2000). However, there are methods that can be used to collect both groups simultaneously, reducing costs and facilitating the fieldwork logistics. This is the case of pitfall traps, which, with some modifications, are efficient in catching both ants and dung beetles (Aquino et al., 2006).

The traps for capturing ant and dung beetles are commonly made from plastic cups, which are buried at ground level and filled with some solution to break water’s superficial tension or preserve the samples, making the cost of confection and installation relatively low (Souza et al., 2016). However, traps aiming at collecting dung beetles commonly are baited with human or pig feces, which attract beetles foraging for food resource (Stork-Tonon et al., 2020). Although some studies use baits in the collection of ants, especially pitfalls placed in the vegetation intended to capture arboreal ants, soil ant traps are preferably installed without any attraction, capturing ants foraging at random outside the colony (Alonso & Agosti, 2000). Field observations and conversations with experts indicated that the number of ants caught in dung beetle traps is often high and is often not assessed. In this way, the collected specimens are deposited without identification in collections or, in many cases, are discarded in the field. Among the main reasons for not using them is the concern of the researchers that the human feces bait may have a negative effect on some species of ants. In fact, to our knowledge, no work has been carried out to assess whether pitfalls for dung beetles are efficient for sampling the ant community in a given location. If the bait for dung beetles does not interfere in the capture of ants, the pitfall trap becomes an important tool to minimize sampling efforts in research and costs in surveys, thus optimizing the sampling protocol (Souza et al., 2012; 2016). Therefore, this work aims to evaluate whether pitfall traps with attractive lures (human feces) used in capturing dung beetles can be used, without prejudice to the capacity of environmental bio-monitoring, to capture ants. For this, we evaluated whether: i) the use of pitfall traps with bait cause any change (increase or decrease) in the number of species of ants captured? ii) the composition of ant species caught in baited and non-baited traps is different? iii) the change in capture observed at both the sample level and the site level?

### Material and methods

#### Study area

Data collections were carried out in 42 areas (farms) of native habitat (Legal Reserves) distributed in eight municipalities (Fig 1; Table S1). These areas are inserted in a region of extensive transition between the Amazon and Cerrado biomes within the State of Mato Grosso (Marques et al., 2019).

The choice of areas was defined based on: i) Minimum distance of 3.5 km between the sample points to guarantee independence and; ii) the permission from rural producers to access property. The sites were characterized by a tropical Savanna climate, according to the Köppen-Geiger classification (Alvares et al., 2013), average temperatures ranging from 24 to 36 °C and annual precipitation of 1.700 mm (Rosa et al., 2007) with well-defined dry and rainy seasons (Marcuzzo & Melo, 2011).

#### Sample protocol

All samples were collected during the rainy season, when dung beetles are more abundant (Hanski & Cambefort, 1991), between November 2017 and February 2018. At each collection site, a linear transect was established within native habitats (Legal Reserve of the farm), 150 m (parallel) from the edge of agricultural crops. In each transect, three pairs of baited-unbaited pitfalls were installed 30 m equidistant, being the baited-unbaited pair separated by a distance of 10 m (Fig S1). The unbaited trap consists of a standard pitfall only containing capture solution (water, detergent and salt), and the baited trap, consisting of a standard pitfall with the capture solution plus a smaller container (coffee cup of 100ml) with about ~30 g of human feces fixed with galvanized wire inside the trap. All traps were standardized with a diameter of 14 cm and volume of 1000 ml, and with the same capture solution, only differing in the presence or absence of the baits (Agosti et al., 2000) (Fig 1). All traps were kept active for 48 hours. Therefore, we have a total sample effort of 252 baited and unbaited traps distributed in the 42 areas. The samples were transferred to the Entomology Laboratory of the State University of Mato Grosso, Campus of Tangará da Serra, where they were screened and morphotyped to the lowest possible taxonomic level. Posteriorly, the ants were identified using dichotomous keys present in literature on Neotropical ant species (Fernández, 2003; Longino, 2009; Lattke et al., 2007; Mackay & Mackay, 2010; Cuezzo & Guerrero, 2011; Baccaro et al., 2015; Feitosa & Prada-Achiardi, 2019), photo types in AntWeb (AntWeb, 2019) and the ant vouchers deposited in the collection of the Laboratório de Ecologia de Comunidades,
Centro de Biodiversidade, UFMT, Cuiabá, Mato Grosso, Brazil. The vouchers are deposited in Entomological Collection of Tangará da Serra (UNEMAT-CEnTg) in Tangará da Serra-Mato Grosso, Brazil.

Data analysis

In order to compare the efficiency of the two pitfall types, species accumulation curves were generated using the \textit{iNEXT} package (Hsieh et al., 2019) ($n = 500$). Extrapolation of displayed curves with 95% confidence intervals was used. To assess the effects of the trap type on the number of ant species per site, we constructed a Mixed Generalized Linear Model (GLMM) with the \textit{glmer} function of the MuMIn package (Barton, 2009). In this model, the trap (with or without bait) was inserted as an explanatory variable and the error family used was Poisson. Since the sampling occurred in Cerrado-Amazonia transition areas, and as the objective of this work is to demonstrate the effect of the bait on the capture of ants regardless of the type of vegetation, the vegetation type of the area of the pitfall pair was inserted as a random variable in the model. To assess whether there was a difference in species composition between traps with and without baits, we used a Permutational Multivariate Analysis (PERMANOVA) (Anderson, 2001). To test the homogeneity of the dispersion within the groups formed by PERMANOVA, we used the \textit{betadisper} function (Oksanen et al., 2018). A Principal Coordinate Analysis (PCoA) was also performed, using a Jaccard index. The first two axes of the PCoA were used to make graphs of the similarity between the points. We used a PROTEST with the \textit{procrustes} function, from the “vegan” package, to check if the composition of the communities of both types of traps co-varied (Peres-Neto & Jackson, 2001).

Finally, the Index of Indicative Values (\textit{IndVal}) analysis of the labdsv package (Roberts, 2016) by Dufrene and Legendre (1997) was used to assess which species were associated with baited and non-baited traps. All statistical analyzes were performed using Software R version 3.4.2 (Team R Core 2018) and the ggplot2 package was used to build the graphs (Wickham, 2016).

Results

Of the 2599 occurrences, 150 species of ants were identified, distributed in seven subfamilies and 38 genera (Table S2). Of these, 131 species were recorded in baited traps and 107 in unbaited traps. Among the species collected, 43 occurred exclusively in unbaited traps and 19 were exclusive to bait traps. Myrmicinae was the subfamily with the largest number of species (77), followed by Formicinae (25) and Ponerinae (17). The species most frequently found in unbaited traps were \textit{Pheidole radoszkowski} Mayr, 1884 with 47 occurrences, \textit{Camponotus} sp1 with 45 occurrences and \textit{Gigantiops destructor} (Fabricius, 1804) with 41 occurrences and the most frequent in baited traps were \textit{Pheidole} sp9 with 128 occurrences, \textit{Atta} sp2 with 108 occurrences and \textit{Camponotus} sp1 with 98 occurrences.

The two species accumulation curves, the unbaited traps and all the traps together, had their confidence intervals overlapping regardless of the number of samples. In both cases, these curves did not overlap with the curve that represents the baited traps (Fig 2). The unbaited traps had an average of 27 species. Baited traps, on the other hand, had a significantly lower number of species, averaging 20 ($X^2 = 52.581; p < 0.001$) (Fig 3).
The species composition also differed between baited and unbaited traps (PERMANOVA: $R^2 = 0.04$, $p < 0.001$). Additionally, there was no difference in dispersion between these two groups (PERMDISP: $F = 0.37$; $p = 0.78$). These different communities co-vary spatially, but with an adjustment of only 0.43 (PROTEST $p < 0.01$) (Fig 4 A, B).

Fig 2. Accumulation curves of ant species collected in all pitfall traps (purple line), pitfall traps without bait (blue line) pitfall traps with bait (red line).

Fig 3. Number of species recorded in pitfall traps with bait (red) and without bait (blue) within the remnants of native habitat. The lines are linking the number of species caught in each type of trap at each collection point.
Fig 4. (A) Principal Coordinates Analysis (PCoA) ordination showing ants species composition per site sampled with pitfall traps with bait (red) and without bait (blue) in 42 sites. (B) Procrustes rotation plot of sampled sites with lines representing changes in species composition between pitfall traps with bait (red) and without bait (blue).

This difference in composition is reinforced by the difference in the most common species, as well as in the values of IndVal. Only two species, *Camponotus* sp8 and *Gnamptogenys* sp2, were associated with baited traps. However, 21 species other than those that occurred in baited pitfalls, presented significant IndVal values to unbaited traps, for example *Pheidole radoszkowskii* with 72% of association, followed by *Camponotus* sp2 with 53%, *Gigantiops destructor* (Fabricius, 1804) with 47% and *Ectatomma edentatum* (Roger, 1863) with 41%. (Table 1).

**Discussion**

Our results strongly suggest that the use of baited traps for dung beetles does not generate fully compatible data with a collection without bait for ants. Conventional traps, recommended in the sampling protocols and used to capture ants (Agosti et al., 2000; Bestelmeyer et al., 2000), should not be replaced by baited traps used to catch dung beetles. Baited traps capture less species and a different composition than those from unbaited ones. However, even though low (43%), there was a correlation between the communities captured by both protocols. This indicates that the communities collected in both methods can respond with some consonance to some changes, such as big disturbances, in the scale in which the sampling of this study was carried out. This correlation was insufficient to suggest that the protocols are similar and that both would capture ecological process and patterns in an equivalent way.

Approximately 26% of the species collected in the two types of traps can be considered as infrequent, as they presented a single record in this study. Some species of the genera *Labidus*, *Apterostigma*, *Cyphomyrmex*, *Myrmicocrypta* or *Strumigenys*, which were considered rare, are already considered of low occurrence in other studies using pitfall

**Table 1.** Species of indicator ants captured in pitfall traps with bait and without bait inside native habitats (Legal Reserve), where the frequency of occurrence represents the total occurrence in pitfalls of the types of traps.

| Indicator Species                  | IndVal | P-value | Frequency |
|------------------------------------|--------|---------|-----------|
| With bait                          |        |         |           |
| *Camponotus* sp8                   | 39%    | 0.008   | 36        |
| *Gnamptogenys* sp2                 | 35%    | 0.003   | 28        |
| Without bait                       |        |         |           |
| *Pheidole radoszkowskii*           | 72%    | 0.001   | 46        |
| *Camponotus* sp2                   | 53%    | 0.033   | 68        |
| *Gigantiops destructor* (Fabricius, 1804) | 47%    | 0.016   | 54        |
| *Ectatomma edentatum* (Roger, 1863) | 41%    | 0.015   | 40        |
| *Solenopsis* sp3                   | 35%    | 0.043   | 39        |
| *Linepithema* sp1                  | 35%    | 0.011   | 29        |
| *Pheidole* sp17                    | 32%    | 0.005   | 22        |
| *Acromyrmex* sp1                   | 32%    | 0.010   | 27        |
| *Trachymyrmex* sp2                 | 31%    | 0.003   | 22        |
| *Pheidole* sp6                     | 31%    | 0.001   | 16        |
| *Pachycondyla harpax* (Latreille, 1802) | 28%    | 0.024   | 24        |
| *Pheidole* sp15                    | 24%    | 0.037   | 20        |
| *Pheidole* bilimeki                | 23%    | 0.003   | 10        |
| *Pheidole* bufo                    | 21%    | 0.050   | 17        |
| *Pheidole* sp7                     | 21%    | 0.008   | 09        |
| *Pheidole* aff transversostriata   | 19%    | 0.007   | 10        |
| *Camponotus* sp12                  | 19%    | 0.010   | 08        |
| *Crepatogaster ienuicula* (Longino, 2003) | 19%    | 0.022   | 11        |
| *Ochetomyrmex neopolitis* (Fernández, 2003) | 16%    | 0.021   | 07        |
| *Pheidole* sp11                    | 14%    | 0.026   | 06        |
| *Odontomachus* sp4                 | 11%    | 0.048   | 05        |
Writing (revision and editing).

Australia by Andersen et al. (2002) that investigated whether and composition of the species sampled (Ivanov & Keiper, 2015; Barthi et al., 2016). However, previous studies have indicated for the collection methods (Longino, 2009; Baccaro et al., 2015), therefore, if some species were attracted to the bait, they could repel other species. However, our data support this hypothesis, since we observed a significant increase in the total workers frequency and number of ant species in bait traps. It is likely that ants with generalist habits are not easily influenced by disturbances and resources (Baccaro et al., 2015; Barthi et al., 2016). Instead, ants with food or environmental preferences (specialists) could avoid the presence of feces, so being less captured or even absent in baited traps.

The observed decrease in the number of species in both scales using baited traps suggests negative effect of the feces bait on the capture of ants, making difficult for some species to be collected and changing the pattern of communities captured by sampling. In fact, none of the ants’ species that dominated conventional traps also dominated baited traps. This demonstrates totally different conditions for the community, with relevance in the species captured by the type of sampling method. For example, an unidentified species of the genus Camponotus (Camponotus sp.8) which was associated by Indval with baited pitfall and Pheidole radoszkowskii, which dominated in unbaited traps and was also strongly associated by Indval with this method. However, the relevance of these species being associated with traps with and without bait, may be associated with the biology of the species, since most of the genera associated with the traps have a generalist habit and are abundant. Thus, the associated species do not provide sufficient indication for the collection methods (Longino, 2009; Baccaro et al., 2015; Barthi et al., 2016). However, previous studies have evaluated sampling techniques only in relation to the number and composition of the species sampled (Ivanov & Keiper, 2009; Tista & Fiedler, 2010) and, there was only one study in Australia by Andersen et al. (2002) that investigated whether pitfall traps used for vertebrate groups could complement surveys of larger ant species. However, to our knowledge, there has been no investigation to ascertain whether methods used for other invertebrates could complement surveys of ant species or not.

In this study, we see that the use of pitfall traps baited with feces, used in sampling dung beetles, has a negative effect on the number of species and composition of the ant community. Depending on the objective of the study, a small decrease in the number of species due to the use of baited pitfalls does not compromise the knowledge of a representative part of the ant fauna of a given region. Therefore, this difference can be revealed by the reduction in the logistical cost in fast-loading works or on a reduced budget. However, for the study of ecological patterns, studies demanding subtle differences among sites, or even for bio-indication, the use of baited traps should not be recommended. We suggest that baited pitfalls should not replace the conventional pitfalls established in collection protocols, particularly in studies with a more ecological approach. However, in order to optimize the material collected in studies of dung beetles, the ants could be used for taxonomic or biogeographic purposes and thus contribute to the species’ distribution patterns.

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Author Contributions

MJB PEREIRA: Project management. MJB PEREIRA: Acquisition of research funding. MJB PEREIRA, D STORCK-TONON, TJ IZZO, RJ SILVA: Methodology. MJB PEREIRA, D STORCK-TONON, RJ SILVA: Logistics for data collection. KR PRZYBYSZEWSKI, JVG FREITAS: Laboratory processing. KR PRZYBYSZEWSKI, TJ IZZO, RE VICENTE: Species identification. KR PRZYBYSZEWSKI, D STORCK-TONON, RJ SILVA: Statistical analysis. D STORCK-TONON, TJ IZZO: Supervision. KR PRZYBYSZEWSKI, D STORCK-TONON, TJ IZZO: Writing (preparation of the original draft). KR PRZYBYSZEWSKI, D STORCK-TONON, TJ IZZO, RJ SILVA, RE VICENTE, JVG FREITAS: Writing (revision and editing).
References

Agosti, D., Majer, J.D., Alonso, L. & Schultz, T.R. (2000). Ants: standard methods for measuring and monitoring biodiversity. Washington: Smithsonian Institution Press, 280 p.

Alonso, L.E. & Agosti, D. (2000). Biodiversity studies, monitoring, and ants: an overview. In: Agosti, D., Majer, J.D., Alonso, L.E. & Schultz, T.R. (Eds.), Ants: standard methods for measuring and monitoring biodiversity (pp. 1-8). Washington: Smithsonian Institution Press, 280 p.

Alvare, C.A., Stape, J.L. & Sentelhas, P.C. (2013). Koppens climate classification map for Brazil. Meteorol Zeitschrift, 22: 711-728. doi: 10.1127/0941-2948/2013/0507

Andersen, A.N., Hoffmann, B.D., Muller, W.J. & Griffiths, A.D. (2002). Using ants as bioindicators in land management: simplifying assessment of ant community responses. Journal of Applied Ecology, 39(1): 8-17. doi:10.1046/j.1365-2664.2002.00704.x

Anderson, M.J. (2001). A new method for non-parametric multivariate analysis of variance. Austral Ecology, 26: 32–46. doi: 10.1111/j.1442-9993.2001.01070.pp.x

AntWeb (2019). AntWeb v8.41. http://www.antweb.org (accessed date: August, 2019).

Aquino, A.M., Aguiar-Menezes, E.L. & Queiroz, J.M. (2006). Recomendações para coleta de artrópodes terrestres por armadilhas de queda (“pitfall-traps”). Seropédica: Embrapa Agrobiologia, 8 p.

Baccaro, F.B., Feitosa, R.M., Fernández, F., Fernandes, I.O., Izzo, T.J., Souza, J.L.P. & Solar, R. (2015). Guia Para os Gêneros de Formigas do Brasil. Manaus: Editora INPA, 388 p. doi:10.5281/zenodo.32912.

Barton, K. (2009). Mu-Mn: Multi-model inference. R Package Version 0.12.2/18. http://R-Forge.R-project.org/projects/mumin/

Bharti, H., Bharti, M. & Pfeifer, M. (2016). Ants as bio-indicators of ecosystem health in Shivalik Mountains of Himalayas: assessment of species diversity and invasive species. Asian Myrmecology, 8: 65-79. doi: 10.20362/am.008023.

Bestelmeyer, B.T., Agosti, D., Alonso, L.E., Brandão, C.R.F., Brown, W.L., Delabie, J.H.C. & Silvestre, R. (2000). Field techniques for the study of ground-dwelling ants: an overview, description, and evaluation. In: Agosti, D., Majer, J.D., Alonso, L.E. & Schultz, T.R. (Eds.), Ants: Standard Methods for Measuring and Monitoring Biodiversity (pp. 122-144). Washington: Smithsonian Institution Press.

Campos, R.I., Vasconcelos, H.L., Andersen, A.N., Frizzo, T.L.M. & Spena, C. (2011). Multi-scale ant diversity in savanna woodlands: an intercontinental comparison. Austral Ecology, 36: 983-992. doi: 10.1111/j.1442-9993.2011.02255.x

Cuezzo, F. & Guerrero, R.J. (2011). The Ant Genus Dorymyrmex Mayr (Hymenoptera: Formicidae: Dolichoderinae) in Colombia. Psyche, 2012 (ID article 516058): 1-24.

Delabie, J.H.C., Fisher, B.L., Majer, J.D. & Wrigth, I.W. (2000). Sampling effort and choice of methods. In: Agosti, D., Majer, J.D., Alonso, L.E. & Schultz, T.R. (Eds.), Ants: Standard Methods for Measuring and Monitoring Biodiversity (pp. 145-154). Washington: Smithsonian Institution Press.

Del Toro, I., Ribbons, R.R. & Pelini, S.L. (2012). The little things that run the world revisited: a review of ant-mediated ecosystem services and disservices (Hymenoptera: Formicidae). Myrmecological News, 17:133-146.

Dufrene, M. & Legendre, P. (1997). Species Assemblages and Indicator Species: the need for a flexible asymmetrical approach. Ecological Monographs, 67: 345-366. doi: 10.2307/2963459.

Feitosa, R.M. & Prada-Achirardi, F.C. (2019). Subfamilia Ectatomminae. Fernández, F.; Guerrero, R.J.; Delsinne, T. (eds.) 2019. Hormigas de Colombia. Bogotá: Universidad Nacional de Colombia, 1198 pp.

Fernández, F. (2003). Myrmicine ants of the genera Ochetomyrinx and Tranopelta (Hymenoptera: Formicidae). Sociobiology, 41: 63-661.

Gardner, T.A., Barlow, J., Araujo, I.S., Ávila-Pires, T.C., Bonaldo, A.B., Costa, J.E. & Peres, C.A. (2008). The cost-effectiveness of biodiversity surveys in tropical forests. Ecology Letters, 11: 139–50. doi: 10.1111/j.1461-0248.2007.01133.x

Gomes, C.B., Souza, J.L.P. & Franklin, E. (2018). A comparison between time of exposure, number of pitfall traps and the sampling cost to capture ground-dwelling poneromorph ants (Hymenoptera: Formicidae). Sociobiology, 65: 138–148. doi: 10.13102/sociobiology.v65i2.1207

Hanski I. & Cambefort, Y. (1991). Dung beetle ecology. Princeton University Press, Cambridge.

Hoffmann, B.D. & Andersen, A.N. (2003). Responses of ants to disturbance in Australia, with particular reference to functional groups. Austral Ecology, 28: 444–464. doi: 10.1046/j.1442-9993.2003.01301.x

Hölldobler, B. & Wilson, E.O. (1990). The ants. Cambridge: Harvard University Press, 732 p.

Hsieh, T.C., Ma, K.H. & Chao, A. (2016). iNEXT: INterpolation to functional groups. Austral Ecology, 28: 1451–1456. doi: 10.1111/aen.12613

Ivanov, K. & Keiper, J. (2009). Effectiveness and biases of winker litter extraction and pitfall trapping for collecting ground-dwelling poneromorph ants in northern temperate forests. Environmental Entomology, 38: 1725–1736. doi: 10.1603/022.038.0626

Lattke, J.E., Fernández, F. & Palacio, E.O. (2007). Identification of the species of Gnamptogenys Roger in the Americas. Memoirs of the American Entomological Institute, 80: 254-270.

Lobo, J.M., Martín-Piera, F. & Veiga, C.M. (1988). Las trampas pitfall con cebo, sus posibilidades en el estudio de las comudades coprófagas de Scarabaeidae (Col.). I. Características...
Table S1. Number of sampled points with their respective geographic coordinates and representative municipalities.

| Locations | Longitude     | Latitude     | Municipalities        |
|-----------|---------------|--------------|-----------------------|
| 1         | 58°14'48W     | 11°57'01S    | Brasnorte             |
| 2         | 58°12'54W     | 11°57'12S    | Brasnorte             |
| 3         | 58°12'28W     | 11°59'35S    | Brasnorte             |
| 4         | 58°18'08W     | 11°58'00S    | Brasnorte             |
| 5         | 58°28'28W     | 13°24'26S    | Sapezal               |
| 6         | 58°26'23W     | 13°23'33S    | Sapezal               |
| 7         | 58°27'56W     | 13°28'05S    | Sapezal               |
| 8         | 58°36'09W     | 13°27'32S    | Sapezal               |
| 9         | 58°36'09W     | 13°27'32S    | Sapezal               |
| 10        | 58°28'10W     | 13°39'45S    | Sapezal               |
| 11        | 57°05'11W     | 13°20'21S    | Nova Maringá          |
| 12        | 57°03'13W     | 13°18'22S    | Nova Maringá          |
| 13        | 57°01'47W     | 13°16'09S    | Nova Maringá          |
| 14        | 57°04'45W     | 13°15'02S    | Nova Maringá          |
| 15        | 57°04'42W     | 13°08'40S    | Nova Maringá          |
| 16        | 57°01'45W     | 13°08'21S    | Nova Maringá          |
| 17        | 57°17'33W     | 14°30'05S    | Santo Afonso          |
| 18        | 57°23'47W     | 14°39'58S    | Tangará da Serra      |
| 19        | 57°43'26W     | 14°19'55S    | Tangará da Serra      |
| 20        | 57°45'13W     | 14°18'52S    | Tangará da Serra      |
| 21        | 57°32'40W     | 14°14'29S    | Nova Marilândia       |
| 22        | 57°37'57W     | 14°03'09S    | Diamantino            |
| 23        | 57°35'50W     | 14°04'22S    | Diamantino            |
| 24        | 57°33'41W     | 13°59'58S    | Diamantino            |
| 25        | 57°36'20W     | 14°00'34S    | Diamantino            |
| 26        | 58°03'45W     | 13°25'17S    | Campo Novo do Parecis |
| 27        | 58°07'02W     | 13°17'45S    | Campo Novo do Parecis |
| 28        | 58°04'19W     | 13°15'39S    | Campo Novo do Parecis |
| 29        | 58°06'35W     | 13°15'22S    | Campo Novo do Parecis |
| 30        | 57°55'12W     | 13°19'09S    | Campo Novo do Parecis |
| 31        | 57°58'47W     | 13°19'22S    | Campo Novo do Parecis |
| 32        | 57°58'12W     | 14°13'19S    | Campo Novo do Parecis |
| 33        | 57°55'55W     | 14°07'38S    | Campo Novo do Parecis |
| 34        | 57°53'19W     | 14°11'05S    | Campo Novo do Parecis |
| 35        | 57°57'36W     | 14°22'35S    | Tangará da Serra      |
| 36        | 57°52'55W     | 13°02'38S    | Brasnorte             |
| 37        | 57°50'13W     | 13°02'46S    | Brasnorte             |
| 38        | 58°06'27W     | 12°27'30S    | Brasnorte             |
| 39        | 58°09'48W     | 12°25'09S    | Brasnorte             |
| 40        | 57°25'10W     | 14°37'15S    | Tangará da Serra      |
| 41        | 58°09'40W     | 12°25'32S    | Brasnorte             |
| 42        | 57°25'66W     | 14°37'19S    | Tangará da Serra      |
Fig S1. Sketch of the sample design of the three pairs of traps with and without bait installed inside Legias Reserves in the State of Mato Grosso.

Table S2. Occurrences of ant species captured in pitfall traps with and without bait within the native habitats sampled in the State of Mato Grosso - Brazil.

| Species                          | Pitfalls          | Total |
|----------------------------------|-------------------|-------|
|                                  | With bait | Without bait |       |
| Subfamily Amblyoponinae          |           |              |       |
| Prionopelta sp1                  | 0         | 1             | 1     |
| Subfamily Dolichoderinae         |           |              |       |
| Azteca sp1                       | 2         | 4             | 6     |
| Azteca sp2                       | 1         | 0             | 1     |
| Dolichoderus attelaboides        | 8         | 4             | 12    |
| Dolichoderus decollates          | 3         | 2             | 5     |
| Dolichoderus ghilianii           | 0         | 1             | 1     |
| Dolichoderus imitator            | 27        | 41            | 68    |
| Dolichoderus aff rugosus         | 11        | 8             | 20    |
| Dolichoderus sp1                 | 1         | 0             | 1     |
| Dorymyrmex brunneus              | 12        | 12            | 24    |
| Dorymyrmex pyramycus             | 15        | 24            | 39    |
| Dorymyrmex sp1                   | 0         | 2             | 2     |
| Linepithema sp1                  | 13        | 49            | 62    |
| Linepithema sp2                  | 0         | 1             | 1     |
| Tapinoma sp1                     | 0         | 1             | 1     |
| Subfamilia Dorylinae             |           |              |       |
| Labidus sp1                      | 1         | 3             | 4     |
| Subfamily Ectatomminae           |           |              |       |
| Ectatomma brunneum               | 0         | 1             | 1     |
| Ectatomma edentatum              | 29        | 58            | 87    |
| Ectatomma lugens                 | 4         | 8             | 12    |
| Ectatomma permagnum              | 7         | 8             | 15    |

| Species                          | Pitfalls          | Total |
|----------------------------------|-------------------|-------|
|                                  | With bait | Without bait |       |
| Ectatomma tuberculatum           | 27        | 32            | 59    |
| (Olivier, 1792)                  |           |              |       |
| Gnamptogenys haenschi            | 0         | 2             | 2     |
| (Emery, 1902)                    |           |              |       |
| Gnamptogenys moelleri            | 13        | 13            | 26    |
| (Forel, 1912)                    |           |              |       |
| Gnamptogenys sp1                 | 9         | 3             | 12    |
| Gnamptogenys sp2                 | 27        | 9             | 36    |
| Gnamptogenys sp3                 | 5         | 13            | 18    |
| Subfamily Formicinae             |           |              |       |
| Acropyga sp1                     | 0         | 2             | 2     |
| Brachymyrmex sp1                 | 10        | 29            | 39    |
| Brachymyrmex sp2                 | 9         | 8             | 17    |
| Camponotus burtoni               | 0         | 1             | 1     |
| (Mann, 1916)                     |           |              |       |
| Camponotus femoratus             | 1         | 6             | 7     |
| (Fabricius, 1804)                |           |              |       |
| Camponotus aff atriceps          | 55        | 34            | 89    |
| Camponotus sp.1                  | 98        | 100           | 198   |
| Camponotus sp.2                  | 74        | 130           | 204   |
| Camponotus sp.3                  | 1         | 4             | 5     |
| Camponotus sp.4                  | 19        | 13            | 32    |
| Camponotus sp.5                  | 15        | 11            | 26    |
| Camponotus sp.6                  | 30        | 30            | 60    |
| Camponotus sp.7                  | 0         | 4             | 4     |
| Camponotus sp.8                  | 56        | 26            | 82    |
| Camponotus sp.9                  | 0         | 1             | 1     |
| Camponotus sp.10                 | 0         | 6             | 6     |
| Camponotus sp.11                 | 3         | 11            | 14    |
| Camponotus sp.12                 | 0         | 9             | 9     |
| Camponotus sp.13                 | 2         | 9             | 11    |
| Camponotus sp.14                 | 0         | 1             | 1     |
| Camponotus sp.15                 | 4         | 1             | 5     |
Table S2. Occurrences of ant species captured in pitfall traps with and without bait within the native habitats sampled in the State of Mato Grosso - Brazil. (Continuation)

| Species                          | Pitfalls | Total |
|----------------------------------|----------|-------|
|                                  | With bait| Without bait |
| Camponotus sp.16                 | 2        | 0     | 2      |
| Camponotus sp.17                 | 1        | 0     | 1      |
| Camponotus sp.18                 | 4        | 0     | 4      |
| Camponotus sp.19                 | 1        | 0     | 1      |
| Gigantiops destructor            | 39       | 79    | 118    |
| (Fabricius, 1804)                |          |       |        |
| Nylanderia sp.1                  | 44       | 54    | 98     |
|                                 |          |       |        |
| Subfamily Myrmicinae             |          |       |        |
| Acromyrmex sp.1                  | 11       | 35    | 46     |
| Acromyrmex sp.2                  | 44       | 40    | 84     |
| Acromyrmex sp.3                  | 4        | 0     | 4      |
| Acromyrmex sp.4                  | 0        | 2     | 2      |
| Acromyrmex sp.5                  | 1        | 0     | 1      |
| Apterostigma megacephala         | 10       | 12    | 22     |
| (Lattke, 1999)                   |          |       |        |
| Apterostigma sp.1                | 1        | 6     | 7      |
| Apterostigma sp.2                | 0        | 1     | 1      |
| Apterostigma sp.3                | 0        | 1     | 1      |
| Atta sp.1                        | 5        | 5     | 10     |
| Atta sp.2                        | 108      | 101   | 209    |
| Atta sp.3                        | 6        | 1     | 7      |
| Atta sp.4                        | 0        | 5     | 5      |
| Basiceros militaris              | 1        | 0     | 1      |
| (Weber, 1950)                    |          |       |        |
| Cephalotes atratus               | 3        | 5     | 8      |
| (Linnaeus, 1758)                 |          |       |        |
| Crematogaster brasiliensis       | 12       | 21    | 33     |
| (Mayr, 1878)                     |          |       |        |
| Crematogaster carinata           | 27       | 40    | 67     |
| (Mayr, 1862)                     |          |       |        |
| Crematogaster limata             | 18       | 11    | 29     |
| (Smith, 1858)                    |          |       |        |
| Crematogaster longispina         | 2        | 3     | 5      |
| (Emery, 1890)                    |          |       |        |
| Crematogaster nigropilosa        | 3        | 3     | 6      |
| (Mayr, 1870)                     |          |       |        |
| Crematogaster tenuicula          | 2        | 16    | 18     |
| (Longino, 2003)                  |          |       |        |
| Crematogaster sp.1               | 1        | 6     | 7      |
| Cyphomyrmex sp.1                 | 4        | 3     | 7      |
| Cyphomyrmex sp.2                 | 1        | 2     | 3      |
| Cyphomyrmex sp.3                 | 2        | 1     | 3      |
| Cyphomyrmex sp.4                 | 0        | 1     | 1      |
| Cyphomyrmex sp.5                 | 0        | 1     | 1      |
| Cyphomyrmex sp.6                 | 0        | 1     | 1      |
| Cyphomyrmex sp.7                 | 0        | 1     | 1      |
| Cyphomyrmex sp.8                 | 0        | 1     | 1      |

| Species                          | Pitfalls | Total |
|----------------------------------|----------|-------|
|                                  | With bait| Without bait |
| Cyphomyrmex sp.9                 | 0        | 1     | 1      |
| Daceton armigerum                | (Latreille, 1802) | 1 | 0 | 1 |
| Mycocepurus smithii              | (Forel, 1893) | 0 | 3 | 3 |
| Myrmicocrypta sp.1               | 0        | 1     | 1      |
| Myrmicocrypta sp.2               | 0        | 1     | 1      |
| Myrmicocrypta sp.3               | 0        | 1     | 1      |
| Ochetomyrmex neopolitus          | (Fernández, 2003) | 0 | 7 | 7 |
| Ochetomyrmex semipolitus         | (Mayr, 1878) | 0 | 1 | 1 |
| Pheidole hyo (Wilson, 2003)      | 6        | 20    | 26     |
| Pheidole gertrudae               | (Forel, 1886) | 4 | 10 | 14 |
| Pheidole nitella (Wilson, 2003)  | 0        | 2     | 2      |
| Pheidole radoszkowskii           | 14       | 97    | 111    |
| Mayr, 1884                       |          |       |        |
| Pheidole aff biconstricta        | 0        | 2     | 2      |
| Pheidole aff bilimeki            | 0        | 11    | 11     |
| Pheidole aff fimbriata           | 0        | 1     | 1      |
| Pheidole aff translusosstriata   | 1        | 11    | 12     |
| Pheidole sp.1                    | 2        | 8     | 10     |
| Pheidole sp.3                    | 0        | 1     | 1      |
| Pheidole sp.5                    | 2        | 7     | 9      |
| Pheidole sp.6                    | 2        | 28    | 30     |
| Pheidole sp.7                    | 0        | 11    | 11     |
| Pheidole sp.8                    | 0        | 4     | 4      |
| Pheidole sp.9                    | 128      | 111   | 239    |
| Pheidole sp.10                   | 29       | 22    | 51     |
| Pheidole sp.11                   | 0        | 6     | 6      |
| Pheidole sp.12                   | 0        | 1     | 1      |
| Pheidole sp.13                   | 4        | 4     | 8      |
| Pheidole sp.14                   | 14       | 11    | 25     |
| Pheidole sp.15                   | 9        | 26    | 35     |
| Pheidole sp.16                   | 62       | 45    | 107    |
| Pheidole sp.17                   | 5        | 22    | 27     |
| Pheidole sp.18                   | 2        | 1     | 3      |
| Pheidole sp.19                   | 0        | 5     | 5      |
| Pheidole sp.20                   | 0        | 1     | 1      |
| Pheidole sp.21                   | 0        | 2     | 2      |
| Pheidole sp.22                   | 3        | 0     | 3      |
| Rogeria sp.1                     | 0        | 1     | 1      |
| Sericomymrex sp.1                | 41       | 63    | 104    |
| Sericomymrex sp.2                | 1        | 0     | 1      |
Table S2. Occurrences of ant species captured in pitfall traps with and without bait within the native habitats sampled in the State of Mato Grosso - Brazil. (Continuation)

| Species               | Pitfalls | Total |
|-----------------------|----------|-------|
|                       | With bait| Without bait | |
| Solenopsis sp.1       | 10       | 6     | 16    |
| Solenopsis sp.2       | 0        | 5     | 5     |
| Solenopsis sp.3       | 29       | 49    | 56    |
| Solenopsis sp.4       | 0        | 2     | 2     |
| Solenopsis sp.5       | 27       | 20    | 47    |
| Solenopsis sp.6       | 0        | 1     | 1     |
| Solenopsis sp.7       | 0        | 1     | 1     |
| Strumigenys sp.1      | 1        | 4     | 5     |
| Strumigenys sp.2      | 0        | 1     | 1     |
| Strumigenys sp.3      | 0        | 1     | 1     |
| Tetramorium sp.1      | 0        | 1     | 1     |
| Tetramorium sp.2      | 1        | 0     | 1     |
| Trachymyrmex sp.1     | 13       | 16    | 29    |
| Trachymyrmex sp.2     | 9        | 46    | 55    |
| Trachymyrmex sp.3     | 1        | 0     | 1     |
| Wasmannia auropunctata (Roger, 1863) | 1 | 1 | 2 |

Subfamily Ponerinae

| Species               | Pitfalls | Total |
|-----------------------|----------|-------|
| Anochetus sp.1        | 3        | 4     | 7     |
| Anochetus sp.2        | 1        | 3     | 4     |
| Hypoponera sp.1       | 0        | 1     | 1     |
| Hypoponera sp.2       | 0        | 3     | 3     |
| Hypoponera sp.3       | 0        | 1     | 1     |
| Hypoponera sp.4       | 6        | 1     | 7     |
| Leptogenys sp.1       | 0        | 2     | 2     |
| Mayaponera sp.1       | 2        | 0     | 2     |
| Neoponera apicalis (Emery, 1901) | 19 | 37 | 56 |

Subfamily Pseudomyrmecinae

| Species               | Pitfalls | Total |
|-----------------------|----------|-------|
| Neoponera inversa     | 2        | 2     | 4     |
| Neoponera commutata   | 4        | 14    | 18    |
| Neoponera verenae     | 12       | 18    | 30    |
| Odontomachus sp.1     | 0        | 5     | 5     |
| Odontomachus sp.2     | 3        | 2     | 5     |
| Odontomachus sp.3     | 20       | 19    | 39    |
| Odontomachus sp.4     | 0        | 6     | 6     |
| Odontomachus sp.5     | 0        | 2     | 2     |
| Pachycondyla crassinoda (Latreille, 1802) | 31 | 59 | 90 |
| Pachycondyla harrax (Latreille, 1802) | 9 | 27 | 36 |

Total number of unique species 15 59 74
Total number of species 107 150 157
Total number of occurrences 1515 2167 3682