Diversity of Braconidae (Insecta, Hymenoptera) of the Parque Natural Municipal de Porto Velho, Rondonia, Brazil

Sian de Souza Gadelha[1], Angelica Maria Penteado-Dias[2] & Alexandre de Almeida e Silva[1,3]

[1]Universidade Federal de Rondônia, Laboratório de Bioecologia de Insetos, Campus - BR 364, Km 9,5, 76801–059 Porto Velho-RO, Brasil. ss_gadelha@hotmail.com
[2]Universidade Federal de São Carlos, Departamento de Ecologia e Biologia Evolutiva. Caixa Postal 676, 13565–905 São Carlos-SP, Brasil. angelica@power.ufscar.br
[3]Fiocruz-Rondônia, Laboratório de Entomologia, Rua da Beira, 7671, 76812–245 Porto Velho-RO, Brasil. alealsil@unir.br

ABSTRACT. Diversity of Braconidae (Insecta, Hymenoptera) of the Parque Natural Municipal de Porto Velho, Rondonia, Brazil. Braconidae is a highly diversified family of Hymenoptera and usually known by their role in biological control both in agricultural and natural ecosystems. Despite of that, little is known about its diversity in the Amazon region. The present work inventoried the braconid fauna of an Open Ombrophylous Forest with Palm Trees of the Parque Natural Municipal de Porto Velho, RO. Insects were collect from June/2008 to May/2009 using six Malaise traps in different parts of the reserve. A total of 377 wasps were captured, 17 subfamilies and 56 genera identified. Braconinae, Microgastrinae, Doryctinae and Rogadinae subfamilies were very abundant, and also the genera *Aleiodes, Bracon, Capitonius, Compsobracon, Heterospilus, Hymenochaonia, Opius*, *Pedinotus*, *Rogas* and *Stantonia*. The calculated Shannon diversity index was 2.15 and 3.3 for subfamily and genera, respectively, which were, generally, higher than the values found for other regions in Brazil. Generally, parasitoids were more abundant during the rainy season. The present work contributes with new genera records and faunistic data of Braconidae in Rondonia State, western Amazon.

KEYWORDS. Ichneumonoidea; parasitoid wasps; richness; Western Amazon.

RESUMO. Diversidade de Braconidae (Insecta, Hymenoptera) do Parque Natural Municipal de Porto Velho, Rondônia, Brasil. Braconidae é uma família altamente diversificada dentro da ordem Hymenoptera, possuindo grande importância no controle biológico tanto em sistemas agrícolas como em sistemas naturais. Contudo, a diversidade do grupo ainda é pouco conhecida para a região amazônica. Neste sentido, o presente estudo vem contribuir para este conhecimento através do inventariamento da assembléia de braconídeos do Parque Natural Municipal de Porto Velho, Rondônia. As coletas foram realizadas pelo período de um ano, utilizando seis armadilhas Malaise em uma área de Floresta Ombrófila Aberta com palmeiras. Foram coletados 377 espécimes, identificados em 17 subfamílias e 56 gêneros. As subfamílias Braconinae, Microgastrinae, Doryctinae e Rogadinae foram consideradas muito abundantes, assim como os gêneros: *Aleiodes*, *Bracon*, *Capitonius*, *Compsobracon*, *Heterospilus*, *Hymenochaonia*, *Opius*, *Pedinotus*, *Rogas* e *Stantonia*. O índice de diversidade calculado para as subfamílias (H = 2,15) e gêneros (H = 3,3) coletados neste trabalho foi maior do que o encontrado em alguns trabalhos em outras regiões do Brasil. A abundância desses insetos durante a estação chuvosa foi significativamente maior do que na seca. Este trabalho contribui com novos dados faunísticos sobre Braconidae para o Estado de Rondônia.

PALAVRAS-CHAVE. Amazônia Ocidental; Ichneumonoidea; riqueza; vespas parasitoides.

Braconidae, the second most diverse family of Hymenoptera, includes more than 15,000 species, but species richness is estimated in 100,000 (Hanson & Gauld 2006). The insect size varies from 1 to 30 mm, excluding ovipositor and antennae. Braconids are cosmopolitan (Gauld & Bolton 1988; Hanson & Gauld 2006) parasitoids of other insects such as Coleoptera and Lepidoptera (Gillot 2005). These wasps have an important role in the population dynamics of phytophagous insects, with emphasis on biological control of agricultural pests (Gauld & Bolton 1988; Gillot 2005).

Diego & Campos (2001) reviewed the distribution of Braconidae genera recorded for the Neotropical region, particularly to Colombia and in general for South America or Central America, without the exact notation of the records. In general, there are few systematic inventories describing the Amazon fauna of parasitoids (Ichneumonoidea). Feitosa *et al.* (2007) collected parasitic wasps in reserves 1112, 1208 and 1301 included in the BDFFP, and reported that the Braconidae comprised 93% of the wasps collected, therefore the most abundant family. Most studies focused on parasitoids of frugivorous insect larvae, *e.g.*, Costa *et al.* (2009) found seven species of Braconidae of the subfamily Alysiinae and three Opiinae in the Adolpho Ducke forest reserve in Manaus. In a similar study, Thomazini & Albuquerque (2009) also reported three species of Opiinae parasitizing the larvae of fruit flies in Acre State. Pereira *et al.* (2010) related the first record of *Doryctobracon areolatus* (Szépligeti) and *Opius bellus* Gahan (Opiinae) in the larvae of fruit flies collected in Rondônia.

In this sense, more studies on the diversity of insect parasitoids in the Neotropical region, especially those that combining biology, distribution, behavior and related subjects are needed. Therefore, the present work aims to contribute with new data on the ecology and diversity of braconid in the Rondonia State, Brazil.

MATERIAL AND METHODS

Area of study. Wasps were collected in the Parque Natural Municipal de Porto Velho (PNMPV), Rondonia (8°40'S; 63°52'W). The park is a conservation area that includes 200 ha of Amazon forest near the limits of the urban area of Porto Velho.

The predominant vegetation at PNMPV is the Open Ombrophylous Forest with Palm Trees of dry land lower areas, i.e., altitude not exceeding 100 meters.

The climate in the region is typically hot and humid tropical during the whole year, with very narrow annual temperature range and remarkable amplitude during daytime, especially in the winter. There are markedly dry (Spring and Summer) and rainy (Autumn and Winter) seasons, and under the influence of Aw climate, the average annual rainfall varies between 1400 and 2500 mm/year, and annual average air temperature between 24°C and 26°C.

Sampling design and data collection. Insect captures were performed with Malaise traps (Townes 1972) from June/2008 to May/2009, comprising approximately 1,460 hours/trap. Six traps were used, and installed in several parts of the park to cover potential vegetation variation in the sampled area. Traps were monitored monthly for removal of collected material and replenishment of lethal liquid (70 % Ethyl Alcohol).

Set of two traps, placed 30 to 45 meters from each other, were distributed in three different areas of PNMPV. The different areas were 100 meters apart from each other, and included a border area, near the limits of the visitation area of the park, characterized by intense human activity and the predominance of small trees and presence of many palm trees; a dryland area with conserved Open Ombrophylous Forest that comprises most of the park area, characterized by the large trees and denser understory; and seasonal flooded area, with Open Lowland Ombrophylous Forest, near the Belmont stream, characterized by regular-sized trees with discontinuous canopy and open understory.

The collected material was identified based on taxonomic keys (Wharton *et al.* 1997; Marsh 2002) and with the help of INCT Hympar Sudeste staff, from Universidade Federal de São Carlos, São Carlos, São Paulo. The specimens are deposited in the collection of entomology at the Universidade Federal de Rondônia – UNIR.

Data analysis. The richness estimation (S) of subfamilies and genera were obtained by the Chao2 index, i.e., $S_{chao2} = S_{obs}+Q_1^2/2Q_2$, meaning: S_{obs} = number of genera observed; Q_1 = number of genera that occurs in only one sample; Q_2 = number of genera that occurs in two samples.

The Shannon diversity index (H) was based on the results from the statistical calculations of the program ANAFAU, developed by the Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ/USP.

The program uses the following formula for the calculation of diversity: $H' = -\sum_{i=1}^{k} pi \log pi$ on which, $pi = \frac{fi}{n}$ and thus have: $H' = \frac{n \log n - \sum_{i=1}^{k} fi \log fi}{n}$ where k = total number of subfamilies/genera, pi = proportion of subfamilies/genera i, fi = frequency of subfamilies/genera i and n = total number of individuals of all subfamilies/genera. Males Microgastrinae subfamily were not included in the analysis of genera diversity, because the identification keys are based on morphological characters of females.

TwoWay Anova tests analyzed parasitoid abundance and richness variation during the sampling period. The variables included were period of sampling (months) and trap. All tests were performed using SigmaStat 2.0.

RESULTS AND DISCUSSION

A total of 377 wasps were collected, 17 subfamilies and 55 genera were identified in one-year period, and also including a not described genus of Cardiochilinae (Table I). The subfamilies collected in the present study comprises 50% of the 34 subfamilies of Braconidae registered for the New World by Wharton *et al.* (1997) and 68% of the estimated value for the richness of subfamilies (S_{CHAO2} = 25). The 56 genera of Braconidae collected in this study comprised 60.87% of the estimated richness of genera (S_{CHAO2} = 92)

The subfamilies Microgastrinae (103), Rogadinae (73), Braconinae (42) and Doryctinae (48) were the most abundant. The other subfamilies had lower numbers, mostly below ten individuals. Nevertheless, the most abundant subfamilies found in the present work are similar to the pattern found in other areas (Cirelli & Penteado-Dias 2003; Scatolini & Penteado-Dias 2003; Restello & Penteado-Dias 2006) (Table I).

Ten genera were the most abundant: *Aleiodes* Wesmael, 1838; *Bracon* Fabricius, 1804; *Capitonius* Brullé, 1846, *Compsobracon* Ashmead, 1900; *Heterospilus* Haliday, 1836; *Hymenochaonia* Dalla Torre, 1898; *Opius* Wesmael, 1835; *Pedinotus* Szépligeti, 1902; *Rogas* Nees, 1818 and *Stantonia* Ashmead, 1904 (Table I). Only two genera, *Aleiodes* and *Heterospilus*, were related by Scatolini & Penteado-Dias (2003) as the most abundant, while Whitfield & Lewis (2001) also found *Aleiodes, Bracon, Heterospilus* and *Opius* among the most abundant genera collected in their work.

The Shannon diversity index (H) in this study was 2.15 and 3.3 for subfamilies and genera, respectively, much higher than observed in other regions of Brazil. Restello & Penteado-Dias (2006) found HH"1.32 for subfamily in Rio Grande do Sul State; Scatolini & Penteado-Dias (2003) in different areas of Parana State found HH"1.30 for braconid genera. On the other hand, Pereira (2009) related higher values for a reforestation area (H = 2.26), a mesophilous semideciduous forest area (H = 3.05), and an agrosilvopastoral system area (H = 2.97) in São Carlos, São Paulo arising from a higher equitability index, as found in the present work.

The number of genera collected in November/2008 was significantly (F = 2.58; P = 0.01) higher than May/2009 and June/2008 (Fig 1).

Table I. Braconidae (Insecta, Hymenoptera) collected in the Parque Natural Municipal de Porto Velho, Rondonia, Brazil, from June/2008 to May/2009.

Subfamily	Genus	N
Agathidinae	*Alabagrus* Enderlein, 1920	6
	Bassus Fabricius, 1804	2
	Coccygidium Saussure, 1892	4
	Dichelosus Szépligeti, 1902	2
	Earinus Wesmael, 1837	2
	Zamicrodus Viereck, 1912	6
Alysiinae	*Microcrasis* Fischer, 1975	1
Braconinae	*Bracon* Fabricius, 1804	15
	Compsobracon Ashmead, 1900	21
	Cyanopterus Haliday, 1835	1
	Gracilibracon Quicke, 1995	1
	Hemibracon Szépligeti, 1906	4
Cardiochilinae	Not described	1
	Toxoneuron Say, 1836	1
Cenocoelinae	*Capitonius* Brullé, 1846	13
	Cenocoelius Haliday, 1840	3
Cheloninae	*Chelonus* Panzer, 1806	1
	Phanerotoma Wesmael, 1838	3
	Pseudophanerotoma Zettel, 1990	1
Doryctinae	*Acrophasmus* Enderlein, 1912	3
	Aivalykus Nixon, 1938	2
	Concurtisella Roman,	1
	Curtisella Spinola, 1853 (1851)	1
	Hansonorum Marsh	2
	Heterospilus Haliday, 1836	11
	Johnsonius Marsh, 1993	1
	Leluthia Cameron, 1887	1
	Megaloproctus Schulz, 1906	7
		Continue

Subfamily	Genus	N
	Nervellius Roman, 1924	1
	Notiospathius Matthews & Marsh, 1973	1
	Pedinotus Szépligeti, 1902	12
	Semirhytus Szépligeti, 1902	1
	Trigonophasmus Enderlein, 1912	4
Gnamptodontinae	*Gnamptodon* Haliday,1833	1
Helconinae	*Eubazus* Nees, 1814	4
	Urosigalphus Ashmead, 1888	1
Homolobinae	*Exasticolus* van Achterberg, 1979	1
Hormiinae	*Hormius* Nees, 1818	1
Macrocentrinae	*Hymenochaonia* Dalla Torre, 1898	24
Microgastrinae	*Alphomelon* Mason, 1981,	1
	Apanteles Foerster, 1862	2
	Diolcogaster Ashmead, 1900	3
	Fornicia Brullé, 1846	1
	Glyptapanteles Ashmead, 1904	4
	Hypomicrogaster Ashmead, 1898	5
	Pseudapanteles Ashmead, 1898	2
	Xanthomicrogaster Cameron, 1911	1
Males		84
Opiinae	*Opius* Wesmael, 1835	9
Orgilinae	*Bentonia* van Achterberg, 1992	4
	Orgilus Nees, 1833	5
	Stantonia Ashmead, 1904	12
Rogadinae	*Aleiodes* Wesmael, 1838	13
	Cystomastax Szépligeti, 1904	2
	Rogas Nees von Esenbeck, 1818	57
	Stiropius Cameron, 1911	1
Sigalphinae	*Pselaphanus* Szépligeti, 1902	3

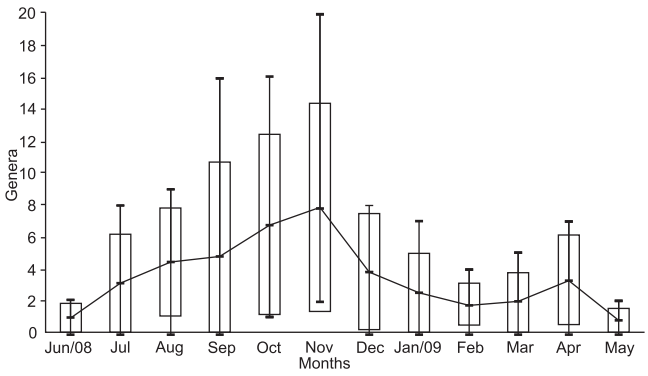

Fig. 1. Total number of Braconidae genera (Insecta, Hymenoptera) collected from June 2008 to May 2009 in the Parque Natural Municipal de Porto Velho, Rondonia, Brazil. Horizontal Bars = Mean; Columns = Standard Errors, Vertical Lines = Standard Deviation

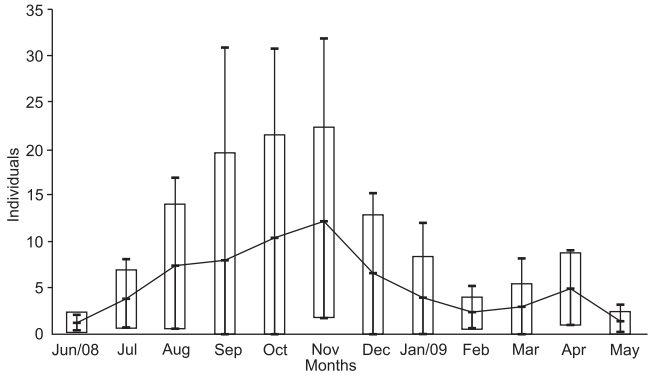

Fig. 2. Total number of individuals of Braconidae (Insecta, Hymenoptera) wasps collected from June 2008 to May 2009 in the Parque Natural Municipal de Porto Velho, Rondonia, Brazil. Horizontal Bars = Mean; Columns = Standard Errors, Vertical Lines = Standard Deviation.

Similarly to genera richness, the abundance of braconid along the sampling period was also higher in November/2008 compared to the months of lowest abundance (June/2008 and May, 2009) ($F = 2.34$; $P = 0.019$) (Fig 2). Parasitoid abundance tended to increase during the rainy season (November/2008-February/2009) but no significant ($P > 0.05$) correlations were found between precipitation and insect abundance.

Coley & Barone (1996) observed that the populations of insects in general decline in the dry season and increasing during the rainy season. This pattern may be related to high leaf production during the rainy season, increasing the abundance of several herbivores (Wolda 1978), and, thus, host availability for parasitoids during this season.

Besides, other complex relations between trap location and vegetation characteristics might also have affected wasp collection in the present study. Irvine and Woods (2007) concluded that Hymenoptera appeared to be sensitive to factors that interact to sun/shade conditions, since it was the group with the most variable results in captures using different sun/shade scenarios to evaluate the efficiency of different Malaise traps, including traditional Malaise traps.

The number of subfamilies, genera, and also the wasp abundance, collected is lower than the average found in the literature in other Brazilian regions, mostly in the South and Southeast (Scatolini & Penteado-Dias 2003, Cirelli & Penteado-Dias 2003, Restello & Penteado-Dias 2006). Moreover, only 38% of the genera in the present work are common within those collected by Cirelli & Penteado-Dias (2003) and Sigalphinae was the only subfamily not collected by Penteado-Dias in previous studies mentioned above.

Despite of that, comparisons are difficult due to differences in sampling effort and methodologies, *e.g*. Restello & Penateado-Dias (2006) collected wasps in 15 days intervals, using three malaise traps during one year in the border areas of different natural landscapes and Scatolini & Penteado-Dias (2003) used one light trap in three different locations.

The use of "old" traps in the present work may also have affected trap efficiency, because Duarte *et al*. (2010) related that new Malaise traps caught a higher number of individuals and also species of Muscidae than 12 and 18 months old traps, probably due to darkening of the mesh after long time exposure in field. Moreover, Lewis & Whitfield (1999) argued that two factors might also be related to the quantitative differences wasp collections. First one is related to increased primary production in disturbed related to climax associations in the short term. Second, undisturbed areas probably offer more vertically stratified habitat options compared to disturbed areas. Pucci (2008) results highlights that sampling only at the ground level resulted in biased representation of the composition of parasitic wasps and data from other insect groups support the importance of stratified collection, *e.g*., Stireman III *et al*. (2012) related that community structure of tachinid parasitoid fauna in understory and canopy are distinct and diverse and must be considered in studies related to diversity, community structure, and the population dynamics of herbivorous insects. Therefore, the use of suspended Malaise traps to access canopy insect community could improve sampling data for parasitoid wasps.

Concluding, despite of the lower wasp abundance and genera richness, population dynamics and diversity value found in the PNMPV is comparable to other Brazilian regions, but presents different genera, thus providing new data and records for Braconidae genera in the Amazon region.

ACKNOWLEDGMENTS

The authors thank the students of the Labein/UNIR/FIOCRUZ for their support during this work. The INCT HYMPAR-SUDESTE staff that helped in the training and identification of specimens and the CNPq for the scholarship.

REFERENCES

Cirelli, K. R. N. & A. M. Penteado-Dias. 2003. Fenologia dos Braconidae (Hymenoptera, Ichneumonoidea) da Área de Proteção Ambiental (APA) de Descalvado, SP. **Revista Brasileira de Entomologia 47**: 99–105.

Coley, P. D. & J. A. Barone. 1996. Herbivory and Plant Defenses in Tropical Forests. **Annual Review of Ecology and Systematics 27**: 305–335.

Costa, S. G. M.; R. B. Querino; B. Ronchi-Teles; A. M. M. Penteado-Dias & R. A. Zucchi. 2009. Parasitoid diversity (Hymenoptera: Braconidae and Figitidae) on frugivorous larvae (Diptera: Tephritidae and Lonchaeidae) at Adolpho Ducke Forest Reserve, Central Amazon Region, Manaus, Brazil. **Brazilian Journal of Biology 69**: 363–370.

Diego, F. & M. Campos. 2001. Lista de los Géneros de Avispas Parasitoides Braconidae (Hymenoptera: Ichneumonoidea) de la Región Neotropical. **Biota Colombiana 2**: 193–232.

Duarte, J. L. P.; R. F. Krüger; C. J. B. de Carvalho & P. B. Ribeiro. 2010. Evidence of the inûuence of Malaise trap age on its efûciency in the collection of Muscidae (Insecta, Diptera). **International Journal of Tropical Insect Science 30**: 115–118.

Feitosa, M. C. B.; R. B. Querino & A. L. Henriques. 2007. Perfil da fauna de vespas parasitóides (Insecta: Hymenoptera) em reserva florestal na Amazônia, Amazonas, Brasil. **Entomotropica 22**(1): 37–43.

Gauld, I. & B. Bolton. 1988. **The Hymenoptera**. Oxford University Press, 332 p.

Gillott, C. 2005. **Entomology**. Canada, Springer, 831 p.

Hanson, P. E. & I. D. Gauld. 2006. Hymenoptera de la región neotropical. **Memoirs of the American Entomological Institute 77**: 994 p.

Irvine, K. M. & Woods S. A. 2007. Evaluating shading bias in Malaise and window-pane traps. **Journal of the Acadian Entomological Society 3**: 38–48.

Lewis, C. N. & J. B. Whitfield. 1999. Braconid Wasp (Hymenoptera: Braconidae) Diversity in Forest Plots Under Different Silvicultural Methods. **Environmental Entomology 28**: 986–997.

Marsh, P. M. 2002. The Doryctinae of Costa Rica (Excluding The Genus *Heterospilus*). **Memoirs of the American Entomological Institute 70**: 319 p.

Pereira, A. G. 2009. Uso de Armadilhas Malaise como Estratégia de Avaliação de Bioindicadores em Agroecossistemas: Diversidade e Guildas de Braconidae em Diferentes Mosaicos Vegetacionais da Fazenda Canchim (EMBRAPA), São Carlos, SP, Brasil. Dissertação de Mestrado São Carlos, Universidade Federal de São Carlos, 94 p. Available from: http://www.bdtd.ufscar.br/htdocs/tedeSimplificado/tde_arquivos/25/TDE-2009-07-15T100439Z-2187/Publico/2262.pdf (accessed 10 October 2011).

Pereira, J. D. B.; D. P. Buriti; W. de P. Lemos; W. R. da Silva & R. A. da Silva. 2010. Espécies de *Anastrepha Schiner* (Diptera: Tephritidae), seus hospedeiros e parasitóides nos Estados do Acre e Rondônia, Brasil. **Biota Neotropica 10**: 441–446.

Pucci, T. 2008. A comparison of the Parasitic Wasps (Hymenoptera) at elevated versus ground yellow pan traps in a Beech-Maple Forest. **Journal of Hymenoptera Research 17**:116–123.

Restello, R. M. & A. M. Penteado-Dias. 2006. Diversidade dos Braconidae (Hymenoptera) da Unidade de Conservação de Teixeira Soares, Marcelino Ramos, RS, com ênfase nos Microgastrinae. **Revista Brasileira de Entomologia 50**: 80–84.

Scatolini, D. & A. M. Peanteado-Dias. 2003. Análise faunística de Braconidae (Hymenoptera) em três áreas de mata nativa do Estado do Paraná, Brasil. **Revista Brasileira de Entomologia 47**: 187–195.

Stireman III, J. O.; P. Cerretti; D. Whitmore; S. Hardersen & D. Gianelle. 2012. Composition and stratification of a tachinid (Diptera: Tachinidae) parasitoid community in a European temperate plain forest. **Insect Conservation and Diversity 5**: 346–357.

Thomazini, M. J. & E. S. Albuquerque. 2009. Parasitóides (Hymenoptera: Braconidae) de *Anastrepha Schiner* (Diptera: Tephritidae) no estado do Acre. **Acta Amazonica 39**: 245–248.

Townes, H. 1972. A light-weight Malaise trap. **Entomological News 83**: 225–229.

Wharton, R. A.; P. M. Marsh & M. J. Sharkey. 1997. **Manual of the New World genera of the family Braconidae (Hymenoptera)**. Washington, The International Society of Hymenopterists, 439 p.

Whitfield, J. B. & C. N. Lewis. 2001. Analytical Survey of the Braconid Wasp Fauna (Hymenoptera: Braconidae) on Six Midwestern U.S. Tallgrass Prairies. **Annals of the Entomological Society of America 94**: 230–238.

Wolda, H. 1978. Seasonal Fluctuations in Rainfall, Food and Abundance of Tropical Insects. **Journal of Animal Ecology 47**: 369–381.

Received 26/10/2011; accepted 5/11/2012
Editor: Rodrigo Krüger