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Checklist of grasshoppers (Orthoptera: Acridoidea) from Reserva Florestal Adolpho Ducke, State of Amazonas, Brazil, and new records for the country

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Abstract

We present a list of grasshoppers from the Reserva Florestal Adolpho Ducke, a preservation area in the outskirts of Manaus, State of Amazonas, Brazil. The Ducke Reserve has been an indispensable tool for scientific development due to its considerable floristic richness. It has provided ample material for studies and research, promoting the conservation of Amazonian rainforest flora and fauna and the protection of endangered species. This checklist is intended to provide basic information on the regional grasshopper fauna, expand the current knowledge of species occurrences, and serve as a basis for systematists interested in revisionary and biogeographic work with a focus on Amazonian endemic areas. We sampled the Ducke Reserve for fifteen days using active and visual searching methods. We collected 38 species of terrestrial and semi-aquatic grasshoppers, 23 which belonged to the Acrididae and 15 to Romaleidae. Twenty four species and subspecies of grasshopper were registered for the first time for the locality and three new species and one new subspecies were recorded for Brazil.

Key words

species richness, geographical distribution, species, taxonomy, Manaus

Introduction

The grasshoppers (Orthoptera: Acridoidea) are the largest superfamily of the orthopteran suborder Caelifera with 11 families, 1709 genera and 7866 valid species (Eades *et al.* 2015). Of these species, South America contains 1620 in 436 genera. Brazil alone contains 567 species in 196 genera (Eades *et al.* 2015). Grasshoppers are of ecological importance for recycling of plant matter, since they are mostly defoliators of decaying plant and moss (Amédégnato 1977). Most species of Acridoidea preferentially occur in environments with open vegetation, and are most active under sunny or partially sunny conditions. Many species are heliophilous and require sunlight for thermoregulation (Amédégnato & Descamps 1978). Acrididae and Romaleidae are the primary families of Acridoidea in terms of species richness, and are well represented in the Amazon region (Amédégnato & Descamps 1979).

The Reserva Florestal Adolpho Ducke (Ducke Reserve) is located on the western margin of two major rivers, Amazonas and Negro, adjacent to their junction. This point is the southwestern limit of

the Guyanan area of endemism, which is one of eight such areas in the Amazon (Cracraft 1985). The Ducke Reserve is a most convenient starting locality for researchers interested in Amazonian faunal sampling and study development, since it is located in the outskirts of Manaus, and protects an extremely biodiverse habitat of Amazonian tropical rainforest. It belongs to and is administered by INPA (National Institute for Amazonia Research), an institution headquartered in Manaus that fosters the development of scientific knowledge in the area. The forest is well preserved and has several trails along which one can work. Furthermore it has room, board, and laboratory facilities which can be accessed with previous authorization.

Species checklists for the Ducke Reserve can be highly beneficial for education purposes because the reserve is located so close to the city of Manaus, that many ecotourism activities take place there and it is frequently the subject of student projects and local faunal collecting trips. Furthermore, a good species checklist can serve as a basis for future Citizen Science initiatives involving the local residents of Manaus in data collection for scientific endeavors, and raising local awareness and interest in important faunal components of this biodiversity hotspot.

The Ducke Reserve is the type locality of dozens of species (Baccaro *et al.* 2008) and has been the subject of some of the most comprehensive field guides that exist for the neotropical region, such as flora (Ribeiro *et al.* 1999), frogs (Lima *et al.* 2006), and lizards (Vitt *et al.* 2008). Nunes & Braga (2008) completed a grasshopper survey and recorded 40 species from the Ducke Reserve. However, since the Ducke Reserve is in an exceptional biodiversity hotspot, we expect species turnover to be exceptionally high on relatively short time scales, and therefore repeated the study for comparison purposes with the study of seven years ago and we contribute by adding new records for the Reserve and for the country.

The aim of this work was to contribute to the knowledge about grasshopper richness of the regional fauna, providing a list of the Acridoidea species that occur at Ducke Reserve. This study is intended to serve as a starting point for future taxonomic, biogeographical and ecological studies. We present new occurrence records which expand the knowledge on distribution of several Brazilian species, data which can be useful for conservation planning.

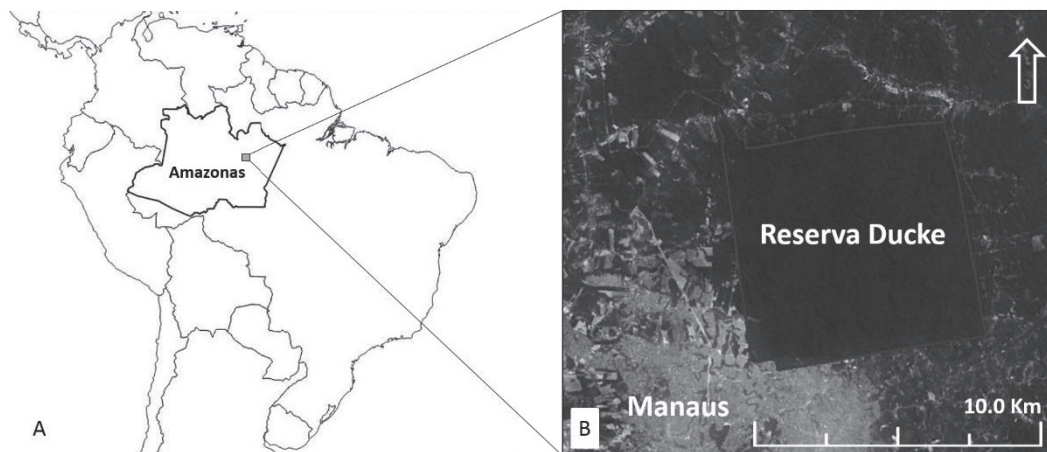


Fig. 1. Location of the Reserva Florestal Adolpho Ducke. A) Map of South America with Amazonas State, Brazil, highlighted in black, and gray rectangle indicating RFAD. B) Satellite image of the region of Manaus city where RFAD is located.

Material and methods

Reserva Florestal Adolpho Ducke, is located in the surroundings of Manaus, the capital city of Amazonas State, Brazil ($02^{\circ}55'S$, $59^{\circ}58'W$; Fig. 1). It belongs to Instituto Nacional de Pesquisas da Amazônia (INPA) and covers 100 km^2 of non-inundated forest lands. The climate is tropical humid, with 75-86% relative humidity, annual rainfall of 1750-2500 mm, and 26°C average annual temperature. The region is covered by tropical rainforest of low altitude, with dense canopy, and consequently dimly lit undergrowth, which is characterized by the abundance of trunkless palms, *Astrocaryum* spp. and *Attalea* spp. The flora is highly diverse, with approximately 1000 species of trees reaching between 45 to 50 m (Baccaro *et al.* 2008). In some portions of the reserve there are gaps in the forest canopy caused by removal of native plants.

Grasshoppers were collected during the morning and afternoon for 15 consecutive days in July 2011 using active and visual searching methods. For active collection, we used standard sweeping nets and alternating forward sweeps through the undergrowth (Buzzi & Miyazaki 1993). In places with closed vegetation we used visual searching. After a grasshopper was visually located resting on plants, it was captured using a hand-held jar, the most commonly used method of grasshopper collection employed by taxonomists. Collecting techniques were completed on an *ad hoc* basis, and were not standardized since we did not aim to quantify grasshopper density or abundance.

The specimens were killed with CO_2 , pinned, placed in cotton layers, and stored in a drying oven until our departure from the forest reserve. For transportation, the cotton layers with the specimens were placed in tightly covered plastic boxes with silica gel (JJ Dessecantes/São Paulo) in the bottom.

Specimens were identified using existing literature and keys to all species and genera (Otte 1979, Descamps 1984, Carbonell 2002). The systematic position adopted for the distribution of species and subspecies within the subfamilies was according to Eades *et al.* (2015). Specimen curation and identification were performed at the Entomology Laboratory, Pontifícia Universidade Católica de Rio Grande do Sul (PUCRS), and vouchers were deposited at the Entomological Collection of that institution.

Map of figure 1A was made in software Quantum Gis (QGIS) version 2.6.0 and figure 1B was obtained from Google Earth 7.1.2.2041 (Google Inc 2013).

Results

We collected 728 specimens of terrestrial and semi-aquatic acridoids encompassing 38 species and subspecies in two families (Table 1): Acrididae was the most abundant family, with 609 specimens (84% of specimens) in 23 species and subspecies. Six subfamilies of the Acrididae were represented: Ommatolampidinae (Abracrini, Clematodinini, Ommatolampini and Syntomacrini), Leptysmiinae (Chloropseustini and Tetrataeniini), Cyrtacanthacridinae (Cyrtacanthacridini), Gomphocerinae (Orphulellini), Pauliniinae and Proctolabinae (Proctolabini). Fifteen species and 119 specimens (16% of all specimens) of Romaleidae were collected. Two subfamilies were represented: Romaleinae (Romaleini and Phaeopariini) and Bactrophorinae (Ophthalmolampini).

Prior to the present publication, the grasshopper fauna of Ducke Reserve consisted of 40 species (Nunes & Braga 2008). Here we add 24 new records, totaling 64 species and subspecies distributed in 3 families, 13 subfamilies, 18 tribes, and 44 genera (Table 1).

Discussion

The Acrididae contain high species diversity in the Amazon (Amédégno & Descamps 1979) and it is the family with the highest number of species in the sample. Within Acrididae, the Ommatolampidinae were particularly abundant and speciose, with 12 species and 336 individuals in the collection. The species of Ommatolampidinae are polyphagous and occur preferentially in shady environments (Descamps 1978). This subfamily is a large and diverse group, and includes approximately 111 genera and 281 species (Eades *et al.* 2015). Its members differ from those of other acridids by their invisible mesonotum or visible only from its posterior region (Costa & Carvalho 2007, Costa *et al.* 2010).

Within the Gomphocerinae (Acrididae), the second most abundant subfamily, *Orphulella concinnula* (Walker, 1870) ($n = 78$), *Orphulella punctata* (De Geer, 1773) ($n = 59$) and *Orphulella elongata* Bruner, 1911 ($n = 2$) were captured in forest-edge areas with plenty of light and are considered heliophilous species. They are characterized by possessing a well developed stridulatory apparatus on the inner surface of the posterior femora (Otte 1979).

The Romaleidae is well represented in the area, with 15 species being recorded out of 92 known from the whole country of Brazil, 48 of which are from the Amazon region (Carbonell *et al.* 2006).

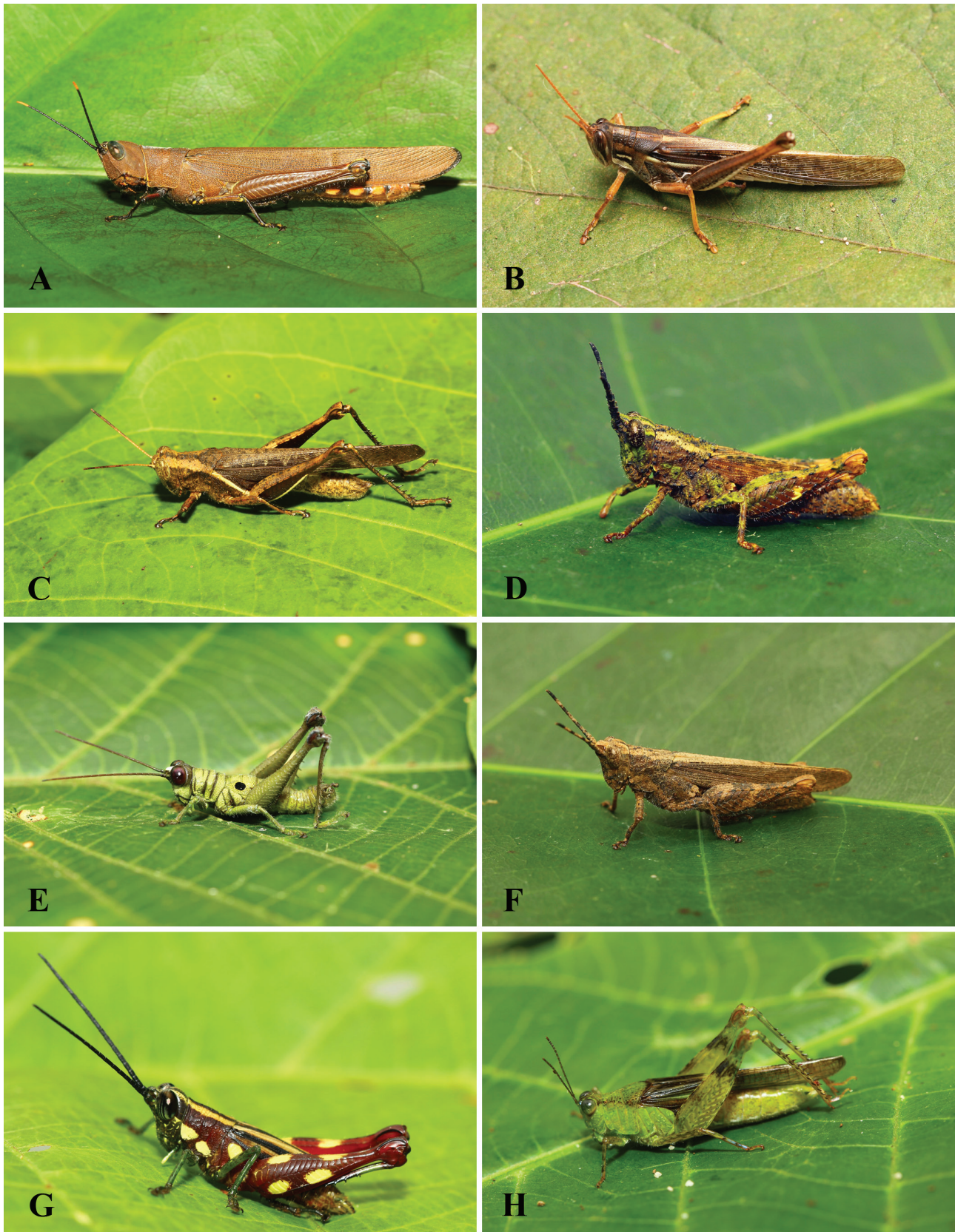


Fig. 2. Grasshoppers from Reserva Florestal Adolpho Ducke. A) *Copiocera surinamensis* Rehn, 1913, female. B) *Schistocerca cancellata cancellata* (Serville, 1838), female. C) *Abracris flavolineata* (De Geer, 1773), male. D) *Locheuma brunneri* (Scudder, 1875), female. E) *Ommatolampis perspicillata* (Johannson, 1763), male. F) *Vilerna rugulosa* Stål, 1878, female. G) *Syntomacris guttulosa* Descamps & Amédégno, 1971, female. H) *Paulinia acuminata* (De Geer, 1773), male. For color version, see Plate III.

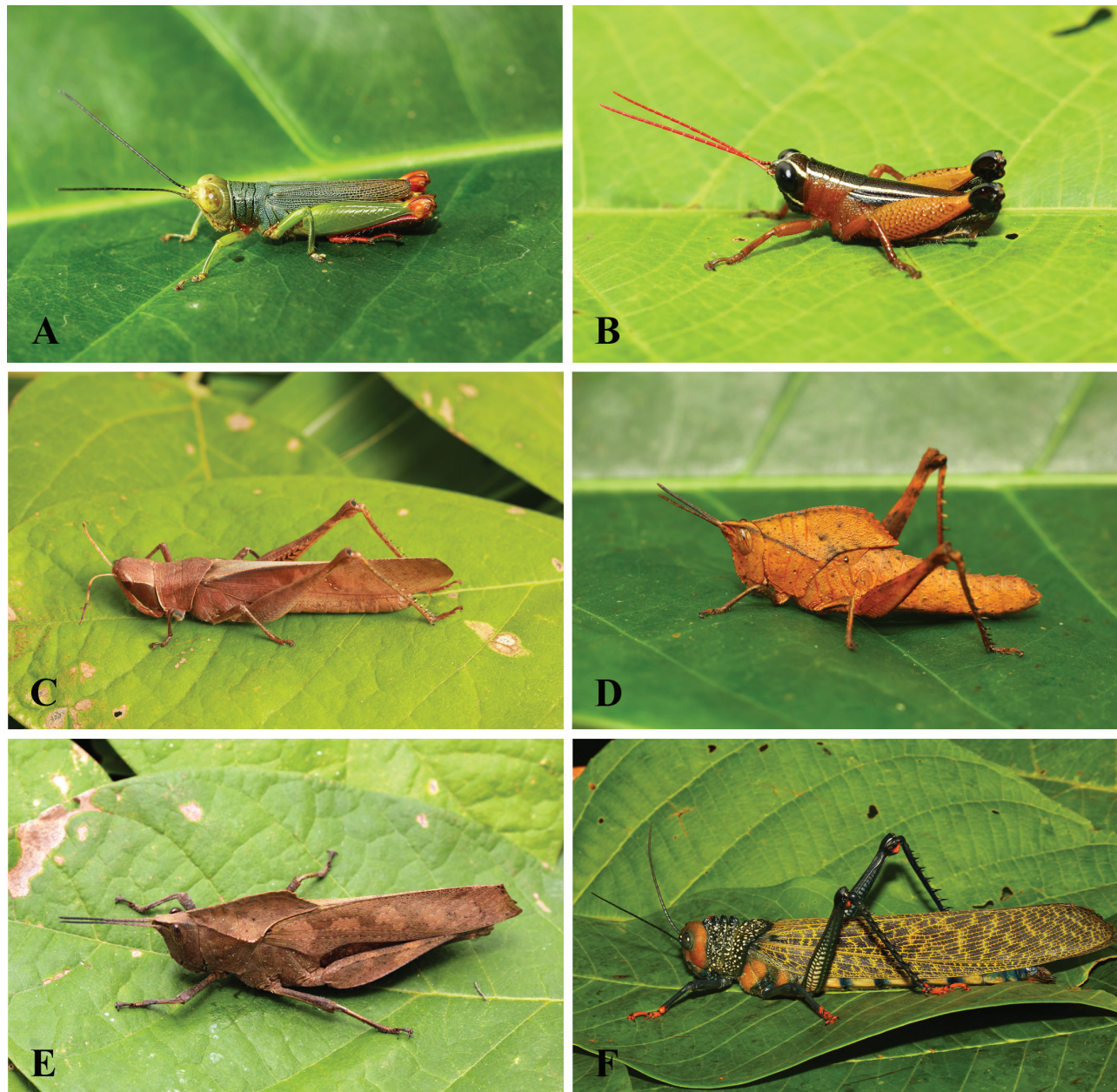


Fig. 3. Grasshoppers from Reserva Florestal Adolpho Ducke. A) *Poecilocloeus prasinatus* Descamps, 1980, male. B) *Ophthalmolampis picea* Descamps, 1981, male. C) *Abila bolivari* Giglio-Tos, 1900, female. D) *Colpolopha biloba* Pictet & Saussure, 1887, male. E) *Colpolopha waehneri* Günther, 1940, female. F) *Tropidacris descampsi* Carbonell, 1986, female. For color version, see Plate IV.

Of these, *Colpolopha waehneri* Günther, 1940 deserves mention ($n = 44$) (Fig. 3E), as it is restricted to forest environments (Silveira-Neto *et al.* 1976) is graminivorous (Amédégnato & Poulain 1994) and its distribution is concentrated in the Amazon region (Carbonell 2002).

The most abundant species in the sample were the two Ommatolampidinae, *Abracris flavolineata* (De Geer, 1773) ($n = 105$, Fig. 2C) and *Locheuma brunneri* (Scudder, 1875) ($n = 95$, Fig. 2D), followed by the semi-aquatic Pauliinae, *Paulinia acuminata* (De Geer, 1773) ($n = 64$, Fig. 2H). The least abundant species and subspecies were the cyrtacanthacrid, *Schistocerca cancellata cancellata* (Serville, 1838) (Fig. 2B), the gomphocerine, *O. elongata*, and the proctolabine, *Poecilocloeus prasinatus* Descamps, 1980 (Fig. 3A) with two specimens each.

In addition to the new records for the sampled area, the following species and subspecies were recorded for the first time in Brazil: *Maculiparia guyanensis* Carbonell, 2002 (previously recorded from French Guiana), *Maculiparia emarginata* (Stål, 1878) (Venezuela), *Maculiparia obtusa obtusa* (Stål, 1878) (known only from Colombia and Peru) and *Euprepacris charpentieri* (Descamps & Amédégnato, 1970) (from French Guiana) (Descamps & Amédégnato 1970, Carbonell 2002).

There is high species richness of Acridoidea at Ducke Reserve and we are certain that a more thorough sampling effort will reveal even more taxa. *Ophthalmolampis* Saussure, 1859, which is characterized by the presence of long hind tarsi (Descamps 1978), consists of 28 valid species (Eades *et al.* 2015), 11 occurring in the Amazon region.

Of these, only three species were found in this study. Descamps (1978) mentions a wide distribution of this genus in Amazonia, but the absence of more species of the *Ophthamolampis* in our sample may be due to difficulty in collecting them since they are tree-top dwellers. In fact, these grasshoppers are scantily represented in entomological collections. We believe that the present checklist adds substantial information and that we hope it will foster future surveys and studies on Amazonian Acridoidea.

The new records we have obtained for the Ducke Reserve, for the state of Amazonas and for the whole country of Brazil are useful for advancing the state of knowledge of the populations of grasshoppers in the region. There is, however, so much to be explored in the reserve area and in the region. More collecting efforts at Ducke Reserve and other Amazonian localities will certainly improve our understanding on grasshopper taxonomy, diversity, richness and species composition.

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Table 1. Species list of grasshoppers from Reserva Florestal Adolpho Ducke. Captions: * = new record for the RFAD; ** = new record for Brazil.

Higher taxon	Species	Reference	
		Present Paper	Nunes & Braga (2008)
Acrididae			
Acridinae			
	Hyalopterygini (3 species)		
	<i>Metaleptea adpersa</i> (Blanchard, 1843)		x
	<i>Orphula</i> sp.		x
	<i>Parorphula graminea</i> Brunner, 1900		x
Copioicerinae			
	Copioicerini (4 species)		
	<i>Copiocera lepida</i> Gerstaecker, 1889		x
	<i>Copiocera matana</i> Descamps, 1984		x
	* <i>Copiocera surinamensis</i> Rehn, 1913 (Fig. 2A)	x	
	<i>Monachidium lunum</i> (Johannson, 1763)		x
Cyrtacanthacridinae			
	Cyrtacanthacridini (2 subspecies)		
	* <i>Schistocerca cancellata cancellata</i> (Serville, 1838) (Fig. 2B)	x	
	<i>Schistocerca nitens nitens</i> (Thunberg, 1815)		x
Gomphocerinae			
	Amblytropidiini (1 species)		
	<i>Amblytropidia trinitatis</i> Bruner, 1904		x
	Compsacriini (1 species)		
	<i>Compsacris pulcher</i> Bolívar, 1890		x
	Orphulellini (5 species)		
	* <i>Dichromorpha australis</i> Bruner, 1900	x	
	<i>Orphulella concinnula</i> (Walker, 1870)	x	x
	* <i>Orphulella elongata</i> Bruner, 1911	x	
	<i>Orphulella punctata</i> (De Geer, 1773)	x	x
	* <i>Orphulina pulchella</i> Giglio-Tos, 1894	x	
Leptysminae			
	Chloropseustini (2 species)		
	<i>Chloropseustes bifurculifer</i> Amédégnato & Descamps, 1978		x
	<i>Chloropseustes leucotylus</i> Rehn, 1918	x	x
	Tetrataeniini (2 species and 1 subspecies)		
	* <i>Cornops frenatum frenatum</i> (Marschall, 1836)	x	
	<i>Stenopola dorsalis</i> (Thunberg, 1827)		x
	<i>Tetrataenia surinama</i> (Linnaeus, 1764)	x	x
Melanoplinae			
	Dichroplini (1 species)		
	<i>Dichroplus</i> sp.		x
Ommatolampidinae			
	Abracrini (4 species)		
	<i>Abracris dilecta</i> Walker, 1870	x	x
	<i>Abracris flavolineata</i> (De Geer, 1773) (Fig. 2C)	x	x
	* <i>Omalotettix obliquus</i> (Thunberg, 1824)	x	
	* <i>Psilosirtus olivaceus</i> Bruner, 1911	x	
	Clematodinini (1 species)		
	<i>Clematodina eckardtiana</i> Günther, 1940	x	x
	Ommatolampini (7 species)		
	* <i>Anabylis longicerca</i> Descamps, 1979	x	
	<i>Anabylis manausana</i> Descamps, 1981		x
	<i>Anabylis teres</i> Giglio-Tos, 1898	x	x
	<i>Locheuma brunneri</i> (Scudder, 1875) (Fig. 2D)	x	x
	<i>Ommatolampis perspicillata</i> (Johannson, 1763) (Fig. 2E)	x	x
	<i>Vilerna aeneooculata</i> (De Geer, 1773)		x
	* <i>Vilerna rugulosa</i> Stål, 1878 (Fig. 2F)	x	

Higher taxon	Species	Reference	
		Present Paper	Nunes & Braga (2008)
	Syntomacrini (1 species)		
	* <i>Syntomacris guttulosa</i> Descamps & Amédégno, 1971 (Fig. 2G)	x	
	Pauliniinae (1 species)		
	<i>Paulinia acuminata</i> (De Geer, 1773) (Fig. 2H)	x	x
	Proctolabinae		
	Proctolabini (2 species)		
	<i>Leioscapheus</i> sp.		x
	* <i>Poecilocloeus prasinatus</i> Descamps, 1980 (Fig. 3A)	x	
Ommexechidae			
	Ommexechinae		
	Ommexechini (1 species)		
	<i>Ommexecha brunneri</i> Bolívar, 1884		x
Romaleidae			
	Bactrophorinae		
	Ophthalmolampini (8 species)		
	<i>Apophylacris incondita</i> Descamps, 1983		x
	** <i>Euprepacris charpentieri</i> (Descamps & Amédégno, 1970)	x	
	<i>Habrolampis bicolor</i> Descamps, 1978		x
	* <i>Ophthalmolampis colibri</i> (Saussure, 1859)	x	
	<i>Ophthalmolampis picea</i> Descamps, 1981 (Fig. 3B)	x	x
	<i>Ophthalmolampis placita</i> Descamps, 1977		x
	* <i>Pseudonautia vermiculatipes</i> Descamps, 1983	x	
	* <i>Nothonautia valens</i> Descamps, 1983	x	
	Romaleinae		
	Phaeopariini (4 species and 3 subspecies)		
	* <i>Abila bolivari</i> Giglio-Tos, 1900 (Fig. 3C)	x	
	** <i>Maculiparia emarginata</i> (Stål, 1878)	x	
	** <i>Maculiparia guyanensis</i> Carbonell, 2002	x	
	** <i>Maculiparia obtusa obtusa</i> (Stål, 1878)	x	
	<i>Maculiparia obtusa solimoensis</i> Carbonell, 2002	x	x
	<i>Phaeoparia lineaalba lineaalba</i> (Linnaeus, 1758)	x	x
	* <i>Phaeoparia rondoni</i> Carbonell, 2002	x	
	Romaleini (8 species and 2 subspecies)		
	<i>Aprionacris fissicauda</i> Descamps, 1978		x
	* <i>Colpolopha biloba</i> Pictet & Saussure, 1887 (Fig. 3D)	x	
	<i>Colpolopha obsoleta</i> (Serville, 1831)		x
	* <i>Colpolopha waehneri</i> Günther, 1940 (Fig. 3E)	x	
	<i>Prionacris cantans</i> Descamps, 1981		x
	<i>Prionolopha serrata</i> (Linnaeus, 1758)		x
	<i>Titanacris picticus picticus</i> (Descamps, 1978)		x
	<i>Tropidacris collaris</i> (Stoll, 1813)		x
	<i>Tropidacris cristata cristata</i> (Linnaeus, 1758)		x
	* <i>Tropidacris descampsi</i> Carbonell, 1986 (Fig. 3F)	x	
TOTAL: 56 species and 8 subspecies			