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Plant Bugs Predators (Hemiptera: Heteroptera: Miridae) with References to Arthropods and Fungi in Brazil

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Abstract: The present study demonstrates 30 plant bugs species associated with 50 records of prey and six records of mycophagy for Brazil. The data were compiled from Schuh's Catalog, the literature, specimens deposited in entomology museums and exemplars from different regions of Brazil sent for identification. Some of the data from the literature used did not presented complete information. This study aims to increase the knowledge of the relationships among plant bugs, prey and fungi and emphasize those species with potential for biological control strategies and pest integrated management.

Key words: arthropod, fungi, insect, prey.

INTRODUCTION

Plant bugs have a very great ecological importance due to the high diversity and occurrence in many zoogeographic regions (Cassis and Schuh 2012). They have a wide feeding behavior varying as phytophagous, predators, saprophagous and fungivorous (Henry and Wheeler 1988, Wheeler 2001). This happens because their mouthparts allow the exploitation of a great variety of food source (Schuh and Slater 1995, Grimaldi and Engel 2005, Gullan 2014), due to the presence of digestive enzymes (Boyd et al. 2002) and other chemical substances released from the salivary glands (Wheeler 2001), which allow the prey immobilization (Cohen 1996).

Plant bugs are among the most important insect groups in agriculture because they can act either as plague for crops as well as biological control agents (Henry and Wheeler 1988, Wheeler 2001). Their predation habit is not commonly recognized as they do not have the morphological structures used to capture prey. However, there are observations in nature about plant bug predating eggs, immature and adult forms of arthropods, and their life cycles may synchronize with those of prey (Schuh and Slater 1995, Wheeler 2000, 2001, Shockley and Murray 2006). In addition, records of plant bugs feeding on dead and disabled invertebrates have been reported (Wheeler 2001).

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Given the ecological and economic importance of plant bugs, the aim of this study is to increase the knowledge about these arthropods in associations with prey and fungi in Brazil. Additionally, the study intends to emphasize potential species for biological control.

MATERIALS AND METHODS

All data came from On-line Systematic Catalog of Plant Bugs (Schuh 2002-2013), Taxonomic Catalog of the Brazilian Fauna (TCBF), specialized literature, information from labels of specimens deposited in the Regional Museum of Entomology of the Universidade Federal de Viçosa, Minas Gerais, Brazil (UFVB), and the National Museum of the Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (MNRJ). Some of the data from the literature used did not presented complete information. The study also included data from many specimens from several regions of Brazil sent for identification to UFVB.

The data were compiled in the Microsoft Excel software relating the plant bug species with prey and mycophagy, the associated plant where the predator and prey were found, and the source of literature.

RESULTS AND DISCUSSION

Up to date, there was no information grouped available about the potential occurrences of predation by plant bugs in Brazil. In this study we found 30 species of plant bugs with potential prey and fungi associations were recorded for Brazil, in all 56 associations, 50 of which were records of prey, six records of mycophagy, of which 18 were associated with plant material (Table I).

The plant bug *Hyaliodocoris insignis* was observed preying on *Duponchelia fovealis* (Lepidoptera: Crambidae) (Zawadneak et al. 2016). This Lepidoptera has many registers attacking strawberry (*Fragaria x ananassa*) crops in many regions of the planet (Bonsignore and Vacante 2010). *D. fovealis* was first recorded in Brazil in 2010 causing serious damages in strawberry (Zawadneak et al. 2016). Until now, there is no record of this plant bug attacking strawberry crops in Brazil. Nevertheless, further studies on the potential of this plant bug as a biological control agent regarding this pest are necessary.

The plant bugs *Engytatus modestus* and *Engytatus varians* have records of predation on *Bemisia tabaci* (Hemiptera: Aleyrodidae) (Gerling et al. 2001). This Aleyrodidae has a vast geographic distribution and was considered pest in more than 500 agricultural crop species around the world (Cock 1993).

E. modestus is a predator of *Dysmicoccus brevipes* (Hemiptera: Pseudococcidae) (Wheeler 2001), a pantropical pest of pineapple (Silva et al. 1968, Scardini 1983, Mau and Kessing 1992). This plant bug is a potential agent of biological control of *Liriomyza trifolii* (Diptera: Agromyzidae), which is a serious pest of a great number of host plants, including ornamental species (Stegmaier 1966, Spencer 1973).

The plant bug *Campyloneuropsis cincticornis* is a predator of *Gratiana spadicea* (Klug) (Coleoptera: Chrysomelidae), a monophagous species that feeds on *Solanum sisymbriifolium*, an invasive plant of pasture and other important crops (Groth 1989, Mentz and Oliveira 2004).

Some species of plant bugs in Brazil are recorded as family Ortheziidae (Hemiptera: Sternorrhyncha) predators (Table I): *Ambracius dufouri* (Ferreira 1998, Wheeler 2001), *Ofellus guaranianus* (Wheeler 2001) and *Adhyalochloria inermis* preying on *Fuchsia regia* (Museu Regional de Entomologia da Universidade Federal de Viçosa). Species of the Ortheziidae, known as scales, usually constitute serious pests associated with plants of economic importance. They occur in most parts of the world mainly in the Neotropics and Nearctic regions (Nascimento et al. 1993).

TABLE I
Plant bugs predators and mycophagous species in Brazil.

Miridae	Prey/mycophagy	Associated Plant	Reference
Adhyalochloria inermis (Carvalho, 1985)	Hemiptera Ortheziidae	*Fuchsia regia* (Onagraceae)	Unpublished data
Ambracius dufouri Stal, 1860	Hemiptera Ortheziidae		Ferreira (1998), Wheeler (2001)
Campyloneuropsis cincticornis (Stal, 1860)	*Gratiana spadicea* (Coleoptera: Chrysomelidae)		Wheeler (2001)
Campyloneuropsis infumatus (Carvalho, 1947)	*Tuta absoluta* (Lepidoptera: Gelechiidae) (eggs and larva)	*Solanum lycopersicum* (Solanaceae)	Martínez et al. (2014)
	Tuta absoluta (Lepidoptera: Gelechiidae)		Van Lenteren et al. (2016)
Ceratocapsus dispersus Carvalho & Fontes, 1983	*Heliothis virescens* (Lepidoptera: Noctuidae)		Wheeler (2001)
	Alabama argilacea (Lepidoptera: Noctuidae) (eggs and larva)	*Gossypium* L. (Malvaceae)	
Ceratocapsus mariliensis Carvalho & Fontes, 1983	*Alabama argilacea* (Lepidoptera: Noctuidae) (eggs and larva)	*Gossypium* L. (Malvaceae)	Wheeler (2001)
	Heliothis virescens (Lepidoptera: Noctuidae)		
Cylapocoris pilosulus Knight, 1930	Auricularia Fungus	Tree debris	Carvalho (1954)
Cylapocoris tiquiensis Carvalho, 1954	Auricularia Fungus	Tree debris	Carvalho (1954)
Cylapus citus Bergroth, 1922	Pirenomiceto Fungus		Schuh (1976), Wheeler (2001)
Cylapus ruficeps Bergroth, 1922	Pirenomiceto Fungus		Schuh (1976), Wheeler (2001)
Engytatus modestus (Distant, 1893)	*Liriomyza trifolii* (Diptera: Agromyzidae)		Unpublished data
	Heliothentines (Lepidoptera: Noctuidae). (larva and pulp)		Wheeler (2001)
	Pieris rapae (Lepidoptera: Pieridae) (larva and pulp)		
	Dysmicoccus brevipes (Hemiptera: Pseudococcidae)	*Ananas comosus* (Bromeliaceae)	
	Tupiocoris notatus (Hemiptera: Miridae) (nimph and adult)	*Nicotiana tabacum* (Solanaceae)	

TABLE I (continuation).

Miridae	Prey/mycophagy	Associated Plant	Reference
	Aphids	*Solanum lycopersicum* (Solanaceae)	
	Myzus persicae (Hemiptera: Aphidae)		
	Bemisia tabaci (Hemiptera: Aleyrodidae)		Gerling et al. (2001)
Engytatus varians (Distant, 1884)	*Bemisia tabaci* (Hemiptera: Aleyrodidae)		Wheeler (2001)
	Heliothis virescens (Lepidoptera: Noctuidae) (initial stages)		Martínez et al. (2014)
	Tuta absoluta (Lepidoptera: Gelechiidae) (eggs and larva)		
	Tuta absoluta (Lepidoptera: Gelechiidae)***		Van Lenteren et al. (2016)
Fulvius anthocoroides Stal, 1862	Hemiptera Aradidae		Alayo (1974)
	Coleoptera		
	Miriapoda		
	Fungus	Tree debris	Schuh (1976)
Fulvius quadristillatus (Stal, 1860)	Auricularia Fungus	Tree debris	Maes and Carvalho (1989)
Hyaliodes beckeri Carvalho, 1953	*Chrysoperla externa* (Neuroptera: Chrysopidae)		Wheeler (2001)
	Erinnyis ello (Lepidoptera: Sphingidae)	*Manihot esculenta* (Euphorbiaceae)	
	Vatiga illudens (Hemiptera: Tingidae)		Oliveira et al. (2002)
Hyaliodocoris insignis Carvalho, 1976	*Duponchelia fovealis* (Lepidoptera: Crambidae)	*Fragaria* × *ananassa* (Rosaceae)	Zawadneak et al. (2016)
Macrolophus basicornis (Stal, 1860)	*Tuta absoluta* (Lepidoptera: Gelechiidae)***		Van Lenteren et al. (2016)
	Tuta absoluta (Lepidoptera: Gelechiidae)	*Solanum lycopersicum* (Solanaceae)	Martínez et al. (2014)
Macrolophus praeclarus (Distant, 1884)	Hymenoptera Formicidae (weakened)		Wheeler (2001)
	Thysanoptera		Unpublished data
	Hemiptera Aleyrodidae		

TABLE I (continuation).

Miridae	Prey/mycophagy	Associated Plant	Reference
Ofellus guaranianus Carvalho, 1985	Hemiptera Ortheziidae		Wheeler (2001)
Perissobasis heroni Ferreira & Coelho, 2009	Small arthropods	*Coffea arabica* (Rubiaceae)	Ferreira et al. (2009)
Peritropis saldaeformis Uhler, 1891	Small insects		Unpublished data
Ranzovius clavicornis (Knight, 1927)	*Anelosimus studiosus* (Araneae: Theridiidae)		Henry (1984)
Ranzovius fennahi Carvalho, 1954	*Anelosimus studiosus* (Araneae: Theridiidae)		Henry (1999)
	Anelosimus eximius (Araneae: Theridiidae) (eggs)		Henry (1984), Maes and Carvalho (1989)
Rhinacloa forticornis Reuter, 1876	*Heliothis virescens* (Lepidoptera: Noctuidae) (larva)		Donnelly (2000)
	Lygus sp. (Hemiptera: Miridae) (Do not occur in Brazil) ***		Wheeler (2001)
Sericophanes obscuricornis Poppius, 1921	*Listronotus bonariensis* (Coleoptera: Curculionidae)		Wheeler (2001)
Termatophylidea opaca Carvalho, 1955	Thysanoptera		Ferreira (1993)
	Cyrtotylus rubricatus (Hemiptera: Miridae)		
Thyttus parviceps (Reuter, 1890)	*Perkinsiella saccharicida* (Hemiptera: Fulgoroidea)		Hernandez and Henry (2010)
	Tagosodes orizicola (Hemiptera: Delphacidae) (eggs)	*Oryza sativa* (Poaceae)	
Trigonotylus tenuis Reuter, 1893	Homoptera (unidentified)	*Oryza sativa* (Poaceae)	Unpublished data
Tupiocoris cucurbitaceus (Spinola, 1852)	*Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae)	*Solanum lycopersicum* (Solanaceae)	López et al. (2012) Sitotroga cerealella eggs and a mix of both
	Hemiptera Cicadellidae		Wheeler (2001)
Tytthus femoralis Henry, 2012	*Perkinsiella* spp. (Hemiptera: Fulgoroidea) (eggs)		Henry (2012)

***captivity.

Three species of plant bugs are recorded as predators of the *Tuta absoluta* (Lepidoptera: Gelechiidae) (Table I): *Campyloneuropsis infumatus*, preying on eggs and larvae found on tomato (Martínez et al. 2014, Van Lenteren et al. 2016); *Engytatus varians*, preying on eggs and larvae (Van Lenteren et al. 2016), and *Macrolophus basicornis*, preying in natural and laboratorial conditions (Martínez et al. 2014, Van Lenteren et al. 2016). *T. absoluta* is a neotropical Lepidoptera found in many countries of South America (Benavent et al. 1978, Souza et al. 1983, Larraín 1986, Cáceres 1992, IAN-JICA 1994). It is responsible for economic losses to Solanaceae crops due to decrease in production. Its common name, the tomato moth, is due to the damage it causes in the tomato (*Solanum lycopersicum*). The larvae of this Lepidoptera produce galleries in different parts of the plant (Benavent et al. 1978, Souza et al. 1983, Cáceres 1992).

Four species of plant bugs are cited as predators of *Heliothis virescens* (Lepidoptera: Noctuidae): *Ceratocapsus dispersus* (Wheeler 2001), *Ceratocapsus mariliensis* (Wheeler 2001), *Engytatus varians* (Martínez et al. 2014), and *Rhinacloa forticornis* (Donnelly 2000). *H. virescens* is considered a pest in the Americas (Fitt 1989, Moraes and Mescher 2005) associated with eight plant families (Yépez et al. 1990). It is known as "tobacco budworm" and is considered the main pest of the cotton crop as it attacks the cotton apple (Santos 2001).

The plant bug *Hyaliodes beckeri* was reported predating *Chrysoperla externa* (Neuroptera: Chrysopidae) (Wheeler 2001). Chrysopidae is an important family in biological control of arthropod pests in many cultures, such as orange crops (Nasca et al. 1983, Gravena et al. 1993). This can reinforce the hypothesis that predatory habit usually has a generalized way in the selection of prey.

Beside this, *H. beckeri*, is predator *Erinnyis ello* (Lepidoptera: Sphingidae) and *Vatiga illudens* (Hemiptera: Tingidae) (Oliveira et al. 2002). *E. ello* is a native pest of manioc (*Manihot esculenta*). It is native from Brazil, but also occurs in other South American countries, presenting large geographic distribution due to its fly ability. *E. ello,* is a defoliator insect that consumes manioc leaves in the larval phase. It also feeds on over 35 plant species (Fazolin et al. 2007). In Brazil, it is commonly known as "Mandarová-da-mandioca" and is considered the most important pest of manioc crop. Another manioc crop pest that presents major importance is the *V. illudens*, which occurs in South and Central America and this pest is able to reduce up to 22 percent the production of manioc root (Fialho et al. 1994).

The plant bug *Sericophanes obscuricornis* is a *Listronotus bonariensis* (Coleoptera: Curculionidae) predator (Wheeler 2001). This Coleoptera is a species of weevil native from South America. The larval and adult stages of weevil are pests of grasses and cereals. In Brazil, wheat, ryegrass, rye, and corn are examples of crops affected by this pest (Gassen 1989).

Thyttus parviceps is the only plant bug *Perkinsiella saccharicida* (Hemiptera: Fulgoroidea) predator (Hernandez and Henry 2010). This Hemiptera is the vector of the Fiji disease virus to sugar cane (Egan et al. 1989).

The plant bug *Tupiocoris cucurbitaceus* is a predator of the *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae). This Hemiptera is known as "whitefly", a pest of many fruits and vegetables such as cucurbits, potatoes, tomatoes, and ornamental crops. It is often found in greenhouses and may cause damage by its feeding behavior, the honeydew, and the transmission of several plant viruses (Russell 1977, López et al. 2012).

The mycophagy is a common feeding behavior among insects that inhabit in remaining vegetables in contact with reproductive and vegetative parts of fungi (Martin 1979). In Brazil this behavior is

presented by the species *Cylapocoris pilosulus*, *C. tiquiensis*, *Cylapus citrus* and *C. ruficeps*. Members of the subfamily Cylapinae, which lives in tree trunks containing fungi, are good examples of plant bugs that feeds on fungi (Leston 1961, Wheeler 2001). Furthermore, the mycophagy behavior of Cylapinae can be confirmed through the observation of fungi material found inside dissected specimens (Wheeler and Wheeler 1994).

In conclusion, this study increases the knowledge of the associations between species of Miridae and their food habits. In addition, the data and information presented in this study show the need for more biological and ecological studies on predator-prey relations and fungi associations, in order to explore the potential of some species of Miridae as biological control agents, as well as important resources for integrated pest management strategies.

AUTHOR CONTRIBUTIONS

BCFN: Article writing and contributed by searching bibliographical material referring to associations of Miridae in Brazil, organization of the data deposited in the UFVB and data processing. PSFF: Assistance to the entomological collection and identification; Elaboration, writing and revision of the manuscript. LAC and DSM: Assistance to the entomological collection; Bibliographic review research and revision of the manuscript. BDB: Bibliographic review research; Elaboration, writing and revision of the manuscript.

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