



**CAROLINE GREVE**

**Filogenia do grupo *Chlorocoris* baseada em morfologia e evidência total, descrição de cinco novas espécies e sinopse de *Chloroeppla* Stål, incluindo análise cladística e biogeográfica (Hemiptera: Heteroptera: Pentatomidae)**

Tese apresentada ao Programa de Pós-Graduação em Biologia Animal, Instituto de Biociências da Universidade Federal do Rio Grande do Sul, como requisito parcial à obtenção do Título de Doutor Biologia Animal.

**Área de concentração:** Biologia Comparada

**Orientadora:** Profa. Dra. Jocélia Grazia

**Co-Orientador:** Prof. Dr. Cristiano F. Schwertner

**UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL**

**PORTO ALEGRE**

**2010**

**“Filogenia do grupo *Chlorocoris* baseada em morfologia e evidência total, descrição de cinco novas espécies e sinopse de *Chloropepla* Stål, incluindo análise cladística e biogeográfica (Hemiptera: Heteroptera: Pentatomidae)”**

**CAROLINE GREVE**

Tese apresentada como parte dos requisitos para obtenção de grau de Doutor em Biologia  
Animal, área de concentração Biologia Comparada.

Comissão examinadora:

---

Dr. Luiz Alexandre Campos

---

Dr. Silvio Shigueo Nihei

---

Taran Grant, PhD

---

Dra. Jocélia Grazia (Orientadora)

**Porto Alegre, 30 de junho de 2010**

“O que nós vemos das coisas são as coisas.  
Por que veríamos nós uma coisa se houvesse outra?  
Por que é que ver e ouvir seria iludirmo-nos  
Se ver e ouvir são ver e ouvir?

O essencial é saber ver,  
Saber ver sem estar a pensar,  
Saber ver quando se vê,  
E nem pensar quando se vê,  
Nem ver quando se pensa.”

(Alberto Caeiro)

“The need to document nature, the need to understand its underlying regularities, and the need to construct an overall picture remain as today as they every were. Naturalists have a vast catalog to complete and a broad tableau to envision: one that includes and has considerable relevance for that uniquely reflective species, *Homo sapiens*.”  
(Paul Lawrence Farber – “Finding order in nature”)

## **Agradecimentos**

Ao meu marido, Fernando por estar sempre aqui comigo, confiando em mim mais do que eu mesma. Obrigada pelo amor, companheirismo a compreensão.

Aos meus pais pelo valor da educação, do estudo. A minha mãe, pela amizade e exemplo de força e dedicação. Ao meu pai pela tranquilidade, paciência e por partilhar os momentos difíceis.

À minha Oma, segunda mãe. Pela preocupação e afeto, sempre.

Aos meus irmãos, Raquel e Gustavo, por serem meus amigos. A minha irmã, pelas risadas e por chorar comigo. Ao meu irmão pela preocupação e pelo nosso alemãozinho (aí, devo agradecer também à Samanta, pela beleza da criação de ambos!).

À família Rocha, pela acolhida sempre calorosa, pela alegria, pelo carinho. À Renata e Camilo pelo meu sobrinho querido!

A minha dinda Suzi, por estar presente enquanto eu crescia como pessoa e profissional. Por estar sempre lá, sempre que eu precisasse.

A família Trein, sede Sterling, pela acolhida carinhosa e alegre.

Ao Ian, “irmãozinho”. Conviver contigo fez meus dias mais interessantes, com certeza! Obrigada pela preocupação com meus prazos!!!

Às minhas “meninas”, Buiuna, Fuinha e Jabuh, pela alegria dos meus dias, pelo afeto simples.

À minha orientadora, Jocélia Grazia pelo exemplo de profissional e pela paciência. Por me ensinar o amor pela taxonomia e pelos percevejos.

Ao meu co-orientador Cristiano F. Schwertner pelo entusiasmo e pela conversas que me fizeram crescer como pesquisadora.

À Viviana por compartilhar de boa parte da minha visão da vida. Tão confortável! Obrigada pelas conversas sobre tudo!

Aos colegas de laboratório que se tornaram amigos, Luciana, Augusto, Jorge, pela descontração em meio aos dias de trabalho, pela companhia agradável e divertida. Especialmente ao Augusto pelas discussões e pela troca constante de informações.

Aos colegas de laboratório: Anne, Brenda, Felipe, Matias, pela convivência enriquecedora.

Cátia, pela amizade à prova da distância.

Clarice, minha “roommate” querida! Pela companhia na fria Fargo, pela serenidade e pela amizade.

Aos meus professores do Departamento de Zoologia, pela formação.

Ao Dr. David Rider, por me receber na North Dakota State University e me ajudar a desempenhar minhas atividades da melhor forma possível.

Ao Dr. Randall Schuh (ANHM), ao Dr. Thomas Henry (NMNH), ao Dr. Paul Tinerella (Illinois University) e Dra. Becky Simmnos (North Dakota University) por me receberem em seus laboratórios e às vezes em suas casas, sempre de forma amável.

Ao CNPq, pela bolsa de doutorado. À CAPES pela bolsa de Estágio de Doutorado no Exterior.

## Sumário

Agradecimentos .....	iv
Abstract .....	ix
Resumo .....	xi
Introdução .....	1
Material e Métodos .....	8
Resultados e Considerações Finais .....	10
Referências.....	12
Capítulo 1 - Two new species of the genus <i>Chloropepla</i> (Hemiptera: Pentatomidae: Pentatominae) from Brazil.....	19
Introduction.....	19
Material and methods.....	20
Key to the species of <i>Chloropepla</i> .....	20
<i>Chloropepla paveli</i> sp. nov.....	22
<i>Chloropepla stysi</i> sp. nov.....	25
References.....	28
Capítulo 2 - Three new species of <i>Chloropepla</i> Stål (Hemiptera: Heteroptera: Pentatomidae) .....	29
Introduction.....	29
Material and Methods .....	30
Key to <i>Chloropepla</i> species .....	30

<i>Chloropepla</i> sp. nov. 1.....	32
<i>Chloropepla</i> sp. nov. 2.....	33
<i>Chloropepla</i> sp. nov. 3.....	35
References.....	37
Capítulo 3 - Synopsis of the genus <i>Chloropepla</i> Stål (Hemiptera, Heteroptera, Pentatomidae), with cladistic and biogeographic analysis of the species.....	47
Abstract.....	47
Introduction.....	47
Materials and Methods.....	50
Results.....	53
Characters .....	53
Cladistic Analysis .....	64
Biogeographic Considerations .....	72
References.....	75
Capítulo 4 - Cladistic analysis of <i>Chlorocoris</i> group (Hemiptera, Heteroptera, Pentatomidae), based on morphological characters and total evidence.....	95
Abstract.....	95
Introduction.....	96
Material and Methods .....	97
Results.....	102
Characters .....	102
Morphological analysis.....	114

Total evidence analysis .....	117
Discussion .....	118
Conclusions .....	120
References .....	121
Anexo I - Normas editorias Australian Journal of Entomology .....	148
Anexo II - Normas editoriais Insects Systematics and Evolution.....	154
Anexo III - Normas editoriais Zootaxa.....	159



## Abstract

The monophyly of Pentatomidae was already highly confirmed. However, the infra-family relationships still need to be clarified. For example, one of the largest taxa of the family, the sub-family Pentatominae is not recognized as a monophyletic group. To solve these problems is necessary to know the diversity of the group as well as to perform cladistics studies at the level of genera and species. In this thesis, five new species of the genus *Chloropepla* (Pentatominae) are described: *C. paveli*, *C. stysi*, *Chloropepla* sp. nov. 1, *Chloropepla* sp. nov. 2 and *Chloropepla* sp. nov. 3. The species are mainly characterized by features of male and female genitalia. An extended key to identification of the species of the genus is provided. The northern distribution of the group is expanded from Venezuela to Costa Rica. A synopsis of *Chloropepla* is also presented, with an extended description of the genus and diagnosis for the species, both based in a parsimonious analysis of the 12 know species. This cladistics analysis confirmed the monophyly of the group, based on ostiolar ruga long and evanescent, wide hypandrium, with dorsal projections flanking the segment X, parameres cylindrical, dorsally directed, membranous conjunctiva reduced, almost entirely obscured by the phallosome. The resultant phylogenetic relationship of *Chloropepla* species were submitted to a BPA with the sub-regions and provinces of Neotropical region as terminals. This analysis showed a near relation among the Amazonian areas and indicated a hybrid nature of the Chacoan subregion. Finally, the relationship of eight Pentatominae genera is investigated: *Arvelius*, *Chlorocoris*, *Chloropepla*, *Eludocoris*, *Fecelia*, *Loxa*, *Mayrinia* and *Rhyncholepta*. Two parsimony analyses were performed: one based solely on morphological characters and other based on morphological plus ribosomal DNA sequences (total evidence). One fragment of 16S mitochondrial and two of 28S nuclear rDNA were sequenced and analyzed using the direct optimization method. The results of both analysis differed in the

relationships of the genera. However, some relations are recovered in both cladograms: *Loxa* + *Mayrinia* + *Chlorocoris* (*Monochrocerus*), *Arvelius* + *E. humeralis* + *R. humeralis* and *Chlorochoris* (*Chlorocoris*) + *Fecelia* + *Chlorochoris* (*Arawacoris*). The results here obtained emphasize the necessity of further studies on the use of molecular data in analyses on genera and species levels in Pentatominae. Besides, the homologies also need to be better investigated and tested within Pentatomidae, Pentatominae and tribes levels, based on cladistics studies.

Key words: Pentatominae, parsimony, Netropical region, BPA, molecular data.

## Resumo

Apesar da monofilia de Pentatomidae ter sido amplamente demonstrada, as relações infrafamiliares precisam ser esclarecidas. Por exemplo, um dos maiores táxons da família, a subfamília Pentatominae, ainda não é reconhecido como um grupo monofilético. Para resolver estes problemas é necessário, além de conhecer a diversidade do grupo, realizar estudos cladísticos nos níveis genéricos e cladísticos. Na presente Tese são descritas cinco novas espécies do gênero *Chloropepla* (Pentatominae): *C. paveli*, *C. stysi*, *Chloropepla* sp. nov. 1, *Chloropepla* sp. nov. 2 e *Chloropepla* sp. nov. 3. As espécies são caracterizadas, principalmente, por atributos da genitália de machos e fêmeas. Uma chave ampliada para a identificação das espécies do gênero é fornecida. A distribuição setentrional do grupo é expandida da Venezuela para a Costa Rica. Uma sinopse de *Chloropepla* também é apresentada, com uma descrição ampliada do gênero e diagnose das espécies, ambas baseadas em análise de parcimônia das 12 espécies conhecidas. Esta análise cladística confirmou a monofilia do grupo, baseada no peritrema ostiolar longo e evanescente, hypandrium amplo com projeções dorsais atingindo o X segmento, parâmeros cilíndricos, dirigidos dorsalmente, conjuntiva membranosa reduzida, quase que inteiramente obscurecida pela phallosheca. A relação filogenética resultante entre as espécies de *Chloropepla* foi submetida à BPA com as subregiões e províncias da região Neotropical como terminais. Esta análise demonstrou uma relação próxima entre as áreas amazônicas e indicou uma natureza híbrida da sub-região chaquenha. Finalmente, a relação entre oito gêneros de Pentatominae é investigada: *Arvelius*, *Chlorocoris*, *Chloropepla*, *Eludocoris*, *Fecelia*, *Loxa*, *Mayrinia* e *Rhyncholepta*. Duas análises de parcimônia foram realizadas: uma baseada somente em caracteres morfológicos e outra baseada em morfologia e em sequências ribossomais (evidência total). Um fragmento de rDNA mitocondrial 16S e dois de rDNA nuclear 28S foram sequenciados e analisados utilizando-se o método de otimização direta. As análises apresentaram diferentes relações

entre os gêneros. Contudo, algumas relações se mantêm em ambos os cladogramas: *Loxa* + *Mayrinia* + *Chlorocoris* (*Monochrocerus*), *Arvelius* + *E. humeralis* + *R. humeralis* and *Chlorochoris* (*Chlorocoris*) + *Fecelia* + *Chlorochoris* (*Arawacoris*). Os resultados obtidos enfatizam a necessidade de estudos futuros sobre o uso de dados moleculares em análises genéricas e específicas em Pentatominae. Além disto, as homologias também precisam ser melhor investigadas e testadas, com base em estudos cladísticos, dentro de Pentatomidae, Pentatominae e tribos.

Palavras-chave: Pentatominae, parcimônia, BPA, região Neotropical, dados moleculares.

## **Introdução**

Classificações biológicas devem constituir sistemas de organização do conhecimento a respeito da biodiversidade, servindo de referência para estudos nas diversas áreas da biologia. Neste sentido devem ser estáveis, fornecer condições para previsão da distribuição de caracteres ainda não estudados e reunir a maior quantidade de informação possível a respeito dos grupos a que se referem (Schuh 1986; Amorim 2002; Schuh & Brower 2009), requisitos fortemente atendidos por sistemas filogenéticos de classificação.

A sistemática filogenética tem como objetivo estabelecer um sistema de classificação biológica baseado na relação de parentesco entre os organismos e expressar esses resultados de uma forma clara e acessível (Hennig 1968). Tal sistema, além de gerar classificações, é importante para elucidação de problemas e formulação de hipóteses em diversos campos das ciências biológicas, como estudos da evolução das espécies, estimativas de diversidade, análises de padrões biogeográficos (Amorim 2002; Sigrist & de Carvalho 2009).

Neste sentido, estudos das relações filogenéticas entre diversos grupos têm avançado em relação ao desenvolvimento de metodologias de análise, com destaque para a metodologia cladística, e de novas tecnologias que permitem o acesso a uma ampla gama de caracteres filogeneticamente informativos, entre eles dados moleculares (Mishler 1994; Hillis & Wiens 2000; Wheeler 2005). O uso de dados moleculares em estudos cladísticos possibilitou o acesso a grandes quantidades de caracteres, principalmente em grupos com morfologia muito simples, e facilitou o estabelecimento de homologias entre níveis taxonômicos elevados, pelo menos para genes conservados (Hillis 1987; Mishler 1994; Nei & Kumar 2000). O acesso a esses dados é, porém, limitado pela indisponibilidade de material molecular em espécimes fósseis ou por grupos com pouca disponibilidade de espécimes, como por exemplo, espécies conhecidas apenas a partir de material tipo (Hillis 1987; Hillis & Wiens 2000; Wiens 2004).

Dessa forma, o acesso a uma amostra taxonômica mais completa, que inclua caracteres de fósseis ou de espécies raras, fica condicionado a estudos morfológicos (Hillis 1987; Hillis & Wiens 2000). Além disso, a grande disponibilidade de dados morfológicos já produzidos ao longo de décadas de estudos e o fato de que os grupos são ainda descritos e identificados a partir da sua morfologia, tornam indispensável a utilização e descoberta de caracteres morfológicos em pesquisas sobre evolução e relações filogenéticas (Hillis 1987; Hillis & Wiens 2000; Wiens 2004; Wheeler 2008).

Entretanto, diversos estudos têm evidenciado que as hipóteses de relações filogenéticas mais robustas e bem fundamentadas são aquelas produzidas com o uso de toda a informação disponível (Kluge 1989; Ernisse & Kluge 1993; Kluge & Wolf 1993; Whiting *et al.* 1997; Kluge 1998; Murrell *et al.* 2001; Kluge 2004; Mishler 2005). Os principais argumentos a favor dessa abordagem dizem respeito à falta de critérios objetivos no estabelecimento de grupos de caracteres (= partições), o que resultaria em categorias artificiais e a necessidade do estabelecimento de hipóteses que justifiquem os supostos limites atribuídos às partições (Kluge 1989; Ernisse & Kluge 1993; Kluge 1998). A análise de congruência de caracteres pelo princípio da parcimônia, no entanto, dispensa o uso de hipóteses extras (Kluge 1998; Kluge & Grant 2006), sendo que os possíveis ruídos na reconstrução filogenética causados por grupos diferentes de caracteres são minimizados pela análise combinada de todos os caracteres de forma simultânea (Kluge 1989; Mishler 2005). Além disso, a parcimônia é um método robusto, baseado em poucas premissas, facilmente interpretável e aplicável de forma geral e irrestrita a qualquer tipo e quantidade de dados, permitindo evidenciar padrões e elaborar hipóteses em sistemática filogenética com a maior quantidade de informações possível a respeito dos organismos estudados (Ernisse & Kluge 1993; Mishler 1994; 2005; Kluge & Grant 2006).

### **A superfamília Pentatomoidea e o grupo *Chlorocoris***

A superfamília Pentatomoidea é representada pelos insetos popularmente conhecidos como percevejos-do-mato. Sua monofilia é amplamente confirmada através de estudos com enfoque cladístico que utilizam dados morfológicos (Gapud 1991; Henry 1997) e moleculares (Li *et al.* 2005). Grazia *et al.* (2008a) reconheceram 15 famílias e corroboraram a monofilia de Pentatomoidea e as relações filogenéticas entre elas com base em dados morfológicos e moleculares; no mesmo trabalho, o monofiletismo de Pentatomidae é definido, porém as relações infra-familiares não são esclarecidas. Resultados semelhantes foram obtidos por outros trabalhos baseados apenas em dados morfológicos (Gapud 1991; Hasan & Kitching 1993).

Pentatomidae é uma das quatro maiores famílias de Heteroptera, com aproximadamente 760 gêneros e 4100 espécies (Schuh & Slater 1995), das quais, a maioria está incluída em Pentatominae (Gapud 1991). Evidências indicam que tanto Pentatominae quanto Pentatomini, a tribo mais diversa dessa subfamília, constituem grupos não monofiléticos (Gapud 1991; Campos & Grazia 2006).

Os problemas de classificação nos níveis infra-familiares podem ser devidos a grande diversidade dos táxons, falta de catálogos modernos e falta de integração entre trabalhos de regiões diferentes do mundo (Schuh 1986; Gapud 1991). Da mesma forma, uma melhor compreensão das relações entre os componentes da subfamília Pentatominae e da tribo Pentatomini, é imprescindível para a definição das relações entre as subfamílias de Pentatomidae.

Trabalhos com ênfase na metodologia cladística, em nível de gênero e tribo, para grupos de Pentatomidae vêm contribuindo para a reunião de elementos que irão auxiliar na resolução dos problemas taxonômicos relativos a este grupo (Grazia 1997; Barcellos & Grazia 2003; Campos & Grazia 2006; Bernardes *et al.* 2009; Ferrari *et al.* 2010).

Rider (2008), em uma proposta não publicada, distribuiu gêneros até então inclusos em Pentatomini em 36 táxons - tribos já nomeadas ou grupos de gêneros que ainda carecem de estudos que confirmem sua monofilia. Entre estes, encontra-se o grupo *Chlorocoris*, composto por oito gêneros: *Arvelius* Spinola, 1837; *Chlorocoris* Spinola, 1837; *Chloropepla* Stål, 1867; *Eludocoris* Thomas, 1992; *Fecelia* Stål, 1872; *Loxa* Amyot & Serville, 1843; *Mayrinia* Horvath, 1925 e *Rhyncholepta* Bergroth, 1911.

Diversos autores indicaram semelhanças entre os gêneros *Chlorocoris*, *Chloropepla*, *Eludocoris*, *Fecelia*, *Loxa*, *Mayrinia* e *Rhyncholepta* (Grazia 1968; Becker & Grazia-Vieira 1971; Grazia-Vieira 1972b; Grazia 1976; Eger 1978; Thomas 1992; 1998) pelo fato de todos, em geral, serem representados por indivíduos de tamanho grande, de coloração verde ou esverdeada, de forma achatada e alongada (Thomas 1992), e por apresentarem espinho dorsal no ápice do fêmur e ângulos umerais prolongados em espinhos (Becker & Grazia-Vieira 1971). Representantes de *Arvelius* também apresentam a morfologia externa geral semelhante aos referidos gêneros, bem como apresentam o espinho dorsal no ápice do fêmur (Brailovsky 1981), sendo referidos por Rider (2008) como proximamente relacionado aos gêneros mencionados.

Além disso, Thomas (1998) sugere que possa haver homologia entre os apêndices (chamados de *hypandria*, *hypandrium* ou apêndices do pigóforo) presentes no bordo ventral do pigóforo em *Chlorocoris*, *Mayrinia*, *Chloropepla*, *Loxa* e *Fecelia*. Tal estrutura é descrita também para *Rhyncholepta* (Becker & Grazia-Vieira 1971).

*Arvelius* conta com 17 espécies, sendo onze descritas por Brailovsky (1981) por ocasião da revisão do gênero. Destas destaca-se *A. albopunctatus* (De Geer 1773), espécie hospede de solanáceas, diversas com importância econômica (Bertels 1961, 1962; Bertels & Bauke 1966, Grazia *et al.* 1984, Link & Grazia 1987, Panizzi *et al.* 2000). Além disso, ocorre em soja (*Glycine max* (L.) Merr.) (Panizzi & Slansky 1985). *Arvelius diluticornis* Breddin,



1909 também ocorre em solanáceas e em girassol (Grazia 1977). O gênero foi descrito por Spinola (1837) para a espécie americana *Cimex gladiator* Fabricius, 1775, que foi sinonimizada a *Cimex albopunctatus* De Geer, 1773 por Amyot & Serville (1843), a qual constitui a espécie-tipo do gênero. Brailovsky (1981) dividiu o gênero em dois grupos, baseando-se em caracteres do pigóforo. Recentemente uma nova espécie foi adicionada ao gênero: *A. thomasi* Ortega-Leon & Chavez-Bermeo (2008).

As espécies de *Arvelius* têm distribuição Neártica (sul dos Estados Unidos e México) e Neotropical (com ampla distribuição no continente e nas ilhas do Caribe) (Brailovsky 1981). *A. albopunctatus* é a espécie mais amplamente distribuída (Froeschner 1988).

*Chlorocoris* possui distribuição Neártica (sul dos Estados Unidos e México) e Neotropical (Thomas 1985). O gênero conta atualmente com 24 espécies, divididas em três subgêneros: *Chlorocoris* Spinola, 1837, *Monochrocerus* Stål, 1872 e *Arawacoris* Thomas, 1998 (Thomas 1985; 1998), sendo que o último foi descrito para uma espécie jamaicana, *Chlorocoris tarsalis* Thomas, 1998. *Chlorocoris complanatus* (Guérin, 1831) é citada como ocorrendo sobre magnólia e guanxuma branca (*Helicteres* sp.) (Grazia 1977), e *C. tau* Spinola, 1837 ocorre em diversas plantas cultivadas, como feijão, soja e fumo (Link & Grazia 1987).

*Chloropepla* foi descrito por Stål (1867) para *Loxa vicens* Stål, 1860. Em 1968, Grazia descreveu a segunda espécie do grupo, *C. lenti*, com base em espécimes venezuelanos. Com isso, a distribuição do gênero, que tinha registro apenas para o Brasil, foi ampliada. A terceira espécie descrita foi *C. nigrispina* Grazia, 1969. Esta espécie foi mais tarde sinonimizada a *Chlorocoris aurea* Pirán, 1963, a qual foi transferida para o gênero *Chloropepla* (Grazia-Vieira 1971). No mesmo trabalho foi descrita *C. pirani* Grazia-Vieira, 1971. Novas descrições de espécies e contribuições ao grupo foram dadas posteriormente por Grazia-Vieira (1972a), Grazia-Vieira (1973a), Grazia & Teradaira (1980) e Grazia (1987).

Mais recentemente cinco novas espécies foram descritas, para as regiões Norte, Nordeste e Centro-Oeste do Brasil, Venezuela e Costa Rica (Grazia *et al.* 2008b; Greve *et al.* submitted). Atualmente *Chloropepla* possui doze espécies descritas, com distribuição Neotropical (América do Sul).

*Eludocoris* é um gênero monotípico (*E. grandis*), descrito com base em espécimes da Costa Rica, por Thomas (1992).

*Fecelia* foi erigido para abrigar *Loxa minor* Vollenhoven, 1868 (Grazia 1976). Atualmente, o grupo possui quatro espécies, com distribuição registrada para Haiti, República Dominicana, Porto Rico, Trinidad, Santo Domingo e Maraval (Grazia 1976; Eger 1980; Grazia 1980).

*Loxa*, descrito para *Cimex flavicollis* Drury, 1773, reúne 10 espécies, com distribuição registrada desde o sul do Texas e da Flórida, até o Uruguai, Argentina e sul do Brasil (Eger 1978). Diversas espécies podem ser pragas primárias ou secundárias de diferentes culturas. Destaca-se *L. deducta* Walker, 1867, como hóspede de leguminosas, como pata-de-vaca (*Bauhinia candicans* Benth.) (Link & Grazia 1987), soja (*Glycine max*) (Panizzi & Slansky 1985) e leucena (*Leucaena leucocephala* (Lam.) de Wit) (Panizzi & Rossi 1991). Além disso, sua ocorrência é registrada em bergamoteira (*Citrus reticulata* L.) (Panizzi & Rossi 1991) e ligustro (*Ligustrum lucidum* W. T. Aiton) (Panizzi *et al.* 1998; Grazia & Frey-Da-Silva 2001). *Loxa flavicollis* também tem ocorrência registrada para *G. max* (Panizzi & Slansky 1985) e tomateiro (Grazia 1977). *Loxa picticornis* foi registrada ocorrendo sobre algodoeiro (Grazia 1977). Trabalhos referentes à morfologia de imaturos e biologia de espécies de *L. deducta*, *L. virescens*, *L. viridis* e *L. flavicollis* já foram realizados (Panizzi & Rossi 1991; Brailovsky *et al.* 1992; Grazia & Frey-Da-Silva 2001).

*Mayrinia* Horvath foi descrito para reunir quatro espécies de *Loxa*, sendo a espécie tipo *L. curvidens* Mayr, 1864. Grazia–Vieira (1972b) revisou o gênero, sinonimizando *M.*

*bartletii* (Distant, 1911) (descrita com base em um único exemplar de fêmea) e *M. variegata* (Distant, 1880) (descrita com base em um exemplar macho e outro não-identificado). O gênero conta hoje com apenas quatro espécies e tem distribuição registrada desde a Nicarágua até a Argentina (Grazia-Vieira 1972b; 1973b). Algumas espécies de *Mayrinia* ocorrem sobre plantas cultivadas, como trigo (Grazia, comunicação pessoal). *Mayrinia curvidens* tem ocorrência registrada sobre soja e arroz (Panizzi & Slansky 1985; Link & Grazia 1987) e solanáceas (Grazia 1977).

*Rhyncholepta* Bergroth tem ocorrência pouco freqüente, sendo conhecidas duas espécies com distribuição registrada para Panamá, Venezuela, Guiana Francesa, Brasil e Bolívia (Becker & Grazia-Vieira 1971).

O presente trabalho de tese foi estruturado na forma de capítulos, cada qual correspondendo a um artigo elaborado dentro de regras específicas de periódicos a que foram ou serão submetidos. Os dois primeiros artigos apresentam a descrição de cinco novas espécies de *Chloropepla* e ambos apresentam chaves de identificação para as espécies.

O terceiro capítulo consiste da sinopse do gênero *Chloropepla*. A análise cladística das espécies é apresentada, bem como uma descrição ampliada do gênero e diagnoses das espécies. Ainda, os dados de distribuição associados à filogenia de *Chloropepla* foram submetidos a uma análise de parcimônia de Brooks (BPA), para discussão dos padrões de distribuição do gênero associados à história evolutiva da região Neotropical.

O quarto capítulo traz a análise cladística de gêneros do grupo *Chlorochoris*, utilizando-se caracteres morfológicos e moleculares. São apresentados dois cladogramas: um resultante da análise apenas com dados morfológicos e outro resultante da análise da evidência total. As análises apresentaram diferentes relações entre os gêneros. Contudo, algumas se mantêm em ambos os cladogramas: *Loxa* + *Mayrinia* + *Chlorocoris* (*Monochrocerus*), *Arvelius* + *E. humeralis* + *R. humeralis* and *Chlorochoris* (*Chlorocoris*) + *Fecelia* + *Chlorochoris*

(*Arawacoris*). Os resultados obtidos enfatizam a necessidade de estudos futuros sobre o uso de dados moleculares em análises genéricas e específicas em Pentatominae. Além disto, as homologies também precisam ser melhor investigas e testadas, com base em estudos cladísticos, dentro de Pentatomidae, Pentatominae e tribos.

### **Material e Métodos**

A descrição das espécies novas foi realizada a partir de espécimes depositados nas seguintes coleções: American Museum of Natural History, New York, New York, United States of America (AMNH), Coleção Zoológica Prof. Paulo Bürnheim, Fundação Universidade do Amazonas, Manaus, Amazonas, Brasil (CZPB), Fundação Instituto Oswaldo Cruz, Rio de Janeiro, Rio de Janeiro, Brasil (FIOC), Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBC), Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande Sul, Porto Alegre, Rio Grande do Sul, Brasil (MCNZ), Museu Paraense Emilio Goeldi, Belém, Pará, Brasil (MPEG), National Museum of Natural History, Washington D.C., United States of America (NMNH), Departamento de Zoologia, Universidade Federal do Rio Grande do Sul Porto Alegre, Rio Grande do Sul, Brasil (UFRG).

Realizou-se a descrição da morfologia geral e de genitália interna e externa de ambos os sexos, quando espécimes suficientes eram disponíveis. Para as dissecções utilizou-se solução de KOH 10% ou supersaturada, com posterior coloração com vermelho congo e/ou clorazol black, quando necessário. Ilustrações foram confeccionadas com uso de câmara clara acoplada ao estereomicroscópio e posteriormente editadas no Adobe Photoshop<sup>®</sup> CS2. Tais procedimentos foram empregados também nos dois últimos capítulos. Adicionalmente, para estes trabalhos foram obtidas eletromicrografias de varredura (Centro de Microscopia da Universidade Federal do Rio Grande do Sul) e imagens digitais em diversos planos

produzidas com câmera digital acoplada ao esteromicroscópio, posteriormente compostas com o programa Helicon Focus<sup>®</sup>.

As análises cladísticas foram baseadas no princípio da parcimônia, utilizando-se sempre o método de comparação com o grupo externo (Nixon & Carpenter 1993) para construção dos cladogramas. A construção das matrizes de caracteres morfológicos, bem como a edição dos cladogramas foram realizadas com utilização do programa Winclada (Nixon 2002). As análises numéricas de caracteres morfológicos foram feitas com o uso do programa TNT (Goloboff *et al.* 2008), com as opções de busca “implicit enumeration” (terceiro capítulo) e “traditional search” (quarto capítulo).

No terceiro capítulo (Sinopse de *Chloropepla*), dados de distribuição das espécies de *Chloropepla* foram obtidos a partir de espécimes analisados e da literatura. Coordenadas das localidades foram buscadas em bases de dados disponíveis on-line, como Global Gazetteer (Falling Rain Genomics 2009), World Gazetteer (2009), Gazetteer of Costa Rican Plant-Collecting Locales (MOBOT 2007). Esses dados submetidos a uma Análise de Parcimônia de Brooks (Brooks *et al.* 2001), utilizando as áreas propostas por Morrone (2006) para a região Neotropical, modificadas por Nihei & de Carvalho (2007) como terminais. Para tanto, as matrizes foram construídas e os cladogramas editados utilizando-se o Winclada. A análise de parcimônia foi realizada com o TNT, com o algoritmo “implicit enumeration”.

No quarto capítulo, sequências de três fragmentos de rDNA foram utilizadas: um da subunidade 16S de rDNA mitocondrial, e dois da sub-unidade 28S de rDNA nuclear. Estes foram obtidos através de extrações não destrutivas a partir de partes do corpo dos insetos (pernas preservadas em álcool) ou a partir de espécimes inteiros preservados a seco, provenientes de coleções. As extrações a partir das pernas foi feita com QIAGEN DNeasy Blood & Tissue Kit<sup>®</sup>, enquanto as extrações de espécime inteiro seguiram a metodologia proposta por Gilbert *et al.* (2007). Procedimentos padrão de amplificação dos fragmentos

extraídos foram adotados (PCR) e sequências foram obtidas junto ao Laboratório de Sequenciamento da University of North Dakota, em Grand Forks, Estados Unidos.

A análise da evidência total foi realizada utilizando-se o programa POY 4.1.2 (Varón *et al.* 2010), com a seguinte linha de comando: build (500) swap ( ) fuse (iterations: 50, swap (trees: 20)) select ( ).

### **Resultados e Considerações Finais**

A partir do presente trabalho, cinco novas espécies foram adicionadas ao gênero *Chloropepla*. Com isso, a distribuição norte do grupo foi ampliada da Venezuela para a Costa Rica.

*Chloropepla* constitui um grupo monofilético, suportado por peritrema ostiolar longo e evanescente; hypandrium típico bem desenvolvido, com projeções dorsais ladeando o segmento X, parâmeros cilíndricos e conjuntiva reduzida e membranosa. O BPA indicou uma relação próxima entre as áreas Amazônicas e a natureza híbrida da sub-região Chaquenha.

A monofilia do grupo *Chlorocoris* não foi confirmada. No entanto, a proximidade de três grupos foi estabelecida, já que os mesmos foram recuperados tanto na análise morfológica quanto na de evidência total: a) *Loxa* + *Mayrinia* + *Chlorocoris* (*Monochrocerus*), b) *Chlorocoris* (*Chlorocoris*) + *Chlorocoris* (*Arawacoris*) + *Fecelia*, e c) *Arvelius* + *E. humeralis* + *R. humeralis*. Na definição dos dois primeiros grupos destaca-se a importância dos caracteres de genitália de macho como forma do hypandrium, forma do parâmero e ausência de conjuntiva. No terceiro grupo (*Arvelius* ++), os caracteres mais importantes na formação do grupo foram carena do metasterno elevada, ventre abdominal com quilha longitudinal e vesica curta.

Tanto a análise baseada em caracteres morfológicos quanto a baseada em evidência total suportam a remoção de *Chlorocoris* (*Arawacoris*) *tarsalis* do gênero *Chlorocoris*. A partir dos dados aqui apresentados, uma nova classificação deverá ser proposta.

Estudos adicionais são necessários para esclarecer a utilidade de caracteres moleculares em análises cladísticas de Pentatomidae e Pentatominae nos níveis de gênero e espécie.

### Referências

- Amorim, D.S. (2002) *Fundamentos de sistemática filogenética*. Holos Ribeirão Preto, 154 pp.
- Amyot, C.J. & Serville, A. (1843) *Histoire Naturelle des Insectes. Hémipteres*. Librairie Encyclopedique de Roret, Paris, lxxvi + 675 pp.
- Barcellos, A. & Grazia, J. (2003) Cladistics analysis and biogeography of *Brachystethus Laporte* (Heteroptera, Pentatomidae, Edessinae). *Zootaxa*, 256, 1-14.
- Becker, M. & Grazia-Vieira, J. (1971) Sobre o gênero *Rhyncholepta* Bergroth, 1911, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia*, 31, 389-399.
- Bernardes, J.L.C., Schwertner, C.F. & Grazia, J. (2009) Cladistic analysis of *Thoreyella* and related genera (Hemiptera: Pentatomidae: Pentatominae: Proclleticini). *Zootaxa*, 1-23.
- Brailovsky, H. (1981) Revision del genero *Arvelius* Spinola (Hemiptera-Heteroptera-Pentatomidae-Pentatomini). *Instituto de Biología Universidad Nacional-Autonomia de Mexico – Série Zoologica*, 51, 239-298.
- Brailovsky, H., Cervantes, L. & Mayorga, C. (1992) Hemiptera: Heteroptera de Mexico 44. Biología, estadios ninfales y fenología de la tribu Pentatomini (Pentatomidae) en la Estacion de Biología Tropical 'Los Tuxtlas', Veracruz. . *Universidad Nacional Autonoma de Mexico Instituto de Biologia Publicaciones Especiales*, 8,
- Brooks, D.R., van Veller, M.G.P. & McLennan, D.A. (2001) How to do BPA, really. *Journal of Biogeography*, 28, 345-358.
- Campos, L.A. & Grazia, J. (2006) Análise cladística e biogeografia de Ochlerini (Hemiptera, Pentatomidae, Discocephalinae). *Iheringia - Série Zoologia*, 96, 147-163.



- Eger, J.E.J. (1978) Revision of the genus *Loxa* (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society*, 86, 224-259.
- Eger, J.E.J. (1980) *Fecelia biorbis* n. sp. (Heteroptera: Pentatomidae), a new species from Haiti. *Journal of the New York Entomological Society*, 88, 29-32.
- Ernissee, D.J. & Kluge, A.G. (1993) Taxonomic congruence versus total evidence, and Amniote phylogeny inferred from fossils, molecules, and morphology. *Molecular Biology and Evolution*, 10, 1170-1195.
- Falling Rain Genomics (2009) *Global Gazetteer*, from: <http://www.fallingrain.com/world/> (March 2010).
- Ferrari, A., Grazia, J. & Schwertner, C.F. (2010) Review, cladistic analysis and biogeography of *Nezara* Amyot & Serville (Hemiptera: Pentatomidae). *Zootaxa*, 2424, 1-41.
- Froeschner, R.C. (1988) Family Pentatomidae Leach, 1815. The stink bugs. In: Henry, T.J. & Froeschner, R.C. (Eds.) *Catalog of the Heteroptera, or true bugs, of Canada and the Continental United States*. E.J. Brill, New York, pp. 958.
- Gapud, V.P. (1991) A generic revision of the subfamily Asopinae, with consideration on its phylogenetic position in the family Pentatomidae and superfamily Pentatomoidea (Hemiptera-Heteroptera). *Philippines Entomology* 8, 865-961.
- Gilbert, M.T.P., Moore, W., Melchior, L. & Worobey, M. (2007) DNA Extraction from Dry Museum Beetles without Conferring External Morphological Damage. *PLoS ONE*, 2, e272.
- Goloboff, P.A., Farris, J.S. & Nixon, K.C. (2008) TNT, a free program for phylogenetic analysis. *Cladistics*, 24, 774-786.
- Grazia-Vieira, J. (1971) Sobre uma nova combinação, uma sinonímia e a descrição de uma nova espécie de *Chloropepla* Stal (Hemiptera, Pentatomidae, Pentatomini). *Papeis Avulsos de Zoologia*, 24, 207-211.

- Grazia-Vieira, J. (1972a) Contribuição ao conhecimento do gênero *Chloropepla* Stal (Hemiptera, Pentatomidae, Pentatomini). *Anais da Sociedade Entomológica do Brasil*, 1, 42-45.
- Grazia-Vieira, J. (1972b) O gênero *Mayrinia* Horvath, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Revista Peruana de Entomologia*, 15, 117-124.
- Grazia-Vieira, J. (1973a) *Chloropepla rolstoni*, uma nova espécie de Pentatomini (Hemiptera, Pentatomidae): uma correção. *Anais da Sociedade Entomológica do Brasil*, 2, 13-19.
- Grazia-Vieira, J. (1973b) Uma nova espécie de *Mayrinia* Horvath, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Iheringia - Serie Zoologia*, 25-33.
- Grazia, J. (1968) Sobre o genero *Chloropepla* Stal, 1867, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia*, 28, 193-206.
- Grazia, J. (1976) Revisão do gênero *Fecelia* Stal, 1872 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia*, 36, 229-237.
- Grazia, J. (1977) Revisão dos pentatomídeos citados no “Quarto catálogo dos insetos que vivem nas plantas do Brasil”(Hemiptera-Pentatomidae-Pentatomini). *Dusenya*, 10, 161-174.
- Grazia, J. (1980) Uma nova espécie do gênero *Fecelia* Stal (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia*, 40, 261-266.
- Grazia, J. (1987) Novas contribuições ao gênero *Chloropepla* Stal, 1867 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Entomologia*, 31, 473-477.
- Grazia, J. (1997) Cladistics analysis of the *Evoplitis* genus group of Pentatomini (Heteroptera, Pentatominae). *Journal of Comparative Biology* 2, 115-129.
- Grazia, J. & Frey-Da-Silva, A. (2001) Descrição dos imaturos de *Loxa deducta* Walker e *Pallantia macunaima* Grazia (Heteroptera: Pentatomidae) em Ligustro, *Ligustrum lucidum* Ait. *Neotropical Entomology*, 30, 73-80.

- Grazia, J., Schuh, R.T. & Wheeler, W.C. (2008a) Phylogenetic relationships of family groups in Pentatomoidea based on morphology and DNA sequences (Insecta: Heteroptera). *Cladistics*, 24, 932-976.
- Grazia, J., Schwertner, C.F. & Greve, C. (2008b) Two new species of genus *Chloropepla* (Hemiptera: Pentatomidae: Pentatominae) from Brazil. *Acta Entomologica Musei Nationalis Pragae*, 48, 533-542.
- Grazia, J. & Teradaira, C.T. (1980) Nova espécie de *Chloropepla* Stal, 1867 coletada em Tucuruí, Pará, Brasil (Heteroptera, Pentatomidae). *Anais da Sociedade Entomológica do Brasil*, 9, 123-131.
- Greve, C., Schwertner, C.F. & Grazia, J. (submitted) Three new species of *Chloropepla* (Heteroptera: Pentatomidae: Pentatominae). *Australian Journal of Entomology*,
- Hasan, S.A. & Kitching, I.J. (1993) A cladistic analysis of the tribes of the Pentatomidae (Heteroptera). *Japanese Journal of Entomology* 61, 651-669.
- Hennig, W. (1968) *Elementos de una sistemática filogenética*. Editorial Universitaria, Buenos Aires, 353 pp.
- Henry, T.J. (1997) Phylogenetic analysis of family groups within the infraorder Pentatomomorpha (Hemiptera: Heteroptera), with emphasis on the Lygaeoidea. *Annals of the Entomological Society of America*, 90, 275-301.
- Hillis, D.M. (1987) Molecular versus morphological approaches to systematics. *Annual Review of Ecology and Systematics*, 18, 23-42.
- Hillis, D.M. & Wiens, J.J. (2000) Molecules versus morphology in systematics: Conflicts, artifacts, and misconceptions. In: Wiens, J.J. (Ed.) *Phylogenetic analysis of morphological data*. Smithsonian Institution Press 220.
- Kluge, A.G. (1989) A concern for evidence and a phylogenetic hypothesis of relationships among Epicrates (Boidae, Serpentes). *Systematic Zoology*, 38, 7-25.

- Kluge, A.G. (1998) Total evidence or taxonomic congruence: Cladistics or consensus classification. *Cladistics*, 14, 151-158.
- Kluge, A.G. (2004) On total evidence: for the record. *Cladistics*, 20, 205-207.
- Kluge, A.G. & Grant, T. (2006) From conviction to anti-superfluity: old and new justifications of parsimony in phylogenetic inference. *Cladistics*, 22, 276-288.
- Kluge, A.G. & Wolf, A.J. (1993) Cladistics - What's in a word. *Cladistics*, 9, 183-199.
- Li, H.M., Deng, R.Q., Wang, J.W., Chen, Z.Y., Jia, F.L. & Wang, X.Z. (2005) A preliminary phylogeny of the Pentatomomorpha (Hemiptera : Heteroptera) based on nuclear 18S rDNA and mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution*, 37, 313-326.
- Link, D. & Grazia, J. (1987) Pentatomidae da região central do Rio Grande do Sul. *Anais da Sociedade Entomológica do Brasil*, 16, 115-129.
- Mishler, B.D. (1994) Cladistic analysis of molecular and morphological data. *American Journal of Physical Anthropology*, 94, 143-156.
- Mishler, B.D. (2005) Logic of the data matrix in phylogenetic analysis. In: Albert, V.A. (Ed.) *Parsimony, Phylogeny and Genomics*. Oxford University Press, Oxford, pp. 229.
- MOBOT (2007) *Gazetteer of Costa Rican Plant-Collecting Locales*, from: <http://www.mobot.org/MOBOT/Research/costaricagaz.shtml> (March 2010).
- Morrone, J.J. (2006) Biogeographic areas and transition zones of Latin America and the Caribbean islands based on panbiogeographic and cladistic analyses of the entomofauna. *Annual Review of Entomology*, 51, 467-494.
- Murrell, A., Campbell, N.J.H. & Barker, S.C. (2001) A total-evidence phylogeny of ticks provides insights into the evolution of life cycles and biogeography. *Molecular Phylogenetics and Evolution*, 21, 244-258.
- Nei, M. & Kumar, S. (2000) *Molecular evolution and phylogenetics*. Oxford University Press, New York, pp.

- Nihei, S.S. & de Carvalho, C.J.B. (2007) Systematics and biogeography of *Polietina* Schnabl & Dziedzicki (Diptera, Muscidae): Neotropical area relationships and Amazonia as a composite area. *Systematic Entomology*, 32, 477-501.
- Nixon, K.C. (2002) WinClada. Published by the author, Ithaca, NY
- Nixon, K.C. & Carpenter, J.M. (1993) On outgroups. *Cladistics*, 9, 413-426.
- Ortega-Leon, G. & Chavez-Bermeo, N. (2008) A new species of the genus *Arvelius* spinola (Hemiptera : Heteroptera : Pentatomidae : Pentatomini) from Mexico. *Proceedings of the Entomological Society of Washington*, 110, 643-646.
- Panizzi, A.R., Mourão, A.P.M. & Oliveira, E.D.M. (1998) Nymph and ault biology and seasonal abundance of *Loxa deducta* (Walker) on privet, *Ligustrum lucidum*. *Anais da Sociedade Entomológica do Brasil*, 27, 199-206.
- Panizzi, A.R. & Rossi, C.E. (1991) Efeito da vagem e da semente de *Leucena* e da vagem de soja no desenvolvimento de ninfas e adultos de *Loxa deducta* (Hemiptera: Pentatomidae). *Revista Brasileira de Biologia*, 51, 607-613.
- Panizzi, A.R. & Slansky, F. (1985) Review of phytophagous pentatomids (Hemiptera, Pentatomidae) associated with soybean in the Americas. *Florida Entomologist*, 68, 184-214.
- Rider, D. (2008) *Pentatomoidea home page*, North Dakota State University, Fargo. Available from: <http://www.ndsu.nodak.edu/nsdu/rider/Pentatomoidea/> (01/07/08).
- Schuh, R.T. (1986) The Influence of Cladistics on Heteropteran Classification. *Annual Review of Entomology*, 31, 67-93.
- Schuh, R.T. & Brower, A.V.Z. (2009) *Biological systematics: principles and applications*. Cornell University Press, Ithaca, 311 pp.
- Schuh, R.T. & Slater, J.A. (1995) *True bugs of the world (Hemiptera: Heteroptera). Classification and natural history*. Cornell University Press, Ithaca, 337 pp.

- Sigrist, M.A. & de Carvalho, C.J.B. (2009) Relacionamentos históricos entre áreas endêmicas na região tropical da América do Sul utilizando a Análise de Parcimônia de Brooks (BPA). *Biota Neotropica*, 9, 1-12.
- Spinola, M. (1837) *Essai sur les genres d'insectes appartenants B l'ordre des HémiptPres, Lin. ou Rhyngotes, Fab. et B la section des HétéroptPres, Dufour*. Yves Gravier, Genova, 383 pp.
- Stål, C. (1867) Bidrag till Hemipterernas Systematik. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar*, 24, 491-560.
- Thomas, D.B. (1985) Revision of the genus *Chlorocoris* Spinola (Hemiptera: Pentatomidae). *Annals of the Entomological Society of America*, 78, 674-699.
- Thomas, D.B. (1992) *Eludocoris*, a new genus of Pentatomidae (Insecta: Heteroptera) from Costa Rica. *Annals of Carnegie Museum*, 61, 63-67.
- Thomas, D.B. (1998) A new species of *Chlorocoris* (Heteroptera: Pentatomidae) from Jamaica. *Florida Entomologist*, 81, 483-488.
- Varón, A., Vinh, L.S. & Wheeler, W.C. (2010) POY version 4: phylogenetic analysis using dynamic homologies. *Cladistics*, 26, 72-85.
- Wheeler, Q.D. (2008) Undisciplined thinking: morphology and Hennig's unfinished revolution. *Systematic Entomology*, 33, 2-7.
- Wheeler, W.C. (2005) Alignment, Dynamic Homology, and Optimization. In: Albert, V.A. (Ed.) *Parsimony, Phylogeny, and Genomics*. Oxford University Press, New York, pp. 229.
- Whiting, M.F., Carpenter, J.C., Wheeler, Q.D. & Wheeler, W.C. (1997) The Strepsiptera problem: phylogeny of the holometabolous insect orders inferred from 18S and 28S ribosomal DNA sequences and morphology. *Systematic Biology*, 46, 1-68.
- Wiens, J.J. (2004) The role of morphological data in phylogeny reconstruction. *Systematic Biology*, 53, 653-661.

## ACTA ENTOMOLOGICA MUSEI NATIONALIS PRAGAE

Published 8.xii.2008

Volume 48(2), pp. 533-542

ISSN 0374-1036

**Two new species of the genus *Chloropepla*  
(Hemiptera: Pentatomidae: Pentatominae)  
from Brazil<sup>\*)</sup>**

Jocélia GRAZIA<sup>1,2)</sup>, Cristiano F. SCHWERTNER<sup>1,3)</sup> & Caroline GREVE<sup>1,4)</sup>

<sup>1)</sup> Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves 9.500, 91501-970, Porto Alegre, Rio Grande do Sul, Brazil

<sup>2)</sup> CNPq Fellowship; e-mail: jocelia@ufrgs.br

<sup>3)</sup> CAPES Fellowship; e-mail: acrosternum@yahoo.com.br

<sup>4)</sup> CNPq Fellowship; e-mail: carolinegreve@yahoo.com.br

**Abstract.** *Chloropepla paveli* sp. nov. and *C. stysi* sp. nov., from Brazil are described, based on the morphology of genitalia for both sexes. Prior to this study, the genus was represented in Amazon region as well as in southern and southeastern Brazil. The addition of the two species described in this paper extends the known geographical distribution to northeastern and central areas of Brazil. A key to the species of *Chloropepla* is presented.

**Key words.** Heteroptera, Pentatomidae, *Chloropepla*, morphology of genitalia, taxonomy, new species, Neotropical region, Brazil

### Introduction

*Chloropepla* was described by STÅL (1867) to include *Loxa vigens* Stål, 1860, based on the long and evanescent ostiolar rugae (short and truncated in *Loxa* Amyot & Serville, 1843) and, on the obsolete or absent dorsal sulcus towards the apex of tibiae (dorsally sulcated in *Loxa*). Six new species were added to the genus as follows: GRAZIA (1968) described *C. lenti* from Venezuela; GRAZIA-VIEIRA (1969) described *C. nigrispina* from Bolivia and Peru, later synonymized to *C. aurea* (Pirán, 1963) (GRAZIA-VIEIRA 1971); GRAZIA-VIEIRA (1971) described *C. pirani* from Bolivia; GRAZIA-VIEIRA (1973) described *C. rolstoni* from French Guiana; GRAZIA & TERADAIIRA (1980) described *C. tucuruensis* from northern Brazil; GRAZIA (1987) described *C. dollingi* from Guyana and northern Brazil. The species color varies from reddish-brown to yellowish in dry preserved specimens; probably green in life. The general shape is oval and the size ranges from 10 mm to 16 mm, approximately; triangular head, with

<sup>\*)</sup> Contribution N° 544 of the Departamento de Zoologia, Universidade Federal do Rio Grande do Sul.



juga surpassing tylus, slightly juxtaposed at apex, rounded; humeral angles produced or not into spines. Diagnostic characters for the genus are of male genitalia: all the species present a well developed hypandrium; the conjunctiva is membranous and reduced (completely obscured by the phallosome); a collar-like process at the base of the vesica is always present. The last two features seem to be unique for the genus.

*Chloropepla* is considered close related to *Loxa*, *Chlorocoris* Spinola, 1837, *Fecelia* Stål, 1872, *Mayrinia* Hováth, 1925, *Eludocoris* Thomas, 1992, and *Rhyncholepta* Bergroth, 1911 for characteristics of general morphology (GRAZIA 1968, 1976; BECKER & GRAZIA-VIEIRA 1971; GRAZIA-VIEIRA 1972; EGER 1978; THOMAS 1992, 1998). The phylogenetic analyses of this group of genera, as well as a synopsis of the genus *Chloropepla*, are in preparation.

In this paper, two new species are described from Brazil (Amazonas, Rio Grande do Norte, Tocantins and Minas Gerais states). A key to the species, complementing the one included in GRAZIA & TERADAIIRA (1980) is offered.

### Material and methods

The description was based on nine specimens, six males and three females, which belong to the following collections:

CZPB	Coleção Zoológica Prof. Paulo Bürnheim, Fundação Universidade do Amazonas, Manaus, Amazonas, Brazil;
FIOC	Fundação Instituto Oswaldo Cruz, Rio de Janeiro, Rio de Janeiro, Brazil;
MCNZ	Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil;
UFRG	Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.

General and genitalic morphology were illustrated using stereomicroscope and drawing tube; genitalia were cleared with 10% KOH and stained with Congo Red. Genitalic terminology followed GRAZIA (1968), DUPUIS (1970) and SCHAEFER (1977). Morphometric parameters measured: total length, abdominal width, head length, head width, interocular distance, lengths of antennal segments I to V, lengths of rostral segments I to IV, pronotal length, pronotal width, scutellum length, scutellum width. Measurements (mean  $\pm$  standard deviation, when available) are given in millimeters; size proportion of both species were defined by comparison with other species of *Chloropepla*.

### Key to the species of *Chloropepla*

- 1 Yellowish callus at apex of radial vein present; anterior border of spiracles with a yellowish callus. .... 3
- 1' Callus at apex of radial vein and at spiracles absent. .... 2
- 2 Lateral margins of juga uniformly curving towards tip, bordered by black; dorsum of tibia lined by black. .... *C. aurea* (Pirán, 1963)
- 2' Lateral margins of juga sinuous, not bordered by black; dorsum of tibia not lined by black. .... *C. pirani* Grazia-Vieira, 1971
- 3 Humeral angles spinose (Grazia 1968: 197, Fig. 2). .... *C. vigens* (Stål, 1860)





Figs. 1-2. 1 – *Chloropepla paveli* sp. nov. (male holotype). 2 – *C. styxi* sp. nov. (male holotype). Scale bars = 2 mm.

- 3' Humeral angles acute, not produced into spines (Grazia 1968: 197, Fig. 1). ..... 4
- 4 Apices of femora with a slightly produced spine. .... *C. paveli* sp. nov.
- 4' Apices of femora inconspicuously produced. .... 5
- 5 Ventral rim of pygophore excavated in 'V' mesially; marginal process of dorsal rim of pygophore laminar; laterotergites 8 with acute apex. .... *C. lenti* Grazia, 1968
- 5' Ventral rim of pygophore excavated in 'U' mesially; marginal process of dorsal rim of pygophore digitiform; laterotergites 8 rounded at apex. .... 6
- 6 Anterior tooth of bucculae absent. .... *C. tucuruensis* Grazia & Teradaira, 1980
- 6' Anterior tooth of bucculae present. .... 7
- 7 Humeral angles bordered by black (Grazia-Vieira 1973: 14, Fig. 1). ....  
..... *C. rolstoni* Grazia-Vieira, 1973
- 7' Humeral angles not bordered by black. .... 8
- 8 Ventral process of hypandrium bilobate (Fig. 6); posterior margins of gonocoxites 8 slightly convex (Fig. 16). .... *C. styxi* sp. nov.
- 8' Ventral process of hypandrium digitiform (Grazia 1987: 474, Fig. 3); posterior margins of gonocoxites 8 concave (Grazia 1987: 474, Fig. 8). .... *C. dollingi* Grazia, 1987

### Taxonomy

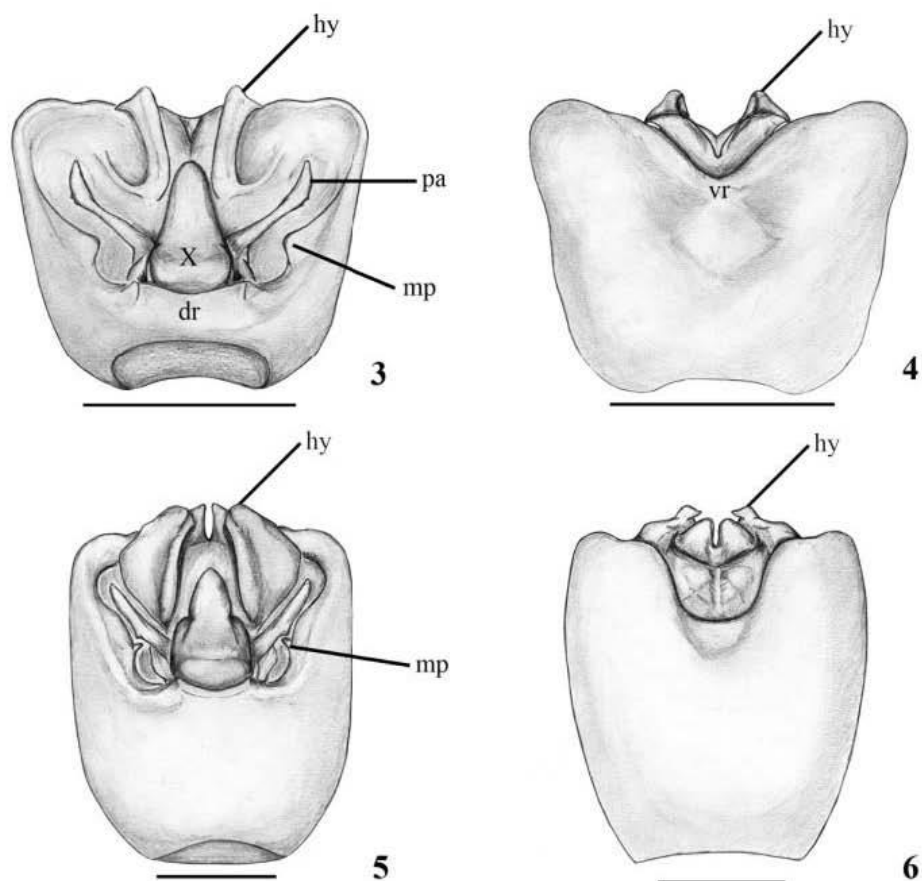
#### *Chloropepla paveli* sp. nov.

(Figs. 1, 3-4, 7-10, 15)

**Type locality.** Brazil, Tocantins: Palmas, S<sup>o</sup> do Lageado, Fazenda Céu.

**Type material.** HOLOTYPE: ♂, BRAZIL: 'TOCANTINS, Palmas, S<sup>o</sup> do Lageado, Fazenda Céu, xi.1992, Exp. MCN-MZSP' (MCNZ 6-96). PARATYPES: BRAZIL: 2 ♂♂, 'RIO GRANDE DO NORTE, Natal, iii.1952, M. Alvarenga' (FIOC); 1 ♀, 'MINAS GERAIS, B[elo] H[orizonte] / Campus UFMG / 3.viii.1978 / Edelberto Dias col.' (UFRG).

**Diagnosis.** Small size (10-12 mm), general color yellowish in dry preserved specimens; body punctures concolorous. Humeral angles acute, but never produced into spines. Pygophore trapezoidal, dorsal rim strongly concave; marginal processes of dorsal rim subtriangular, rounded



Figs. 3-6. Male external genitalia. 3-4 – *Chloropepla paveli* sp. nov., pygophore. 3 – dorsal view; 4 – ventral view. 5-6 – *C. styxi* sp. nov., pygophore. 5 – dorsal view; 6 – ventral view. Scale bars = 1 mm (dr – dorsal rim; hy – hypandrium; mp – marginal process of dorsal rim; pa – paramere; vr – ventral rim; X – segment X).

at apex. Hypandrium with an apical process ventrally produced; lateral margins of hypandrium dorsally produced and slightly extended posteriorly. Paramere cylindrical, elongated, apex slightly spatulated; apical and medial spines present, close to each other at apical third of the outer surface. Segment X ogival, surface of basal two thirds strongly concave. Phallosome without process. Vesica tubular and narrow. Gonocoxites 8 quadrangular, surface convex; posterior margin slightly convex, apical third of sutural margins divergent. Laterotergites 8 and 9 with apical angles rounded; laterotergites 9 not surpassing laterotergites 8.

**Description.** General body shape oval (Fig. 1), small in size (male length:  $10.4 \pm 0.5$ , width  $5.8 \pm 0.2$ ; female length:  $11.3$ ; width:  $6.1$ ).

**Coloration.** Dry preserved specimens yellowish, probably green in life, punctures concolorous.

**Head.** Triangular in shape, 0.5 times longer than wide (males head length:  $2.1 \pm 0.2$ ; female:  $2.1$  – males head width:  $1.7$ ; female:  $1.8$  – males interocular distance of:  $1.5 \pm 0.1$ ; female:  $1.6$ ). Jugal process surpassing clypeus, slightly juxtaposed at apex, rounded; lateral margins sinuate. Proportion of antennal segments:  $I < II < III < IV \approx V$  (males antennal segments length:  $I = 1.0 \pm 0.1$ ;  $II = 1.3 \pm 0.1$ ;  $III = 1.7 \pm 0.3$ ;  $IV = 2.2 \pm 0.2$ ;  $V = 2.1$ ; females:  $I = 1$ ;  $II = 0.88$ ;  $III = 2.08$ ;  $IV = 2.04$ ). Bucculae evanescent at base of head; anterior angle rounded; first rostral segment slightly surpassing bucculae. Rostrum surpassing metacoxae; proportion of rostral segments:  $I < II > III > IV$  (males rostral segments length:  $I = 1.0 \pm 0.1$ ;  $II = 1.5$ ;  $III = 1.3 \pm 0.1$ ;  $IV = 1.1 \pm 0.1$ ; female:  $I = 1.2$ ;  $II = 1.8$ ;  $III = 1.4$ ;  $IV = 1.1$ ).

**Pronotum.** Trapezoidal, anterior half slightly declivent, punctures denser, cicatrices immaculate. Basal two thirds of anterolateral margins crenulated. Anterior margin concave, behind the eyes truncated. Humeral angles acute, but not produced into spines. Pronotum length: males  $1.9 \pm 0.1$ ; females  $2.0$ ; pronotum width: males  $5.9 \pm 0.2$ ; females  $5.8$ .

**Scutellum.** Apex rounded; punctures uniformly distributed. Scutellum length: males  $3.7 \pm 0.2$ ; female:  $3.9$ ; scutellum width: males  $3.3 \pm 0.1$ ; females:  $3.4$ .

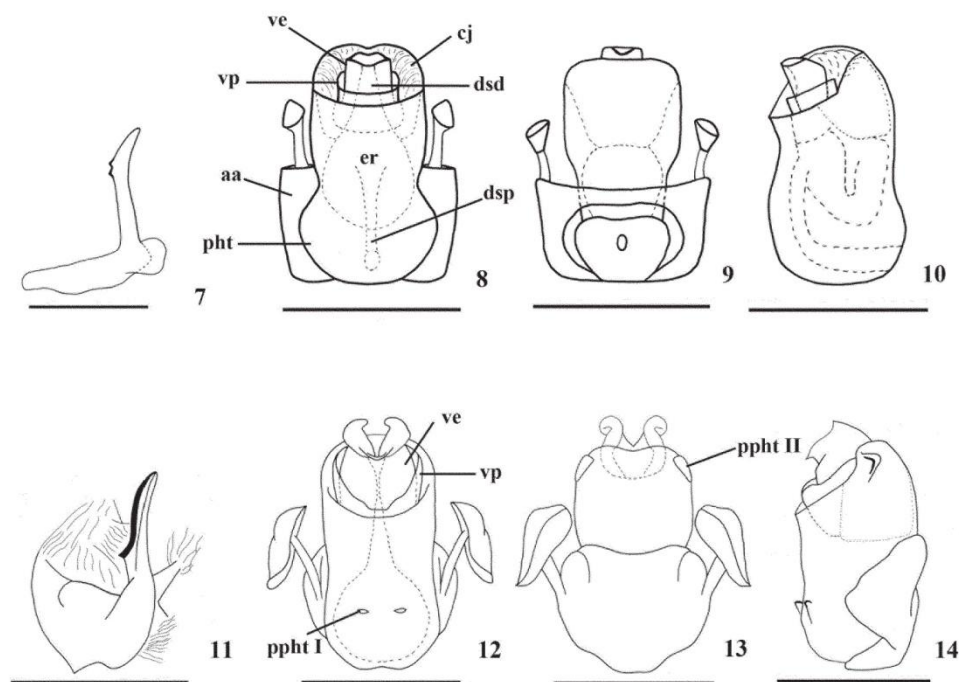
**Hemelytra.** Wide, almost covering connexiva completely. Corium uniformly punctured; apical angle of corium rounded, reaching apex of connexivum VII; yellowish callus at apex of radial vein present.

**Thoracic venter.** Ostiolar rugae attaining nearly  $\frac{3}{4}$  of metapleura, ostiolar orifice elliptical. Distal spine of dorsal face of femur slightly produced; at least distal  $\frac{1}{2}$  of tibiae dorsally sulcated.

**Abdominal venter.** Slightly convex; anterior margins of spiracles surrounded by yellowish callus.

**Male genitalia** (Figs. 3-4, 7-14). Pygophore trapezoidal, dorsal rim strongly concave dorsally (Fig. 3; dr), dorsal wall reduced, more or less  $\frac{1}{4}$  the total length of pygophore. Marginal processes of dorsal rim subtriangular (Fig. 3; mp), rounded at apex. Median excavation of ventral rim V-shaped in ventral view (Fig. 4; vr). Hypandrium more or less quadrangular, with an apical process ventrally produced; lateral margins of hypandrium dorsally produced and slightly extended posteriorly (Figs. 3-4; hy). Paramere cylindrical, elongated, apex slightly spatulated; apical and medial spines present, close to each other at apical third of the outer surface (Fig. 7). Segment X ogival; surface of basal two thirds strongly concave and with lateral margins carinated (Fig. 3; X).





Figs. 7-14. Male external and internal genitalia. 7-10 – *Chloropepla paveli* sp. nov. 7 – right paramere, dorsal view; 8 – phallus, dorsal view; 9 – phallus, ventral view; 10 – phallus, lateral view. Scale bars = 0.5 mm. 11-14 – *C. styxi* sp. nov. 11 – right paramere, dorsal view; 12 – phallus, dorsal view; 13 – phallus, ventral view; 14 – phallus, lateral view. Scale bars = 1 mm (aa – articulatory apparatus; cj – conjunctiva; dsd – ductus seminis distalis; dsp – ductus seminis proximalis; pht – phallotheca; ppht I – processus phallothecae I; ppht II – processus phallothecae II; ve – vesica; vp – vesica collar process).

Articulatory apparatus about half the length of phallotheca (Figs. 8-9; aa). Phallotheca subcylindrical, wide opened dorsally; without process (Fig. 8). Conjunctiva reduced, completely obscured by phallotheca (Figs. 8-10; cj). Vesica tubular, narrow; basal portion surrounded by a collar-like process (Figs. 8-10; ve, vp).

**Female genitalia** (Fig. 15). Gonocoxites 8 quadrangular and convex; posterior margin slightly convex, apical third of sutural margins divergent (Fig. 15; gc8). Apical angles of laterotergites 8 and 9 rounded (Fig. 15; la8, la9); laterotergites 9 not surpassing laterotergites 8. Gonocoxites 9 trapezoidal, posterior margins concave (Fig. 15; gc9). Female not dissected.

**Differential diagnosis.** This species can be distinguished from other species of *Chloropepla* by characters of male and female genitalia. In males the parameres have the apex slightly spatulated; apical and medial spines present, close to each other at apical third of the outer surface (Fig. 7) and hypandrium is more or less quadrangular, with an apical process ventrally produced; lateral margins of hypandrium dorsally produced and slightly extended posteriorly (Figs. 3-4). The shape of gonocoxites 8 and apex of laterotergites 8 not produced into spines (Fig. 15) separate the female of *C. paveli* sp. nov. from the remaining species.

**Etymology.** This species is dedicated to Prof. Pavel Štys for his great contribution to the knowledge of the heteropterous insects.

**Bionomics.** Unknown.

**Distribution.** *Chloropepla paveli* sp. nov. is distributed in the north, northeastern and southeastern Brazil, occurring in Tocantins, Rio Grande do Norte and Minas Gerais states (Fig. 18).

***Chloropepla štysi* sp. nov.**

(Fig. 2, 5-6, 11-14, 16-17)

**Type locality.** Brazil, Amazonas: Coari, Rio Urucu.

**Type material.** HOLOTYPE: ♂, BRAZIL: 'AMAZONAS, Coari, Rio Urucu, Ig. Marta-3, 4°50'0.73" S 65°02'37" W 14-25.viii.1993, P.F. Bührnheim et al. col., à luz mista de mercúrio' (CZPB). PARATYPES: ♀, same label data as holotype (CZPB); BRAZIL: ♂, 'AMAZONAS, Rio Urubu, 2°10'S 59°49'W, 08-09.v.1983, P. Bührnheim, N. Otaviano & F. Peralta col.' (CZPB); ♂, 'BRAZIL, AMAZONAS, Coari, Rio Urucu, LOC - 09°, 4°51'56" S 65°04'56" W, 25.i.-10.ii.1995, P.F. Bührnheim et al. col. // à luz mista de mercúrio' (UFRG); ♀, 'BRAZIL, AMAZONAS, Juruá, Mineruazinho, 03°34'85" S 66°59'15" W, 13-25.i.1996 P. Bührnheim, N.O. Aguiar et al. col. // à luz mista de mercúrio' (UFRG).

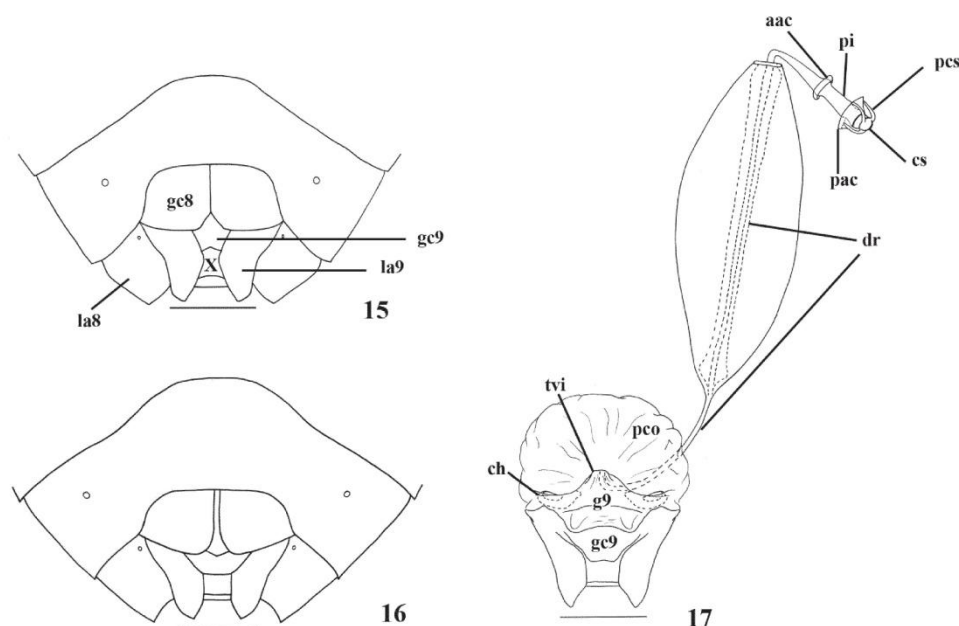
**Diagnosis.** Medium size (12-15 mm), general color yellowish in dry preserved specimens; body punctures ferruginous. Antennae with dark ornamentation. Humeral angles acute, not produced into spines. Pygophore rectangular, lateral third of dorsal rim folded toward the genital chamber; marginal process digitiform. Hypandrium with a broad laminar-like expansion dorsally; ventrally, with a bilobate process and 1+1 tumescent areas. Parameres apex elongated; apical spine present, medial spine absent. Phallosome with two pairs of processes. Vesica obovate. Gonocoxites 8 quadrangular, posterior margin slightly convex; sutural margins divergent. Apical angles of laterotergites 8 and 9 acute, black in color; laterotergites 9 not surpassing laterotergites 8.

**Description.** General body shape oval (Fig. 2), medium in size. Males total length of:  $12.6 \pm 0.1$ ; females:  $14.3 \pm 0.23$ ; males abdominal width:  $7.2 \pm 0.2$ ; females: 7.6.

**Coloration.** Dry preserved specimens yellowish, probably green in life; punctures ferruginous. In black: a longitudinal line in the outer surface of antennal segments I to III, apex of segment II, apical half of segment III, and apical three-fourths of segments IV and V; dorsal punctures on lateral margins of tibia; apical portion of tibia; all first and second tarsi segments and basal half of third. Reddish to grayish spots present on hemelytral membrane.

**Head.** Triangular, 0.5 times longer than wide (males head length:  $2.6 \pm 0.1$ ; females: 2.6; males head width: 2.0; female: 2.2; males interocular distance: 1.6; females:  $1.8 \pm 0.06$ ). Juga surpassing clypeus, slightly juxtaposed at apex; external margins convex. Proportion of antennal segments:  $I > II > III \approx IV \approx V$  (male antennal segments length:  $I = 1.3$ ;  $II = 1.7 \pm 0.11$ ;  $III = 2.1 \pm 0.11$ ;  $IV = 2.1 \pm 0.06$ ; females:  $I = 1.3$ ;  $II = 1.7 \pm 0.11$ ;  $III = 2.1$ ,  $IV = 2.3 \pm 0.11$ ;  $V = 2.3$ ). Bucculae evanescent at base; anterior angle truncated. Rostrum reaching metacoxae, first rostral segment slightly surpassing bucculae; proportion of rostral segments:  $I < II > III \approx IV$  (males rostral segments length:  $I = 1.3 \pm 0.06$ ;  $II = 2.0 \pm 0.08$ ;  $III = 1.5 \pm 0.05$ ;  $IV = 1.3 \pm 0.04$ ; females:  $I = 1.5 \pm 0.14$ ;  $II = 2.0 \pm 0.03$ ;  $III = 1.8 \pm 0.06$ ;  $IV = 1.3 \pm 0.11$ ).

**Pronotum.** Trapezoidal, punctures denser on posterior half; cicatrices immaculate. Anterior third of anterolateral margins slightly crenulated. Humeral angles acute, but not produced into spines (males pronotum length:  $2.7 \pm 0.05$ ; females: 2.8; males pronotum width:  $7.5 \pm 0.25$ ; females:  $8.2 \pm 0.11$ ).



Figs. 15-17. Female genitalia. 15 – *Chloropepla paveli* sp. nov., genital plates. 16-17 – *C. styxi* sp. nov., female genitalia. 16 – genital plates; 17 – gonocoxites and gonapophyses of ninth segment and ectodermal genital ducts. Scale bars = 1 mm (aac – anterior annular crest; cs – capsula seminalis; ch – chitinellipsen; g9 – gonapophyses 9; gc8 – gonocoxites 8; gc9 – gonocoxites 9; la8 – laterotergites 8; la9 – laterotergites 9; pac – posterior annular crest; pco – pars communis; pi – pars intermedialis; tvi – thickening of vaginal intima; X – segment X).

**Scutellum.** Apex rounded, punctures uniformly distributed. Scutellum length: males  $4.7 \pm 0.2$ ; females  $4.9 \pm 0.06$ ; scutellum width: males  $4.5 \pm 0.2$ ; females 4.3.

**Hemelytra.** Wide, almost completely covering connexival segments. Corium uniformly punctured, apical angle rounded and surpassing posterior half of connexivum VII; yellowish callus at apex of radial vein present.

**Thoracic venter.** Ostiolar rugae attaining nearly  $\frac{3}{4}$  of metapleura width, ostiolar orifice elliptical. Dorsal surface of femur with inconspicuous projection at apex; tibiae dorsally sulcated.

**Abdominal venter.** Strongly convex; anterior margins of spiracles surrounded by yellowish callus.

**Male genitalia** (Figs. 4-5, 11-14). Pygophore rectangular, 0.1 times longer than wide (Fig. 5-6); dorsal wall with half the length of pygophore. Dorsal rim emarginated medially; lateral third of dorsal rim folded toward the genital chamber; marginal process digitiform (Fig. 5; mp). Posterolateral angles slightly produced. Median excavation of ventral rim U-shaped in ventral view (Fig. 6); infolding of ventral rim with 1+1 darkish process dorsally produced, on the sides of the excavation.

Hypandrium longer than ventral rim, in a broad laminar-like expansion dorsally; ventrally, with a bilobate process and 1+1 tumescent areas (Figs. 5-6). Apex of parameres elongated and



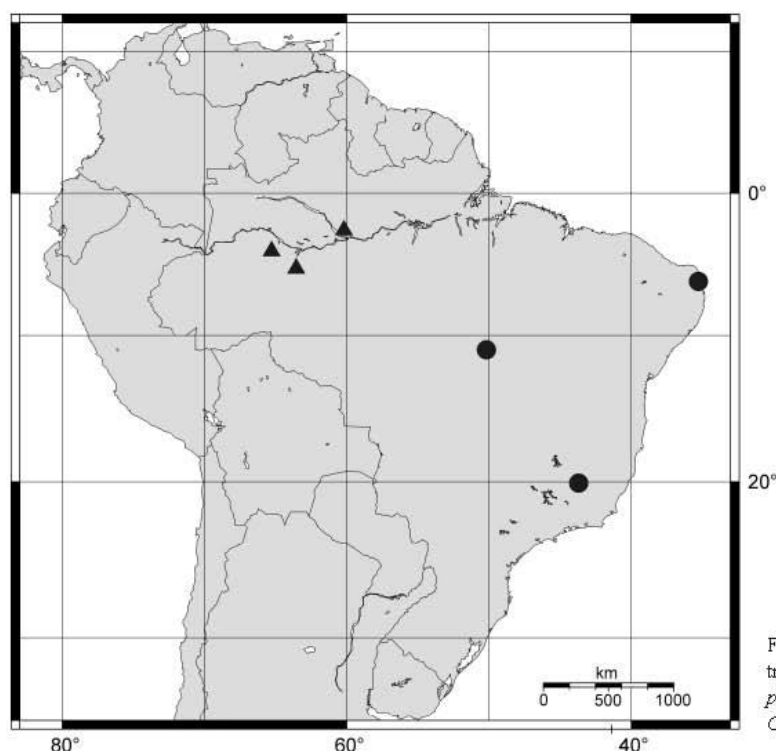


Fig. 18. Geographical distribution of *Chloropepla paveli* sp. nov. (●) and *C. styxi* sp. nov. (▲).

flat at inner surface; apical spine present, medial spine absent (Fig. 11). Segment X constricted medially; basal surface convex, apex ogival (Fig. 5).

Articulatory apparatus about half the length of phallosome (Figs. 12-13). Phallosome cylindrical, opening dorso-posteriorly, with two pairs of processes: 1+1 elliptical at base of dorsal wall (= processus phallosomae I) (Fig. 12; ppht I); 1+1 ear-like at postero-lateral angles of ventral wall (= processus phallosomae II) (Fig. 13; ppht II). Conjunctiva reduced, completely obscured by phallosome. Vesica obovate; basal portion surrounded by a collar-like process (Fig. 12; ve).

**Female genitalia** (Figs. 16-17). Genital plates hairy. Gonocoxites 8 quadrangular and flat; posterior margin slightly convex; sutural margins divergent at posterior forth (Fig. 16). Apical angles of laterotergites 8 and 9 acute, black in color; laterotergites 9 not surpassing laterotergites 8 in length (Fig. 16). Gonocoxites 9 trapezoidal, posterior margins subrectilinear (Fig. 16). Capsula seminalis subcylindrical (Fig. 17; cs), with three processes variable in length (Fig. 17; pcs): two reaching the free margin of the annular crest, and one surpassing the margin.

**Differential diagnosis.** This species can be distinguished from other species of *Chloropepla* by characters of male and female genitalia. In males the parameres with apex elongated; apical spine present, medial spine absent (Fig. 11) and hypandrium with a broad laminar-like expansion dorsally; ventrally, with a bilobate process and 1+1 tumescent areas (Figs. 5-6).

The shape of gonocoxites 8 and apex of laterotergites 8 acute (Fig. 16) separate the female of *C. stysi* sp. nov. from the remaining species.

**Etymology.** This species is dedicated to Prof. Pavel Štys for his great contribution to the knowledge of the heteropterous insects.

**Bionomics.** Unknown.

**Distribution.** *Chloropepla stysi* sp. nov. is distributed in northern Brazil, in Amazonas state, Coari and Juruá localities.

### Acknowledgements

To the curators of the collections for the loan of specimens: CZPB (N. O. Aguiar); MCNZ (A. Barcellos), and FIOC (J. Costa). To David Rider (North Dakota State University, Fargo, USA) and an anonymous referee for the valuable suggestions to improve the manuscript.

### References

- BECKER M. & GRAZIA-VIEIRA J. 1971: Sobre o gênero *Rhyncholepta* Bergroth, 1911, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia* **31**: 389-399.
- DUPUIS C. 1970: Heteroptera. Pp. 190-208. In: TUXEN S. L. (ed.): *Taxonomist's Glossary of Genitalia of Insects*. Munksgaard, Copenhagen, 359 pp.
- EGER J. E. 1978: Revision of the genus *Loxa* (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society* **86**: 224-259.
- GRAZIA J. 1968: Sobre o gênero *Chloropepla* Stål, 1867, com a descrição de uma nova espécie. (Hemiptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia* **8**: 193-206.
- GRAZIA J. 1976: Sobre o gênero *Fecelia* Stål, 1872 (Hemiptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia* **36**: 229-237.
- GRAZIA J. 1987: Novas contribuições ao gênero *Chloropepla* Stål, 1867 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Entomologia* **31**: 473-477.
- GRAZIA J. & TERADAIIRA C. T. 1980: Nova espécie de *Chloropepla* Stål, 1867 coletada em Tucuruí, Pará, Brasil (Heteroptera, Pentatomidae). *Anais da Sociedade Entomológica do Brasil* **9**: 123-131.
- GRAZIA-VIEIRA J. 1969: Una nueva especie del genero *Chloropepla* (Hemiptera, Pentatomidae, Pentatomini). *Neotropica* **15**: 105-111.
- GRAZIA-VIEIRA J. 1971: Sobre uma nova combinação, uma sinonímia e a descrição de uma nova espécie de *Chloropepla* Stål (Hemiptera, Pentatomidae, Pentatomini). *Papéis Avulsos de Zoologia* **24**: 207-211.
- GRAZIA-VIEIRA J. 1972: O gênero *Mayrinia* Hovarth, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Revista Peruana de Entomologia* **5**: 117-124.
- GRAZIA-VIEIRA J. 1973: *Chloropepla rolstoni*, uma nova espécie de Pentatomini (Heteroptera, Pentatomidae): uma correção. *Anais da Sociedade Entomológica do Brasil* **2**: 13-19.
- SCHAEFER C. W. 1977: Genital capsule of the trichophoran male (Hemiptera: Heteroptera: Geocorisae). *International Journal of Insect Morphology and Embryology* **6**: 277-301.
- STÅL C. 1867: Bidrag till Hemipterernas Systematik. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar* **24**: 491-560.
- THOMAS D. B. 1992: *Eludocoris*: a new genus of Pentatomidae (Insecta: Heteroptera) from Costa Rica. *Annals of Carnegie Museum* **61**: 63-67.
- THOMAS D. B. 1998: A new species of *Chlorocoris* (Heteroptera: Pentatomidae) from Jamaica. *Florida Entomologist* **81**: 483-488.



## Capítulo 2

Normas editorias Australian Journal of Entomology

(<http://www.wiley.com/bw/submit.asp?ref=1326-6756&site=1>)

### Three new species of *Chloropepla* Stål (Hemiptera: Heteroptera: Pentatomidae)

**Abstract.** Three new species of the Neotropical genus *Chloropepla* are described. They are distributed in Costa Rica, Venezuela and Brazil. The present paper extends the northern distribution of the genus to Costa Rica registering the presence of *Chloropepla* in Central America. An extended key to the species is presented.

**Key words:** Hemiptera, new taxa, Neotropical region.

### Introduction

*Chloropepla* is a Neotropical genus with nine known species. The genus was described by Stål (1867) to include *Loxa vigens* Stål, 1860 based on the long and evanescent ostiolar rugae (short and truncated in *Loxa* Amyot & Serville, 1843) and on the obsolete or absent dorsal sulcus towards the apex of tibiae (dorsally sulcated in *Loxa*). The species are also characterized by pale yellow color in dry specimens (probably green in life), triangular head, juga surpassing clypeus and a large process in the ventral wall of the pygophore, the hypandrium, which always present dorsal expansions flanking the segment X. These expansions vary in shape and size, according to the species. Also, all the species show a reduced conjunctiva and a collar-like process around the base of vesica, which is short. Of the ten known species, two was recently described by Grazia et al. (2008).

Traditionally *Chloropepla* was approximated to *Loxa*, *Chlorocoris* Spinola, 1837, *Fecelia* Stål, 1872, *Mayrinia* Hováth, 1925, *Eludocoris* Thomas, 1992, and *Rhyncholepta* Bergroth, 1911 by characteristics of general and genitalia morphology (Grazia 1968, 1976; Becker & Grazia-Vieira 1971; Grazia-Vieira 1972; Eger 1978; Thomas 1992, 1998). A study of the relationships among these genera is under preparation. Also, the relationships among the *Chloropepla* species, using cladistics, were investigated by Greve et al. (submitted).

In this paper, three new species are described from Costa Rica, Venezuela, north and central Brazil. In this way, the genus *Chloropepla* has the northern distribution extended to Central America (Costa Rica). An extended key, from that included in Grazia et al. (2008) containing the new taxa, is here provided.

## Material and Methods

The descriptions were based in 30 specimens, 21 females and 9 males from the following collections (curator in parenthesis): AMNH - American Museum of Natural History, New York, United States of America (R. T. Schuh), INBC - Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (J. Lewis), MPEG - Museu Paraense Emilio Goeldi, Belém, Pará, Brazil (O. T. Silveira), NMNH - National Museum of Natural History, Washington D.C., United States of America (T. J. Henry).

The general and genitalia morphology was observed and described using stereomicroscope. The genitalia was dissected and cleared with 10% KOH and stained with Congo red. The illustrations were made with drawing tube. The terminology followed Dupuis (1970), Schaffer (1977) and Grazia et al. (2008). The morphometric parameters measured were the same as in Grazia et al. (2008). Measurements (mean  $\pm$  standard deviation, when available) are given in millimeters and are presented in table 1; size proportion of species was defined by comparison with other species of *Chloropepla*.

## Key to *Chloropepla* species

- 1. Humeral angles produced into spines ..... 2
- 1'. Humeral angles acute but not produced into spines ..... 4
- 2. Humeral angles lined by black..... 3
- 2'. Humeral angles not lined by black ..... *C. vicens* (Stål, 1860)
- 3. Lateral margins of juga uniformly curving towards tip, bordered by black; dorsum of tibia lined by black..... *C. aurea* (Pirán, 1963)
- 3'. Lateral margins of juga sinuous, not bordered by black; dorsum of tibia not lined by black .....  
..... *C. pirani* Grazia-Vieira, 1971
- 4 Apices of femora with conspicuous spine ..... 5
- 4' Apices of femora inconspicuously produced..... 6

- 5 Hypandrium with 1+1 broad expansions flanking segment X, each expansion bearing an elongated outgrowth on dorsal surface; posterior margin of gonocoxites 9 straight ..... *Chloropepla* sp. nov. 1
- 5' Hypandrium with 1+1 narrow expansions flanking segment X, without outgrowth on dorsal surface; posterior margin of gonocoxites 9 convex ..... *C. paveli* Grazia et al. 2008
- 6 Ventral rim of pygophore mesially excavated in "V"; marginal process of dorsal rim of pygophore triangular; gonocoxites 9 strongly convex, with lateral margins nearly parallel ..... 7
- 6' Ventral rim of pygophore mesially excavated in "U"; marginal process of dorsal rim of pygophore digitiform, gonocoxites 9 slightly convex, with lateral margins divergent ..... 8
- 7 Apex of hypandrium rounded, without process; apex of laterotergites 8 and 9 acute ..... *C. lenti* Grazia, 1968
- 7' Apex of hypandrium with 1+1 narrow, rectangular process; apex of laterotergites 8 and 9 rounded ..... *Chloropela* sp. nov. 3
- 8 Humeral angles lined by black ..... 9
- 8' Humeral angles not lined by black ..... 10
- 9 Dorsal expansions of hypandrium broad, with 1+1 laminar processes with quadrangular form along dorsal surface, near apex ..... *Chloropepla* sp. nov. 2
- 9' Dorsal expansion of hypandrium narrow. Without process in dorsal surface ..... *C. rosltoni* Grazia-Vieira, 1973
- 10 Ventral process of hypandrium digitiform ..... *C. dollingi* Grazia, 1987
- 10' Ventral process of hypandrium bilobate ..... 11
- 11 Ventral surface of hypandrium mesially bearing 1+1 laminar process, oblique to the longitudinal axes of the hypandrium; parameres short, not reaching the margin of pygophore; posterior margin of gonocoxites 8 strongly angulate ..... *C. tucuruensis* Grazia & Teradaira, 1980
- 11' Ventral surface of hypandrium without process; parameres long, almost surpassing the margin of pygophore; posterior margin of gonocoxites 8 slightly convex ..... *C. stysi* Grazia et al. 2008

***Chloropepla* sp. nov. 1**

*Holotype*. Brazil, Bahia: ♂, labelled BRAZIL, Bahia, Encruzilhada, 960 m, nov. 1972, M. Alvarenga col.' (AMNH)

*Paratypes*. Brazil, Bahia: 6♀ and 4♂ labelled as holotype (AMNH; 1♀ and 1♂ UFRG). Minas Gerais: 2♀ and ♂ 'BRAZIL, Minhas Geraes [*sic*], Pedra Azul, 900m, November, 1972, M. Alvarenga col.' (AMNH)

**Description.**

Dry preserved specimens pale yellow, probably green in life, punctures concolor. General body shape oval (Fig. 1), small sized. Head triangular. Juga surpassing clypeus, juxtaposed at the apex. Proportion of antennal segments:  $I < II < III \leq IV \leq V$ . Bucculae evanescent at base. First rostral segment slightly surpassing bucculae. Proportion of rostral segments:  $I < II > III \geq IV$ .

Pronotum trapezoidal, anterior half slightly declivous; punctures uniformly distributed, cicatrices immaculate. Basal two thirds of anterolateral margins crenulated. Anterior margin concave, behind the eyes truncated. Humeral angles acute, but not produced into spines. Apex of scutellum rounded; punctures uniformly distributed. Hemelytra wide, almost obscuring connexiva completely. Corium uniformly punctured; apical angle of corium rounded, reaching base of connexivum VII; yellow callus at apex of radial vein present. Ostiolar ruga attaining nearly  $\frac{3}{4}$  of metapleura, ostiolar orifice elliptical. Distal spine of dorsal surface of femur distinct; at least distal half of tibiae dorsally sulcated. Abdominal venter slightly convex; anterior margins of spiracles surrounded by yellow callus.

Male genitalia (Figs 4-9). Pygophore rectangular (Figs 4, 5), approximately 0.2 times longer than wide. Median region of dorsal rim (Fig. 4, dr) with two rounded projections backward directed; lateral third of dorsal rim slightly folded toward the genital chamber; marginal processes of dorsal rim triangular (Fig. 4, mp), closely related to the parameres (Fig. 4, pa). Median excavation of ventral rim U-shaped (Fig. 5, vr). Hyandrium (Figs 4, 5, hy) surpassing ventral rim; with 1+1 broad laminar-like expansions flanking the segment X dorsally, bearing an elongated process (Fig. 4, epr), extending from the base to almost the apex of the expansion; ventral wall of hyandrium shorter than dorsal, flat, without processes (Fig. 5, vwwhy). Paramere club-shaped (Fig. 6), apical and medial spines present. Segment X ogival (Fig. 4, X), with 1+1 lateral carina at base. Phallus (Figs 7-9). Articulatory apparatus (Figs 7-9, aa) about half the length of phallotheca (Figs 7-9, ph). Phallotheca cylindrical, with

two pairs of processes: 1+1 elliptical at base of the posterior wall (= processus phallothecae I) (Fig. 7, prphI); 1+1 ear-like at postero-lateral angles of the anterior wall (= processus phallothecae II) (Fig. 9, prphII). Conjunctiva reduced (Fig. 7, cj), completely obscured by phallotheca. Vesica short (Figs 7,8, ve), cylindrical and much wider than the final portion of the ductus ejaculatory; basal portion surrounded by a collarlike process (Fig. 7, vp)

Female genitalia (Figs 10, 11). Gonocoxites 8 rectangular (Fig. 10, gc8), posterior margin convex, apical third of sutural margins divergent. Apical angle of laterotergites 8 acute (Fig. 10, la8); rounded in laterotergites 9 (Fig. 10, la9). Laterotergites 9 slightly shorter than laterotergites 8. Gonocoxites 9 trapezoidal (Fig. 10, gc9), posterior margin straight. Gonapophyses 9 with 1+1 triangular sclerotized regions (Fig. 11, g9). Anterior thickening of vaginal intima tube shaped (Fig. 11, tvi), nearly as long as the gonapophyses 9. Base of internal rod of ductus receptaculi bulbous-shaped. Capsula seminalis subcylindrical (Fig. 11, cs), with three processes variable in length (Fig. 11, pcs): two surpassing the posterior annular flange (Fig. 11, paf) in almost the half of their length and the third nearly reaching the anterior annular flange (Fig. 11, aaf).

**Distribution.** Brazil: Bahia and Minas Gerais.

**Differential diagnosis.** *Chloropepla* sp. nov. 1 differs from the remaining species of *Chloropepla* by the shape of the hypandrium which is unique, with the broad dorsal expansions bearing elongated processes. Also, in the female internal genitalia the well developed thickening of vaginal intima and the long processes of the capsula seminalis are distinct in this species.

### *Chloropepla* sp. nov. 2

*Holotype.* Brazil, Pará: ♂, labelled 'Flona Caxiuanã- Melgaço, Pará, Brasil, XI-2003 Fernandes, J.A.M.', 'Base da Estação Científica Ferreira Penna, coleta manual noturna sob luz branca' (MPEG)

*Paratypes.* Brazil, Pará: ♀ labelled as holotype (UFRG). Venezuela, Amazonas: 1♂ and 3♀ 'VENEZUELA, Exp. Territorio Amazonas, Mount Marahuaca, N. Slopes, Benitez Camp, May 1-25, 1950, J. Maldonado Capriles col., Drake Colln.' (USNM)

### **Description**

Dry preserved specimens pale yellow, probably green in life, punctures concolor. Anterior margin of the pronotum with sparse dark punctuations.

Anterior margin of humeral angles with a dark line. Dark line in the apical half of lateral surface of antennal segment I, and along the lateral surface of antennal segment II. Apical third of antennal segment III dark, segment IV and V with at least the apical  $\frac{3}{4}$  dark. Apex of tibiae and tarsal segments I and II bordered by black; base of tarsal segment III bordered by black. Postero-lateral angles of connexiva with tiny dark acute process.

General body shape oval (Fig. 2), medium size. Head triangular in shape. Juga surpassing clypeus, slightly juxtaposed at apex, rounded. Lateral margins sinuate. Proportion of antennal segments:  $I < II < IV = V$ . Bucculae evanescent at base of head; anterior angle with an acute process (denticle); first rostral segment slightly surpassing bucculae. Rostrum reaching the third abdominal segment; proportion of rostral segments:  $I < II > III \geq IV$ . Pronotum trapezoidal, anterior half slightly declivous; cicatrices immaculate. Basal two thirds of antero-lateral margins crenulated. Anterior margin concave, behind the eyes truncated. Humeral angles acute, but not produced into spines. Apex of scutellum rounded; punctures uniformly distributed. Hemelytra wide, almost obscuring connexiva completely. Corium uniformly punctured; apical angle of corium rounded, reaching half of connexivum VII; yellow callus at apex of radial vein present. Ostiolar ruga attaining nearly  $\frac{3}{4}$  of metapleura, ostiolar orifice elliptical. Distal spine of dorsal surface of femur inconspicuously produced; at least distal half of tibiae dorsally sulcated. Abdominal venter slightly convex; anterior margins of spiracles surrounded by yellow callus.

Male genitalia (Figs 12-17). Pygophore quadrangular (Figs 12, 13), almost as long as wide. Median region of dorsal rim (Fig. 12, dr) posteriorly projected into two acute processes; lateral third of dorsal rim folded toward the genital chamber; marginal processes of dorsal rim digitiform (Fig. 12, mp), closely related to the parameres (Fig. 12, pa). Median excavation of ventral rim U-shaped in ventral view (Fig. 13, vr); infolding of ventral rim with 1+1 darkish process dorsally produced, on the sides of the excavation. Hypandrium surpassing ventral rim (Figs 12, 13, hy); with 1+1 broad laminar-like expansions flanking the segment X, dorsally bearing a laminar process near the apex (Fig. 12, lpr); ventral wall of hypandrium almost as long as dorsal wall, projected posteriorly in a gutter-like process and medially projected in 1+1 triangular flaps (Fig. 13, vpr). Paramere cylindrical at the base and spatulated at the apex (Fig. 14), only apical spine present; lateral surface, near the apex, with granular texture. Apex of segment X ogival (Fig. 12, X), with 1+1 lateral tubercle at base. Phallus (Figs 15-17). Articulatory apparatus (Figs 15, aa) about half the length of phallotheca (Figs 15, ph). Phallotheca cylindrical, with two pairs of processes: 1+1 elongated at the base of posterior wall (=processus phallothecae I) (Fig. 15, prphI) and 1+1 ear-like at postero-

lateral angles of anterior wall (=processus phallothecae II) (Fig. 17, prphII). Conjunctiva reduced (Fig. 15, cj), completely obscured by phallotheca. Vesica short (Fig. 15, ve), bulbous; basal portion surrounded by a collar-like process (Fig. 15, vp).

Female genitalia (Figs 18, 19). Gonocoxites 8 quadrangular (Fig. 18, gc8); posterior margin slightly convex; apical forth of sutural margins divergent. Laterotergites 8 and 9 equal in length (Fig. 18, la8, la9); both with apical angle triangular (nearly acute). Gonocoxites 9 trapezoidal (Fig. 18, gc9). Gonapophyses 9 with 1+1 triangular sclerotized regions (Fig. 19, g9). Anterior thickening of vaginal intima reduced, hood-shaped (Fig. 19, tvi). Base of internal rod of ductus receptaculi bulbous-shaped. Capsula seminalis subcylindrical (Fig. 19, cs), with three processes variable in length (Fig. 19, pcs): one reaching the free margin of posterior annular flange (Fig. 19, paf) and the other two shorter.

**Distribution.** Venezuela: Amazonas; Brazil: Pará.

**Differential diagnosis.** *Chloropela* sp. nov. 2 may be distinguished by characteristics of the hypandrium: the shape of the dorsal expansions and the shape of the ventral projection. The reduced thickening of vaginal intima associated to the shape of capsula seminalis are also useful to differentiate the females of this species.

### *Chloropepla* sp. nov. 3

*Holotype.* Costa Rica, Guanacaste: ♂, labelled 'COSTA RICA, Guanacaste Province, Estacion Cacao, 1000-1400 m SW side Volcan Cacao, Malaise trap, 1988-1989, GNP Biodiv. Survey, 323300, 375700' (INBC).

*Paratypes.* Costa Rica, Guanacaste: ♀, 'COSTA RICA, Prov. Guanacaste, La Cruz, P.N. Guanacaste, Est. Pitilla, 9 km S Santa Cecilia, 5-30 AGO 1988 Espinoza, C. Chávez Manual (red. Libre) L\_N\_330200\_380200 #52602' (INBC); ♀, 'COSTA RICA, Prov. Guanacaste A.C.G. Libéria, P.N. Gte, Est Mengo Volcán Cacao, Bque Primario 1000 m 13 Jun 1987 Janzen Manual L\_N\_322740\_375198 #52569' (INBC); ♀, 'Est. Maritza, 600m, lado O Vol. Orosi, Prov. Guanacaste, Costa Rica, Tp Malaise, Ene a abr 1992, L-N 326900, 373000' (INBC); 2♀, 'Estac. Pitilla, 700m, 9 km S. Santa Cecilia, Guanac. PR. COSTA RICA Nov 1988 GNP Biodiversity Survey (W85 25'40'', N 10 59'26'')' (INBC); ♀, 'COSTA RICA, Prov. Guanacaste. P.N. Guanacaste Finca Del Oro 585m. 19-20 DEC 2006 B. Gamboa, R. Franco Tp. Luz L\_N\_331221\_377077 #90351' (INBC); ♀, 'Estacion Mengo, 1100m. SW side Volcan Cacao Guanacaste PV. COSTA RICA Malaise TR. 1987 DH Janzen & W.

Hallwachs' (INBC). Alajuela: ♀, 'Finca San Gabriel Alaj. Prov. COSTA RICA 650 m (16 km ENEQueb. Grande) I. Gauld & J. Thompson 11-15 June 1986' (INBC).

### **Description.**

Dry preserved specimens pale yellow to green, probably green in life, punctures concolor. General body shape oval (Fig. 3), medium size. Head triangular. Juga surpassing clypeus, slightly juxtaposed at apex, rounded. Lateral margins sinuate. Proportion of antennal segments:  $I < II < III < IV \leq V$ . Bucculae evanescent at base of head; anterior angle with an acute process (denticle); first rostral segment slightly surpassing bucculae. Rostrum reaching the third abdominal segment; proportion of rostral segments:  $I < II > III > IV$ . Pronotum trapezoidal, anterior half slightly declivous; cicatrices immaculate. Basal two thirds of antero-lateral margins crenulated. Anterior margin concave, behind the eyes truncated. Humeral angles produced in small pyramidal spines. Apex of scutellum rounded; punctures uniformly distributed. Hemelytra wide, almost obscuring connexiva completely. Corium uniformly punctured; apical angle of corium rounded, reaching base of connexivum VII; yellow callus at apex of radial vein present. Ostiolar ruga attaining nearly  $\frac{3}{4}$  of metapleura, ostiolar orifice elliptical. Distal spine of dorsal surface of femur slightly produced; at least distal half of tibiae dorsally sulcated. Abdominal venter slightly convex; anterior margins of spiracles surrounded by yellow callus.

Male genitalia (Figs 20, 21). Pygophore quadrangular (Figs 20, 21), nearly as long as wide. Median region of dorsal rim (Fig. 20, dr) projected posteriorly into two rounded process; lateral third of dorsal rim folded toward genital chamber; marginal processes of dorsal rim triangular (Fig. 20, mp), closely related to the parameres (Fig. 20, pa). Posterolateral angles flat, quadrangular (Fig. 20, pan). Median excavation of ventral rim V-shaped in ventral view (Fig. 21, vr). Hypandrium surpassing ventral rim (Figs 20, 21, hy); with 1+1 broad laminar-like expansions flanking segment X, dorsally bearing two narrow, apical rounded processes: one laterad directed (Fig. 20, lpr) and other backward directed (Fig. 20, ppr); ventral wall shorter than dorsal expansions, in a channel-like structure (Fig. 21, vw). Parameres spatulated, apical and medial spines present. Segment X ogival (Fig. 20, X), with 1+1 tubercle laterad to the constriction line. Male not dissected.

Female genitalia (Figs 22, 23). Gonocoxites 8 quadrangular (Fig. 22, gc8); posterior margin slightly convex; apical fourth of sutural margins divergent; transversal carina arising from the sutural angles. Laterotergites 8 and 9 equal in length (Fig. 22, la8, la9); posterior angle of laterotergites 8 acute; posterior angle of laterotergites 9 rounded. Gonocoxites 9 trapezoidal, strongly convex (Fig. 22, gc9). Gonapophyses 9 with 1+1 triangular sclerotized



areas (Fig. 23, g9). Anterior thickening of vaginal intima in a ring-like structure (Fig. 23, tvi). Base of internal rod of ductus receptaculi bulbous-shaped. Capsula seminalis subcylindrical (Fig. 23, cs), with three processes variable in length (Fig. 23, pcs): two reaching the free margin of posterior annular flange (Fig. 23, paf) and another shorter.

**Distribution.** Costa Rica: Costa Rica, Guanacaste.

**Differential diagnosis.** This species can be distinguished by the shape of the hypandrium dorsal expansions, specially by the two apical processes. Also, the shape of the posterolateral angles of pygophore (flat and quadrangular) is unique. The female genitalia shows as differential characteristic the carina on the surface of gonocoxites 8 associated with a strongly convex gonocoxites 9.

## References

- Becker M. & Grazia-Vieira J. 1971. Sobre o gênero *Rhyncholepta* Bergroth, 1911, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia* **31**, 389-399.
- Dupuis C. 1970. Heteroptera. In: *Taxonomist's Glossary of Genitalia of Insects* (ed. SL Tuxen) pp. 190-208. Munksgaard, Copenhagen.
- Eger J. E. 1978. Revision of the genus *Loxa* (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society* **86**, 224-259.
- Grazia J. 1968. Sobre o gênero *Chloropepla* Stål, 1867, com a descrição de uma nova espécie. (Hemiptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia* **8**, 193-206.
- Grazia J. 1976. Sobre o gênero *Fecelia* Stål, 1872 (Hemiptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia* **36**, 229-237.
- Grazia J, Schwertner CF & Greve C. 2008. Two new species of the genus *Chloropepla* (Hemiptera: Pentatomidae: Pentatominae) from Brazil. *Acta Entomologica Musei Nationalis Pragae* **48**, 533-542.
- Greve C, Schwertner CF & Grazia J. submitted. Synopsis of the genus *Chloropepla* Stål (Hemiptera, Heteroptera, Pentatomidae), with cladistic analysis of the species. *Insects Systematic and Evolution*.
- Grazia-Vieira J. 1972. O gênero *Mayrinia* Hovarth, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Revista Peruana de Entomologia* **5**, 117-124.
- Schaefer CW. 1977. Genital capsule of the trichophoran male (Hemiptera: Heteroptera: Geocorisae). *International Journal of Insect Morphology and Embryology* **6**, 277-301.

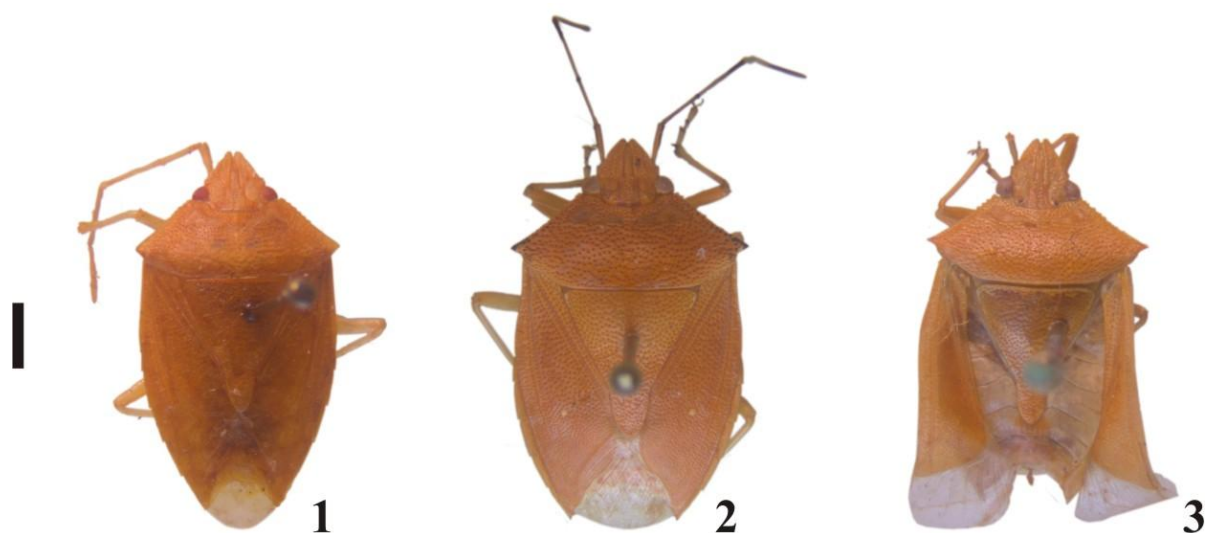
Stål C. 1867. Bidrag till Hemipterernas Systematik. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar* **24**, 491-560.

Thomas D B. 1992. *Eludocoris*: a new genus of Pentatomidae (Insecta: Heteroptera) from Costa Rica. *Annals of Carnegie Museum* **61**, 63-67.

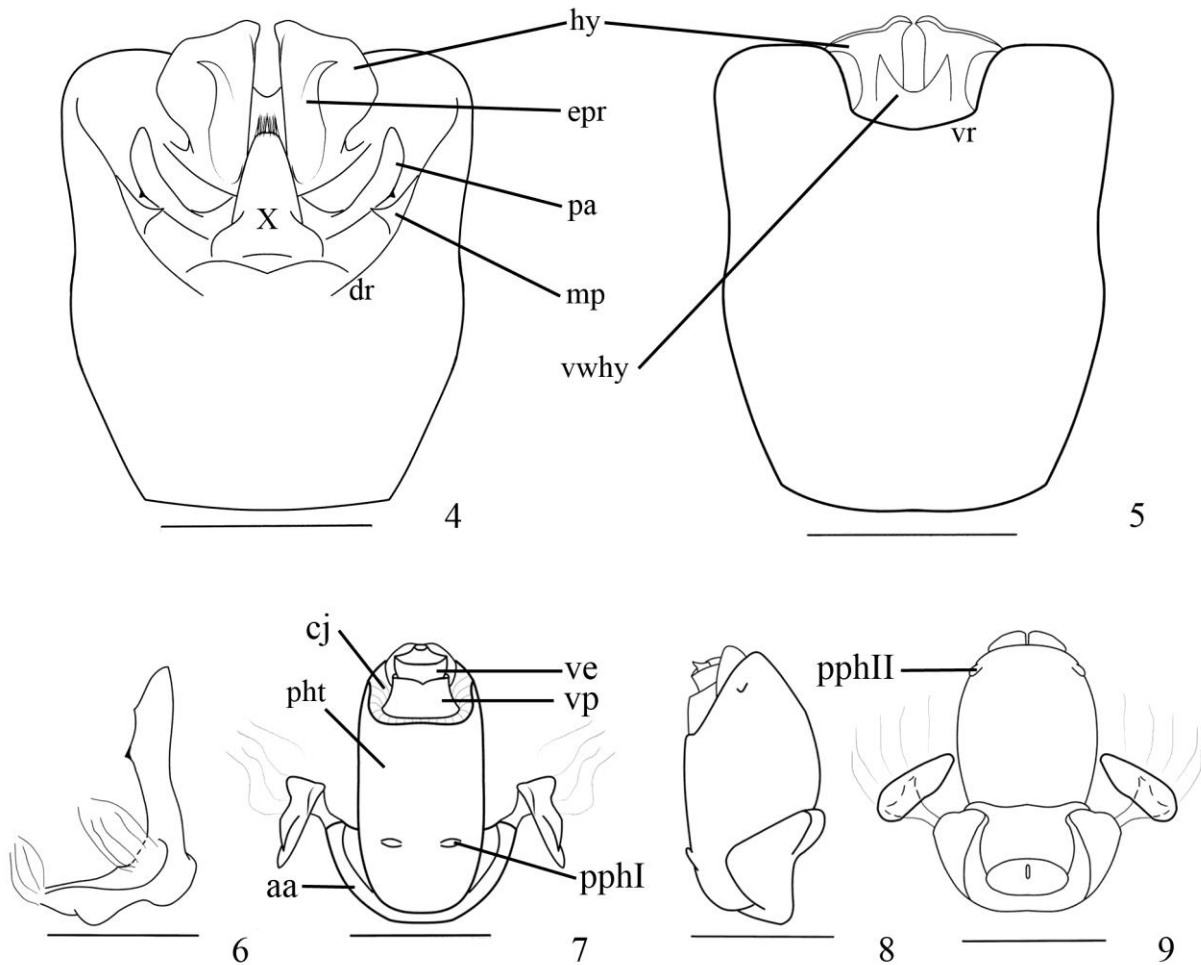
Thomas DB. 1998. A new species of *Chlorocoris* (Heteroptera: Pentatomidae) from Jamaica. Florida *Entomologist* **81**, 483-488.

Table 1. Morphometric parameters measurements (mean  $\pm$  standard deviation) of three new species of *Chloropepla* (in millimeters).

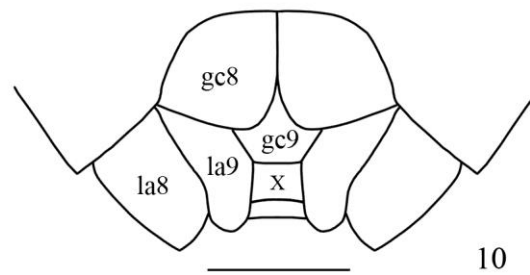
		sp. nov. 1		sp. nov. 2		sp. nov. 3	
		♂	♀	♂	♀	♂	♀
Body length		11.6 $\pm$ 0.1	12.8 $\pm$ 0.2	13.4 $\pm$ 0.1	14.0 $\pm$ 0.7	13.0	13.8 $\pm$ 0.3
Abdominal width		6.5 $\pm$ 0.2	7.1 $\pm$ 0.2	8.4	8.3 $\pm$ 0.3	7.3	7.6 $\pm$ 0.3
Head length		1.8	1.9 $\pm$ 0.1	2.1	2.1	2.4	2.5 $\pm$ 0.1
Head with		2.1 $\pm$ 0.1	2.3 $\pm$ 0.1	2.6 $\pm$ 0.1	2.6 $\pm$ 0.1	1.9	2.0 $\pm$ 0.1
Interocular distance		1.6	1.7	1.7	1.8 $\pm$ 0.1	1.7	1.7 $\pm$ 0.1
Antennal segments length	I	0.9 $\pm$ 0.1	0.9 $\pm$ 0.1	1.4 $\pm$ 0.1	1.2 $\pm$ 0.1	1.1	1.1 $\pm$ 0.1
	II	1.1	1.2 $\pm$ 0.1	1.7	1.7 $\pm$ 0.1	1.5	1.5 $\pm$ 0.1
	III	1.5 $\pm$ 0.1	1.5 $\pm$ 0.1	2.1 $\pm$ 0.1	2.0 $\pm$ 0.2	2.0	2.0 $\pm$ 0.1
	IV	1.5 $\pm$ 0.1	1.6	2.3 $\pm$ 0.1	2.2 $\pm$ 0.2	1.8	1.7 $\pm$ 0.1
	V	1.6 $\pm$ 0.1	1.6 $\pm$ 0.1	2.2 $\pm$ 0.2	2.1 $\pm$ 0.2	-	1.9 $\pm$ 0.1
Rostral segments length	I	0.9	1.0 $\pm$ 0.1	1.3	1.3 $\pm$ 0.1	1.1	1.2 $\pm$ 0.1
	II	1.4 $\pm$ 0.1	1.6 $\pm$ 0.1	2.1 $\pm$ 0.1	2.0	1.6	1.8 $\pm$ 0.1
	III	1.3	1.2 $\pm$ 0.1	1.6 $\pm$ 0.1	1.6 $\pm$ 0.1	1.5	1.5 $\pm$ 0.1
	IV	1.0	1.0 $\pm$ 0.1	1.3 $\pm$ 0.1	1.3 $\pm$ 0.1	1.2	1.3 $\pm$ 0.1
Pronotum length		2.0	2.3 $\pm$ 0.1	2.9 $\pm$ 0.1	2.9 $\pm$ 0.2	2.7	2.9 $\pm$ 0.1
Pronotum width		5.7 $\pm$ 0.1	6.3 $\pm$ 0.1	7.3 $\pm$ 0.2	7.1 $\pm$ 0.2	6.8	7.0 $\pm$ 0.1
Scutellum length		3.9 $\pm$ 0.1	4.3 $\pm$ 0.1	5.1 $\pm$ 0.1	5.2 $\pm$ 0.2	4.6	5.1 $\pm$ 0.1
Scutellum width		3.4 $\pm$ 0.1	3.7 $\pm$ 0.1	4.4 $\pm$ 0.1	4.4 $\pm$ 0.1	4.0	4.2 $\pm$ 0.1



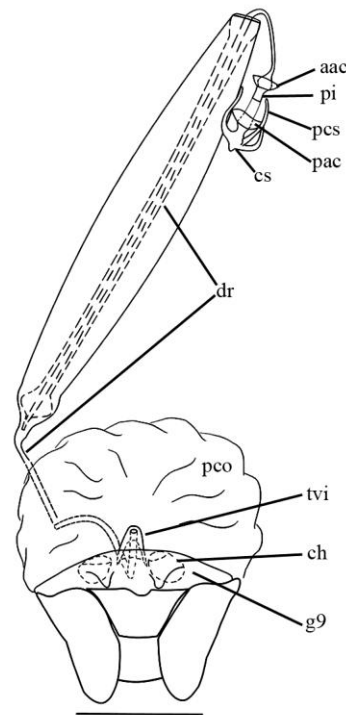
**Figs 1-3.** (1) *Chloropepla* sp. nov. 1 (male holotype); (2) *Chloropepla* sp. nov. 2 (male holotype); (3) *Chloropepla* sp. nov. 3 (male holotype). Scale line: 2 mm.



**Figs 4-9.** *Chloropepla* sp. nov. I: male external and internal genitalia: (4) pygophore in dorsal view; (5) pygophore in ventral view; (6) lateral view of left paramere; (7) posterior view of phallus; (8) lateral view of phallus; (9) anterior view of phallus. aa, articulatory apparatus; cj, conjuntiva; dr, dorsal rim; epr, elongated process of hypandrium; hy, hypandrium; mp; marginal process of dorsal rim; pa; paramere; pht, phallotheca; pphtI, processus phallothecae I; pphtII, processus phallothecae II; ve, vesica; vp, vesica collar process; vr; ventral rim; vw, ventral wall of hypandrium; X, segment X. Scale lines 1 mm (Figs 4-5), 0.5 mm (Figs 6-9).

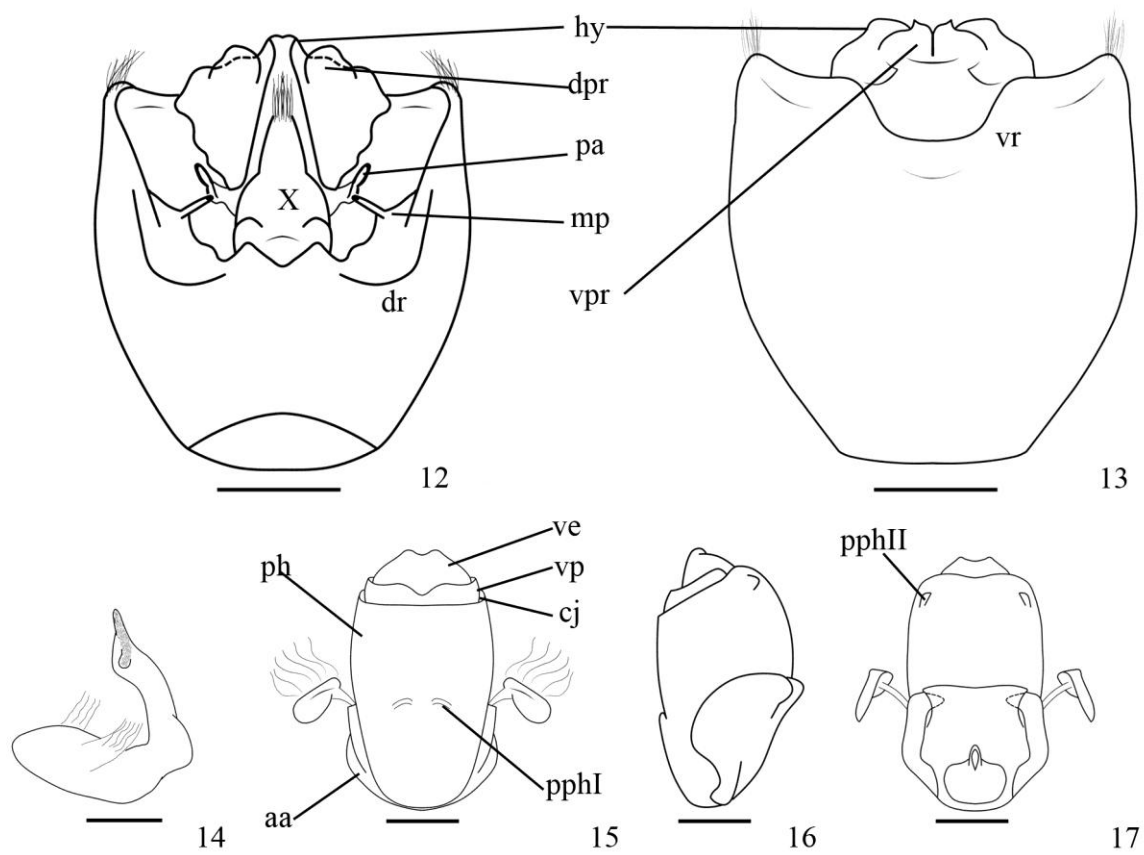


10

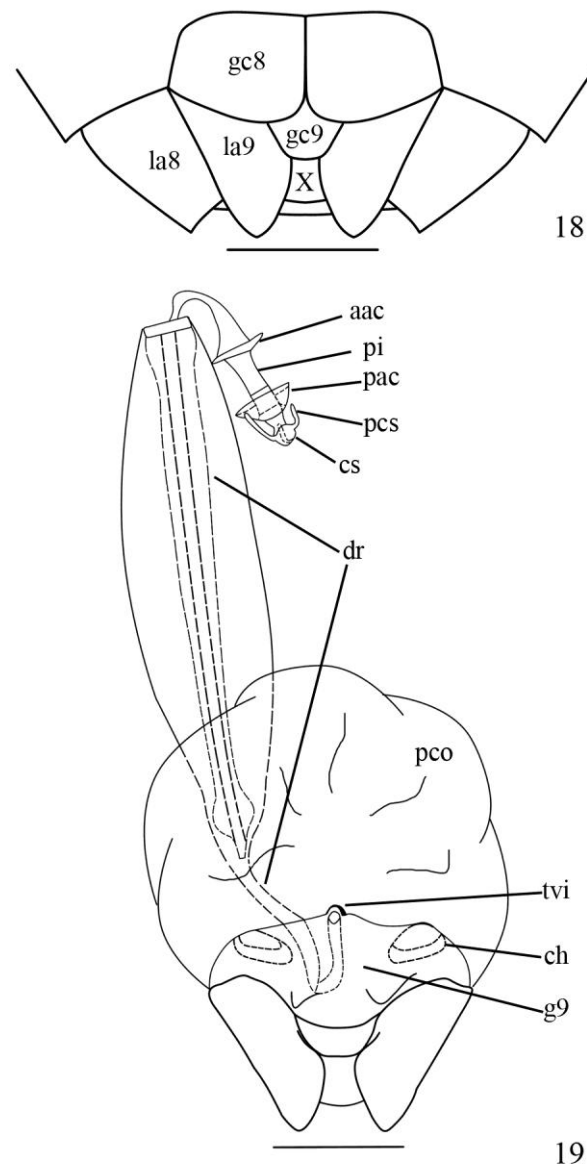


11

**Figs 10-11.** *Chloropepla* sp. nov. I: female external and internal genitalia: (10) genital plates; (11) gonocoxites and gonapophyses of ninth segment and ectodermal genital ducts. aac, anterior annular crest; cs, capsula seminalis; ch, chitinellipsen; g9, gonapophyses 9; gc8, gonocoxites 8; gc9, gonocoxites 9; la8, laterotergites 8; la9, laterotergites 9; pac, posterior annular crest; pco, pars communis; pi, pars intermedialis; tvi, thickening of vaginal intima; X, segment X). Scale lines 1 mm.

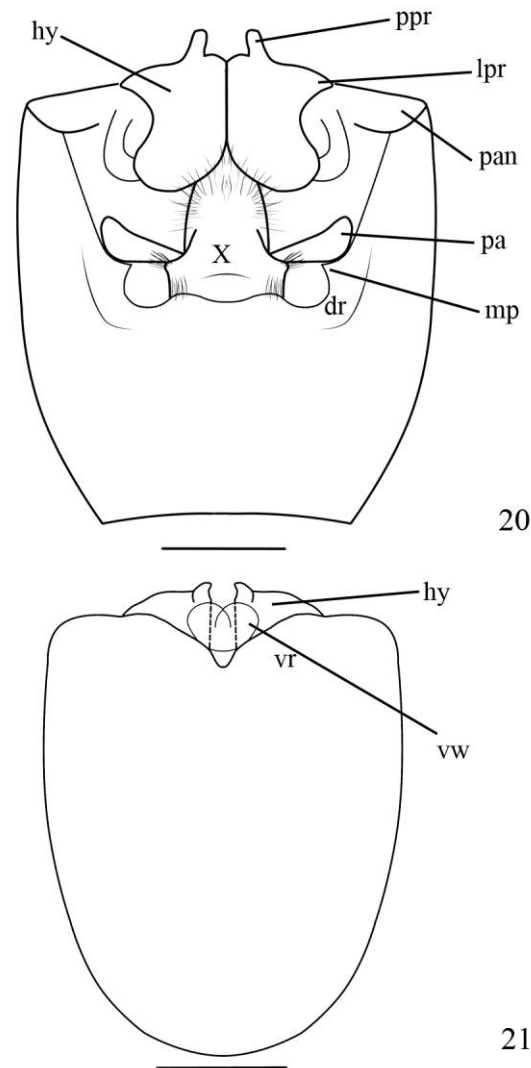


**Figs 12-17.** *Chloropepla* sp. nov. II: male external and internal genitalia: (12) pygophore in dorsal view; (13) pygophore in ventral view; (14) lateral view of left paramere; (15) posterior view of phallus; (16) lateral view of phallus; (17) anterior view of phallus. aa, articulatory apparatus; cj, conjuntiva; dr, dorsal rim; hy, hypandrium; dpr, dorsal process of hypandrium; mp; marginal process of dorsal rim; pa; paramere; pht, phallosome; pphtI, processus phallosomae I; pphtII, processus phallosomae II; ve, vesica; vp, vesica collar process; vpr, ventral process of hypandrium; vr, ventral rim; X, segment X. Scale lines 1 mm (Figs 12-13), 0.5 mm (Figs 14-17).

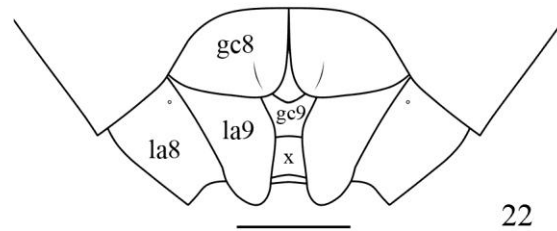


**Figs 18-19.** *Chloropepla* sp. nov. II: female external and internal genitalia: (18) genital plates; (19) gonocoxites and gonapophyses of ninth segment and ectodermal genital ducts. aac, anterior annular crest; cs, capsula seminalis; ch, chitinellipsen; g9, gonapophyses 9; gc8, gonocoxites 8; gc9, gonocoxites 9; la8, laterotergites 8; la9, laterotergites 9; pac, posterior annular crest; pco, pars communis; pi, pars intermedialis; tvi, thickening of vaginal intima; X, segment X). Scale lines 1 mm.

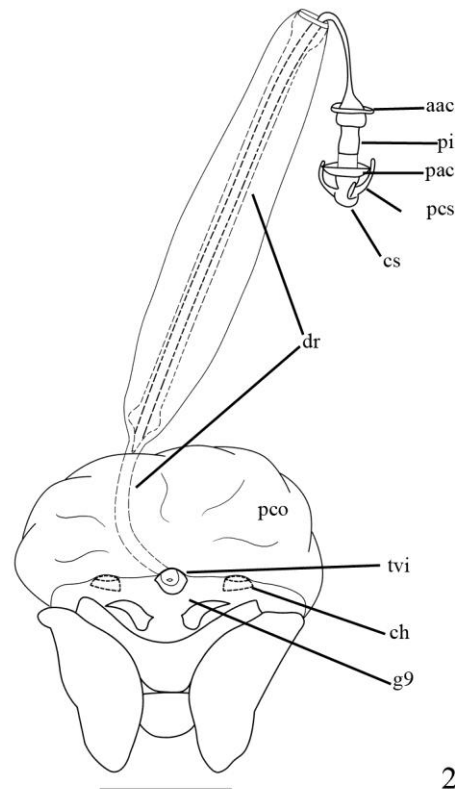




**Figs 20-21.** *Chloropepla* sp. nov. III: male external and internal genitalia: (20) pygophore in dorsal view; (21) pygophore in ventral view. dr, dorsal rim; hy, hypandrium; lpr, lateral process of hypandrium; mp, marginal process of dorsal rim; pa, paramere; pan, posterolateral angle of pygophore; ppr, posterior process of hypandrium; vr, ventral rim; vw, ventral wall of hypandrium; X, segment X. Scale lines 1 mm.



22



23

**Figs 22-23.** *Chloropepla* sp. nov. III: female external and internal genitalia: (22) genital plates; (23) gonocoxites and gonapophyses of ninth segment and ectodermal genital ducts. aac, anterior annular crest; cs, capsula seminalis; ch, chitinellipen; g9, gonapophyses 9; gc8, gonocoxites 8; gc9, gonocoxites 9; la8, laterotergites 8; la9, laterotergites 9; pac, posterior annular crest; pco, pars communis; pi, pars intermedialis; tvi, thickening of vaginal intima; X, segment X). Scale lines 1 mm.

### Capítulo 3

Normas editoriais Insects Systematics and Evolution

(<http://www.brill.nl/AuthorsInstructions/ISE.pdf>)

#### **Synopsis of the genus *Chloropepla* Stål (Hemiptera, Heteroptera, Pentatomidae), with cladistic and biogeographic analysis of the species**

##### **Abstract**

The genus *Chloropepla* (Pentatomidae) has 12 known species distributed from Costa Rica to South Brazil. The last revision of the group was done in 1968; since then, ten new species were added. The present work brings together the dispersed information about *Chloropepla*. A cladistics analysis was performed: 15 terminals (12 ingroup and 3 outgroup) and 26 morphological characters were submitted to a parsimony analysis. The monophyly of *Chloropepla* was confirmed, being supported by ostiolar ruga long and evanescent, wide hypandrium, with dorsal projections flanking the segment X, parameres cylindrical, dorsally directed, membranous conjunctiva reduced, almost entirely obscured by the phallotheca. An extended description of the genus and diagnosis for the species were elaborated, using the characters and results of the cladistic analysis as background. Based on the phylogenetic results and on the distributional data of *Chloropepla*, a Brooks Parsimony Analysis was performed. The BPA showed a near relation among the Amazonian areas and indicated a hybrid nature of the Chacoan subregion.

Key words: parsimony, Pentatominae, BPA, Neotropical region.

##### **Introduction**

The genus *Chloropepla* has 12 known species distributed in the Neotropical region, from Costa Rica to south Brazil. It was described by Stål, 1867, to include *Loxa vigens* Stål, 1860.

*Chloropepla* species have long and evanescent ostiolar rugae and the dorsal sulcus of the tibia is obsolete or absent. On the other hand, *Loxa* species show a short and truncated ostiolar ruga and the tibia are dorsally sulcated.

New species were added by Grazia (1968), with the description of *Chloropepla lenti*, based on specimens from Venezuela. Grazia (1969) described *Chloropepla nigrispina* based on specimens from Bolivia and Peru. This species was later synonymized to *Chlorocoris aurea* Pirán, 1963 and transferred to *Chloropepla* (Grazia-Vieira 1971). In addition Grazia-Vieira (1971) described *Chloropepla pirani*, based on a male from Bolivia belonging to the typical series of *C. nigrispina*. The female of *C. pirani* was mistakenly described by Grazia-Vieira (1972a) for three specimens from French Guyana. Later, these specimens were treated as a new species, *C. rolstoni* and the female of *C. pirani* was re-described based on a specimen from Bolivia (Grazia-Vieira 1973a). Grazia & Teradaira (1980) described *Chloropepla tucuruensis* based on specimens from Tucuruí, Pará, Brazil and presented a key to the identification of the species. *Chloropepla dollingi* was later described from Guyana and north of Brazil (Grazia 1987). In this paper the description of the male of *C. rolstoni*, based on a specimen from French Guyana, was provided. Grazia et al. (2008b) described two new species from Brazil: *Chloropepla paveli* from north, northeast and southeast regions, and *C. stysi* from north region; a key to the species containing the new taxa was presented. Finally, three new additions were made to the genus: *Chloropepla* sp. nov. 1 from Brazil (Bahia and Minas Gerais), *Chloropepla* sp. nov. 2 from Venezuela and north Brazil (Pará) and *Chloropepla* sp. nov. 3 from Costa Rica (Greve *et al.* submitted). An expanded key to the species was also included.

Several papers indicate a close relationship between *Chloropepla* with and genera of Pentatomidae (i.e. *Loxa*, *Chlorocoris*, *Fecelia*, *Mayrinia*, *Rhyncolepta* and *Eludocoris*) evidenced by shared characteristics of general and genitalia morphology. The main similarities of general morphology are the shape of the head, pronotum and scutellum, the development of humeral

angles in spines and the presence of a dorsal spine-like projection at the distal end of femur (Grazia 1968; 1976; Becker & Grazia-Vieira 1971; Grazia-Vieira 1972b; Eger 1978; Thomas 1992; 1998). In the male genitalia the presence of a ventral rim process of the pygophore, the “hypandrium” (Becker & Grazia-Vieira 1971) or “pygophoral appendages” (Thomas 1998) is also a characteristic shared by *Chloropepla* and the related genera. The phylogenetic relationships of these taxa are being investigated and will be published elsewhere.

The historical origins of the distributional patterns of the biota in the Neotropical region had been widely studied, producing different classifications systems for areas and several hypothesis of relation among these areas (Cracraft 1985; Amorim & Pires 1996; Morrone 2006). Among the main proposals of classification for the region are the one proposed by Amorim & Pires (1996) and the one proposed by Morrone (2001, 2006)

Amorim & Pires (1996) used phylogenetic and distributional data on entomofauna and establishes three main areas in the Neotropical region: Caribbean, Northwest Neotropical region and Southeast Neotropical region. According to this classification, the Amazonia consists in a composite area and can be divided in three components: north and southwest, closely related to Caribbean areas; and southeast, related to Atlantic forest formations (Amorim & Pires 1996).

The classification proposed by Morrone (2006) is based both on track and cladistic biogeographic analyses of the distributional patterns of entomofauna from Latin America and Caribbean. As result, the Netropical region was divided in four subregions: Caribbean, Amazonian, Chacoan and Parana. These subregions are subdivided in provinces. Morrone (2006) also describes transitions zones (areas where typical biotas of different regions overlaps). Contrary to Amorim & Pires (1996), that classification considers the Amazonian forest as a historical unit and includes data on dry areas from South America (Nihei & de Carvalho 2007; Sigrist & de Carvalho 2009). In the boundary between Neotropical and Andean region is located

the South American Transition Zone, characterized by the overlapping elements of both Neotropical and Andean faunas (Morrone 2004; 2006).

Two studies tested Morrone's (2001, 2006) and Amorim & Pires's (1996) proposals using Brooks Parsimony Analysis approach: Nihei & de Carvalho (2007) and Sigrist & de Carvalho (2009).

Nihei & de Carvalho's (2007) analyses, based on data on the Neotropical genus *Polietina* (Diptera), did not corroborate the hypothesis of areas and relationship between areas of Amorim & Pires (1996). On the other hand, when testing the areas proposed by Morrone (2001), they found better resolution while considering the Amazonia as a composite area, as proposed by Amorim & Pires (1996).

Similarly, Sigrist & de Carvalho (2009), analyzing 12 phylogenetically unrelated taxa (114 species) with distributions restricted to South America, suggested that the better classification for the Neotropical region includes the classification of Amorim & Pires (1996) for forested areas (especially Amazonian) and the classification of Morrone (2006) for non-forested areas.

In this paper a cladistics analysis of *Chloropepla* species is presented. The resultant hypothesis of relationship is used as framework for the synopsis of the information on the species. The genus is redescribed and new diagnoses for the species are provided. The geographical distribution of the taxa is also discussed, based on a Brook's Parsimony Analysis.

## **Materials and Methods**

The specimens analyzed belong to the following collections (acronyms and curators in parenthesis): American Museum of Natural History, New York, New York, United States of America (AMNH, R. T. Schuh); Coleção Zoológica Prof. Paulo Bürnheim, Fundação Universidade do Amazonas, Manaus, Amazonas, Brazil (CZPB, N. O. Aguiar); David Rider Collection, North Dakota State University, North Dakota, Fargo, (DRC, D. Rider); Departamento

de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil (UFRG, J. Grazia); Donald Thomas Collection, Weslaco, Texas, United States of America (DTC, D. Thomas); Fundação Instituto Oswaldo Cruz, Rio de Janeiro, Rio de Janeiro, Brazil (FIOC, J. Costa); Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBC, J. Lewis); Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil (MCNZ, A. Barcellos); Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZSP, C. Campaner); Museu Paraense Emilio Goeldi, Belém, Pará, Brazil (MPEG, O. T. Silveira); National Museum of Natural History, Washington D.C., United States of America (NMNH, T. Henry).

With a few exceptions *Chloropepla* specimens are rare in collections. The species *C. lenti*, *C. dollingi*, *C. pirani*, *C. tucuruensis* and *Chloropepla* sp. nov. I, II and III are known only by the type series. We were not able to analyze males of *C. pirani*, since the type is lost and no other specimen was available. Data on this species were inferred, whenever possible, from the literature (i.e. Grazia 1968; 1987; Grazia-Vieira 1971).

Female paratypes of *C. lenti*, *C. pirani*, *C. rositoni* and *C. dollingi* and the type series of *C. paveli*, *C. stysi* and *Chloropepla* sp. nov. I, II and III were analyzed.

The data matrix for cladistics analysis was composed of 15 terminals: the 12 known species of *Chloropepla* as ingroup and *Loxa deducta* Walker, 1867, *Rhyncholepta grandicallosa* Bergroth, 1911 and *Mayrinia curvidens* (Mayr, 1864) for outgroup comparison (*sensu* Nixon & Carpenter 1993), with the root on *R. grandicallosa*. These three species were chosen as exemplar-taxa because they represent the morphological diversity of genera they belong. The outgroup choice was based on information from literature, which indicates these genera as close related to *Chloropepla* by sharing characteristics of general morphology as well genitalia morphology (Grazia 1968; Becker & Grazia-Vieira 1971; Grazia-Vieira 1972b; Eger 1978).

A total of 26 morphological (12 multistates) characters were included (Table 1). Some of the characters were already used in phylogenetic studies within Pentatomidae (Barcellos & Grazia 2003; Fortes & Grazia 2005; Campos & Grazia 2006; Bernardes *et al.* 2009). Other characters are studied here for the first time. In the matrix, not applicable data (not possible to establish the homology) were coded “-” and missing data were coded “?” (usually because of the lack of specimens).

Illustrations of the characters were made using camera lucida adapted to the stereomicroscope. Pictures in different focus levels were obtained with the digital camera mounted on a stereomicroscope and composed with Helicon Focus<sup>®</sup>. Edition of all images were performed through Adobe Photoshop<sup>®</sup> CS2.

The following notations are used in the “Results and Discussion” section:  $X_y$ , to designate a character condition, where “X” is the number of the character and “y” corresponds to the condition of this character; “s”, to the number of steps; “ci”, to consistency index (Kluge & Farris 1969); and “ri”, to retention index (Farris 1989).

The data matrix was constructed using the WinClada (Nixon 2002). The numeric analysis was carried out with TNT 1.1 (Goloboff *et al.* 2008) using the implicit enumeration algorithm, with all characters equally weighted. All multistate characters were treated as non additive. The ambiguously distributed characters were not optimized. Branch support was assessed with Bremer support calculation (Goodman *et al.* 1982; Bremer 1994), retaining sub-optimal trees with up to 5 extra steps (5.250 trees retained), also using TNT. The number of steps, consistency and retention indexes for the cladogram and for each character were obtained with WinClada.

An extended description for the genus and diagnosis for the species were elaborated. The internal female genitalia of *C. paveli* is described for the first time (specimen labeled: “Dianópolis GO, Brasil 16-22.I.1962 J. Bechyné col.” (MZSP)). The average total length of each species is presented in millimeters.



Data on the distribution of *Chloropepla* species were obtained from analyzed specimens and from literature (original descriptions). Latitude and longitude of localities were search on the available databases like Global Gazetteer (Falling Rain Genomics 2009), World Gazetteer (2009), Gazetteer of Costa Rican Plant-Collecting Locales (MOBOT 2007). When it was not possible to determine the exact locality of some specimen, the data was not included. The coordinates were plotted in *georeferenced maps using the Quantum Gis software, Mimas version*.

A Brook's Parsimony Analysis (Brooks *et al.* 2001) was performed using the classification of areas of Neotropical region proposed by Morrone (2006), with modifications made by Nihei & de Carvalho (2007). The matrix and trees editing and viewing was made using WINCLADA. The parsimony analysis was performed by TNT, using the implicit enumeration algorithm.

## Results

### Characters

#### Head

Character 0 (Figs 1A,B). Juga, median margins: (0) not overlapping the apex of clypeus (Fig. 1A) (1) slightly overlapping the apex of clypeus (Fig. 1B). [s: 2;ci: 50, ri: 0]

In *Chloropepla* species the juga are convergent toward the apex, overlapping the clypeus at its distal end (Fig. 1A). This feature is evident because of the narrowing of the clypeus apex. It is observed in the whole genus *Chloropepla* and in *R. grandicallosa*.

#### Thorax

Character 1 (Figs 1C-E). Humeral angles: (0) produced in cylindrical spine, dorsally directed: (1) produced in cylindrical spine, laterally directed (Fig. 1C) (2) produced in pyramidal spine,

laterally or anteriorly directed (Fig. 1D) (3) triangular but not produced in spine (Fig. 1E). [s: 4; ci: 75; ri:75]

The shape and degree of humeral angle development are variable within Pentatomidae species, but can be useful to establish phylogenetic relations in different taxonomic categories (Grazia & Becker 1997; Fortes & Grazia 2005; Grazia *et al.* 2008a; Bernardes *et al.* 2009). The humeral angles developed in spine, in addition to the outgroup, are found in *C. aurea*, *C. pirani*, *Chloropepla* sp. nov. 3 and *C. vicens*. However, the shape of humeral spine of *C. vicens* is highly modified in relation to the other *Chloropepla*. If compared to outgroup, *C. vicens* has laterally oriented spines, instead of dorsally oriented, as in *L. deducta* and *R. grandicallosa*.

Character 2 (Figs 1D, E). Humeral angle coloration: (0) margins outlined in black (Fig. 1D) (1) margins concolor (Fig. 1E). [s:5; ci: 20, ri: 20]

The humeral angles of *C. aurea*, *C. pirani* and *C. rositoni* are outlined in black (Fig. 1D); dark punctures may co-occur. *Mayrinia curvidens* also shows this feature. The presence of a black line is not linked to the development of humeral angles into spines.

Character 3. Pale yellow callus at apex of radial vein: (0) present (1) absent. [s: 2; ci: 50; ri: 66]

Several groups of Pentatomidae have a pale yellow callus in the discal region of the corium, near the apex of the radial vein. In the ingroup, this callus is absent in *C. aurea* and *C. pirani*.

Character 4 (Figs 2A,b). Ostiolar ruga: (0) short, rounded at apex, not surpassing half of the width of the evaporatorium area (Fig. 2A) (1) long, evanescent, extending for at least 2/3 of the evaporatorium area (Fig. 2B). [s:1; ci:100; ri:100]

Species of Pentatomidae have the ostiolar ruga elongated, reaching or surpassing the mid-point of the metapleurum (Gapud 1991). This condition is considered apomorphic but has multiple origins in the family (Gapud 1991). In this study all the species of *Chloropepla* have a long ostiolar ruga which extend for at least 2/3 of the metapleurum width and have evanescent apex (Fig. 2B). In outgroup the ostiolar ruga is short, not surpassing the half of the metapleurum width, with rounded apex (Fig. 2A).

Character 5 (Figs 2C,D). Mesosternum carina: (0) weak (Fig. 2C) (1) strong, forming a conspicuous keel (Fig. 2D). [unif]

The mesosternum forms a conspicuous keel in all the species analyzed except *M. curvidens*.

Character 6 (Figs 2E-G). Femur apical spine: (0) moderate (Fig. 2E) (1) inconspicuous (Fig. 2F) (2) strong (Fig. 2G). [s:4; ci: 50; ri:71]

This character considers the development of the dorsal spine-like projection at the distal end of femur, feature highly variable in Pentatomidae. However, the degree of development of this projection already proved to be useful in grouping species in phylogenetic hypothesis (Bernardes *et al.* 2009). “Inconspicuous” is the lower degree of development: only a tiny blunt projection is present (Fig. 2F). The “moderately produced” state refers to the intermediate degree of development, characterized by the presence of a small pyramidal projection (Fig. 2E). The apical projection is “strongly produced” in *C. vigens* and *Chloropepla* sp. nov. 1. In these species the femora bear a big and acute spine like projection at the distal end (Fig. 2G).

### Female genitalia

Character 7 (Figs 3A,B). Posterior margins of gonocoxites 8: (0) slightly convex or sub-rectilinear (Fig. 3A) (1) strongly triangular (Fig. 3B). [s: 1; ci: 100; ri: 100]

The posterior margins of gonocoxites 8 are variable in shape. The condition strongly triangular is shared only by *C. tucuruiensis* and *C. dollingi* (Fig. 3B).

Character 8 (Fig. 3C) Gonocoxites 8 surface: (0) entirely flat (1) posterior third deflected (Fig. 3C). [s:2; ci:50; ri: 0]

The surface of the posterior third of gonocoxites 8 varies from flat to deflected. Gonocoxites 8 deflected is characterized by the presence of a small concavity in the deflected portion and occurs in *C. stysi* and *C. rolstoni*.

Character 9 (Figs 3D,E). Gonocoxites 9: (0) long (Fig. 3D) (1) short, anterior margin placed backward to the laterotegites 9 anterior margins (Fig. 3E). [s: 2; ci: 50; ri: 80]

The gonocoxites 9 of the analyzed species may be longer than wide or wider than long. The anterior margin of gonocoxites 9 trapezoidal, long is placed nearly at the same level as laterotegites 9 anterior margins, forming a straight or slightly concave line (Fig. 3D). The anterior margin of gonocoxites 9 trapezoidal, short is placed backward to the laterotegites 9 anterior margins, forming a strongly concave line (Fig. 3E). This condition is shared in the ingroup by *Chloropepla* sp. nov. 2, *C. stysi*, *C. rolstoni*, *C. dollingi* and *C. tucuruiensis*. It is found also in *R. grandicallosa*.

Character 10 (Figs 3D-F). Thickening of vaginal intima: (0) inconspicuous or reduced to small plate (Fig. 3F) (1) in a hood-like structure (Fig. 3E) (2) in a short tube (Fig. 3G) (3) in a long tube (Fig. 3D). [s: 4; ci: 75; ri: 85]

The thickening of vaginal intima consists of a sclerite which surrounds the orificium receptaculi, probably homologous with the second valvulae (Grazia *et al.* 2008a). Typically this structure is composed of a pair of antero-posteriorly oriented sclerites (Grazia *et al.* 2008a). In the species studied the thickening of vaginal intima varies from an inconspicuous or reduced plate to a well developed tube. The “hood-like” state consists of a curved plate, placed anteriorly to the orificium receptaculi (Fig. 3E); it is found in *Chloropepla* sp. nov. 2, *C. stysi*, *C. rositoni*, *C. dollingi* and *C. tucuruensis*. The “short tube” state is characterized by a ring-like plate that surrounds the proximal part of the ductus receptaculi (Fig. 3G). The “long tube” state consists of a tube with almost the same length as the gonapophyses 9 (Fig. 3D); it is shared by *C. vicens*, *C. paveli* and *Chloropepla* sp. nov. 1.

Character 11 (Figs 3H,I). Capsula seminalis, processes: (0) short, reaching the posterior annular flange (Fig. 3H) (1) at least one long, surpassing the posterior annular flange or reaching the anterior annular flange (Fig. 3I). [s: 2; ci: 50; ri: 66]

All the species studied have three processes arising from capsula seminalis. In the ingroup *C. lenti*, *C. vicens*, *C. paveli* and *Chloropepla* sp. nov. I have at least one process which surpasses the posterior annular flange and usually reaches the anterior annular flange (Fig. 3I).

### Male genitalia

Character 12 (Figs 4 A-D). Pygophore, marginal process of the dorsal rim: (0) absent (1) present, triangular (Figs 4A,B) (2) present, digitiform (Figs 4C,D). [s: 2; ci: 100; ri: 100]

The structures referred by Grazia & Teradaira (1980) and Grazia (1987) as “processes of diaphragm” are here treated as marginal processes of dorsal rim. The shape of these processes in the ingroup can be triangular or digitiform. This variation in shape is associated to a variation in the position of the process inside genital cup: digitiform processes are more deeply placed as a result of a major infolding of the dorsal rim (Figs 4C,D).

Schaefer (1977) highlights the importance of the infold of the dorsal rim which is variable within Pentatomomorpha. According to Schaefer (1977) the more deeply infolded condition is considered to be more advanced.

Character 13 Figs 4E,F). Pygophore, ventral rim: (0) with median excavation in “U” or “V”, in a continuous trajectory (Fig. 4E) (1) median excavation in “U” with apices strongly angulated (Fig. 4F). [s: 2; ci: 50; ri: 80]

The median excavation of ventral rim in all the species analyzed is “U” or “V” shaped. However, the trajectory described by the ventral rim varies. In *C. stysi*, *C. rolstoni*, *C. dollingi*, *C. tucuruensis*, *Chloropepla* sp. nov. 1 and 2 the excavation shows sub-acute angles at the apices of the “U” (Fig. 4F). In the other species, the trajectory of the ventral rim is continuous, not forming angles (Fig. 4E).

Character 14 (Fig. 4G). Pygophore, processes of ventral rim: (0) absent (1) present, tubercle like (Fig. 4G) (2) present, reduced to a carina. [s: 2; ci: 100; ri: 100]

Some *Chloropepla* species may have 1+1 processes in the internal surface of ventral wall, near the ventral rim, laterad of the median excavation. The shape of these processes is variable. They are tubercle as in *Chloropepla* sp. nov. 2, *C. stysi*, and *C. tucuruensis* (Fig. 4G), and reduced to a carina in *Chloropepla* sp. nov. 3 and *C. aurea*.

Character 15 (Figs 4H-I). Hyandrium (0) short (Fig. 4H) (1) long, not flanking the segment X (Fig. 4I) (2) long, flanking the segment X (Fig. 4J). [s: 2; ci: 100; ri: 100]

The pygophore can bear an elongation in the median portion of the internal ventral wall, known as hyandrium (*sensu* Dupuis 1970). This structure is observed in the species analyzed in this study as well as in other genera of the family: *Fecelia*, *Rideriana* and *Chlorocoris* (Grazia 1976; Thomas 1998; Grazia & Frey-da-Silva 2003). The hyandrium is highly variable in shape and size, being useful in the characterization of genera and sometimes of species. *Loxa deducta* and *M. curvidens* show a triangular hyandrium, shorter than parameres and only visible in ventral view (Fig. 4H) (state 0). It is the shortest hyandrium among the studied species. *Rhyncholepta grandicallosa* bear a wide, flat hyandrium which surpasses the ventral rim in almost the half of its length, being visible from both ventral and dorsal sides (Fig. 4I) (state 1). In *Chloropepla* species the hyandrium is also well developed, surpassing the ventral rim and being visible from ventral and dorsal sides (Fig. 4J) (state 2). But, the hyandrium in *Chloropepla* is unique in having dorsal expansions forming a structure where the segment X rests. Beside, in *Chloropepla* the ventral wall shows a deeper infolding than in *Rhyncholepta*. The expansions from the ventral wall of the pygophore are recognized as features with taxonomic and phylogenetic importance (Baker 1931; Schaefer 1977).

Character 16 (Figs 4E,F,L). Hyandrium, ventral wall: (0) flat (Fig. 4E); (1) forming a channel-like structure (Fig. 4L); (2) with processes, ventrally projected (Fig 4F). [s: 3; ci: 66; ri: 85]

In the ventral wall of the hyandrium processes may be absent or present, or a channel-like structure may appear. The ventral wall of hyandrium flat, without process, has approximately the same length as the dorsal portion of the hyandrium. This characteristic is found in the

outgroup terminals *L. deducta* and *M. curvidens* and in the ingroup species *C. vicens*, *C. paveli*, and *Chloropepla* sp. nov. 1 (Fig. 4E). The ventral wall of hypandrium in a channel-like structure is characterized by a strongly curved ventral wall, almost forming a tube, sometimes with a gutter-like structure at middle, ventrally directed; the ventral wall is shorter than the dorsal expansion (Fig. 4L) and is found in *C. lenti*, *Chloropepla aurea*, *C. pirani* and *Chloropepla* sp. nov. 3. The ventral wall of the hypandrium with processes is defined by the presence of a process, bilobed in *R. grandicallosa*, *C. tucuruensis*, *C. rosltoni*, *C. stysi* and *Chloropepla* sp. nov. 2, and digitiform in *C. dollingi* (Fig. 4F).

Character 17 (Figs 4M,N). Segment X, processes: (0) absent (2) present, in 1+1 tubercles (Fig. 4M) (3) present, in 1+1 carina (Fig. 4N). [s: 2; ci: 100; ri: 100]

The segment X of *Chloropepla* species has a constriction in its basal third where 1+1 tubercles can be observed (Fig 4M), except in *C. vicens*, *C. paveli* and *Chloropepla* sp. nov. 1. In these species the basal third of the segment X is laterally carinated (Fig. 4N).

Character 18. Paramere, shape and position (Figs 4A,O,P): (0) wide with several processes (Fig. 4O); (1) nearly cylindrical, posteriorly directed (Fig. 4P); (2) nearly cylindrical, dorsally directed (Fig. 4A) . [s: 2; ci: 100; ri: 100]

The parameres are very variable in shape and size (Baker 1931; Dupuis 1970). They have important characters which are useful to diagnose genera and species. *Loxa deducta* and *M. curvidens* have both laminar parameres with a variable number of processes (Grazia-Vieira 1972b; Eger 1978) (Fig. 4O). In the other hand, the parameres of *Chloropepla* are nearly cylindrical without conspicuous processes (Figs 4A,P). In *C. vicens*, *C. paveli* and *Chloropepla* sp. nov. 1 the parameres are clearly posteriorly directed (Fig. 4P). All the other species of



*Chloropepla* have dorsally directed parameres (Fig. 4A). Parameres are absent in *Rhyncolepta grandicallosa*.

Character 19 (Figs 5A,B). Paramere, median spine: (0) present (Fig. 5A) (1) absent (Fig 5B).  
[s:1; ci: 50; ri: 80]

In the studied species the parameres have one or two spine-like projections at the lateral surface (Fig. 5A). When only one projection was present it was considered apical and the median spine absent (state 1).

Character 20 (Figs 5B,C). Paramere, microsculpture: (0) absent (1) present, conspicuous (Fig. 5B) (2) present, reduced (Fig. 5C). [s: 2; ci: 100; ri: 100]

Part of the lateral surface of the parameres of *C. stysi*, *C. rositoni*, *C. tucuruiensis* and *Chloropepla* sp. nov. 2 is clearly darker with a rough texture (Fig. 5B). This area is in contact with the marginal process of dorsal rim which is more deeply placed inside the genital cup than in the remaining *Chloropepla* species. In *C. aurea* and *Chloropepla* sp. nov. 3 the parameres have also a texturized area, smaller and much less pigmented than in the species mentioned above (Fig. 5C).

Character 21 (Fig. 5D). Phallus, processus phallothecae 1: (0) present (Fig. 5D) (1) absent. [s: 3; ci: 33; ri: 60]

The *processus phallothecae* 1 are small structures, strongly sclerotized and occurring in pairs in the basal half of the posterior surface of the phallotheca (Fig. 5D). Here “posterior surface” has the same meaning as “dorsal wall” in the original descriptions of the species (Grazia 1968; 1969;

Grazia-Vieira 1971; 1972a; 1973a; Grazia & Teradaira 1980; Grazia 1987). This terminology is preferred because it reflects the rest position of the phallus inside the pygophore. The occurrence of these structures is widely spread within Pentatomidae species. In this study, it occurs in the outgroup species *L. deducta* and *M. curvidens* and in the ingroup species *C. aurea*, *C. pirani*, *C. lenti*, *Chloropepla* sp. nov. 1, *Chloropepla* sp. nov. 2 and *C. stysi*.

Character 22 (Fig. 5E). Phallus, processus phallothecae 2: (0) present (Fig. 5E) (1) absent. [s: 3; ci: 33; ri: 50]

The *processus phallothecae* 2 occur in pairs, at the angles of the distal margin of the anterior surface of the phallotheca (Fig. 5E) and are characteristic of several groups of Pentatomidae. Here, “anterior surface” means the same as “ventral wall” in the original descriptions of the species (see explanation in character 21). In the analyzed species this structure is usually ear-like and is present in all taxa except for *R. grandicallosa*, *L. deducta*, *C. vogens*, *C. paveli* and *C. rosltoni*.

Character 23 (Figs 5F-H). Conjunctiva: (0) absent (Fig. 5F) (1) reduced, completely obscured by the phallotheca (Fig. 5G) (2) conspicuous, membranous, laterally flattened (Fig. 5H). [s: 2; ci: 100; ri: 100]

The variation in the shape and size of the conjunctiva is an important taxonomic character in Pentatomoidea (Leston 1955). Gapud (1991) analyzing the Pentatomidae family indicates a tendency to the reduction of the conjunctiva in some groups. This reduction can be characterized by reduction of the size or by the complete sclerotization of conjunctiva, with loss of membranous parts. The complete loss of membranous parts can be observed in some Edessini, Discocephalinae and in some neotropical Pentatominae genera as in *Loxa* and *Chlorocoris*

(Gapud 1991). All the species of *Chloropepla* show a reduction in the size of the conjunctiva which is membranous and almost completely obscured by the phallotheca (Fig. 5G).

Character 24 (Figs 5D,G,H). Vesica: (0) in a long tube (Fig. 5H) (1) in a short tube (Fig. 5G) (2) bulbous (Fig. 5D). [s: 2; ci: 100; ri: 100]

In the ingroup the vesica may be a short tube (Fig. 5G) (not surpassing or slightly surpassing the most distal margin of phallotheca) or may be bulb-like conspicuously wider than the ductus seminis distalis, enlarging from base to apex (Fig. 5D). This condition is observed in *C. stysi*, *C. rolstoni*, *C. dollingi*, and *C. tucuruiensis*. In the outgroup the vesica is tube like with a constant diameter involving the ductus seminis distalis along its way (Fig. 5H) and is longer than in *Chloropepla* species, far surpassing the most distal margin of phallotheca.

Character 25 (Fig. 5D). Vesica, collar like process: (0) absent (1) present (Fig. 5D). [s: 2; ci: 50; ri: 0]

The collar-like process on the base of vesica was described for *C. lenti* and *C. vigens* (Grazia 1968). Subsequent descriptions treated this structure as belonging to conjunctiva (Grazia 1969; Grazia-Vieira 1971; Grazia & Teradaira 1980; Grazia 1987). Here the character is interpreted as a process of vesica (*sensu* Grazia 1968). This process is observed in all species of *Chloropepla* and in *L. deducta*.

### Cladistic Analysis

The parsimony analysis of 15 terminals, 25 informative characters resulted in one most parsimonious cladogram with 61 steps (Fig. 6), consistency index of 65 and retention index of 77.

The monophyly of the genus *Chloropepla* is evidenced by four non-homoplastic synapomorphies: ostiolar ruga long and evanescent (4<sub>1</sub>), wide hypandrium, with dorsal projections flanking the segment X (15<sub>2</sub>), paremeres cylindrical, posteriorly directed (18<sub>1</sub>), membranous conjunctiva reduced, almost entirely obscured by the phallotheca (23<sub>1</sub>) (Fig. 6).

The clade formed by *Chloropela* sp. nov.1 + *C. vicens* + *C. paveli* is the sister group of the remaining *Chloropepla* species and is sustained by having at least one long process in the capsula seminalis surpassing the posterior annular flange or reaching the anterior annular flange (11<sub>1</sub>).

The branch gathering the remaining species of *Chloropepla* is defined by four synapomorphies: femur apical process inconspicuous (6<sub>1</sub>), processes of ventral rim of pygophore reduced to a carina (14<sub>2</sub>), ventral wall of hypandrium in a channel like structure (16<sub>1</sub>), microsculpture on lateral surface of paramere reduced (20<sub>2</sub>).

The first dichotomy among these species separates *C. lenti* from the remaining species. Those are divided in two main groups: one with *Chloropepla* sp. nov. 3 + *C. aurea* + *C. pirani*, and the other composed by *Chloropepla* sp. nov. 2 + *C. stysi* + *C. rolstoni* + *C. dollingi* + *C. tucuruiensis*. The *Chloropepla* sp. nov. 3 ++ branch is sustained by humeral angles produced in pyramidal spine, laterally directed (1<sub>2</sub>) and femur apical process moderately produced (6<sub>0</sub>).

The clade *Chloropepla* sp. nov. 3 ++ is the best supported (Bremer support = 5) by eight characters: gonocoxites 9 short (9<sub>1</sub>), thickening of vaginal intima in a hood-like structure (10<sub>1</sub>), marginal process of the dorsal rim of pygophore digitiform (12<sub>2</sub>), median excavation of ventral

rim of pygophore in “U” with apices strongly angulated (13<sub>1</sub>), processes of ventral rim of pygophore tubercle like (14<sub>1</sub>), ventral wall of hypandrium with process (16<sub>2</sub>); median spine of paramere absent (19<sub>1</sub>); and microsculpture on lateral surface of paramere conspicuous (20<sub>1</sub>).

*Chloropepla* Stål. 1867

**Diagnosis.** Small to medium sized. Head triangular, juga surpassing clypeus. Synapomorphies: ostiolar ruga long, evanescent, extending over at least 2/3 of the evaporatorium area; hypandrium surpassing ventral margin of pygophore, with dorsal expansions flanking segment X; basal third of segment X with 1+1 tubercle-like or carina-like processes; paramere nearly cylindrical, dorsally or posteriorly directed; reduced membranous conjunctiva, almost entirely obscured by phallosome; vesica in a short tube.

Color. Dark green, reddish brown or pale yellow in dry preserved specimens. Probably green in life. Concolor to ferruginous punctures. External margins of juga and humeral angles concolor or lined by black. Humeral angles with or without black punctures near the black line. Antennal segments concolor or with black stripes of variable size. Lateral margins of dorsal surface of tibia with or without black line or black punctures.

Small (average length 10.4 mm of *C. paveli*) to medium (15.96 mm of *C. dollingi*) sized species.

General shape oval.

Head triangular, wider than long or width and length approximately equal. Juga longer than clypeus; lateral margins convex or sinuous. Buccula evanescent, reaching base of head, anterior angle rounded or angulated. Proportion among antennal segments length variable: usually increasing from I to V, sometimes with III longest or sub-equal to IV (in this case, IV shorter than V), sometimes with IV and V sub-equal.

Pronotum trapezoidal; anterior half or 2/3 of antero-lateral margins crenulated. Humeral angles produced in spines of variable shape or triangular (not produced in spine).

Scutellum covering more than half of abdomen; rounded apex, posterior forth slightly constricted. Corium of hemelytra longer than scutellum; yellow callous at apex of radial vein present or not. Tibia dorsally flat with sulcus of variable length. Dorsal spine-like projection at the distal end of femur with variable degree of development: from inconspicuous to strongly produced.

Abdomen strongly or slightly convex.

Male genitalia. Pygophore rectangular or quadrangular. Lateral third of dorsal rim plain or deeply infolded, bearing triangular (in plain or slightly infolded rim) or digitiform process (in deeply infolded rim). Ventral rim concave, “V” or “U” shaped. Ventral wall deeply infolded inside the genital capsule bearing a strongly developed process, the hypandrium. Hypandrium surpassing ventral rim, with dorsal expansions flanking segment X; ventral wall of hypandrium flat, developed or not in a process, or channel-like. Segment X parallel to the longitudinal axis of pygophore, constricted on the basal third or half; constriction line flanked by 1+1 tubercle-like process or base of segment X flanked by 1+1 carina; apex ogival, narrower than base. Parameres nearly cylindrical narrowing from base toward apex, sometimes with dilated apex; bearing one (apical) or two (apical and medial) spine-like projections on the lateral surface, near the apex. Phallosome cylindrical, slightly curved posteriorly; processus phallosomae 1 and 2 present or absent. Vesica short slightly surpassing the posterior margin of the phallosome; in a narrow tube or in a bulbous-like structure, conspicuously wider than ductus seminis distalis. Base of vesica surrounded by a collar like process.

Female genitalia. Gonocoxites 8 usually convex, some species with a small concavity in the posterior third; posterior margins sub-rectilinear or triangular; at least posterior third of sutural margins divergent. Posterior angles of laterotergites 9 variable in shape, always surpassing the posterior end of body. Gonocoxites 9 trapezoidal. Gonapophyses 9 bearing sclerotized areas of variable shape. Thickening of vaginal intima tube or cone shaped, with variable length, or

reduced to a small hood-like structure. Capsula seminalis globular or nearly conical, bearing three processes with variable size among species. At least the basal half of pars intermedialis striated.

Distribution: Costa Rica, Venezuela, French Guyana, Guyana, Bolivia, Brazil (AM, PA, RN, TO, DF, MT, MG, RJ, SP, SC, RS), Argentina, Uruguay.

*Chloropepla* sp. nov. 1

Diagnosis. Small size (male: 11.6; female: 12.8). Male. Pygophore rectangular, almost 0.2 times longer than wide. Lateral thirds of dorsal rim slightly folded toward genital capsule; marginal processes of dorsal rim triangular. Median excavation of ventral rim “U” shaped, with apices strongly angulated. Dorsal expansions of hypandrium wide, bearing 1+1 elongate process extending from the base to almost the apex of the expansion. Paramere club shaped, with apical and medial spines. Processus phallothecae 1 and 2 present. Vesica bulbous, wider than final portion of ductus seminis. Female. Gonocoxites 8 rectangular; apical third of sutural margins divergent. Laterotergites 8 slightly longer than 9, apical angle acute in laterotergites 8 and rounded in 9. Anterior thickening of vaginal intima tube shaped, nearly as long as gonapophyses 9. Processes of capsula seminalis: two surpassing the posterior annular flange in almost half of their length, the third nearly reaching the anterior annular flange.

Distribution: Brazil (Bahia, Minas Gerais)

*Chloropepla vigens* (Stål, 1860)

Diagnosis. Medium size (12.4) (Grazia 1968). Humeral angles produced in a cylindrical spine, laterad directed (autapomorphy). Male. Pygophore rectangular, almost as long as wide. Dorsal rim plain, not folded toward the genital capsule. Dorsal expansion of hypandrium narrow, with rounded apices. Apex of paramere enlarged, with apical and medial spines. Vesica in a narrow tube, slightly wider than ductus seminis. Female. Gonocoxites 8 quadrangular; posterior third of

sutural margins divergent. Laterotergites 8 longer than laterotergites 9, posterior angle slightly acute. Posterior angle of laterotergites 9 rounded. Capsula seminalis processes: two reaching the posterior annular flange, the third almost reaching the anterior annular flange.

Distribution: Brazil (DF new occurrence, RJ, SP, SC, RS)

*Chloropepla paveli* Grazia, Schwertner & Greve, 2008

Diagnosis. Small size (male: 10.4; female: 11.3). Male. Pygophore trapezoidal. Lateral thirds of dorsal rim not infolded. Dorsal expansion of hypandrium narrow. Apex of paramere spatulate; apical and medial spines present. Vesica in a narrow tube, slightly wider than ductus seminis.

Female. Gonocoxites 8 quadrangular; posterior third of sutural margins divergent. Laterotergites 8 and 9 subequal, with rounded apex.

Female (Fig. 7). Gonocoxites 9 (Fig. 7, gc9) trapezoidal, longer than wide. Gonapophyses 9 (Fig. 7, g9) with 1+1 hatchet-like sclerotized areas. Thickening of vaginal intima (Fig. 7, tv) conical, tube like; long, with almost the same length as gonapophyses 9. Capsula seminalis (Fig. 7, cs) conical, with three cylindrical processes: two slightly surpassing the free margin of posterior annular flange (Fig. 7, paf), the third surpassing half of the pars intermedialis (Fig. 7, pi) length.

Distribution: Bolivia (Santa Cruz, Cochabamba), Brazil (RN, TO, MG, RS).

*Chloropepla lenti* Grazia, 1968

Diagnosis. Medium size (14.1) (Grazia 1968). Male. Pygophore rectangular, longer than wide. Median excavation of ventral rim “U” shaped, in a continuous trajectory. Dorsal projection of hypandrium narrow; apex with globular expansions (Grazia 1968). Paramere narrowing from base to apex, with apical and medial spines (Grazia 1968). Phallosome with processus phallosomae 1 and 2 (Grazia 1968). Female. Gonocoxites 8 triangular. Apex of laterotergites 8 strongly acute. Laterotergites 9 longer than laterotergites 8. Two processes of the capsula seminalis reaching the posterior annular flange, the third surpassing it (Grazia, 1968).

Distribution: Venezuela (Carabobo).



*Chloropepla* sp. nov. 3

Diagnosis. Medium size (male: 13.0; female: 13.8). Male. Pygophore triangular, almost as long as wide. Postero-lateral angles flat, quadrangular. Marginal process of dorsal rim triangular. Median excavation of ventral rim “V” shaped. Dorsal expansion of hypandrium wide, with two narrow, apical rounded processes: one laterad directed and other backward directed. Parameres spatulated, lateral surface bearing two spine-like processes; dorsally directed. Female. Gonocoxites 8 quadrangular; apical fourth of sutural margins divergent; transversal carina arising from the sutural angles. Laterotergites 8 and 9 equal in length; posterior angle of laterotergites 8 acute; posterior angle of laterotergites 9 rounded. Gonocoxites 9 trapezoidal, strongly convex. Anterior thickening of vaginal intima in a ring like structure. Processes of capsula seminalis: two reaching the free margin of posterior annular flange, the third shorter.

Distribution: Costa Rica (Guanacaste, Alajuela)

*Chloropepla aurea* (Pirán, 1963)

Diagnosis. Medium size (male: 14.1; female: 14.3) (Grazia 1969). Lateral margins of jugum convex, outlined by black. Humeral angles and dorsal sulcus of tibia outlined by black. Male. Pygophore rectangular, longer than wide. Median excavation of ventral rim “V” shaped. Dorsal projection of hypandrium wide, apices nearly acute. Apex of paramere wedge shaped; apical and medial spines present. Phallosome bearing one pair of acute processes in its posterior surface (processus phallosomae 1) and one pair of ear-like processes in its anterior surface (processus phallosomae 2). Vesica with bifurcate process at apex. Female. Gonocoxites 8 nearly pentagonal; sutural margins divergent at posterior half. Apical angles of laterotergites 8 acute, longer than laterotergites 9. Proximal two thirds of pars intermedialis striated. Processes of capsula seminalis: two reaching the posterior annular flange, one third shorter, not reaching the base of capsula seminalis.

Distribution: Bolivia (Cochabamba, La Paz), Brazil (MT, new occurrence), Peru (San Martín)

*Chloropepla pirani* Grazia-Vieira, 1971

Diagnosis. Medium size (male: 14; female: 15.99) (Grazia-Vieira 1971). Lateral margins of juga sinuous. Humeral angles produced in pyramidal spine, outlined by black. Male. Pygophore quadrangular, almost as long as wide; posterolateral angles projected toward median line; median third of dorsal rim projected onto segment X in a biconvex elevation. Median excavation of ventral rim deeply “U” shaped. Dorsal projection of hypandrium wide, ventral and dorsal walls with nearly the same length. Paramere bearing only the apical spine. Phallotheca with processus phallotheca 1 and 2. Vesica tubular, secondary gonopore racket shaped on posterior view (Grazia-Vieira 1971). Female. Gonocoxites 8 pentagonal; posterior third of sutural margins divergent. Latergites 8 longer than laterotergites 9. Proximal two thirds of pars intermedialis striated. Capsula seminalis bearing three processes reaching the free margin of posterior annular flange (Grazia-Vieira 1973).

Distribution: Bolivia (Cochabamba, La Paz).

*Chloropepla* sp. nov. 2

Diagnosis. Medium size (male: 13.4; female: 14.0). Anterior margin of humeral angles with dark line. Male. Pygophore quadrangular, nearly as long as wide. Dorsal expansions of hypandrium wide, with laminar process near the apex. Paramere cylindrical at the base and spatulated at the apex. Processus phallothecae 1 and 2 present. Female. Gonocoxites 8 quadrangular; apical fourth of sutural margins divergent. Laterotergites 8 and 9 equal in length, both with nearly acute apex. Processes of capsula seminalis: one reaching the free margin of posterior annular flange, the other two shorter.

Distribution: Venezuela (Amazonas), Brazil (PA).

*Chloropepla stysi* Grazia Schwertner & Greve, 2008

Diagnosis. Medium size (male: 12.6; female: 14.3). Male. Pygophore rectangular, longer than wide. Lateral thirds of dorsal rim infolded toward the genital capsule. Dorsal expansion of

hypandrium wide; ventral wall of hypandrium with bilobed process and 1+1 medial tumescent areas. Paramere spatulate. Processus phallosomae 1 and 2 present. Female. Gonocoxites 8 subquadrangular; posterior fourth of sutural margins divergent. Laterotergites 8 and 9 subequal, with rounded apex. Processes of capsula seminalis: two processes reaching the posterior annular flange, the third barely surpassing it.

Distribution: Ecuador (Napo), Brazil (AM).

*Chloropepla rosltoni* Grazia-Vieira, 1973

Diagnosis. Medium size (male: 14.61; female: 14.1) (Grazia-Vieira 1973, Grazia 1987). Humeral angles outlined by black. Male. Pygophore quadrangular, almost as long as wide. Dorsal expansions of hypandrium narrow, posteriorly convergent; ventral wall with apical bilobed process and 1+1 medial mushroom-like processes. Paramere narrowing from base toward apex. Phallosoma without processes. Secondary gonopore U-shaped. Female. Gonocoxites 8 quadrangular; sutural margins parallel in the whole extension. Laterotergites 8 and 9 nearly equal in length. Pars intermedialis striated in the anterior two thirds. Two processes of capsula seminalis barely reaching the posterior annular flange, the third nearly reaching the posterior margin of this flange (Grazia-Vieira 1972).

Distribution: French Guyana (Guyane), Bolivia (La Paz), Brazil (AM, new occurrence).

*Chloropepla dollingi* Grazia, 1987

Diagnosis. Medium size (male: 15.96; female: 16.29) (Grazia 1987). Male. Pygophore rectangular, a bit longer than wide. Dorsal expansion of hypandrium narrow, with lateral margins concave; ventral wall with digitiform process. Paramere narrowing from base toward apex. Secondary gonopore projecting beyond the vesica. Female. Gonocoxites 8 posterior margin triangular; posterior third of sutural margins divergent. Laterotergites 8 slightly shorter than 9. Internal genitalia similar to *C. tucuruensis* (Grazia 1987).

Distribution: Brazil (PA), Guyana.

*Chloropepla tucuruiensis* Grazia & Teradaira, 1980

Diagnosis. Medium size (male: 12.93; female: 13.66) (Grazia & Teradaira 1980). Male. Pygophore triangular, a bit longer than wide. Dorsal projection of hypandrium widening from base toward apex; ventral wall with apical bilobed process and 1+1 medial triangular processes. Paramere narrowing from base toward apex. Processus phallothecae 2 ear-like; processus phallothecae 1 absent (Grazia & Teradaira 1980). Female. Gonocoxites 8 posterior margin triangular; posterior third of sutural margins divergent. Laterotergites 9 slightly shorter than laterotergites 8; both with acute apex. Basal half of pars intermedialis striated. The three processes of capsula seminalis reaching the posterior annular flange (Grazia & Teradaira 1980). Distribution: Brazil (PA, MT).

### Biogeographic Considerations

*Chloropepla* species are distributed exclusively in the Neotropical region (*sensu* Amorim & Pires 1996) or in the Neotropical region and South American Transition Zone (*sensu* Morrone 2006).

The largest number of records of the clade *Chloropepla* sp. nov. 1 + are in eastern and southern Brazil. *Chloropepla paveli* is the species most widely distributed, being registered in eastern and central Bolivia, central Brazil (Tocantins state), northeast Brazil (Rio Grande do Norte), southeast Brazil (Minas Gerais state) and southern Brazil (Rio Grande do Sul state). *Chloropepla* sp. nov. 1 occurs in northeast Brazil (Minas Gerais and Bahia states), while *C. vicens* is distributed from northeast to south Brazil (Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul states).

*Chloropepla lenti* is registered only in Venezuela, while *Chloropepla* sp. nov. 3 occurs in Costa Rica and *Chloropepla aurea* is found in north Peru, northwestern and central Brazil (in Amazonas and Mato Grosso states) and in Bolivia. *Chloropepla pirani* occurs in west Bolivia.

The clade *Chloropepla* sp. nov. 3 + occurs mainly in north region of South America. *Chloropepla stysi* is registered in northeast Ecuador and in north Brazil, Amazonas state. In the same state is found *C. rolstoni*, which also occurs in French Guyana. Still in north Brazil, Pará state, are registered *C. tucuruensis*, *C. dollingi* and *Chloropepla* sp. nov. 2. Additionally, *C. tucuruensis* found in central Brazil, Mato Grosso state, *C. dollingi* is registered in south Guyana and *Chloropepla* sp. nov. 2 occurs in south Venezuela.

#### Brook's Parsimony Analysis

The areas of occurrence of each species according to the classification proposed by Nihei & de Carvalho (2007) are shown in Figure 8.

The analysis using the subregions as terminals (Tab. 2) resulted in one most parsimonious cladogram with 32 steps, consistence index of 68 and retention index of 56 (Fig. 9A). The areas were distributed in three main branches: one composed by Caribbean subregion, one by Chacoan and Parana subregions, and another by South American Transition Zone + Amazonian components. The SWAm appears as sister group of SEAm+Nam. On opposition that found by Nihei & de Carvalho (2007), our results sustained the Amazonia region as an historical unit, in agreement with Morrone (2001, 2006).

When performing the BPA using the provinces of Chacoan subregion as terminals (Table 2), one most parsimonious tree was obtained with 29 steps, consistency index 75 and retention index 80 (Fig. 9B). The Parana subregion was maintained as terminal since only the monophyletic clade *Chloropepla* sp. nov. 1+ occurs there. In this tree, the areas are divided in two main branches: one composed by Cerrado + Parana + Caatinga + Pampa and the other by the Caribbean subregion as sister from the remaining areas. The South American Transition Zone and the Chaco province appear in the same branch with the clade composed by the Amazonian components. These results show the hybrid nature of the Chacoan subregion, as already

hypothesized by other studies. Sigrist & de Carvalho's (2009) results showed Cerrado and Chaco provinces clustered in the Amazonian component. The Parana provinces are together in a branch, while Caatinga and Pampa appear in a polytomy, as sisters of the remaining areas.

Morrone et al. (2004) found that the Chaco province has a complex biota, with Amazonian, Parana and Patagonian elements. Still, the Cerrado presents elements of both Chacoan and Amazonian biotas, being formerly included in the Amazonian domain (Morrone 2006). Moreover, a phylogeographic analysis of Costa (2003) showed evidence of the existence of connections between small mammalian fauna from Amazonian and Atlantic forest through the Chacoan subregion, probably due to forested corridors found especially in the Brazilian Cerrado (Silva 1996). Testing this hypothesis, Porzecanski & Cracraft (2005) found that the removal of the avian forest species from a Cladistic Analysis of Distribution and Endemism (CADE) test resulted in better definition of the Central South America area relation, with a strongly supported clade formed by Chaco and Cerrado areas, closely related to Caatinga.

## References

- Amorim, D.S. (2002) Fundamentos de sistemática filogenética. Holos Ribeirão Preto: 154 pp.
- Amorim, D.S. & Pires, M.R.S. (1996) Neotropical biogeography and a method for maximum biodiversity estimation. In: Bicudo, C.E.M. & Menezes, N.A. (eds.) Biodiversity in Brazil: a first approach. CNPq, São Paulo, Brazil: pp. 183-219.
- Amyot, C.J. & Serville, A. (1843) Histoire Naturelle des Insectes. Hémipteres. Librairie Encyclopedique de Roret, Paris: lxxvi + 675 pp.
- Baker, A.B. (1931) A study of male genitalia of Canadian species of Pentatomidae. *Canadian Journal of Research* **4**: 148-179.
- Barcellos, A. & Grazia, J. (2003) Cladistics analysis and biogeography of *Brachystethus* Laporte (Heteroptera, Pentatomidae, Edessinae). *Zootaxa* **256**: 1-14.
- Becker, M. & Grazia-Vieira, J. (1971) Sobre o gênero *Rhyncholepta* Bergroth, 1911, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia* **31**: 389-399.
- Bernardes, J.L.C., Schwertner, C.F. & Grazia, J. (2009) Cladistic analysis of *Thoreyella* and related genera (Hemiptera: Pentatomidae: Pentatominae: Procliticini). *Zootaxa*: 1-23.
- Brailovsky, H. (1981) Revision del genero *Arvelius* Spinola (Hemiptera-Heteroptera-Pentatomidae-Pentatomini). *Instituto de Biología Universidad Nacional-Autónoma de México – Série Zoologica* **51**: 239-298.
- Brailovsky, H., Cervantes, L. & Mayorga, C. (1992) Hemiptera: Heteroptera de México 44. Biología, estadios ninfales y fenología de la tribu Pentatomini (Pentatomidae) en la Estación de Biología Tropical 'Los Tuxtlas', Veracruz. . *Universidad Nacional Autónoma de México Instituto de Biología Publicaciones Especiales* **8**.
- Bremer, K. (1994) Branch support and tree stability. *Cladistics* **10**: 295-304.

- Brooks, D.R., van Veller, M.G.P. & McLennan, D.A. (2001) How to do BPA, really. *Journal of Biogeography* **28**: 345-358.
- Campos, L.A. & Grazia, J. (2006) Análise cladística e biogeografia de Ochlerini (Hemiptera, Pentatomidae, Discocephalinae). *Iheringia - Série Zoologia* **96**: 147-163.
- Costa, L.P. (2003) The historical bridge between the Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography with small mammals. *Journal of Biogeography* **30**: 71-86.
- Cracraft, J. (1985) Historical biogeography and patterns of differentiation within the South American avifauna: areas of endemism. In: Buckley, P.A., Foster, M.S., Morton, E.S., Ridgley, R.S. & Buckley, F.G. (eds.) Ornithological Monographs no. 36. The American Ornithologists' Union, Washington, D. C.: pp. 49-84.
- Dupuis, C. (1970) Heteroptera. In: Tuxen, S.L. (ed.), Taxonomist's Glossary of Genitalia of Insects. Munksgaard, Copenhagen: pp. 190-208
- Eger, J.E.J. (1978) Revision of the genus *Loxa* (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society* **86**: 224-259.
- Eger, J.E.J. (1980) *Fecelia biorbis* n. sp. (Heteroptera: Pentatomidae), a new species from Haiti. *Journal of the New York Entomological Society* **88**: 29-32.
- Ernis, D.J. & Kluge, A.G. (1993) Taxonomic congruence versus total evidence, and Amniote phylogeny inferred from fossils, molecules, and morphology. *Molecular Biology and Evolution* **10**: 1170-1195.
- Falling Rain Genomics. (2009) Global Gazetteer. <http://www.fallingrain.com/world/> (accessed March 2010).
- Ferrari, A., Grazia, J. & Schwertner, C.F. (2010) Review, cladistic analysis and biogeography of *Nezara* Amyot & Serville (Hemiptera: Pentatomidae). *Zootaxa* **2424**: 1-41.
- Fortes, N.D.F. & Grazia, J. (2005) Review and cladistic analysis of *Serdia* Stal (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira De Entomologia* **49**: 294-339.



- Froeschner, R.C. (1988) Family Pentatomidae Leach, 1815. The stink bugs. In: Henry, T.J. & Froeschner, R.C. (eds.) *Catalog of the Heteroptera, or true bugs, of Canada and the Continental United States*. E.J. Brill, New York: pp. 958.
- Gapud, V.P. (1991) A generic revision of the subfamily Asopinae, with consideration on its phylogenetic position in the family Pentatomidae and superfamily Pentatomoidea (Hemiptera-Heteroptera). *Philippines Entomology* **8**: 865-961.
- Gilbert, M.T.P., Moore, W., Melchior, L. & Worobey, M. (2007) DNA Extraction from Dry Museum Beetles without Conferring External Morphological Damage. *PLoS ONE* **2**: e272.
- Goloboff, P.A., Farris, J.S. & Nixon, K.C. (2008) TNT, a free program for phylogenetic analysis. *Cladistics* **24**: 774-786.
- Grazia-Vieira, J. (1971) Sobre uma nova combinação, uma sinonímia e a descrição de uma nova espécie de *Chloropepla* Stal (Hemiptera, Pentatomidae, Pentatomini). *Papeis Avulsos de Zoologia* **24**: 207-211.
- Grazia-Vieira, J. (1972a) Contribuição ao conhecimento do gênero *Chloropepla* Stal (Hemiptera, Pentatomidae, Pentatomini). *Anais da Sociedade Entomológica do Brasil* **1**: 42-45.
- Grazia-Vieira, J. (1972b) O gênero *Mayrinia* Horvath, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Revista Peruana de Entomologia* **15**: 117-124.
- Grazia-Vieira, J. (1973a) *Chloropepla rolstoni*, uma nova espécie de Pentatomini (Hemiptera, Pentatomidae): uma correção. *Anais da Sociedade Entomológica do Brasil* **2**: 13-19.
- Grazia-Vieira, J. (1973b) Uma nova espécie de *Mayrinia* Horvath, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Iheringia - Serie Zoologia*: 25-33.
- Grazia, J. (1968) Sobre o genero *Chloropepla* Stal, 1867, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia* **28**: 193-206.
- Grazia, J. (1969) Una nueva especie del Genero *Chloropepla* Stal, 1867 (Hemiptera, Pentatomidae, Pentatomini). *Neotropica* **15**: 1-12.

- Grazia, J. (1976) Revisão do gênero *Fecelia* Stal, 1872 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia* **36**: 229-237.
- Grazia, J. (1977) Revisão dos pentatomídeos citados no “Quarto catálogo dos insetos que vivem nas plantas do Brasil”(Hemiptera-Pentatomidae-Pentatomini). *Dusenía* **10**: 161-174.
- Grazia, J. (1980) Uma nova espécie do gênero *Fecelia* Stal (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia* **40**: 261-266.
- Grazia, J. (1987) Novas contribuições ao gênero *Chloropepla* Stal, 1867 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Entomologia* **31**: 473-477.
- Grazia, J. (1997) Cladistics analysis of the Evoplitus genus group of Pentatomini (Heteroptera, Pentatominae). *Journal of Comparative Biology* **2**: 115-129.
- Grazia, J. & Becker, M. (1997) Adevoplitus, a new genus of Neotropical Pentatomini (Heteroptera, Pentatomidae). *Journal of the New York Entomological Society* **103**: 386-400.
- Grazia, J. & Frey-Da-Silva, A. (2001) Descrição dos imaturos de *Loxa deducta* Walker e *Pallantia macunaima* Grazia (Heteroptera: Pentatomidae) em Ligustro, *Ligustrum lucidum* Ait. *Neotropical Entomology* **30**: 73-80.
- Grazia, J. & Frey-da-Silva, A. (2003) Rideriana amazonica gen. nov. and sp. nov. of Pentatomini (Heteroptera, Pentatomidae). *Revista Brasileira de Zoologia* **20**: 507-510.
- Grazia, J., Schuh, R.T. & Wheeler, W.C. (2008a) Phylogenetic relationships of family groups in Pentatomoidea based on morphology and DNA sequences (Insecta: Heteroptera). *Cladistics* **24**: 932-976.
- Grazia, J., Schwertner, C.F. & Greve, C. (2008b) Two new species of genus *Chloropepla* (Hemiptera: Pentatomidae: Pentatominae) from Brazil. *Acta Entomologica Musei Nationalis Pragae* **48**: 533-542.

- Grazia, J. & Teradaira, C.T. (1980) Nova espécie de *Chloropepla* Stal, 1867 coletada em Tucuruí, Pará, Brasil (Heteroptera, Pentatomidae). *Anais da Sociedade Entomológica do Brasil* **9**: 123-131.
- Greve, C., Schwertner, C.F. & Grazia, J. (submitted) Three new species of *Chloropepla* (Heteroptera: Pentatomidae: Pentatominae). *Australian Journal of Entomology*.
- Hasan, S.A. & Kitching, I.J. (1993) A cladistic analysis of the tribes of the Pentatomidae (Heteroptera). *Japanese Journal of Entomology* **61**: 651-669.
- Hennig, W. (1968) Elementos de una sistemática filogenética. Editorial Universitária, Buenos Aires: 353 pp.
- Henry, T.J. (1997) Phylogenetic analysis of family groups within the infraorder Pentatomomorpha (Hemiptera: Heteroptera), with emphasis on the Lygaeoidea. *Annals of the Entomological Society of America* **90**: 275-301.
- Hillis, D.M. (1987) Molecular versus morphological approaches to systematics. *Annual Review of Ecology and Systematics* **18**: 23-42.
- Hillis, D.M. & Wiens, J.J. (2000) Molecules versus morphology in systematics: Conflicts, artifacts, and misconceptions. In: Wiens, J.J. (ed.), *Phylogenetic analysis of morphological data*. Smithsonian Institution Press, Washington D.C.: pp. 220.
- Kluge, A.G. (1989) A concern for evidence and a phylogenetic hypothesis of relationships among Epicrates (Boidae, Serpentes). *Systematic Zoology* **38**: 7-25.
- Kluge, A.G. (1998) Total evidence or taxonomic congruence: Cladistics or consensus classification. *Cladistics* **14**: 151-158.
- Kluge, A.G. (2004) On total evidence: for the record. *Cladistics* **20**: 205-207.
- Kluge, A.G. & Grant, T. (2006) From conviction to anti-superfluity: old and new justifications of parsimony in phylogenetic inference. *Cladistics* **22**: 276-288.
- Kluge, A.G. & Wolf, A.J. (1993) Cladistics - What's in a word. *Cladistics* **9**: 183-199.

- Leston, D. (1955) The function of the conjunctiva in copulation of a shield bug, *Piezodorus lituratus* (Fabricius) (Hemiptera, Pentatomidae). *Journal of the Society for British Entomology* **5**: 101-105.
- Li, H.M., Deng, R.Q., Wang, J.W., Chen, Z.Y., Jia, F.L. & Wang, X.Z. (2005) A preliminary phylogeny of the Pentatomomorpha (Hemiptera : Heteroptera) based on nuclear 18S rDNA and mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution* **37**: 313-326.
- Link, D. & Grazia, J. (1987) Pentatomidae da região central do Rio Grande do Sul. *Anais da Sociedade Entomológica do Brasil* **16**: 115-129.
- Mishler, B.D. (1994) Cladistic analysis of molecular and morphological data. *American Journal of Physical Anthropology* **94**: 143-156.
- Mishler, B.D. (2005) Logic of the data matrix in phylogenetic analysis. In: Albert, V.A. (ed.), *Parsimony, Phylogeny and Genomics*. Oxford University Press, Oxford: pp. 229.
- MOBOT. (2007) Gazetteer of Costa Rican Plant-Collecting Locales. <http://www.mobot.org/MOBOT/Research/costaricagaz.shtml> (accessed March 2010).
- Morrone, J.J. (2001) Biogeografía de América Latina y el Caribe. MT - Manuales & Tesis SEA, Zaragoza, 3: 148 pp.
- Morrone, J.J. (2004) La Zona de Transición Sudamericana: caracterización y relevancia evolutiva. *Acta Entomologica Chilena* **28**: 41-50.
- Morrone, J.J. (2006) Biogeographic areas and transition zones of Latin America and the Caribbean islands based on panbiogeographic and cladistic analyses of the entomofauna. *Annual Review of Entomology* **51**: 467-494.
- Morrone, J.J., Mazzucconi, S.A. & Bachmann, A.O. (2004) Distributional patterns of chacoan water bugs (Heteroptera : Belostomatidae, Corixidae, Micronectidae and Gerridae). *Hydrobiologia* **523**: 159-173.

- Murrell, A., Campbell, N.J.H. & Barker, S.C. (2001) A total-evidence phylogeny of ticks provides insights into the evolution of life cycles and biogeography. *Molecular Phylogenetics and Evolution* **21**: 244-258.
- Nei, M. & Kumar, S. (2000) Molecular evolution and phylogenetics. Oxford University Press, New York: pp.
- Nihei, S.S. & de Carvalho, C.J.B. (2007) Systematics and biogeography of *Polietina* Schnabl & Dziedzicki (Diptera, Muscidae): Neotropical area relationships and Amazonia as a composite area. *Systematic Entomology* **32**: 477-501.
- Nixon, K.C. (2002) WinClada. 1.00.08, Published by the author, Ithaca, NY.
- Nixon, K.C. & Carpenter, J.M. (1993) On outgroups. *Cladistics* **9**: 413-426.
- Ortega-Leon, G. & Chavez-Bermeo, N. (2008) A new species of the genus *Arvelius* spinola (Hemiptera : Heteroptera : Pentatomidae : Pentatomini) from Mexico. *Proceedings of the Entomological Society of Washington* **110**: 643-646.
- Panizzi, A.R., Mourão, A.P.M. & Oliveira, E.D.M. (1998) Nymph and ault biology and seasonal abundance of *Loxa deducta* (Walker) on privet, *Ligustrum lucidum*. *Anais da Sociedade Entomológica do Brasil* **27**: 199-206.
- Panizzi, A.R. & Rossi, C.E. (1991) Efeito da vagem e da semente de *Leucena* e da vagem de soja no desenvolvimento de ninfas e adultos de *Loxa deducta* (Hemiptera: Pentatomidae). *Revista Brasileira de Biologia* **51**: 607-613.
- Panizzi, A.R. & Slansky, F. (1985) Review of phytophagous pentatomids (Hemiptera, Pentatomidae) associated with soybean in the Americas. *Florida Entomologist* **68**: 184-214.
- Porzecanski, A.L. & Cracraft, J. (2005) Cladistic analysis of distributions and endemism (CADE): using raw distributions of birds to unravel the biogeography of the South American aridlands. *Journal of Biogeography* **32**: 261-275.

Rider, D. (2008) Pentatomoidea home page.

<http://www.ndsu.nodak.edu/nsdu/rider/Pentatomoidea/> (accessed 01/07/08).

Schaefer, C.W. (1977) Genital capsule of the tricophoran male (Hemiptera: Heteroptera: Geocorisae). *International Journal of Insect Morphology and Embriology* **6**: 277-301.

Schuh, R.T. (1986) The Influence of Cladistics on Heteropteran Classification. *Annual Review of Entomology* **31**: 67-93.

Schuh, R.T. & Brower, A.V.Z. (2009) Biological systematics: principles and applications. Cornell University Press, Ithaca: 311 pp.

Schuh, R.T. & Slater, J.A. (1995) True bugs of the world (Hemiptera: Heteroptera). Classification and natural history. Cornell University Press, Ithaca: 337 pp.

Sigrist, M.A. & de Carvalho, C.J.B. (2009) Relacionamentos históricos entre áreas endêmicas na região tropical da América do Sul utilizando a Análise de Parcimônia de Brooks (BPA). *Biota Neotropica* **9**: 1-12.

Silva, J.M.C. (1996) Distribution of Amazonian and Atlantic birds in gallery forests of the cerrado region, South America. *Ornitologia Neotropical* **7**: 1-18.

Spinola, M. (1837) Essai sur les genres d'insectes appartenants B l'ordre des HémiptPres, Lin. ou Rhyngotes, Fab. et B la section des HétéroptPres, Dufour. Yves Graviers, Genova: 383 pp.

Stål, C. (1867) Bidrag till Hemipterernas Systematik. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar* **24**: 491-560.

Thomas, D.B. (1985) Revision of the genus *Chlorocoris* Spinola (Hemiptera: Pentatomidae). *Annals of the Entomological Society of America* **78**: 674-699.

Thomas, D.B. (1992) *Eludocoris*, a new genus of Pentatomidae (Insecta: Heteroptera) from Costa Rica. *Annals of Carnegie Museum* **61**: 63-67.

Thomas, D.B. (1998) A new species of *Chlorocoris* (Heteroptera: Pentatomidae) from Jamaica. *Florida Entomologist* **81**: 483-488.

- Varón, A., Vinh, L.S. & Wheeler, W.C. (2010) POY version 4: phylogenetic analysis using dynamic homologies. *Cladistics* **26**: 72-85.
- Wheeler, Q.D. (2008) Undisciplined thinking: morphology and Hennig's unfinished revolution. *Systematic Entomology* **33**: 2-7.
- Wheeler, W.C. (2005) Alignment, Dynamic Homology, and Optimization. In: Albert, V.A. (ed.), Parsimony, Phylogeny, and Genomics. Oxford University Press, New York: pp. 229.
- Whiting, M.F., Carpenter, J.C., Wheeler, Q.D. & Wheeler, W.C. (1997) The Strepsiptera problem: phylogeny of the holometabolous insect orders inferred from 18S and 28S ribosomal DNA sequences and morphology. *Systematic Biology* **46**: 1-68.
- Wiens, J.J. (2004) The role of morphological data in phylogeny reconstruction. *Systematic Biology* **53**: 653-661.

Table 1. Character state matrix for the cladistic analysis of *Chloropepla*: “-” code for inapplicable data, “?” code for missing data.

	1										2									
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9
<i>Rhyncolepta grandicallosa</i>	1	0	0	1	0	1	2	0	0	1	2	1	0	0	0	1	2	0	--	0
<i>Mayrinia curvidens</i>	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
<i>Loxa deducta</i>	0	0	1	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Chloropepla</i> sp. nov. 3	1	2	1	0	1	1	0	0	0	2	0	1	0	2	2	1	1	2	0	2
<i>C. aurea</i>	1	2	0	1	1	1	0	0	0	2	0	1	0	2	2	1	1	2	0	2
<i>C. pirani</i>	1	2	0	1	1	1	0	0	?	0	2	0	1	0	?	2	1	?	2	1
<i>C. lenti</i>	1	3	1	0	1	1	1	0	0	2	0	1	0	2	2	1	1	1	0	2
<i>Chloropepla</i> sp. nov. 1	1	3	1	0	1	1	2	0	0	3	1	1	1	0	2	0	2	1	0	0
<i>C. vicens</i>	1	1	1	0	1	1	2	0	0	3	1	1	0	0	2	0	2	1	0	0
<i>C. paveli</i>	1	3	1	0	1	1	0	0	0	3	1	1	0	0	2	0	2	1	0	0
<i>Chloropepla</i> sp. nov. 2	1	3	0	0	1	1	1	0	0	1	1	0	2	1	1	2	2	1	1	0
<i>C. stysi</i>	1	3	1	0	1	1	1	0	1	1	1	0	2	1	1	2	2	1	1	0
<i>C. rolstoni</i>	1	3	0	0	1	1	1	0	1	1	1	0	2	1	?	2	2	1	1	1
<i>C. dollingi</i>	1	3	1	0	1	1	1	0	1	1	0	2	1	?	2	2	1	2	1	?
<i>C. tucuruiensis</i>	1	3	1	0	1	1	1	?	1	1	0	2	1	1	2	2	1	2	1	1



Table 2. Areas of occurrence of *Chloropepla* species used in two Brook's Parsimony Analysis (SATZ – South American Transition Zone; SEAm – Southeast Amazonian; SWAm – Southwest Amazonian; NAm – North Amazonian).

Species	Distribution	
	BPA1	BPA2
<b><i>Chloropepla</i> sp. nov. 3</b>	Caribbean	Caribbean
<b><i>C. aurea</i></b>	SATZ	SATZ
	Chacoan	Chaco
	SEAm, SWAm	SEAm, SWAm
<b><i>C. pirani</i></b>	SATZ	SATZ
<b><i>C. lenti</i></b>	Caribbean	Caribbean
<b><i>Chloropepla</i> sp. nov. 1</b>	Parana	Parana
<b><i>C. vicens</i></b>	Parana	Parana
	Chacoan	Caatinga, Pampa
<b><i>C. paveli</i></b>	Parana	Parana
	Chacoan	Caatinga, Cerrado, Chaco, Pampa
	SEAm	SEAm
<b><i>Chloropepla</i> sp. nov. 2</b>	NAm	NAm
<b><i>C. stysi</i></b>	NAm, SWAm	NAm, SWAm
<b><i>C. rolstoni</i></b>	NAm	NAm
<b><i>C. tucuruiensis</i></b>	NAm, SEAm	NAm, SEAm
<b><i>C. dollingi</i></b>	NAm	NAm

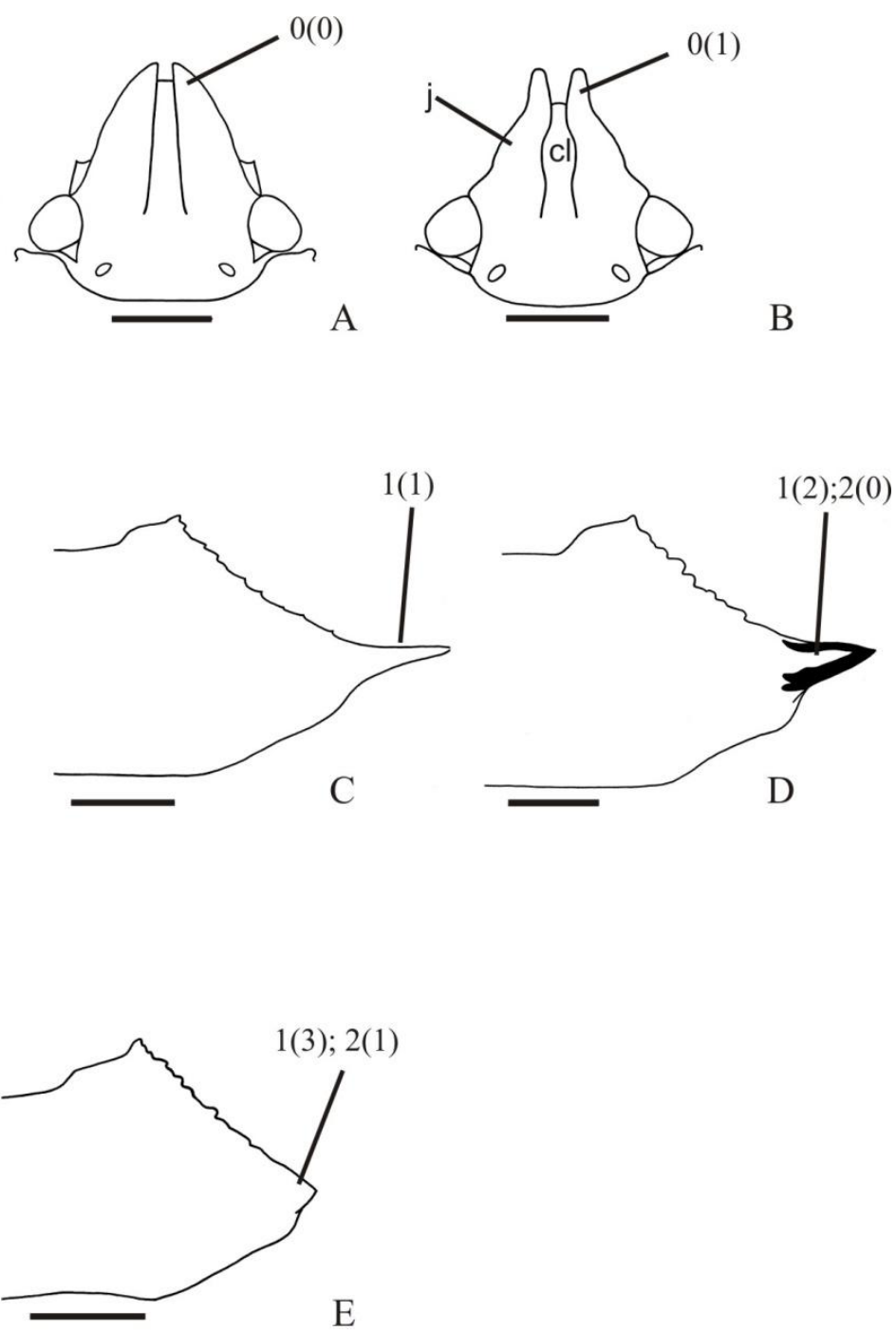


Figure 1 - Characters 0-2. A-B - Head dorsal view: A - *Chloropepla vicens*; B - *Mayrinia curvidens*. C-E - Humeral angles: C - *C. vicens*; D - *C. aurea*; E - *C. paveli*. (j - juga, cl - clypeus). Scale bar = 1 mm.

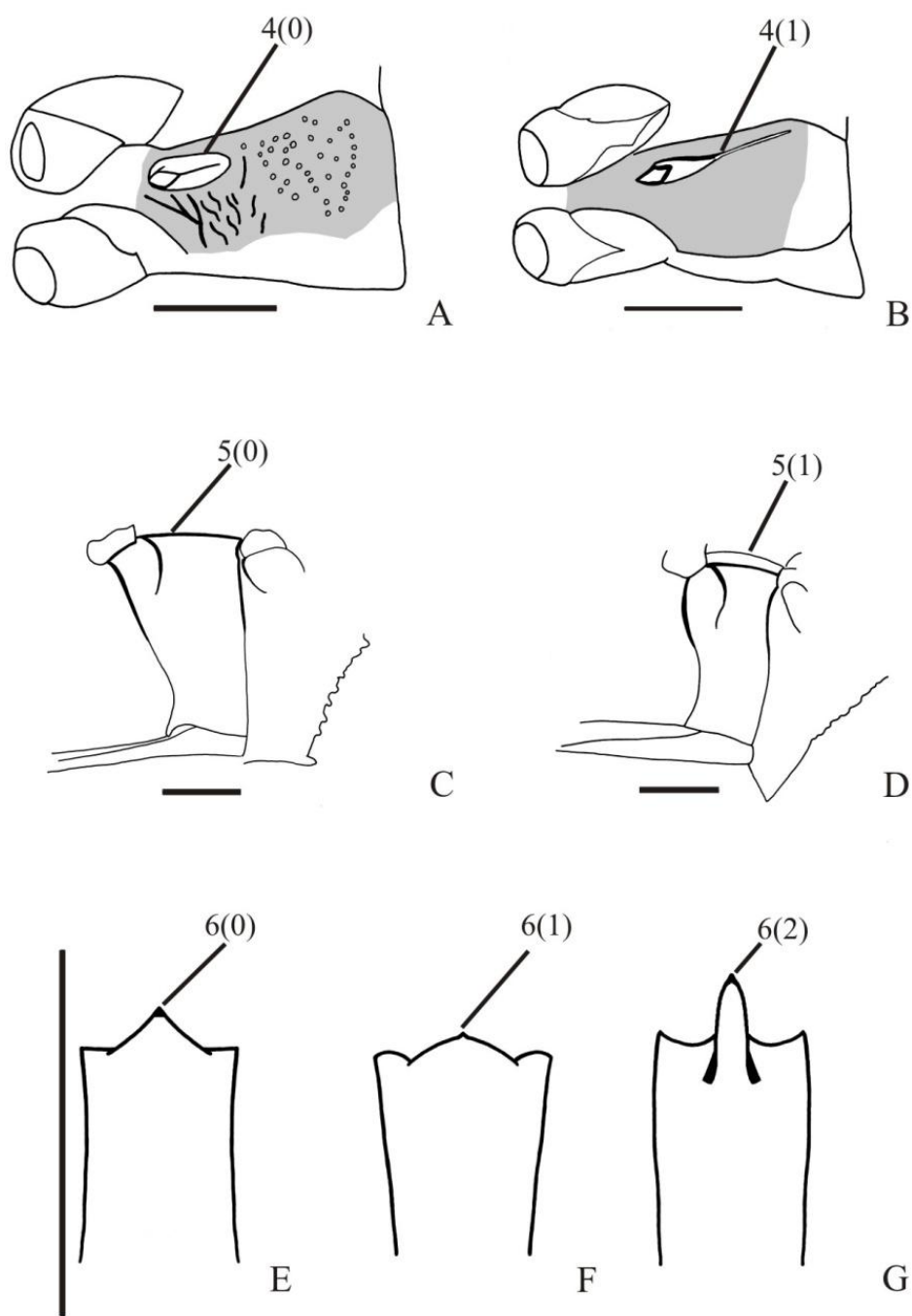


Figure 2 – Characters 4 – 6. A, B – Ostiolar ruga: A – *Mayrinia curvidens*; B – *Chloropepla vigens*. B, C – Metasternum carina: C – *M. curvidens*; D – *C. vigens*. E-G – Femur apical spine: E – *C. paveli*; F – *C. stysi*; G – *C. vigens*. Scale bar = 1 mm.

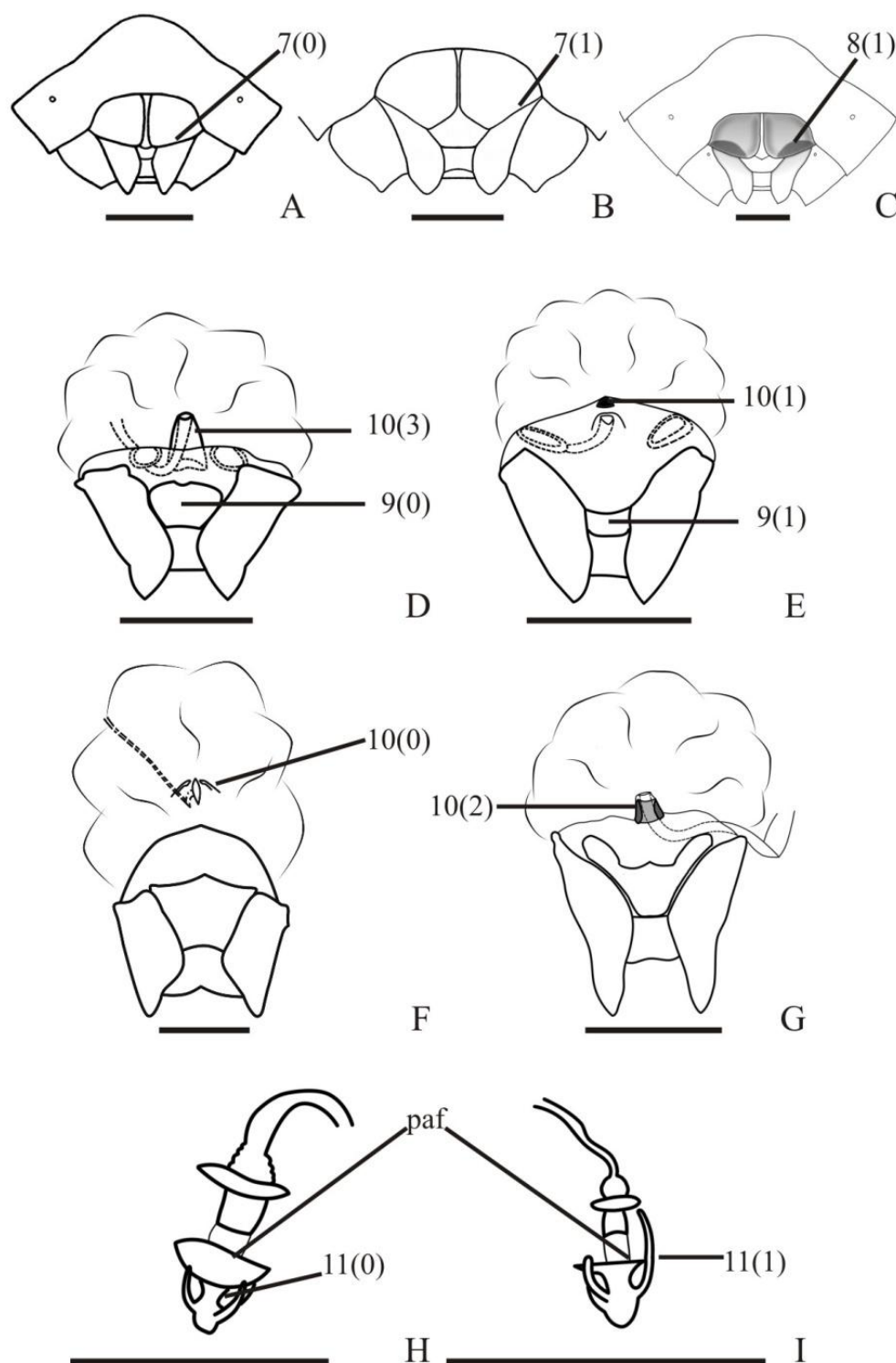


Figure 3 – Characters 7 -11. A-C – Female external genitalia: A,C – *Chloropepla rolstoni*; B – *C. tucuruensis*. D-G - Female internal genitalia: D – *Chloropepla vicens*; E – *C. rolstoni*; F *Loxa deducta*; G – *C. aurea*. H, I – Capsula seminalis: H – *C. vicens*; I – *C. rolstoni*. (paf – posterior annular flange). Scale bar = 1 mm.

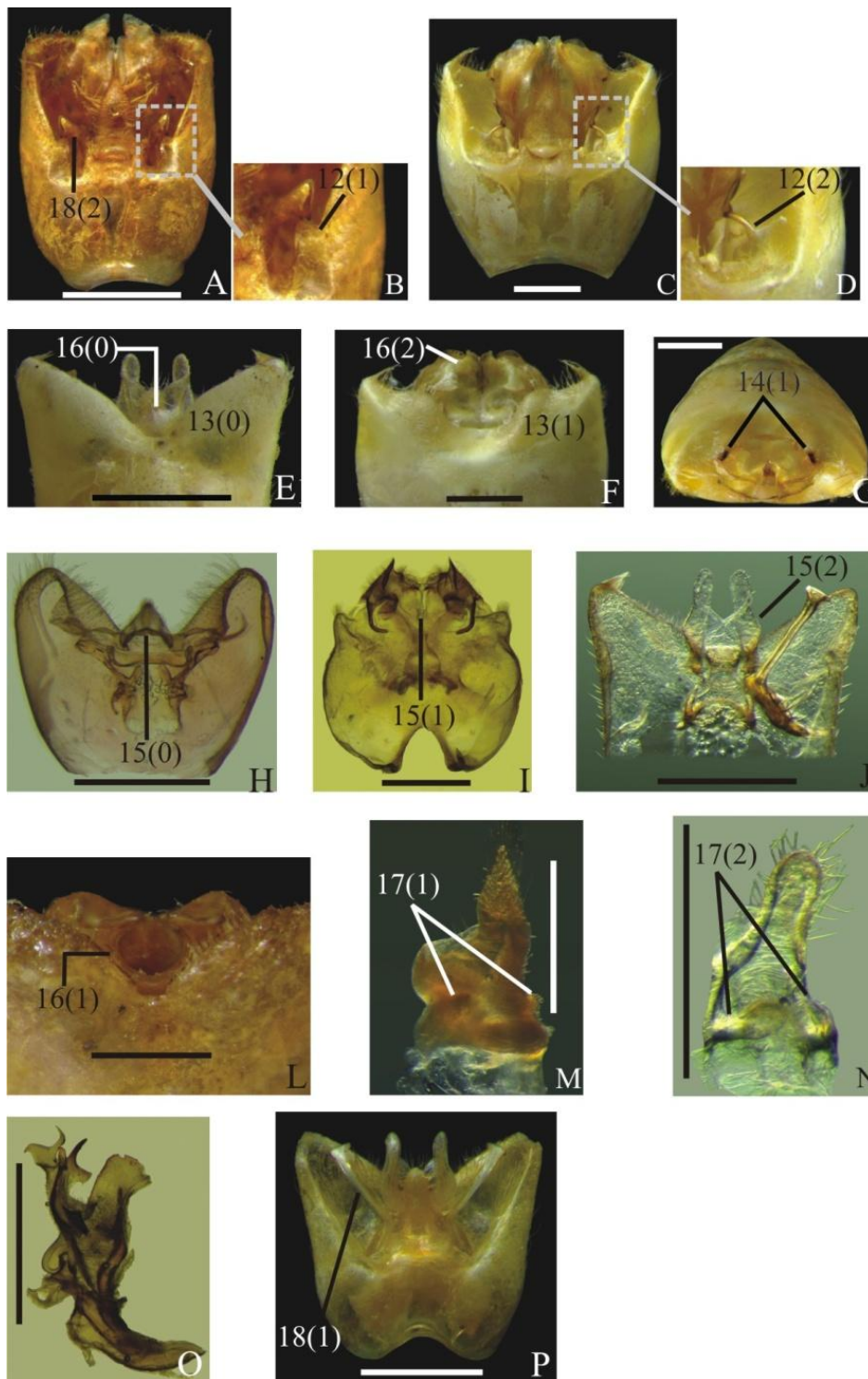


Figure 4 – Characters 12-18. A-D – Pygophore dorsal view: A, B– *Chloropepla aurea*; C, D – *Chloropepla* sp. nov. 2. E, F – Pygophore ventral view: E – *C. vicens*; F – *Chloropepla* sp. nov. 2. G – Pygophore posterior view, *Chloropepla* sp. nov. 2. H-J – Pygophore ventral wall (internal view): H – *Mayrinia curvidens*; I – *Rhyncholepta grandicallosa*; J – *C. vicens*. L – Pygophore posterior-ventral view, *C. aurea*. M, N - Male segment X: M – *Chloropepla* sp. nov. 2; N – *C. vicens*. O – Paramere, *Loxa deducta*. P – Pygophore dorsal view, *C. vicens*. Scale bar A-J, M-P = 1 mm; scale bar L = 0.5 mm.

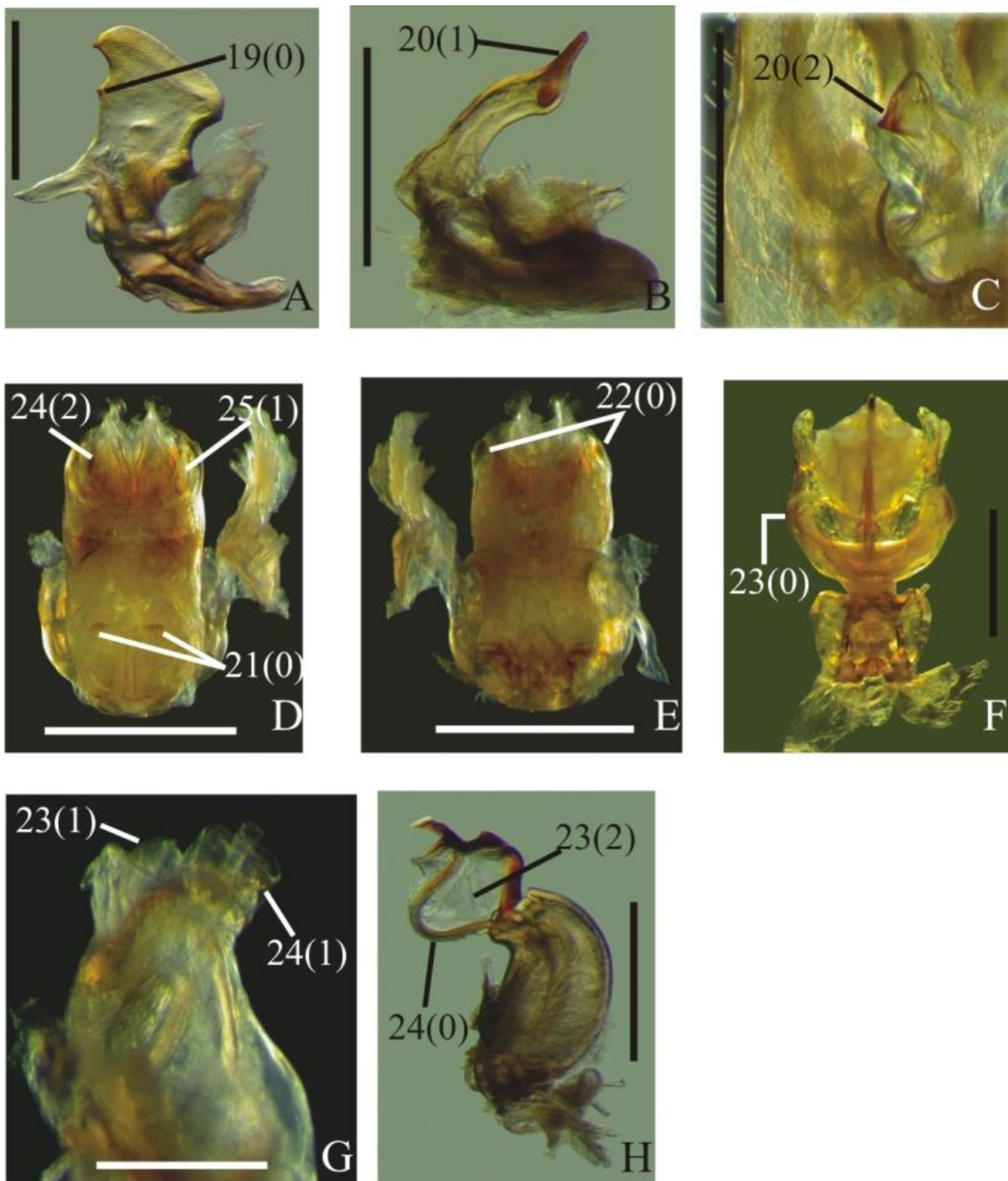


Figure 5 – Characters 19-24. A-C – Paramere, lateral view: A – *Mayrinia curvidens*; B – *Chloropepla* sp. nov2; C- *C. aurea*. D-G – Phallus: D - *C. stysi*, posterior view; E – *C. stysi*; anterior view; F – *Loxa deducta*, posterior view; G – *C. vicens*, lateral view; H – *Rhyncholepta grandicallosa*, lateral view. Scale bar A, B, D-G = 1 mm; scale bar C = 0.5 mm.



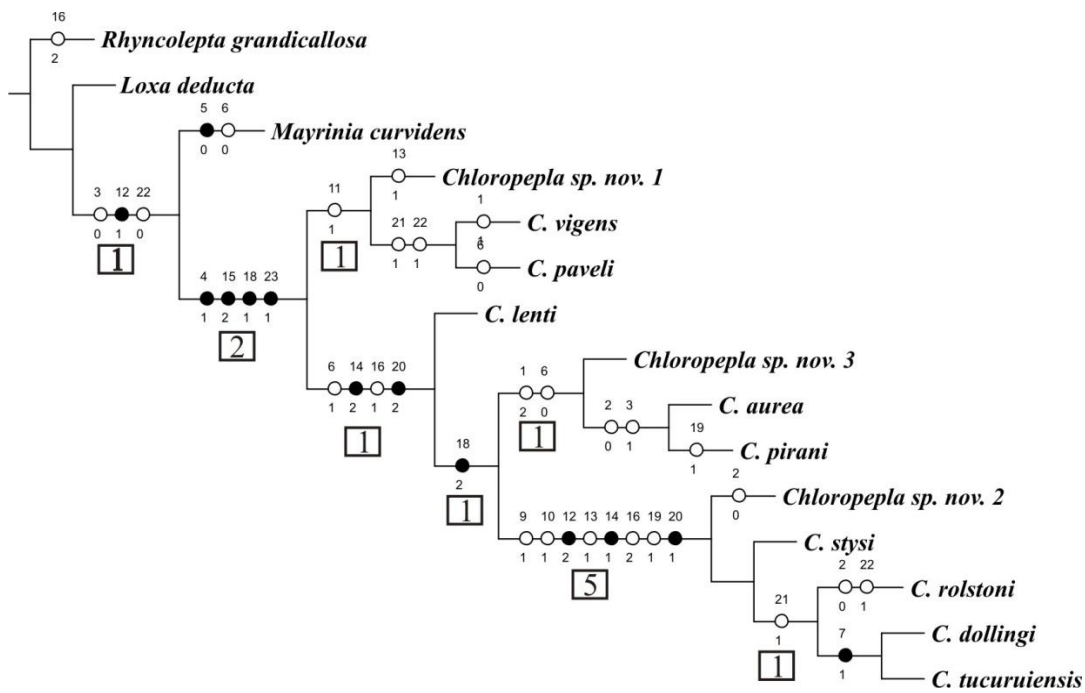


Figure 6 – Most parsimonious cladogram of *Chloropepla* species (61 steps, CI: 65, RI: 77). (white circles: not uniquely derived synapomorphies; black circles: uniquely derived synapomorphies; numbers in squares: Bremer support). Only unambiguous transformations are shown.

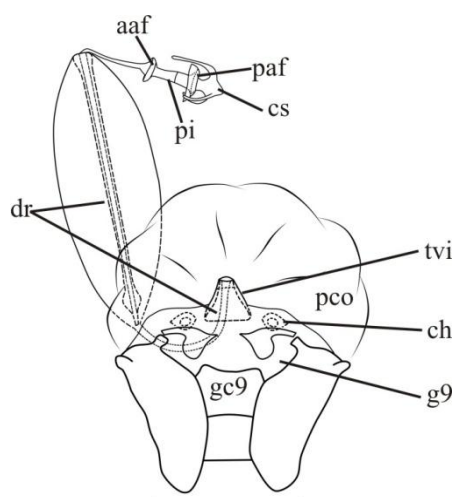


Figure 7 – *Chloropepla paveli* female internal genitalia (aaf – anterior annular flange, ch – chitinellipsen, cs – capsula seminalis, dr – ductus receptaculi, g 9 – gonapophyses 9, gc9 – gonocoxites 9, paf – posterior annular flange, pco – pars communis, pi – pars intermedialis, tvi – tickening of vaginal intima). Scale bar = 1 mm.





Figure 8 – Distribution map of *Chloropepla* species based on Nihei & Carvalho 2007) (CA – Caribbean subregion, CAA – Caatinga province, CE – Cerrado province, CHA – Chaco province, NAm – North Amazon, PAR – Parana subregion, SATZ – South American Transition Zone, SEAm – Southeast Amazon, SWAm – Southwest Amazon). Scale bar: 20,000 km).

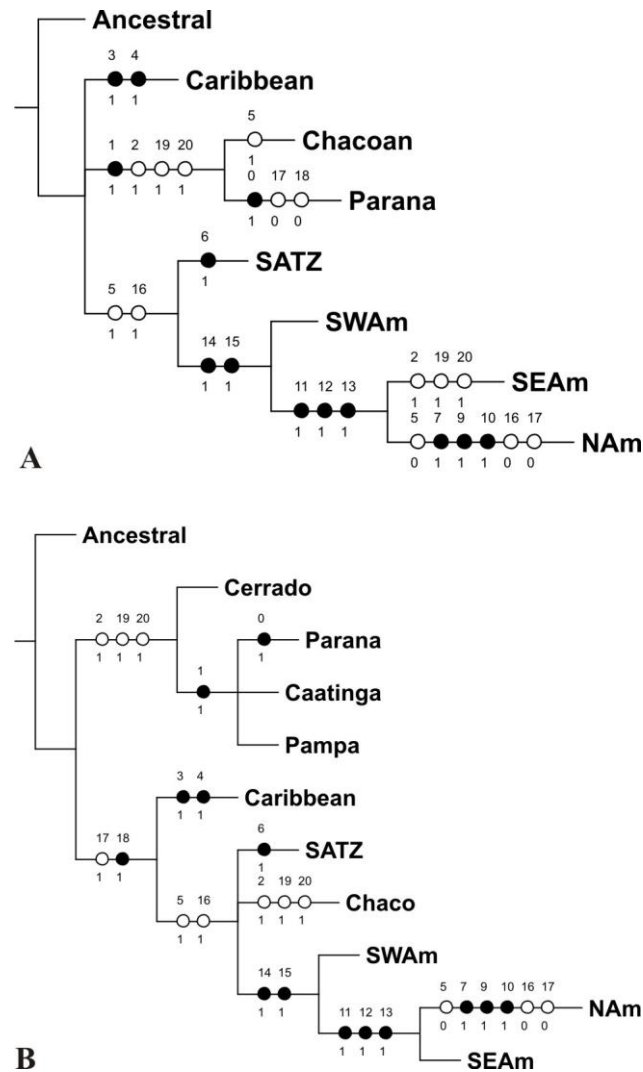


Figure 9 – A - Most parsimonious cladogram from BPA analysis using subregions as terminals (32 steps, CI = 68, RI = 56); B - most parsimonious cladogram from BPA analysis using Chacoan provinces + Neotropical subregions as terminals (29 steps, CI = 75; RI = 80). (CA – Caribbean subregion, CAA – Caatinga province, CE – Cerrado province, CHA – Chaco province, NAm – North Amazon, PAR – Parana subregion, SATZ – South American Transition Zone, SEAm – Southeast Amazon, SWAm – Southwest Amazon).

## Capítulo 4

Normas editoriais Zootaxa

(<http://www.mapress.com/zootaxa/support/author.html>)

### **Cladistic analysis of *Chlorocoris* group (Hemiptera, Heteroptera, Pentatomidae), based on morphological characters and total evidence**

#### **Abstract**

The phylogenetic relationships of eight Pentatominae genera was investigated: *Arvelius*, *Chlorochoris*, *Chloropepla*, *Eludocoris*, *Fecelia*, *Loxa*, *Mayrinia* and *Rhyncholepta*. Two data sets were used: one based on 37 morphological characters and other based on total evidence. The total evidence data set was composed by the morphological characters plus approximately 1,767 pairs of bases of mitochondrial 16S and nuclear 28S and 28SD ribosomal DNA, and was submitted to the dynamic optimization method. Both analyses differ and none confirmed the monophyly of the ingroup, preventing the proposal of a classification for the group. However, some relations are recovered in both cladograms: *Loxa* + *Mayrinia* + *Chlorocoris* (*Monochrocerus*), *Arvelius* + *E. humeralis* + *R. humeralis* and *Chlorochoris* (*Chlorocoris*) + *Fecelia* + *Chlorochoris* (*Arawacoris*). The results here obtained emphasize the necessity of further studies on the use of molecular data in analyses on genera and species levels in Pentatominae. Besides, the homologies also need to be better investigated and tested within Pentatomidae, Pentatominae and tribes levels, based on cladistics studies.

Key words: parsimony, molecular data, Pentatominae.

## Introduction

Pentatomoidea includes 15 families of stink bugs and their allies (Grazia *et al.* 2008a). Its monophyly was already widely corroborated by phylogenetic studies using both molecular and morphological characters (Gapud 1991; Henry 1997; Li *et al.* 2005; Grazia *et al.* 2008a).

Pentatomidae is the largest family of Pentatomoidea, with approximately 760 genera and more than 4,100 species (Schuh & Slater 1995). Several studies confirmed its monophyly without, however, resolving the infra-family relations (Gapud 1991; Hasan & Kitching 1993; Grazia *et al.* 2008a). However, there is evidence that Pentatomini and Pentatominae, two of the most diverse taxa in the family, do not constitute monophyletic groups (Gapud 1991; Campos & Grazia 2006).

Rider (2008) grouped eight genera of Pentatomini (*Arvelius* Spinola, 1837, *Chlorocoris* Spinola, 1837; *Chloropepla* Stål, 1867; *Eludocoris* Thomas, 1992; *Fecelia* Stål, 1872; *Loxa* Amyot & Serville, 1843; *Mayrinia* Horvath, 1925 and *Rhyncholepta* Bergroth, 1911) suggesting that they could be included in a new tribe, named “Chlorocorini” (manuscript). The grouping is based mainly on information from the literature, which hypothesized a relationship among these genera based on shared characteristics as general green color, elongate and flat body, apex of femora usually with dorsal process and humeral angles produced in spine (Grazia 1968; 1976; Becker & Grazia-Vieira 1971; Grazia-Vieira 1972b; Eger 1978; Thomas 1992; 1998). Additionally, *Chlorocoris*, *Mayrinia*, *Chloropepla*, *Loxa*, *Fecelia* and *Rhyncholepta* have the ventral rim of phygophore produced into a process, considered a likely homology among these taxa (Thomas 1998).

Several studies revealed that the use of the total amount of available information enable the construction of better supported cladistic hypothesis (Kluge 1989; 1998; 2004; Ernisse & Kluge 1993; Kluge & Wolf 1993; Mishler 1994; Whiting *et al.* 1997; Murrell *et al.* 2001; Kluge & Grant 2006). Among the reasons for this is the lack of objective criteria in the

establishment of characters partitions, resulting in artificial categories (Ernissee & Kluge 1993; Kluge 1998; 2004). Also, when partitions are adopted, *ad hoc* hypothesis are needed to explain them (Ernissee & Kluge 1993; Kluge 1998; 2004).

The aim of this study is to investigate the relationship of the eight above mentioned genera and to establish if they constitute a monophyletic group. To do that, a cladistic analysis using morphological and molecular data would be.

## Material and Methods

### Terminals

Initially, eight genera (*Arvelius*, *Chlorochoris*, *Chloropepla*, *Eludocoris*, *Fecelia*, *Loxa*, *Mayrinia* and *Rhyncholepta*) and *Chlorocoris* subgenera were the ingroup terminal. The biggest number possible of species was analyzed in the survey of characters. If some variation in the character were identified among congeneric species additional taxa were included as terminals. Following this criteria, three species of *Fecelia* (*F. minor*, *F. nigridens* and *F. proxima*), one of *Loxa* (*L. deducta*), one of *Chloropepla* (*C. lenti*) and three of *Chlorocoris* (*Monochrocerus*) (*C. rufispinus*, *C. hebetatus* and *C. werneri*) were included as terminals.

*Evoplitus humeralis* was included in the outgroup based on the previous study that indicates its relationship with *Arvelius* (Grazia 1997). Representatives of different tribes currently assigned to Pentatominae were included, to test the ingroup position in relation to the classification within this sub-family (see Rider 2008: *Brepholoxa heidemanni* Van Duzee, 1904 (Procliticini), *Rhynchocoris humeralis* (Thunberg, 1783) (Rhynchocorini), *Evoplitus humeralis* (Westwood 1837) (Pentatomini), *Carpocoris purpureipennis* (DeGeer, 1773) (Carpocorini), *Euschistus heros* (Fabricius, 1798) (Carpocorini), *Dichelops furcatus* (Fabricius, 1775) (Carpocorini). The cladogram was rooted in *Podisus crassimargo* (Stal,

1860) (Asopinae). The matrix included 24 terminals, 17 in the ingroup and seven in the outgroup.

### Specimens

The specimens analyzed for the survey of the morphological characters belong to the following collections (acronyms and curators in parenthesis): The American Museum of Natural History, New York, New York, USA (AMNH, R. T. Schuh); Coleção Zoológica Prof. Paulo Bürnheim, Fundação Universidade do Amazonas, Manaus, Amazonas, Brazil (CZPB, N. O. Aguiar); David Rider Collection, North Dakota State University, North Dakota, Fargo, USA (DRC, D. Rider); Departamento de Zoologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil (UFRG, J. Grazia); Donald Thomas Collection, Weslaco, Texas, USA (DTC, D. Thomas); Fundação Instituto Oswaldo Cruz, Rio de Janeiro, Rio de Janeiro, Brazil (FIOC, J. Costa); Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBC, J. Lewis); Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil (MCNZ, A. Barcellos); Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZSP, C. Campaner); Museu Paraense Emilio Goeldi, Belém, Pará, Brazil (MPEG, O. T. Silveira); National Museum of Natural History, Washington D.C., USA (NMNH, T. Henry).

Specimens used for extraction were mostly collected for this trial, except for the ones used to the whole specimen extraction. These belong to Instituto Nacional de Biodiversidad, Santo Domingo de Heredia (Costa Rica) and Donald B. Thomas Collection. All specimens used in the extractions are deposited at David Rider Collection (Fargo, USA), identified with an identification code.

### Morphological data

Morphological characters were observed on stereomicroscope. Dissections of genitalia were performed, with clarification on KOH supersaturated solution. When necessary, the structures were stained with Congo Red and Chlorazol Black. When no specimens were available to observation and/or dissection, the characters were surveyed base on literature.

Terminology followed McDonald (1966), Grazia (1968), Dupuis (1970), Schaefer (1977) and and Grazia *et al.* (2008a).

Illustrations of the characters were made using camera lucida adapted to the steromicroscope. Pictures in different focus levels were obtained with the digital camera mounted on a steromicroscope and composed with Helicon Focus<sup>®</sup>. Electromicrographies were obtained in a scanning electron microscope (JEOL<sup>®</sup>, model JSM 5800) at Centro de Microscopia Eletrônica, Universidade Federal do Rio Grande do Sul. Edition of all images were performed through Adobe Photoshop<sup>®</sup> CS2.

A total of 37 caracteres were surveyed, 18 of them multistate (Tab 1), all treated as non-additive. The multistate characters with ambiguous distribution were not optimized.

#### Molecular data

Three fragments of 14 terminals (Tab. 1) were used in this study: one of mitochondrial 16S rDNA and two of nuclear 28S rDNA. The 16S primers used were 5'-CGC CTG TTT AAC AAA AAC AT-3' (Simon *et al.* 1994) and 5'-TTT AAT CCA ACA TCG AGG-3' (Cognato & Vogler 2001). For the 28S were used 5'-ACC CSC TGA AYT TTA AGC CAT-3' (McArthur & Koop 1999) and 5'-AAC TCT CTC MTT CAR AGT TC-3' (Colgan *et al.* 2003), and for de D1 expansion segment 5'-CCACAGCGCCAGTTCTGCTTAC-3'/5'-CCCGTCTTGAAACACGGACCA-3' (Muraji & Taschikawa 2000). The 16S, 28S and 28SD fragments had approximately 470, 560 and 380 pb, respectively.

The extraction was not destructive, using only one or two legs of each specimen or using the whole specimen.

Extractions from the leg were made with QIAGEN DNeasy Blood & Tissue Kit<sup>®</sup>. The PCR of these extractions were performed using GE Healthcare Life Sciences PuReTaq-Ready-To-Go-PCR-Beads<sup>™</sup>. The thermocycler program used for fragment 16S and 28SD used the same temperatures for denaturation and extension: denaturation 93 °C (30 s), annealing temperature depending on primer (30 s), extension 72°C (1 min) with initial denaturation 93 °C (3 min) and final extension 72 °C (1 min). However, the annealing temperature for 16S was 50 °C and for 28SD was 53 °C. Still, for the 16S fragment there were performed 32 cycles of denaturation-extension, while for 28SD were performed 31 cycles. For 28S fragment the program was: denaturation 95 °C (30 s), annealing 47 °C (30 s), extension 72 °C (1 min) for 40 cycles; with initial denaturation 95 °C (3 min) and final extension 72 °C (1 min).

The whole specimen extraction was modified from Gilbert *et al.* (2007) and was used to extract DNA from dry preserved specimens of *C. rufispinus*, *F. nigridens*, *A. porrectispinus*, *E. grandis* and *R. grandicallosa*. The most antique specimen had 5 years. According to this method the whole specimen is immersed in digestion buffer and incubated overnight at 55° C with gentle agitation. Each 50 µl of PCR reaction contained 1 µl of extracted DNA, 5 µl buffer, 4 µl of dNTP's, 16 µl of primer and 2.4 µl of TAQ. The thermocycler program used for these extraction was: denaturation 94 °C (1 min), annealing temperature depending on the primer (1 min), extension 72 °C (1 min) for 29 cycles; with initial denaturation 94 °C (1 min) and final extension 72 ° C (10 min). The annealing temperature for 16S, 28S and 28SD were 50 °C, 47 °C and 53 °C, respectively.

The sequencing was performed in the University of North Dakota Sequencing Facility.

#### Cladistic analysis



Two analyses were performed: one using only the morphological characters, and the other with the total evidence. Both followed the outgroup comparison method (*sensu* Nixon & Carpenter 1993). An analysis using only the molecular data was considered not informative because of the few taxa from which sequences were available (Tab. 1).

The cladogram with only morphological characters was selected through parsimony analysis, with the TNT software (Goloboff *et al.* 2008) using the “traditional search” option, random seed = 0; 200 replications and 20 trees saved per replication. Matrix construction, the edition of the cladogram and estimation of consistency and retention indexes were performed using Winclada (Nixon 2002), disregarding autapomorphic characters. Bremer support (Goodman *et al.* 1982; Bremer 1994) was calculated with TNT, based on 1,520 trees with up to 20 extra steps.

The total evidence cladogram was estimated with POY 4.1.2 (Varón *et al.* 2010), with the direct optimization method. The substitution and indel cost were 1 (tcm (1,1)). The analysis was performed with 500 random addition sequences Wagner builds with TBR branch swapping. The trees were then submitted 50 rounds of fusing, each holding 20 trees. The command line used was: build (500) swap (trees:10) fuse (iterations: 50, swap (trees: 20)) select ( ). Consistency and retention indexes were also calculated using POY. In the results section, when only one value of consistency and one of retention indexes of the character are shown it means that in both analysis (morphological and total evidence) the values were the same. When two sets of values are provided, the first set corresponds to the morphological analysis and the second to the total evidence.

The following notations are used in the “Results” and “Discussion” sections and Figures:  $X_y$  in the sections and  $X(Y)$  in the figures, to designate a character condition, where “X” is the number of the character and “y” corresponds to the condition of this character; “s”,

to the number of steps; “ci”, to consistency index; and “ri”, to retention index. The number of steps, consistency and retention indexes of the characters in both analyses are provided.

## Results

### Characters

#### Head

**Character 0** (Fig. 1A-B). Head, margin before eyes: (0) concave (1) straight (s: 5, ci: 20, ri: 20);

In the groups studied, the lateral margins of head might be strongly concave in front of the eyes, as in *P. crassimargo*, *E. heros*, *Rhyncholepta* spp., *Arvelius* spp., *E. humeralis* and *E. grandis* (Fig. 1A). Alternatively, these margins can be straight or slightly sinuous, which is usually related to a convergent trajectory of the juga (Fig. 1B).

**Character 1** (Fig. 1B-C). Apex of juga: (0) straight forward directed (1) curving towards tip of clypeus 9 (s: 1, ci: 100, ri: 100);

The position of the apex of juga in relation to the apex of the clypeus is variable in Pentatomidae, being already tested in cladistic analysis and showing a homoplastic distribution (Campos & Grazia 2006). The state 1 (Fig. 1C) was recorded in *Chlorocoris* (*Monochrocerus*) species, and this feature is used to differentiate that subgenus from *Chlorocoris* (*Chlorocoris*), which present the state 0 (Fig. 1B) (Thomas 1985).

**Character 2** (Fig. 1A-B, D). Juga, shape of the apex: (0) thin, without process (1) thin, with an acute process (2) wide, without process (s: 5, ci: 40, ri: 50);

*Arvelius* spp., *Loxa* spp., *F. proxima* and *F. nigridentis* present the juga ending in an acute process (state 1) (Fig. 1D). In *Eludocoris grandis* and *P. crassimargo* the juga have nearly the same width from the base to the apex, therefore presenting a wide apex (state 2) (Fig. 1A). In

the remaining groups, the juga tend to narrowing toward the apex, turning the apex thin (state 0) (Fig. 1B).

**Character 3** (Fig. 1E). Maxillary plates, (1+1) acute process: (0) absent (1) present (uninf)

The maxillary plates are elongated in Heteroptera (Spooner 1938). They form most of the lateral and ventral aspects of head (Spooner 1938). In *Rhyncholepta* spp. a pair of acute processes is present in this region, approximately in front of the antenniferous tubercles (Fig. 1E).

**Character 4** (Fig. 1E-G). Anterior angle of buccula: (0) rounded (1) truncate (2) with process (s: 9, ci: 22, ri: 12);

The buccula arise from the ventral margins of maxillary plate, with the function of protection and support of the rostrum (Spooner 1938). In the ingroup, states 1 (Fig. 1E) and 2 (Fig. 1G) are observed. State 0 (Fig. 1F) occurs only in *P. crassimargo*, *D. furcatus* and *E. humeralis*.

**Character 5** (Fig. 1E, G). First rostral segment: (0) longer than buccula (1) shorter than buccula (s: 2, ci: 50, ri: 0);

The relation between the length of the first rostral segment and the buccula is highly variable in Pentatomidae and is frequently used in cladistic studies in this family, contributing to the establishment of the relationships among taxa (Grazia 1997; Barcellos & Grazia 2003). Only *R. humeralis* and *E. grandis* have the first rostral segment shorter than the buccula (state 1) (Fig. 1G).

## Thorax

**Character 6** (Fig. 1H-J). Antero-lateral margins of pronotum: (0) anterior half crenulated (1) entirely crenulated (2) not crenulated or less than ¼ of length crenulate (s: 5, ci: 40, ri: 62/s: 6, ci: 33, ri: 50);

The extension of the antero-lateral margins crenulated region is highly variable among the groups studied. The humeral spine, when present, was not considered in the estimation of the crenulated region. The state 2 is observed only in the outgroup: *P. crassimargo*, *B.heidemanni*, *C. purpureipennis* and *R. humeralis*. The state 0 is found in *Arvelius* spp., *Rhyncholepta* spp. *Chloropepla* spp. and *C. (Arawacoris) tarsalis*.

**Character 7** (Fig. 1I-J). Humeral angles: (0) produced into spine (1) triangular, not produced into spine (2) rounded (s: 4, ci: 50, ri: 0);

The shape of humeral angles is frequently used in cladistic analysis of pentatomid groups (Fortes & Grazia 2005; Bernardes *et al.* 2009). The humeral angles developed into spines is a feature used to approximate *Rhyncholepta*, *Loxa* and *Fecelia* (Becker & Grazia-Vieira 1971) (Fig. 1I). However, this feature is highly variable in Pentatomidae, even among species of the same genus (Fortes & Grazia 2005). Except for some species of *Chloropepla* and of *Chlorocoris* (*Monochrocerus*), where the humeral angles are triangular (state 1), all ingroup have the humeral angles produced into spine (state 0) (Fig. 1L). Only *C. purpureipennis* have rounded humeral angles (state 2) (Fig. 1J).

**Character 8** (Fig. 1H-I). Posterior margin of pronotum: (0) concave (1) straight (s: 1, ci: 100, ri: 100);

The posterior margin of pronotum concave is a synapomorphy for the *Evoplitus* group (*Evoplitus* + *Adevoplitus* + *Pseudevoplitus*) (Grazia 1997) (Fig. 1H). Among the species analyzed, *R. humeralis* also present this characteristic.

**Character 9** (Fig. 1H-I). Scutellum apex: (0) bifid (1) entire (uninf);

The apex of scutellum bifid is a synapomorphy for the *Evoplitus* group (Grazia 1997) (Fig. 1H). None of the other groups studied have this feature.

**Character 10** (Fig. 2A-C). Ostiolar ruga: (0) long, reaching lateral third of the metapleura (1) auricular, short, not surpassing half of the metapleura (2) median size, reaching the mid length of metapleura (s: 7, ci: 28, ri: 50/s: 9, ci: 22, ri: 30);

The length of ostiolar ruga is highly variable in Pentatominae, probably with several independent origins among the genera (Gapud 1991). This character has been repeatedly used in studies concerning relationships among Pentatomidae taxa, presenting homoplastic distribution (Barcellos & Grazia 2003; Ferrari *et al.* 2010) or grouping genera (Grazia 1997; Fortes & Grazia 2005). A long ostiolar ruga (state 0) (Fig. 1A), far surpassing the half of the metapleura is found in *R. humeralis*, *E. humeralis*, *E. grandis* and *Chloropepla* spp. The medium size ostiolar ruga might reach the half of the metapleura, but not surpasses it (Fig. 1C). This condition is characteristic of *P. crassimargo*, *C. purpureipennis*, *Arvelius* spp., *Rhyncholepta* spp., *Chlorocoris* (*Chlorocoris*) spp. *Mayrinia* spp. and *F. nigridens*. The remaining species/genera included in the analysis present the ostiolar ruga auricular, which is characteristically short (Fig. 1B).

**Character 11** (Fig. 3A-C). Mesosternum carina: (0) plateau shaped, anteriorly produced (1) keel shaped, well developed (2) weakly developed (s: 5, ci: 40, ri: 72);

The mesosternum carena strongly developed and produced toward the prosternum is a synapomorphy for the *Evoplitus* group (Grazia 1997) (Fig. 3A). This feature is also found in *R. humeralis*. Among the ingroup, *E. grandis*, *Chloropepla* spp., *Chlorocoris* (*Chlorocoris*) spp., *Fecelia* spp. and *Loxa* spp. present the carena of mesosternum produced in a conspicuous keel (Fig. 3B).

**Character 12** (Fig. 3B-C). Metasternum carina: (0) raised (1) not raised (s: 1, ci: 100, ri: 100);

The metasternum plate raised consists of a hexagonal or keel-like, elevated structure. It is one of the characteristics shared by *Arvelius* and *Evoplitus* which delimit the sister group

relationship among *Arvelius* and the *Evoplitus* group (Grazia 1997) (Fig. 3B). This state is also found in *R. humeralis*

**Character 13** (Fig. 3D-E). Femur, dorsal projection: (0) absent (1) present (s: 3, ci: 33, ri: 81/s: 6, ci: 16, ri: 54);

The presence of the dorsal projection on the apex of the femur (Fig. 3E) is highlighted by several authors as a feature that approximate *Loxa*, *Chloropepla*, *Mayrinia*, *Fecelia*, *Rhyncholepta* and *Chlorocoris* (*Arawacoris*) (Becker & Grazia-Vieira 1971; Grazia-Vieira 1971; Grazia 1976; Thomas 1998). It also had already been used in other cladistic studies of pentatomids, being useful in grouping species of the same genus in Procleticini tribe (Bernardes *et al.* 2009). In the present study, the only groups of the ingroup which don't present the dorsal projection of femur developed are *Chlorocoris* (*Chlorocoris*) and *Chlorocoris* (*Monochrocerus*) (Fig. 3D). This dorsal projection is absent in the outgroup.

### Abdomen

**Character 14** (Fig. 3B-C). Abdominal spine: (0) present (1) absent (s: 2, ci: 50, ri: 75);

The spine process in the third abdominal segment is a highly widespread characteristic in Pentatomidae (Gapud 1991) and is frequently included in studies addressing pentatomids relationships in different taxonomic levels (Gapud 1991; Grazia 1997; Barcellos & Grazia 2003; Fortes & Grazia 2005; Campos & Grazia 2006; Bernardes *et al.* 2009; Ferrari *et al.* 2010). Among the groups included in this analysis, *Podisus crassimargo*, *B. heidemanni*, *Arvelius* spp., *R. humeralis* and *E. humeralis* present this process (Fig. 3B).

**Character 15** (Fig. 3F-G). Abdominal venter: (0) flat (1) with longitudinal sulcus (2) with longitudinal keel (s: 4, ci: 50, ri: 80/s: 3, ci: 66, ri: 90);

*Chlorocoris* spp. (all the three sub-genera) and *Fecelia* spp. present a sulcus, variable in length, along mid longitudinal abdominal venter (Fig. 3F). *Arvelius* spp. and *Evoplitus* group

share as a synapomorphy the surface of abdominal venter elevated in a keel (Grazia 1997), characteristic also found in *R. humeralis* (Fig. 3G).

**Character 16** (Fig. 3H). Anterior margin of urosternite VII, in males: (0) not strongly extended anteriorly (1) strongly extended anteriorly (s: 1, ci: 100, ri: 100);

*Loxa* spp. has the anterior margin of the urosternite VII strongly curved (Fig. 3H), increasing the size of the segment, which reaches or surpasses the half of the abdominal length. As a consequence, the other abdominal segments are shortened at middle.

### Female Genitalia

**Character 17** (Fig. 4A-B). Laterotergites 9: (0) surpassing the band uniting laterotergites 8 (1) not surpassing (s: 4, ci: 25, ri: 62/s: 5, ci: 20, ri: 50);

The state 1 is observed in *P. crassimargo*, *B. heidemanni*, *R. humeralis*, *E. grandis* and *Chlorocoris* (*Monochrocerus*) spp (Fig. 4B). Included in this state are the extremely short laterotergites 9, which don't reach the band (some species of *Monochrocerus* sub-genus), and the laterotergites that reach but not surpasses the band.

**Character 18** (Fig. 4A-B). Laterotergites 9, apex: (0) rounded or angulated (1) acute (s: 4, ci: 25, ri: 25);

Laterotergites 9 with acute apex are observed in *Rhyncholepta* spp., *Mayrinia* spp. and *Fecelia* spp (Fig. 4A). The remaining taxa have laterotergites 9 rounded or slightly angulated (Fig. 4B).

**Character 19** (Fig. 4A-B). Laterotergites 8, apex: (0) with process (1) without process (s: 2, ci: 50, ri: 83/s: 3, ci: 33, ri 66);

The laterotergites 8 apex produced into an acute or rounded process is observed in the outgroup: *D furcatus*, *E. heros*, *R. humeralis* and *E. humeralis* (Fig. 4A). In the ingroup, only *Chlorocoris* (*Monochrocerus*) spp. present the apex of laterotergites 8 simply rounded or triangular, not produced into a process (Fig. 4B).

**Character 20** (Fig. 4C-E). Posterior thickening of vaginal intima: (0) plate-shaped (1) ring or tube shaped (2) reduced or absent (s: 4, ci: 50, ri: 70/s: 5, ci: 40, ri: 57);

The thickening of vaginal intima (Grazia & Becker 1995) consists of sclerites related to the opening of the orificium receptaculli in the pars communis, homologous to the second valvulae (gonapophyses 9) (Dupuis 1955; Schaefer 1968). According to Gapud (1991) a pair of antero-posteriorly oriented sclerites on the spermathecal base (orificium receptaculi) is an apomorphy of Pentatomidae. In the present study, these sclerites were considered as two distinct characters: one posterior and another anterior. When only one structure was present, it was described as a posterior thickening when surrounding the orificium receptaculli. In *Mayrinia* spp., the posterior thickening of vaginal intima is absent, while in *R. humeralis*, *E. humeralis*, *E. grandis*, *Loxa* spp. and *Fecelia* spp. it is composed by a plate-shaped structure (Fig. 4C), with different levels of development. In the remaining species the sclerites form a ring (sometimes a tube) around the orificium receptaculi (Fig. 4D).

**Character 21** (Fig. 4C, E). Anterior thickening of vaginal intima: (0) arc shaped (1) plates (2) absent (s: 4, ci: 50, ri: 77/s: 6, ci: 33, ri: 55);

The anterior thickening of vaginal intima is absent in *B. heidemanni*, *Rhyncholepta* spp., *E. grandis* and *Chloropepla* spp. In *Loxa* spp. and *Mayrinia* spp. it is characterized by a pair of small plates (Fig. 4C). The remaining species present a single structure often arc shaped, sometimes almost straight (Fig. 4E).

**Character 22** (Fig. 4F-G). Capsula seminalis processes: (0) absent (1) two or more (s: 1, ci: 100, ri: 100/s: 3, ci: 33, ri: 50);

The process of capsula seminalis (Fig. 4G) are structures found exclusively in Pentatomidae, having arisen multiple times in Pentatominae (Gapud 1991). These structures vary in shape and number in Pentatomidae (Gapud 1991; Grazia 1997; Campos & Grazia 2006; Bernardes *et al.* 2009; Ferrari *et al.* 2010), being frequently used in cladistic studies in the group. Gapud



(1991) highlights the importance of these structures in grouping genera. In the groups analyzed the processes of capsula seminalis are absent only in species of the outgroup: *P. crassimargo*, *B. heidemanni*, *C. purpureipennis*, *D. furcatus* and *E. heros* (Fig. 4F).

**Character 23** (Fig. 4F-H). Capsula seminalis, proximal region: (0) tubular (1) funnel shaped (2) bulbous (s: 6, ci: 33, ri: 55/s: 7, ci: 28, ri: 44);

The proximal region of the capsula seminalis (before the anterior annular flange) varies in shape, usually determining a variation in the ductus receptaculi caliber posterior to the vesicular area: the tubular and bulbous shape (Fig. 4F) is usually associated to a thick ductus receptaculi, while the funnel shape is associated to a thin and longer ductus receptaculi. The state 1 (Fig. 4G) is observed in the outgroup in *R. humeralis* and *B. heidemanni*. In the ingroup this state is present in *Chlorocoris* (*Chlorocoris*) spp., *Chlorocoris* (*Monochrocerus*) spp. (except for *C. hebetatus*), *Mayrinia* spp., *Fecelia* spp. and *Loxa* spp.

### Male genitalia

**Character 24** (Fig. 5A). Pygophore, processes of dorsal rim: (0) present (1) absent (s: 4, ci: 25, ri: 25)

The processes of pygophore dorsal rim occur in pairs, in the lateral third of the dorsal rim (Fig. 5A) and are frequently observed in pentatomids. They might present different shapes and positions among species of the same genus, being these features useful in cladistic analysis of species group level (Fortes & Grazia 2005). The processes of dorsal rim are present only in *Chloropepla* spp. and *Mayrinia* spp.

**Character 25** (Fig. 5B). Pygophore, superior processes: (0) absent (1) present (s: 4, ci: 25, ri: 72/s: 6, ci: 16, ri: 54);

The superior processes of pygophore are 1+1 sclerotized areas, laterad to segment X with variable shapes and levels of development (Dupuis 1970) (Fig. 5B). Their location signals externally the insertion point of the abductor muscles of parameres (Dupuis 1970), being

frequently removed linked to the parameres in the dissection process. The occurrence of superior processes is common among Pentatomoidea (Dupuis 1970). The shape or presence/absence of these structures is variable and can be useful to establish relationships in both species and genera levels (Barcellos & Grazia 2003; Fortes & Grazia 2005; Ferrari *et al.* 2010). In the present study, they were registered in the outgroup (*P. crassimargo*, *B. heidemanni*, *C. purpureipennis*, *E. heros* and *D. furcatus*) and in the ingroup (*Arvelius*, *Rhyncholepta*, *Loxa* and *Fecelia* species).

**Character 26** (Fig. 6A-C). Hypandrium (0) absent (1) *Chloropepla* type (2) *Rhyncholepta* type (3) *Loxa* type (s: 3, ci: 100, ri: 100/s: 4, ci: 75, ri: 88);

The hypandrium consist of an elongation of the inferior margin of the external wall of pygophore (Dupuis 1970). It lack muscles (Dupuis 1970) and its function in the copulation is unknown. Different terminologies had been used to designate this structure: inferior ridge (McDonald 1966; Eger 1978), median projection (Thomas 1985), pseudoclasper (Thomas 1998), hypandrium (Grazia 1968; 1969; Grazia-Vieira 1971; 1972a; b; 1973a; c; Grazia 1976; 1980; Grazia & Teradaira 1980; Grazia 1987; Grazia & Frey-da-Silva 2003). Among the genera of the ingroup all except for *Avelius* and *Eludocoris* bear this structure. It is found also in *Rideriana* Grazia & Frey-da-Silva (2003) species. The presence of hypandrium has been indicated as a feature which approximates *Chloropepla*, *Rhyncholepta*, *Loxa*, *Mayrinia*, *Fecelia* and *Chlorocoris* (Becker & Grazia-Vieira 1971; Thomas 1998). Both *Chloropepla* and *Rhyncholepta* types of hypandrium are long, far surpassing the ventral rim of the pygophore and being visible ventrally and dorsally. The *Chloropepla* type (Fig. 6A) is related to an infolding of the ventral rim deeply produced inside the pygophore, and is characterized by dorsal expansions flanking the segment X. Occurs only in *Chloropepla* species. The *Rhyncholepta* (Fig. 6C) type is exclusive of this genus and consists of a flat, wide structure. The *Loxa* type (Fig. 6B) of hypandrium is the shortest one, only visible in ventral view.

Usually this kind of hypandrium is related to a shallow infolding of the ventral rim and is characteristic of *Mayrinia*, *Fecelia* and *Chlorocoris* species, besides *Loxa*.

**Character 27** (Fig. 6B-D). Median projection: (0) inconspicuous (1) apical (2) lateral (s: 2, ci: 100, ri: 100/s: 6, ci: 33, ri: 69);

The ventral wall of the pygophore infolds inside the genital capsule given rise to structures “whose function appears to be the support and the orientation of the aedeagus during copulation”: the infolding of ventral rim, the cup like sclerite and the median projection (Schaefer 1977). The median projection is attached to the distal part of the cup like sclerite (Schaefer 1977). There are significant differences on the shape and development of these structures among taxa and they can be almost entirely fused (Schaefer 1977). In *Chloropela* spp., *E. grandis*, *Chlorocoris* (*Chlorocoris*) spp. and *Chlorocoris* (*Monochocerus*) spp. the median projection is a unique structure, sometimes bilobated, located apically to the cup like sclerite (Fig. 6D). On the other hand in *Loxa* spp., *Mayrinia* spp., *Fecelia* spp. and *Chlorocoris* (*Arawacoris*) *tarsalis* the median projection occurs as a pair of processes laterad to the cup like sclerite and prolonged into 1+1 arms (Fig. 6B). In the remaining species the median projection is inconspicuous, probably strongly fused to the infolding of ventral rim and to the cup like sclerite (Fig. 6C).

**Character 28** (Fig. 7A-B). Segment X apical processes: (0) absent (1) present, anteriorly directed (2) present, posteriorly directed (s: 3, ci: 66, ri: 88);

Apical processes in the X segment are common in Pentatomidae. In *Chlorocoris* the shape of these processes varies among subgenera: in *Chlorocoris* they are elongate, cephalad directed (Fig. 7A) and in *Monochocerus* they are short, converging medially (Thomas 1985), and posteriorly oriented, characteristic shared with *Mayrinia* spp., *Fecelia* spp. (except for *F. minor*), *Chlorocoris* (*Arawacoris*) *tarsalis* and *Loxa* spp. (Fig. 7B).

**Character 29** (Fig. 7B-C). Segment X placement in relation to longitudinal axis of pygophore: (0) perpendicular (1) parallel (s: 2, ci: 50, ri: 85/s: 5, ci: 20, ri: 42);

The position of the X segment inside the pygophore is probably related to the direction of the external opening of the genital capsule (Baker 1931). Schaffer (1977) highlights the phylogenetic significance of that feature in Pentatomoidea, Lygaeoidea, Coreoidea and Pyrrhocoroidea. In the present study *E. grandis*, *Chloropepla* spp., *Chlorocoris* spp., *Mayrinia* spp., *Loxa* spp. and *Fecelia* spp. have the segment X in a parallel position in relation to the longitudinal axis of the pygophore (Fig. 7B).

**Character 30** (Fig. 7D-E). Paramere (0) nearly cylindrical, without big processes (1) laminar, with wide processes (2) inconspicuous (s: 4, ci: 50, ri: 80/s: 5, ci: 40, ri: 70);

The shape and size of parameres are highly variable among Pentatomidae groups, what turns the establishment of homologies difficult (Baker 1931; Dupuis 1970). The variations in the parameres in the infra-genus level usually are useful to establish relationships among species (Fortes & Grazia 2005; Ferrari *et al.* 2010). The understanding of the homologies in the higher levels is still scarce. In the present study, *Rhyncholepta* spp. lack parameres, probably by the secondary lost of these structures. The laminar parameres armed with several, usually acute processes are observed in *C. purpureipennis*, *Chlorocoris* spp., *Fecelia* spp. (except for *F. proxima*) and *Loxa* spp. (Fig. 7E).

**Character 31** (Fig. 6A, 7F). Paramere: (0) not connected to ventral wall of pygophore (1) connected to the ventral wall (s: 2, ci: 50, ri: 83/ s: 4, ci: 25, ri: 50);

Traditionally the parameres are considered to connect to the pygophore walls through muscles and to the basal plate of the articulatory apparatus of the phallus by ligaments (Dupuis 1970). Besides these connections a connection of the paramere by ligament with the ventral wall was detected in *Chloropepla* spp., *Mayrinia* spp., *Fecelia* spp. and *Loxa* spp.

(Fig. 6A, 7F). Associated with this characteristic there is the enlargement of the paramere base.

**Character 32** (Fig. 7E). Paramere, basal process: (0) absent (1) present (s: 1, ci: 100, ri: 100/s: 3, ci: 33, ri: 66);

The parameres of *Loxa*, *Mayrinia*, *Fecelia* species and *C. (Arawacoris) tarsalis* bear a rounded process near the base, ventrally directed (Fig. 7E).

**Character 33** (Fig. 7G, H, J). Thecal shield: (0) absent (1) present, large (2) present, short (3) titillators (s: 6, ci: 50, ri: 76/s: 8, ci: 37, ri: 61);

The thecal shield is a distal expansion of the phallosome typical of Asopinae (McDonald 1966; Gapud 1991). In the ingroup, the species that show a high developed thecal shield (state 1) (Fig. 7G), present also a reduced phallosome: *Mayrinia* spp., *Loxa* spp. and *Fecelia* spp. These species, together with *P. crassimargo*, present a large, bowl-shaped thecal shield, that surrounds the base of vesica. The thecal shield described as state 2 also surrounds the base of vesica, but is short and nearly cylindrical, with smooth margins (Fig. 7H). In the present work, the structures described as titillators by Baker (1931) were considered homologous to the thecal shield. The titillators consist of a pair of finger-like structures arising from distal margin in the posterior surface of phallosome and are found in *C. purpureipennis*, *D. furcatus*, *E. heros* and *R. humeralis* (Fig. 7J).

**Character 34** (Fig. 7I, 8). Conjunctiva: (0) absent (1) present, conspicuous (2) present, completely obscured by the phallosome (s: 4, ci: 50, ri: 77);

The reduction or absence of the conjunctival appendages was considered by Gapud (1991) as an apomorphy for Pentatomidae. The complete loss of conjunctiva grouped Edessini, Discocephalinae and some neotropical genera of Pentatominae (*Arvelius*, *Loxa*, *Chlorocoris* and *Vulsirea*) (Gapud 1991). However, in the present study the presence of membranous conjunctival appendages in *Arvelius* is verified. In *Rhyncholepta* spp. and *Chloropepla* spp.

the conjunctiva is reduced, almost entirely obscured by the phallosome (state 2) (Fig. 8). It is absent in *E. humeralis*, *Chlorocoris* spp., *Mayrinia* spp., *Fecelia* spp. and *Loxa* spp.

**Character 35** (Fig. 7 H, J; 8). Vesica: (0) short (1) medium size (2) long (s: 5, ci: 40, ri: 50/s: 4, ci: 50, ri: 66);

The length of vesica is highly variable in Pentatomidae (Gapud 1991; Barcellos & Grazia 2003; Fortes & Grazia 2005; Campos & Grazia 2006) and apparently there is the tendency of its extreme elongation in some genera like *Euschistus*, and reduction in others, like *Arvelius*, *Chlorocoris* and *Loxa* (Gapud 1991). The short vesica is a synapomorphic characteristic for some Edessinae genera (Barcellos & Grazia 2003). However, this feature can be variable among species of the same genus, like *Serdia* (Fortes & Grazia 2005). The short vesica (state 0) (Fig. 8) doesn't surpass much the length of conjunctiva, when the last is conspicuous as in *R. humeralis*, *B. heidemanni* and *Arvelius* spp. or slightly surpasses the distal border of phallosome, as seen in *Chloropepla* spp. and *E. humeralis*. The long vesica (state 2) (Fig. 7I) is characteristic of *C. purpureipennis* and *E. heros* and is equivalent to the penisfilum described by Baker (1931). It consists of a long tube, winded and far surpassing the distal end of the conjunctiva. In the remaining species studied, the vesica was considered medium sized (state 1) (Fig. 7H).

**Character 36** (Fig. 8). Vesica, basal process: (0) absent (1) present (s: 5, ci: 20, ri: 60/s: 6, ci: 16, ri: 50);

The basal process of vesica is a collar-like structure, which surrounds the base of vesica in *Chloropepla* spp. (Fig. 8) or a sheath-like structure, surrounding the vesica in *Fecelia* spp., *C. (Arawacoris) tarsalis* and *Loxa* spp.

#### Morphological analysis

The cladistic analysis resulted in four more parsimonious cladograms with 123 steps, CI of 43 and RI of 73. The strict consensus of those trees is shown in Figure 9.

*Brepholoxa heidemanni* appears as sister group of all remaining terminals, followed by *C. purpureipennis*, *D. furcatus* and *E. heros*. The last two taxa are in the same branch, supported by short ostiolar ruga (10<sub>1</sub>).

The monophyly of the ingroup was not confirmed: *R. humeralis* and *E. humeralis* are clustered in a branch with *Arvelius* spp. and *Rhyncholepta* spp. This first branch has a Bremer support = 1, with characters margin of head before the eyes concave (0<sub>0</sub>), anterior half of pronotum antero-lateral margins crenulated (6<sub>0</sub>) and proximal region of capsula seminalis tubular (23<sub>0</sub>). *Rhyncholepta* spp. appears as sister group of the clade composed by *Arvelius* spp + *R. humeralis* + *E. humeralis*. These groups share a well developed carina of metasternum (12<sub>0</sub>), third urosternite spine present (14<sub>0</sub>), abdominal venter with longitudinal keel (15<sub>2</sub>) and short vesica (35<sub>0</sub>). *Rhynchocoris humeralis* and *E. humeralis* form a well sustained dichotomy (Bremer support = 3) defined by posterior margin of pronotum concave (8<sub>0</sub>), short ostiolar ruga (10<sub>0</sub>), carina of mesosternum well developed, produced toward the prosternum (11<sub>0</sub>), apices of femora unarmed (13<sub>0</sub>), posterior thickening of vaginal intima in plate (20<sub>0</sub>) and superior process of pygophore absent (25<sub>0</sub>).

The remaining species are included in a monophyletic group, which corroborate the relationship of the *Chlorocoris* group, excluding *Arvelius* and *Rhyncholepta*. The *Chlorocoris* group is delimited by superior process of pygophore absent (25<sub>0</sub>), median projection of infolding of ventral rim conspicuous, apical to the cup-like sclerite (27<sub>1</sub>) and segment X parallel to the longitudinal axis of pygophore (29<sub>1</sub>). This is a well supported branch (Bremer support = 3). The first inside dichotomy separates *E. grandis* + *Chloropepla* spp. from the remaining species. This two genera share long ostiolar ruga (10<sub>0</sub>) and anterior thickening of vaginal intima absent (21<sub>2</sub>).

The genera *Chlorochoris*, *Mayrinia*, *Fecelia* and *Loxa* are grouped in a strongly supported branch (Bremer support = 7), sustained by proximal portion of capsula seminalis

funnel shaped (23<sub>1</sub>), shape of the hypandrium (26<sub>3</sub>), segment X processes present, posteriorly directed (28<sub>2</sub>), laminar paramere armed with conspicuous processes (30<sub>1</sub>) and conjunctiva absent (34<sub>0</sub>). Internally to this branch there is a split between *Chlorocoris* (*Chlorochoris*) + *Chlorochoris* (*Monochrocerus*) and *Mayrinia* + *Fecelia* + *Chlorocoris* (*Arawacoris*) + *Loxa*. The first clade share the absence of dorsal process of femora (13<sub>0</sub>) and laterotergites 9 not surpassing the band uniting the laterotergites 8 (17<sub>1</sub>). *Chlorocoris* (*Chlorocoris*) appear as sister group of *Chlorocoris* (*Monochrocerus*) species, that despite the morphological great variation, are grouped in a highly supported branch (Bremer support = 4).

The remaining species are grouped by sharing laterotergites 9 apex acute (18<sub>1</sub>), anterior thickening of vaginal intima in plates (21<sub>1</sub>), median projection conspicuous, laterally placed in relation to the cup like sclerite (27<sub>2</sub>), paramere connected to the ventral rim (31<sub>1</sub>) and presence of a basal process in the paramere (32<sub>1</sub>). This clade is strongly supported (Bremer support = 12). *Mayrinia* appears as sister taxon of the remaining species. *Fecelia* spp. and *Chlorocoris* (*Arawacoris*) appear in a polytomy, while *Loxa* spp. are grouped in a branch supported by abdominal venter plain (15<sub>0</sub>), anterior margin of 7<sup>th</sup> urosternite strongly produced anteriorly (16<sub>1</sub>) and laterotergites 9 with a rounded apex (18<sub>0</sub>).

The placement of *C. (Arawacoris) tarsalis* indicates that the taxonomic status of this species needs to be reviewed, since it is more closely related to *Fecelia* and *Loxa* species than to *Chlorocoris* (*Chlorocoris*) and *Chlorocoris* (*Monochrocerus*) species. In the description of *C. (Arawacoris) tarsalis*, Thomas (1992) highlighted the difficulty in interpret its genitalia structure as well as the genitalia of similar genera (*Loxa* and *Chloropepla*). The author assigned to this difficulty the decision of maintaining the species within *Chlorocoris* rather than erect a new genus for *C. tarsalis*.

Despite any synapomorphy support *Fecelia* species they grouped in the same branch, indicating that the genus is valid. This certainly happened because the high variability



observed in these species. For example, *F. nigridens* and *F. minor* have a well developed paramere, with wide process, which is not found in *F. proxima*. Furthermore, the processes of segment X that are very conspicuous in *F. nigridens* and *F. proxima*, are absent or inconspicuous in *F. minor*. However, the morphology of phallus is very similar among all species, as well as with *Loxa*, *Mayrinia* and *Chlorocoris* (*Arawacoris*). A better understanding of the male pygophore structures is necessary to identify the characters that would define this group.

#### Total evidence analysis

One most parsimonious tree resulted from the combined data set analysis. The cladogram has 1783 steps, CI of 75 and RI of 76 (Fig. 10).

*Brepholoxa heidemanni* appears in the most basal branch of the tree. The remaining groups are separated in two main groups. One composed by *Loxa*, *Mayrinia*, and *Chlorocoris* (*Monochrocerus*). In this branch *Loxa* occupies the most basal position as sister group of the remaining taxa of the clade. The morphological characters which support this clade are: hypandrium shape (26<sub>3</sub>), median projection laterally to the cup like sclerite (27<sub>2</sub>), segment X processes posteriorly directed (28<sub>2</sub>), paramere laminar with wide processes (30<sub>1</sub>) and conjunctiva absent (34<sub>0</sub>).

The other branch has only one morphological character supporting it: proximal region of capsula seminalis bulbous (23<sub>2</sub>). It shows basally *E. heros* + *C. purpureipennis* supported by vesica long (35<sub>2</sub>). The remaining taxa are grouped only by molecular characters. The first dichotomy inside this branch splits *Eludocoris grandis* + *Arvelius* + *E. humeralis* + *R. humeralis* from the other species sharing margin of head before the eyes concave (0<sub>0</sub>) and ostiolar ruga long (10<sub>0</sub>). *Arvelius*, *E. humeralis* and *R. humeralis* are grouped exclusively by morphological characters: anterior half of antero-lateral margins of pronotum crenulated (6<sub>0</sub>), metasternum carina raised (12<sub>0</sub>), abdominal spine present (14<sub>0</sub>), abdominal venter with

longitudinal keel (15<sub>2</sub>), proximal region of capsula seminalis tubular (23<sub>0</sub>) and vesica short (35<sub>0</sub>). The other branch is divided in two clades: one grouping *D. furcatus* + *Rhyncholepta* + *Chloropepla*, and the other with + *Chlorocoris* (*Chlorocoris*) + *Fecelia* + *Chlorocoris* (*Arawacoris*). The first clade is supported only by molecular characters, while the second one is supported by abdominal venter with longitudinal sulcus (15<sub>1</sub>), proximal region of capsula seminalis funnel shaped (23<sub>1</sub>), shape of hypandrium (26<sub>3</sub>), paramere laminar with wide processes (30<sub>1</sub>) and conjunctiva absent (34<sub>0</sub>).

## Discussion

The results derived from the total evidence analysis and the morphological analysis alone are not in complete agreement. *Loxa*, *Mayrinia*, and *Chlorocoris* (*Monochrocerus*) are closely related in both hypotheses. In the morphological based hypothesis however, these groups are also related to *Chlorocoris* (*Chlorocoris*), *Chlorochoris* (*Arawacoris*) and *Fecelia*, which is not observed in the evidence total analysis results. Instead, the three last taxa appear in a group with *D. furcatus*, *Rhyncholepta* and *Chloropepla*, supported only by molecular characters. Further studies are needed to define these relationships, since morphologically there is good evidence that *Loxa*, *Mayrinia*, *Chlorocoris* and *Fecelia* are related: in both cladograms these groups share the shape of hypandrium (26<sub>3</sub>), the shape of paramere (30<sub>1</sub>) and the absence of conjunctiva (34<sub>0</sub>). Several studies highlight the importance and unique features of these structures in these taxa (McDonald 1966; Grazia-Vieira 1972b; Grazia 1976; Eger 1978; Thomas 1985; 1998). Moreover, the grouping of *D. furcatus* + *Rhyncholepta* + *Chloropepla* and *Chlorocoris* (*Chlorocoris*) + *Chlorochoris* (*Arawacoris*) + *Fecelia* could be explained by the long-branch attraction effect (Felsenstein 2004; Bergsten 2005). This effect is probably caused by insufficient taxa sampling (Bergsten 2005), since only 13 terminals

have sequences included in the analysis, and only 10 of these have all the fragments available (see Tab. 1).

The grouping of *Fecelia* and *Chlorocoris* (*Arawacoris*) is maintained in both results, indicating that the position of *C. tarsalis* should be reassigned. Another relationship that is maintained in both hypotheses is *Arvelius* + *E. humeralis* + *R. humeralis*. The relationship of the first two was already addressed by a cladistic study (Grazia 1997) and both genera have been treated as belonging to the Pentatomini. *Rhynchocoris humeralis*, however, belongs to the Rhynchocorini species, and the relationship of these taxa should be better investigated.

The results achieved from both data sets showed differences in the position and relation of Carpocorini species. In morphological based cladogram, *C. purpureipennis* is sister of all the remaining taxa (except *B. heidemanni*, which is more basal) and *E. heros* appears in a dichotomy with *D. furcatus*. In the total evidence hypothesis, however, *E. heros* is in a dichotomy with *C. purpureipennis*, while *D. furcatus* is grouped with *Rhyncholepta* and *Chloropepla*. Despite the monophyly of Carpocorini has not been yet investigated in a phylogenetic basis the species included in the analysis are really close morphologically and probably share several synapomorphies. For instance, the genitalia of both sexes of *D. furcatus* and *E. heros* are very similar. Anyway, the homologies also need to be better investigated and tested within Pentatomidae, Pentatominae and tribes levels.

The use of molecular data in cladistic analysis at genera level relationships within Pentatomidae and Pentatominae has not yet been studied in detail. The results of the present study are preliminary and show that the use of sequence data at this level of analysis need to be more investigated. For example: more information is needed about the use of sequences at this level. This is illustrated by the distribution of characters in the total evidence cladogram: the interior branches are mainly defined by the molecular data, while the peripheral ones by the morphological characters. This may indicate that the sequences used in the present

analysis are informing about higher relationships instead of the ones which were addressed here.

The fossil evidence indicates that most Pentatomoidea families evolved in Cretaceous (Grimaldi & Engel 2005). As discussed in the literature for other taxa, the 28S sequences are informative about events occurred in the Paleozoic and Mesozoic, while mitochondrial ribosomal genes (like 16S) are informative when used to compare taxa evolved in the Cenozoic (Hillis & Dixon 1991). Maybe the addition of faster-evolving sequences to the analysis could provide a better definition for the relation among the genera studied here.

## Conclusions

The differences among the two hypothesis of relationship prevent the proposal of a unified classification for the taxa studied. Some insights, however, can be drawn.

First, the relationship of *Loxa*, *Mayrinia*, *Chlorochoris* and *Fecelia* species needs to be further investigated since they show substantial morphological evidence, especially concerning the male genitalia, to support their proximity. The characters investigated in the present study should be analyzed in other Pentatominae groups, which could help in the clarification of infra-subfamily relations. The results showed here reinforce the necessity of cladistics studies at genera and species levels in Pentatominae. More morphological characters should be explored and the utility of molecular data must be addressed.

The classification of *Chlorocoris* (*Arawacoris*) *tarsalis* should be revised, since in both analyses this taxon appears more related to *Fecelia* species than to *Chlorocoris*.

## References

- Amorim, D.S. (2002) *Fundamentos de sistemática filogenética*. Holos Ribeirão Preto, 154 pp.
- Amorim, D.S. & Pires, M.R.S. (1996) Neotropical biogeography and a method for maximum biodiversity estimation. *In*: Bicudo, C.E.M. & Menezes, N.A. (Eds.) *Biodiversity in Brazil: a first approach*. CNPq, São Paulo, pp. 183-219.
- Amyot, C.J. & Serville, A. (1843) *Histoire Naturelle des Insectes. Hémiptères*. Librairie Encyclopedique de Roret, Paris, lxxvi + 675 pp.
- Baker, A.B. (1931) A study of male genitalia of Canadian species of Pentatomidae. *Canadian Journal of Research* 4, 148-179.
- Barcellos, A. & Grazia, J. (2003) Cladistics analysis and biogeography of *Brachystethus Laporte* (Heteroptera, Pentatomidae, Edessinae). *Zootaxa*, 256, 1-14.
- Becker, M. & Grazia-Vieira, J. (1971) Sobre o gênero *Rhyncholepta* Bergroth, 1911, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia*, 31, 389-399.
- Bergroth, E. (1911) Zur Kenntnis der neotropischen Arminen (Hem. Het.). *Wiener Entomologische Zeitung*, 30, 117-130.
- Bergsten, J. (2005) A review of long-branch attraction. *Cladistics*, 21, 163-193.
- Bernardes, J.L.C., Schwertner, C.F. & Grazia, J. (2009) Cladistic analysis of *Thoreyella* and related genera (Hemiptera: Pentatomidae: Pentatominae: Procliticini). *Zootaxa*, 1-23.
- Brailovsky, H. (1981) Revision del genero *Arvelius* Spinola (Hemiptera-Heteroptera-Pentatomidae-Pentatomini). *Instituto de Biología Universidad Nacional-Autónoma de México – Série Zoologica*, 51, 239-298.

- Brailovsky, H., Cervantes, L. & Mayorga, C. (1992) Hemiptera: Heteroptera de Mexico 44. Biología, estadios ninfales y fenología de la tribu Pentatomini (Pentatomidae) en la Estación de Biología Tropical 'Los Tuxtlas', Veracruz. . *Universidad Nacional Autónoma de México Instituto de Biología Publicaciones Especiales*, 8,
- Bremer, K. (1994) Branch support and tree stability. *Cladistics*, 10, 295-304.
- Brooks, D.R., van Veller, M.G.P. & McLennan, D.A. (2001) How to do BPA, really. *Journal of Biogeography*, 28, 345-358.
- Campos, L.A. & Grazia, J. (2006) Análise cladística e biogeografia de Ochlerini (Hemiptera, Pentatomidae, Discocephalinae). *Iheringia - Série Zoologia*, 96, 147-163.
- Cognato, A.I. & Vogler, A.P. (2001) Exploring data interaction and nucleotide alignment in a multiple gene analysis of *Ips* (Coleoptera : Scolytinae). *Systematic Biology*, 50, 758-780.
- Colgan, D.J., Ponder, W.F., Beachman, E. & Maracanas, J.M. (2003) Molecular phylogenetic studies of Gastropoda based on six gene segments representing coding or non-coding and mitochondrial or nuclear DNA. *Molluscan Research*, 123, 123-148.
- Costa, L.P. (2003) The historical bridge between the Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography with small mammals. *Journal of Biogeography*, 30, 71-86.
- Cracraft, J. (1985) Historical biogeography and patterns of differentiation within the South American avifauna: areas of endemism. In: Buckley, P.A., Foster, M.S., Morton, E.S., Ridgley, R.S. & Buckley, F.G. (Eds.) *Ornithological Monographs no. 36*. The American Ornithologists' Union, Washington, D. C., pp. 49-84.
- Dupuis, C. (1955) Les génitalia des Hémiptères Hétéroptères (Génitalia externes de deux sexes; Voies ectodermiques familles). Revue de la morphologie Lexique de la nomenclature. Index bibliographique analytique. *Memoirs du Museum National d'Histoire Naturelle (France). Nouvelle Serie. Serie A. Zoologie*, 6, 183-278.

- Dupuis, C. (1970) Heteroptera. In: Tuxen, S.L. (Ed.) *Taxonomist's Glossary of Genitalia of Insects*. Munksgaard, Copenhagen, pp. 190-208
- Eger, J.E.J. (1978) Revision of the genus *Loxa* (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society*, 86, 224-259.
- Eger, J.E.J. (1980) *Fecelia biorbis* n. sp. (Heteroptera: Pentatomidae), a new species from Haiti. *Journal of the New York Entomological Society*, 88, 29-32.
- Ernisse, D.J. & Kluge, A.G. (1993) Taxonomic congruence versus total evidence, and Amniote phylogeny inferred from fossils, molecules, and morphology. *Molecular Biology and Evolution*, 10, 1170-1195.
- Falling Rain Genomics (2009) *Global Gazetteer*, from: <http://www.fallingrain.com/world/> (March 2010).
- Farris, J.S. (1989) THE RETENTION INDEX AND THE RESCALED CONSISTENCY INDEX. *Cladistics-the International Journal of the Willi Hennig Society*, 5, 417-419.
- Felsenstein, J. (2004) *Inferring phylogenies*. Sinauer, Sunderland 664 pp.
- Ferrari, A., Grazia, J. & Schwertner, C.F. (2010) Review, cladistic analysis and biogeography of *Nezara* Amyot & Serville (Hemiptera: Pentatomidae). *Zootaxa*, 2424, 1-41.
- Fortes, N.D.F. & Grazia, J. (2005) Review and cladistic analysis of *Serdia* Stal (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira De Entomologia*, 49, 294-339.
- Froeschner, R.C. (1988) Family Pentatomidae Leach, 1815. The stink bugs. In: Henry, T.J. & Froeschner, R.C. (Eds.) *Catalog of the Heteroptera, or true bugs, of Canada and the Continental United States*. E.J. Brill, New York, pp. 958.
- Gapud, V.P. (1991) A generic revision of the subfamily Asopinae, with consideration on its phylogenetic position in the family Pentatomidae and superfamily Pentatomoidea (Hemiptera-Heteroptera). *Philippines Entomology*, 8, 865-961.

- Gilbert, M.T.P., Moore, W., Melchior, L. & Worobey, M. (2007) DNA Extraction from Dry Museum Beetles without Conferring External Morphological Damage. *PLoS ONE*, 2, e272.
- Goloboff, P.A., Farris, J.S. & Nixon, K.C. (2008) TNT, a free program for phylogenetic analysis. *Cladistics*, 24, 774-786.
- Goodman, M., Olson, C.B., Beeber, J.E. & Czelusniak, J. (1982) New perspectives in the molecular biological analysis of mammalian phylogeny. *Acta Zoologica Fennica*, 169, 19-35.
- Grazia-Vieira, J. (1971) Sobre uma nova combinação, uma sinonímia e a descrição de uma nova espécie de *Chloropepla* Stal (Hemiptera, Pentatomidae, Pentatomini). *Papeis Avulsos de Zoologia*, 24, 207-211.
- Grazia-Vieira, J. (1972a) Contribuição ao conhecimento do gênero *Chloropepla* Stal (Hemiptera, Pentatomidae, Pentatomini). *Anais da Sociedade Entomológica do Brasil*, 1, 42-45.
- Grazia-Vieira, J. (1972b) O gênero *Mayrinia* Horvath, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Revista Peruana de Entomologia*, 15, 117-124.
- Grazia-Vieira, J. (1973a) *Chloropepla rolstoni*, uma nova espécie de Pentatomini (Hemiptera, Pentatomidae): uma correção. *Anais da Sociedade Entomológica do Brasil*, 2, 13-19.
- Grazia-Vieira, J. (1973b) Uma nova espécie de *Mayrinia* Horvath, 1925 (Heteroptera, Pentatomidae, Pentatomini). *Iheringia - Serie Zoologia*, 25-33.
- Grazia-Vieira, J. (1973c) Uma nova espécie de *Mayrinia* Horvath, 1925 (Heteroptera. *Iheringia - Série Zoologia*, 42, 25-33.
- Grazia, J. (1968) Sobre o genero *Chloropepla* Stal, 1867, com a descrição de uma nova espécie (Hemiptera, Pentatomidae, Pentatominae). *Revista Brasileira de Biologia*, 28, 193-206.
- Grazia, J. (1969) Una nueva especie del Genero *Chloropepla* Stal, 1867 (Hemiptera, Pentatomidae, Pentatomini). *Neotropica*, 15, 1-12.



- Grazia, J. (1976) Revisão do gênero *Fecelia* Stal, 1872 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia*, 36, 229-237.
- Grazia, J. (1977) Revisão dos pentatomídeos citados no “Quarto catálogo dos insetos que vivem nas plantas do Brasil”(Hemiptera-Pentatomidae-Pentatomini). *Dusenía*, 10, 161-174.
- Grazia, J. (1980) Uma nova espécie do gênero *Fecelia* Stal (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Biologia*, 40, 261-266.
- Grazia, J. (1987) Novas contribuições ao gênero *Chloropepla* Stal, 1867 (Heteroptera, Pentatomidae, Pentatomini). *Revista Brasileira de Entomologia*, 31, 473-477.
- Grazia, J. (1997) Cladistics analysis of the Evoplitus genus group of Pentatomini (Heteroptera, Pentatominae). *Journal of Comparative Biology* 2, 115-129.
- Grazia, J. & Becker, M. (1995) *Adevoplitus*, a new genus of Neotropical Pentatomini (Heteroptera, Pentatomidae). *New York Entomological Society*, 103, 386-400.
- Grazia, J. & Becker, M. (1997) *Adevoplitus*, a new genus of Neotropical Pentatomini (Heteroptera, Pentatomidae). *Journal of the New York Entomological Society*, 103, 386-400.
- Grazia, J. & Frey-Da-Silva, A. (2001) Descrição dos imaturos de *Loxa deducta* Walker e *Pallantia macunaima* Grazia (Heteroptera: Pentatomidae) em Ligustro, *Ligustrum lucidum* Ait. *Neotropical Entomology*, 30, 73-80.
- Grazia, J. & Frey-da-Silva, A. (2003) *Rideriana amazonica* gen. nov. and sp. nov. of Pentatomini (Heteroptera, Pentatomidae). *Revista Brasileira de Zoologia*, 20, 507-510.
- Grazia, J., Schuh, R.T. & Wheeler, W.C. (2008a) Phylogenetic relationships of family groups in Pentatomoidea based on morphology and DNA sequences (Insecta: Heteroptera). *Cladistics*, 24, 932-976.
- Grazia, J., Schwertner, C.F. & Greve, C. (2008b) Two new species of genus *Chloropepla* (Hemiptera: Pentatomidae: Pentatominae) from Brazil. *Acta Entomologica Musei Nationalis Pragae*, 48, 533-542.

- Grazia, J. & Teradaira, C.T. (1980) Nova espécie de *Chloropepla* Stal, 1867 coletada em Tucuruí, Pará, Brasil (Heteroptera, Pentatomidae). *Anais da Sociedade Entomológica do Brasil*, 9, 123-131.
- Greve, C., Schwertner, C.F. & Grazia, J. (submitted) Three new species of *Chloropepla* (Heteroptera: Pentatomidae: Pentatominae). *Australian Journal of Entomology*,
- Grimaldi, D. & Engel, M.S. (2005) *Evolution of the insects*. Cambridge University Press, New York, pp.
- Hasan, S.A. & Kitching, I.J. (1993) A cladistic analysis of the tribes of the Pentatomidae (Heteroptera). *Japanese Journal of Entomology*, 61, 651-669.
- Hennig, W. (1968) *Elementos de una sistemática filogenética*. Editorial Universitaria, Buenos Aires, 353 pp.
- Henry, T.J. (1997) Phylogenetic analysis of family groups within the infraorder Pentatomomorpha (Hemiptera: Heteroptera), with emphasis on the Lygaeoidea. *Annals of the Entomological Society of America*, 90, 275-301.
- Hillis, D.M. (1987) Molecular versus morphological approaches to systematics. *Annual Review of Ecology and Systematics*, 18, 23-42.
- Hillis, D.M. & Dixon, M.T. (1991) Ribosomal DNA: Molecular Evolution and Phylogenetic Inference. *The Quarterly Review of Biology*, 66, 411.
- Hillis, D.M. & Wiens, J.J. (2000) Molecules versus morphology in systematics: Conflicts, artifacts, and misconceptions. In: Wiens, J.J. (Ed.) *Phylogenetic analysis of morphological data*. Smithsonian Institution Press 220.
- Horváth, G. (1925) De pentatomidarum genere *Loxa* Am. et Serv. et de novo genere ei affini. *Annales Musei Nationalis Hungarici* 22, 307-328.
- Kluge, A.G. (1989) A concern for evidence and a phylogenetic hypothesis of relationships among Epicrates (Boidae, Serpentes). *Systematic Zoology*, 38, 7-25.

- Kluge, A.G. (1998) Total evidence or taxonomic congruence: Cladistics or consensus classification. *Cladistics*, 14, 151-158.
- Kluge, A.G. (2004) On total evidence: for the record. *Cladistics*, 20, 205-207.
- Kluge, A.G. & Farris, J.S. (1969) QUANTITATIVE PHYLETICS AND EVOLUTION OF ANURANS. *Systematic Zoology*, 18, 1-&.
- Kluge, A.G. & Grant, T. (2006) From conviction to anti-superfluity: old and new justifications of parsimony in phylogenetic inference. *Cladistics*, 22, 276-288.
- Kluge, A.G. & Wolf, A.J. (1993) Cladistics - What's in a word. *Cladistics*, 9, 183-199.
- Leston, D. (1955) The function of the conjunctiva in copulation of a shield bug, *Piezodorus lituratus* (Fabricius) (Hemiptera, Pentatomidae). *Journal of the Society for British Entomology*, 5, 101-105.
- Li, H.M., Deng, R.Q., Wang, J.W., Chen, Z.Y., Jia, F.L. & Wang, X.Z. (2005) A preliminary phylogeny of the Pentatomomorpha (Hemiptera : Heteroptera) based on nuclear 18S rDNA and mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution*, 37, 313-326.
- Link, D. & Grazia, J. (1987) Pentatomidae da região central do Rio Grande do Sul. *Anais da Sociedade Entomológica do Brasil*, 16, 115-129.
- McArthur, A.G. & Koop, B.F. (1999) Partial 28S rDNA sequences and the antiquity of hydrothermal vent endemic gastropods. *Molecular Phylogenetics and Evolution*, 13, 255-274.
- McDonald, F.J.D. (1966) The genitalia of North American Pentatomoidea (Hemiptera: Heteroptera). *Quaestiones Entomologicae*, 2, 7-150.
- Mishler, B.D. (1994) Cladistic analysis of molecular and morphological data. *American Journal of Physical Anthropology*, 94, 143-156.
- Mishler, B.D. (2005) Logic of the data matrix in phylogenetic analysis. In: Albert, V.A. (Ed.) *Parsimony, Phylogeny and Genomics*. Oxford University Press, Oxford, pp. 229.

- MOBOT (2007) *Gazetteer of Costa Rican Plant-Collecting Locales*, from: <http://www.mobot.org/MOBOT/Research/costaricagaz.shtml> (March 2010).
- Morrone, J.J. (2001) *Biogeografía de América Latina y el Caribe*. MT - Manuales & Tesis SEA, Zaragoza, 148 pp.
- Morrone, J.J. (2004) La Zona de Transición Sudamericana: caracterización y relevancia evolutiva. *Acta Entomologica Chilena*, 28, 41-50.
- Morrone, J.J. (2006) Biogeographic areas and transition zones of Latin America and the Caribbean islands based on panbiogeographic and cladistic analyses of the entomofauna. *Annual Review of Entomology*, 51, 467-494.
- Morrone, J.J., Mazzucconi, S.A. & Bachmann, A.O. (2004) Distributional patterns of chacoan water bugs (Heteroptera : Belostomatidae, Corixidae, Micronectidae and Gerridae). *Hydrobiologia*, 523, 159-173.
- Muraji, M. & Taschikawa, S. (2000) Phylogenetic analysis of water striders (Hemiptera: Gerridoidea) based on partial sequences of mitochondrial and nuclear ribosomal RNA genes. *Entomological Science*, 3, 615-626.
- Murrell, A., Campbell, N.J.H. & Barker, S.C. (2001) A total-evidence phylogeny of ticks provides insights into the evolution of life cycles and biogeography. *Molecular Phylogenetics and Evolution*, 21, 244-258.
- Nei, M. & Kumar, S. (2000) *Molecular evolution and phylogenetics*. Oxford University Press, New York, pp.
- Nihei, S.S. & de Carvalho, C.J.B. (2007) Systematics and biogeography of *Polietina* Schnabl & Dziedzicki (Diptera, Muscidae): Neotropical area relationships and Amazonia as a composite area. *Systematic Entomology*, 32, 477-501.
- Nixon, K.C. (2002) WinClada. Published by the author, Ithaca, NY
- Nixon, K.C. & Carpenter, J.M. (1993) On outgroups. *Cladistics*, 9, 413-426.

- Ortega-Leon, G. & Chavez-Bermeo, N. (2008) A new species of the genus *Arvelius* spinola (Hemiptera : Heteroptera : Pentatomidae : Pentatomini) from Mexico. *Proceedings of the Entomological Society of Washington*, 110, 643-646.
- Panizzi, A.R., Mourão, A.P.M. & Oliveira, E.D.M. (1998) Nymph and ault biology and seasonal abundance of *Loxa deducta* (Walker) on privet, *Ligustrum lucidum*. *Anais da Sociedade Entomológica do Brasil*, 27, 199-206.
- Panizzi, A.R. & Rossi, C.E. (1991) Efeito da vagem e da semente de *Leucena* e da vagem de soja no desenvolvimento de ninfas e adultos de *Loxa deducta* (Hemiptera: Pentatomidae). *Revista Brasileira de Biologia*, 51, 607-613.
- Panizzi, A.R. & Slansky, F. (1985) Review of phytophagous pentatomids (Hemiptera, Pentatomidae) associated with soybean in the Americas. *Florida Entomologist*, 68, 184-214.
- Porzecanski, A.L. & Cracraft, J. (2005) Cladistic analysis of distributions and endemism (CADE): using raw distributions of birds to unravel the biogeography of the South American aridlands. *Journal of Biogeography*, 32, 261-275.
- Rider, D. (2008) *Pentatomoidea home page*, North Dakota State University, Fargo. Available from: <http://www.ndsu.nodak.edu/nsdu/rider/Pentatomoidea/> (01/07/08).
- Schaefer, C.W. (1968) The homologies of the female genitalia in the Pentatomoidea (Hemiptera-Heteroptera). *Journal of the New York Entomological Society*, 76, 87-91.
- Schaefer, C.W. (1977) Genital capsule of the tricophoran male (Hemiptera: Heteroptera: Geocorisae). *International Journal of Insect Morphology and Embriology* 6, 277-301.
- Schuh, R.T. (1986) The Influence of Cladistics on Heteropteran Classification. *Annual Review of Entomology*, 31, 67-93.
- Schuh, R.T. & Brower, A.V.Z. (2009) *Biological systematics: principles and applications*. Cornell University Press, Ithaca, 311 pp.

- Schuh, R.T. & Slater, J.A. (1995) *True bugs of the world (Hemiptera: Heteroptera). Classification and natural history*. Cornell University Press, Ithaca, 337 pp.
- Sigrist, M.A. & de Carvalho, C.J.B. (2009) Relacionamentos históricos entre áreas endêmicas na região tropical da América do Sul utilizando a Análise de Parcimônia de Brooks (BPA). *Biota Neotropica*, 9, 1-12.
- Silva, J.M.C. (1996) Distribution of Amazonian and Atlantic birds in gallery forests of the cerrado region, South America. *Ornitologia Neotropical*, 7, 1-18.
- Simon, C., Frati, F., Beckenbach, A., Crespi, B., Liu, H. & Flook, P. (1994) Evolution, weighting, and phylogenetic utility of mitochondrial gene-sequences and a compilation of conserved polymerase chain-reaction primers. *Annals of the Entomological Society of America*, 87, 651-701.
- Spinola, M. (1837) *Essai sur les genres d'insectes appartenants B l'ordre des HémiptPres, Lin. ou Rhyngotes, Fab. et B la section des HétéroptPres, Dufour*. Yves Gravier, Genova, 383 pp.
- Spooner, C.S. (1938) The phylogeny of the Hemiptera based on a study of the head capsule, p. 51. *In*: University of Illinois Bulletin. Vol. 35. University of Illinois, Urbana
- Stål, C. (1867) Bidrag till Hemipterernas Systematik. *Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar*, 24, 491-560.
- Stål, C. (1872) Enumeratio Hemipterorum. Bidrag till en förteckning öfver alla hittels kända Hemiptera, Jemte Systematiska meddelanden. *Kungliga Svenska Vetenskaps-Akademiens Handlingar*, 10, 1-159.
- Thomas, D.B. (1985) Revision of the genus *Chlorocoris* Spinola (Hemiptera: Pentatomidae). *Annals of the Entomological Society of America*, 78, 674-699.
- Thomas, D.B. (1992) *Eludocoris*, a new genus of Pentatomidae (Insecta: Heteroptera) from Costa Rica. *Annals of Carnegie Museum*, 61, 63-67.

- Thomas, D.B. (1998) A new species of *Chlorocoris* (Heteroptera: Pentatomidae) from Jamaica. *Florida Entomologist*, 81, 483-488.
- Varón, A., Vinh, L.S. & Wheeler, W.C. (2010) POY version 4: phylogenetic analysis using dynamic homologies. *Cladistics*, 26, 72-85.
- Wheeler, Q.D. (2008) Undisciplined thinking: morphology and Hennig's unfinished revolution. *Systematic Entomology*, 33, 2-7.
- Wheeler, W.C. (2005) Alignment, Dynamic Homology, and Optimization. In: Albert, V.A. (Ed.) *Parsimony, Phylogeny, and Genomics*. Oxford University Press, New York, pp. 229.
- Whiting, M.F., Carpenter, J.C., Wheeler, Q.D. & Wheeler, W.C. (1997) The Strepsiptera problem: phylogeny of the holometabolous insect orders inferred from 18S and 28S ribosomal DNA sequences and morphology. *Systematic Biology*, 46, 1-68.
- Wiens, J.J. (2004) The role of morphological data in phylogeny reconstruction. *Systematic Biology*, 53, 653-661.

**Table 1.** List of species of genera, sequenced species and type material and species examined.

Sub-Family/Tribe	Genus	Species	16S	28S	28SD	Type specimens examined	Examined	
							Male	Female
Asopinae	<i>Podisus</i> Herrich-Schäffer, 1851	<i>P. crassimargo</i> (Stal, 1860)	X	X	X		X	X
Procliticini	<i>Brepholoxa</i> Van Duzee, 1904	<i>B. heidemani</i> Van Duzee, 1904					X	X
Rhynchocorini	<i>Rhynchocoris</i> Westwood, 1837	<i>R. humeralis</i> (Thunberg, 1783)					X	X
Carpocorini	<i>Carpocoris</i> Kolenati, 1846	<i>C. purpureipennis</i> (DeGeer, 1773)					X	X
	<i>Euschistus</i> Dallas, 1851	<i>E. heros</i> (Fabricius, 1798)	X	X	X		X	X
	<i>Dichelops</i> Spinola, 1837	<i>D. furcatus</i> (Fabricius, 1775)	X	X	X		X	X
Pentatomini	<i>Evoplitus</i> Amyot & Serville, 1843	<i>E. humeralis</i> (Westwood 1837)					X	X
	<i>Arvelius</i> Spinola, 1837	<i>A. albopunctatus</i> (DeGeer, 1773)*					X	X
		<i>A. porrectispinus</i> Breddin, 1909	X	X	X		X	X
		<i>A. tuxtlaensis</i> Brailovsky, 1981						X
		<i>A. crassispinus</i> Brailovsky, 1981					X	X
		<i>A. tecpanus</i> Brailovsky, 1981					X	X
		<i>A. caballeroi</i> Brailovsky, 1981					X	X
		<i>A. paralongirostris</i> Brailovsky, 1981				X	X	
		<i>A. diluticornis</i> Breddin, 1909					X	X
		<i>A. longirostris</i> Brailovsky, 1981				X	X	
		<i>A. confusus</i> Brailovsky, 1981					X	X
		<i>A. haitianus</i> Brailovsky, 1981				X		
		<i>A. latus</i> Breddin, 1909					X	X
		<i>A. peruanus</i> Brailovsky, 1981				X	X	X



Table 1. Cont.

Sub-Family/Tribe	Genus	Species	16S	28S	28SD	Type specimens examined	Examined	
							Male	Female
		<i>A. nigroantennatus</i> Brailovsky, 1981				X		X
		<i>A. intermedius</i> Brailovsky, 1981					X	X
		<i>A. ecuatorensis</i> Brailovsky, 1981				X	X	X
		<i>A. acutispinus</i> Breddin, 1909					X	X
		<i>A. thomasi</i> Ortega-León & Chávez-Berneo, 2008						
	<i>Chlorocoris</i> Spinola, 1837							
	<i>Chlorocoris</i> ( <i>Chlorocoris</i> )	<i>C. nigricornis</i> Schmidt, 1907						X
		<i>C. humeralis</i> Thomas, 1985					X	
		<i>C. complanatus</i> (Guérin-Meneville, 1831)					X	X
		<i>C. sanguinursus</i> Thomas, 1985				X	X	X
		<i>C. tibialis</i> Thomas, 1985				X	X	X
		<i>C. vandoersburg</i> Thomas, 1985						
		<i>C. isthmus</i> Thomas, 1985				X	X	X
		<i>C. distinctus</i> Signoret, 1851	X	X	X		X	X
		<i>C. fabulosus</i> Thomas, 1985						X
		<i>C. sororis</i> Thomas, 1985					X	X
		<i>C. deplanatus</i> (Herrich-Schaeffer, 1842)					X	X
		<i>C. tau</i> Spinola, 1837*				X	X	X
		<i>C. depressus</i> (Fabricius, 1803)					X	X

Table 1. Cont.

Sub-Family/Tribe	Genus	Species	16S	28S	28SD	Type specimens examined	Examined	
							Male	Female
	<i>Chlorocoris</i> ( <i>Monochrocerus</i> )	<i>C. weneri</i> Thomas, 1985					X	X
		<i>C. flaviridis</i> Barber, 1914					X	X
		<i>C. rufispinus</i> Dallas, 1851*	X	X	X		X	X
		<i>C. irroratus</i> Distant, 1880						
		<i>C. hebetatus</i> Distant, 1880					X	X
		<i>C. loxoides</i> Thomas, 1985				X	X	X
		<i>C. rufopictus</i> Walker, 1868					X	X
		<i>C. subrugosus</i> Stål, 1872					X	X
		<i>C. championi</i> Distant, 1880					X	X
		<i>C. biconicus</i> Thomas, 1985				X	X	X
	<i>Chlorocoris</i> ( <i>Arawacoris</i> )	<i>C. tarsalis</i> Thomas, 1998				X	X	X
	<i>Chloropepla</i> Stål, 1867	<i>C. tucuriensis</i> Grazia & Teradaira, 1980				X	X	
		<i>C. lenti</i> Grazia, 1968				X	X	X
		<i>C. aurea</i> (Pirán, 1963)					X	X
		<i>C. rolstoni</i> Grazia-Vieira, 1973					X	X
		<i>C. vicens</i> (Stål, 1860)*	X		X		X	X
		<i>C. pirani</i> Grazia-Vieira, 1971				X		X
		<i>C. dollingi</i> Grazia, 1987				X		X
		<i>C. paveli</i> Grazia et al., 2008				X	X	X
		<i>C. stysi</i> Grazia et al., 2008				X	X	X
		<i>Chloropepla</i> sp. nov. 1				X	X	X

Table 1. Cont.

Sub-Family/Tribe	Genus	Species	16S	28S	28SD	Type specimens examined	Examined	
							Male	Female
		<i>Chloropepla</i> sp. nov. 2				X	X	X
		<i>Chloropepla</i> sp. nov. 3				X	X	X
<i>Eludocoris</i> Thomas, 1992		<i>E. grandis</i> Thomas, 1992	X		X	X	X	X
<i>Fecelia</i> Stål, 1872		<i>F. minor</i> (Vollenhoven, 1868)*				X	X	X
		<i>F. nigridentis</i> (Walker, 1867)	X	X	X		X	X
		<i>F. proxima</i> Grazia, 1980					X	X
		<i>F. biorbis</i> Eger, 1980				X		X
<i>Loxa</i> Amyot & Serville, 1843		<i>L. flavicollis</i> (Drury, 1773)*					X	X
		<i>L. virescens</i> Amyot & Serville, 1843					X	X
		<i>L. peruviansis</i> Eger, 1978				X	X	X
		<i>L. melanita</i> Eger, 1978				X	X	X
		<i>L. deducta</i> Walker, 1867	X	X	X		X	X
		<i>L. viridis</i> (Palisot de Beauvois, 1805)	X	X	X		X	X
		<i>L. parapallida</i> Eger, 1978				X	X	
		<i>L. pallida</i> Van Duzee, 1907					X	X
		<i>L. planiceps</i> Horvath, 1925					X	X
		<i>L. nesiotes</i> Horvath, 1925					X	X
<i>Mayrinia</i> Horváth, 1925		<i>M. curvidens</i> (Mayr, 1864)*	X	X	X		X	X

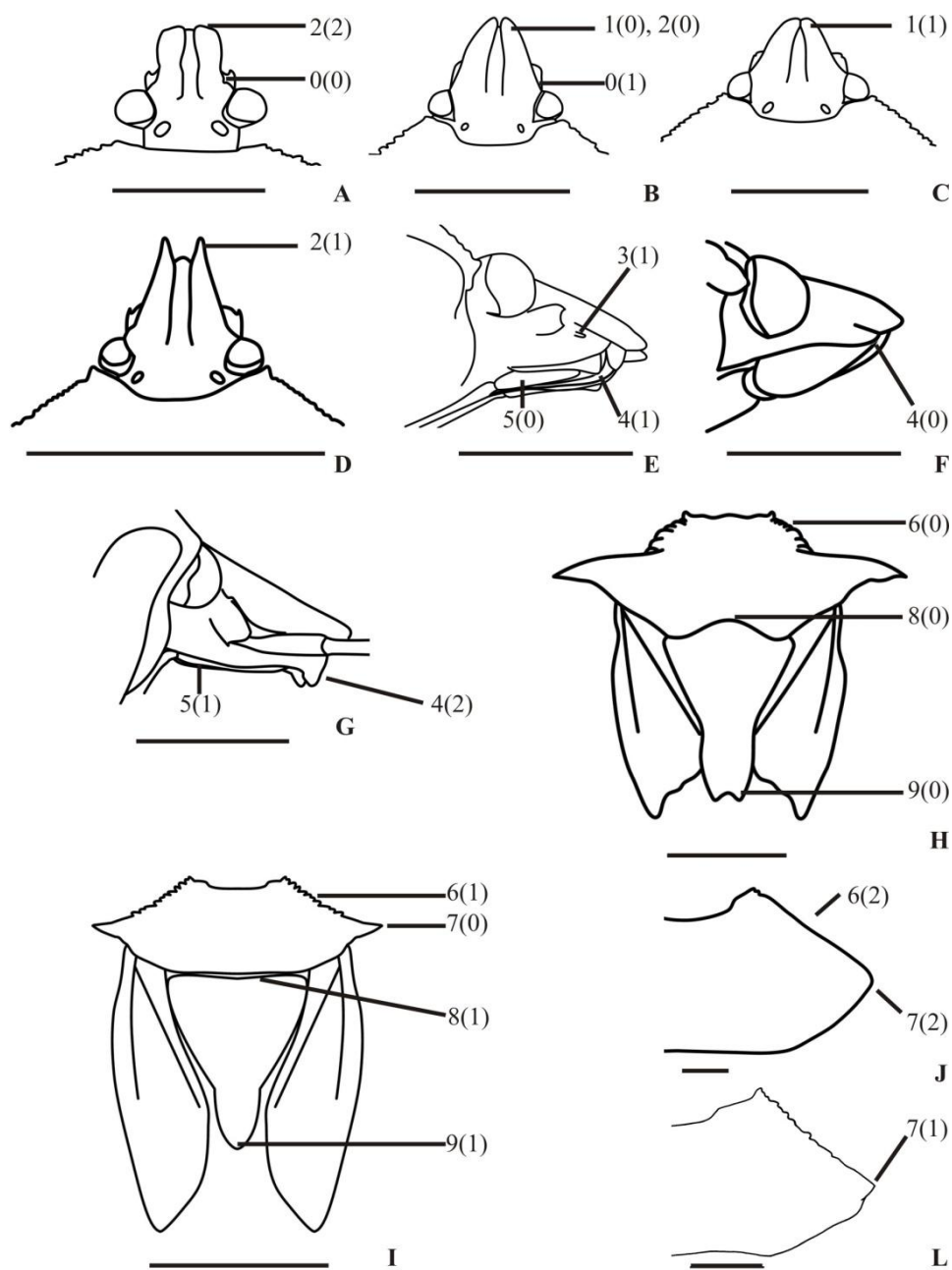
**Table 1.** Cont.

Sub-Family/Tribe	Genus	Species	16S	28S	28SD	Type specimens examined	Examined	
							Male	Female
		<i>M. rectidens</i> (Mayr, 1868)				X	X	X
		<i>M. variegata</i> (Distant, 1880)					X	X
		<i>M. brevispina</i> Grazia-Vieira, 1973				X	X	X
	<i>Rhyncolepta</i> Bergroth, 1911	<i>R. grandicallosa</i> Bergroth, 1911*	X		X		X	X
		<i>R. meinaderi</i> Becker & Grazia-Vieira, 1971					X	X

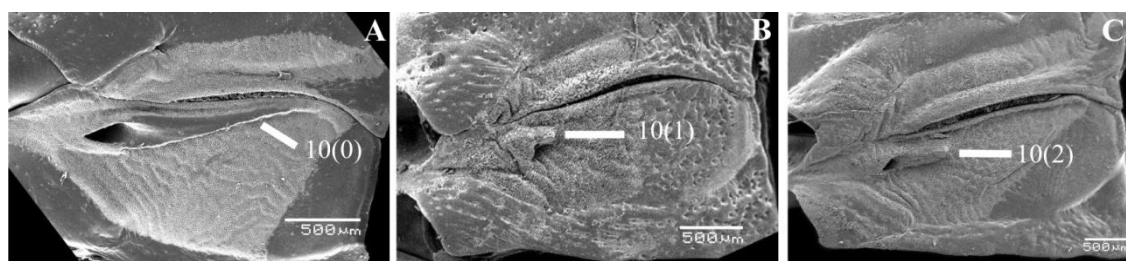
\* Type species of the genus.

**Table 2.** Character state matrix for the cladistic analysis of *Chlorochoris* group: “-” code for inapplicable data, “?” code for missing data.

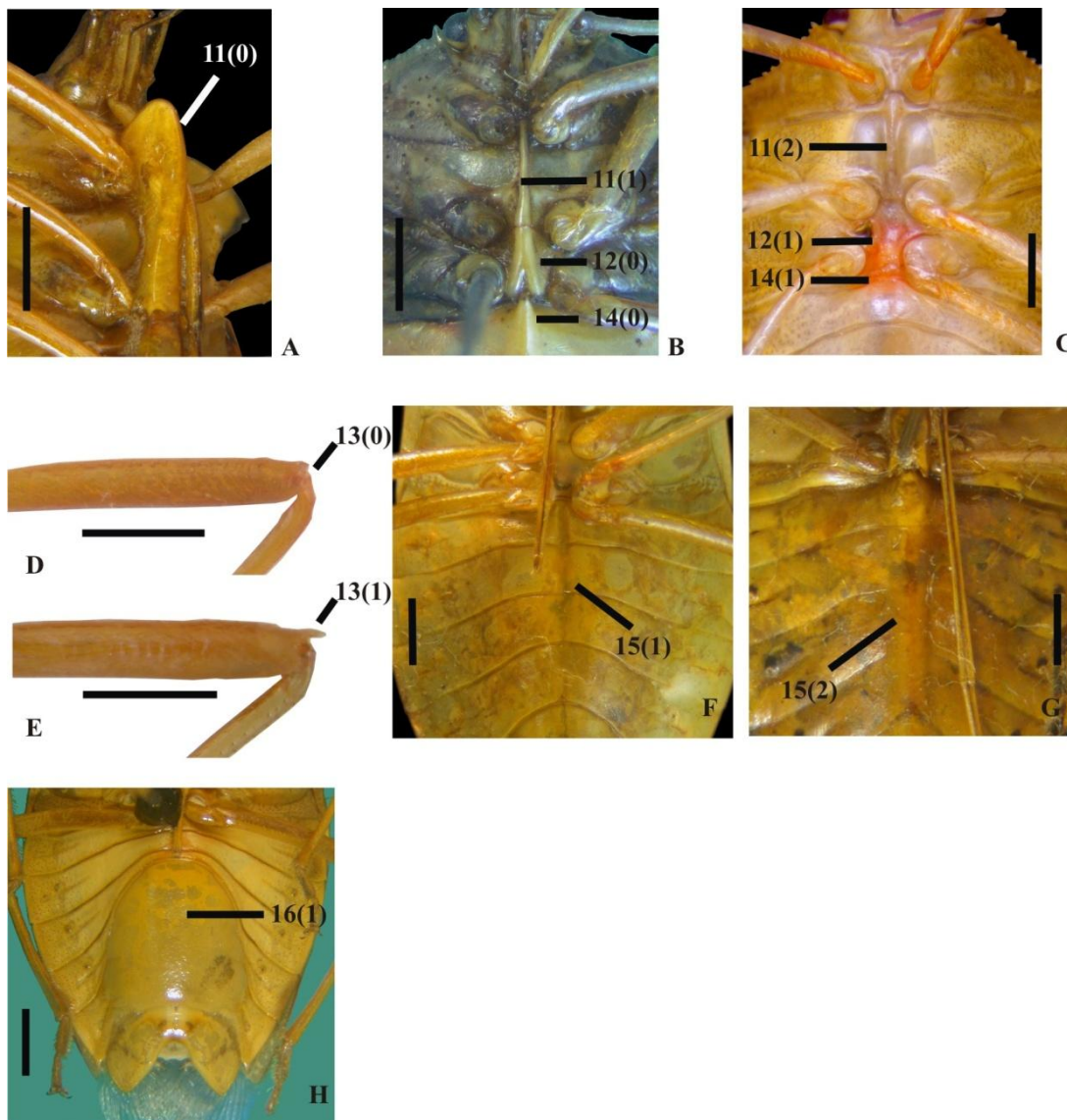
	1	2	3
	0123456789012345678901234567890123456		
<i>Podisus crassimargo</i>	002000201122100000101100011000000001110		
<i>Carpocoris purpureipennis</i>	100020221122101000001100211000001003120		
<i>Rhynchocoris humeralis</i>	100022200100000020100001110000000003100		
<i>Brepholoxa heidemanni</i>	10002021111210000010112011100010000100		
<i>Dichelops furcatus</i>	10000010111210100000100211000000003111		
<i>Euschistus heros</i>	00001010111210100000100211000000003120		
<i>Evoplitus humeralis</i>	000000000000000200000001010000000000001		
<i>Arvelius</i> spp.	00101000112101020000101011000000000101		
<i>Chloropepla</i> spp.	10002000110111100000012120011010100201		
<i>Chloropepla lenti</i>	10002001110111100000012120011010100201		
<i>Chlorocoris</i> ( <i>Chlorochoris</i> ) spp.	1000201011211011010010111031111002010		
<i>Chlorocoris</i> ( <i>Monochrocerus</i> ) spp.	1100201011121011010110111031211002010		
<i>Chlorochoris</i> ( <i>M.</i> ) <i>hebetatus</i>	11002011111210110101101000031211002010		
<i>Chlorocoris</i> ( <i>M.</i> ) <i>rufispinus</i>	1100101011121011010110111031211002010		
<i>Chlorocoris</i> ( <i>M.</i> ) <i>weneri</i>	1100101011121011010110111031211002010		
<i>Fecelia minor</i>	1000201011111111001001111132011111011		
<i>Fecelia proxima</i>	1010201011111111001001111132210?11011		
<i>Fecelia nigridens</i>	1010201011211111001001111132211111011		
<i>Loxa deducta</i>	1010201011111110100001111132211111011		
<i>Loxa</i> spp.	1010201011111110100001110132211111011		
<i>Mayrinia</i> spp.	1000201011221110001021110032211111010		
<i>Rhyncholepta</i> spp.	0001100011221110001012101120002--0210		
<i>Eludocoris grandis</i>	0020121011011110010002121001010000110		
<i>Chlorocoris</i> ( <i>Arawacoris</i> ) <i>tarsalis</i>	10101000111111110000????1032211?11011		



**Figure 1.** A-D. Dorsal view of head (A - *E. grandis*, B - *C. tau*, C - *C. hebetatus*, D - *A. albopunctatus*). E-G. Lateral view of head (E - *R. grandicallosa*, F - *P. crassimargo*, G - *R. humeralis*). H-I. Dorsal view of pronotum and scutellum (H - *E. humeralis*, I - *L. deducta*). J-L. Dorsal view of pronotum (J - *C. purpureipennis*, L - *C. paveli*). (Scale: 5 mm).

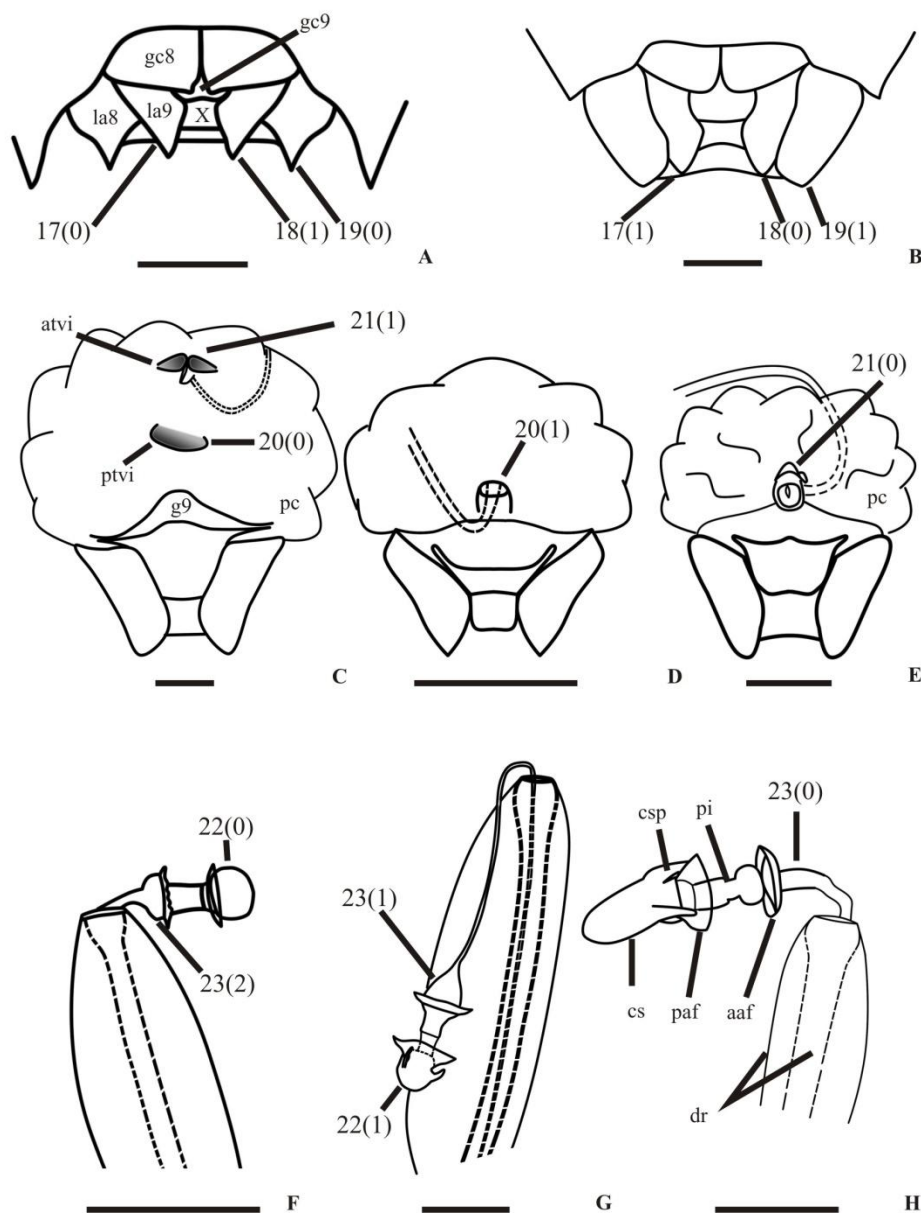


**Figure 2.** A-C. Ostiole ruga (A – *C. vicens*, B – *E. heros*, C – *A. albopunctatus*).

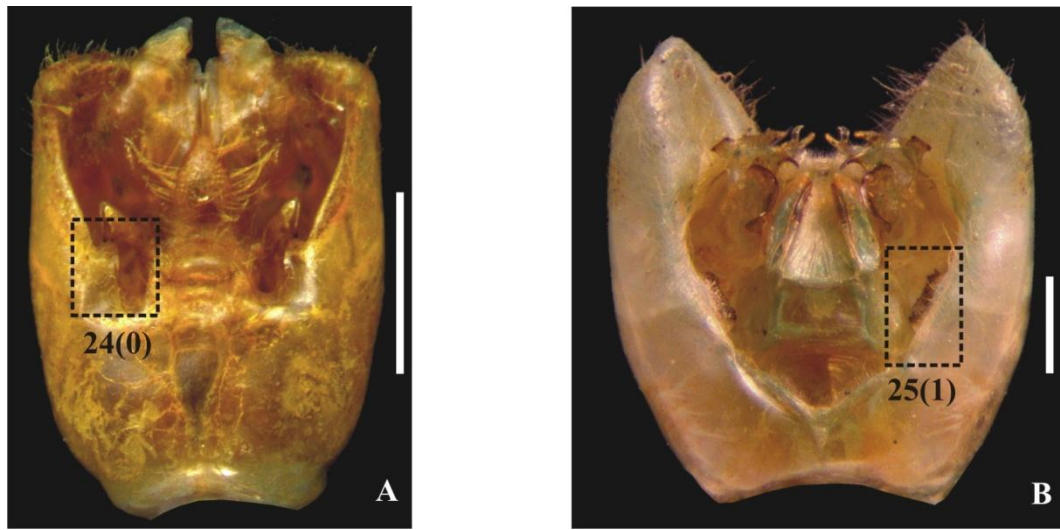


**Figure 3.** A-C. Thoracic ventral view (A – *R. humeralis*, B – *A. albopunctatus*, C – *M. curvidens*). D-E. Lateral View of femur (D – *C. complanatus*, E – *L. deducta*). F-G. Abdominal ventral view (F – *C. rufopictus*, G – *R. humeralis*, H – *L. deducta*) (A-E scale: 1mm; F-H: 2 mm).

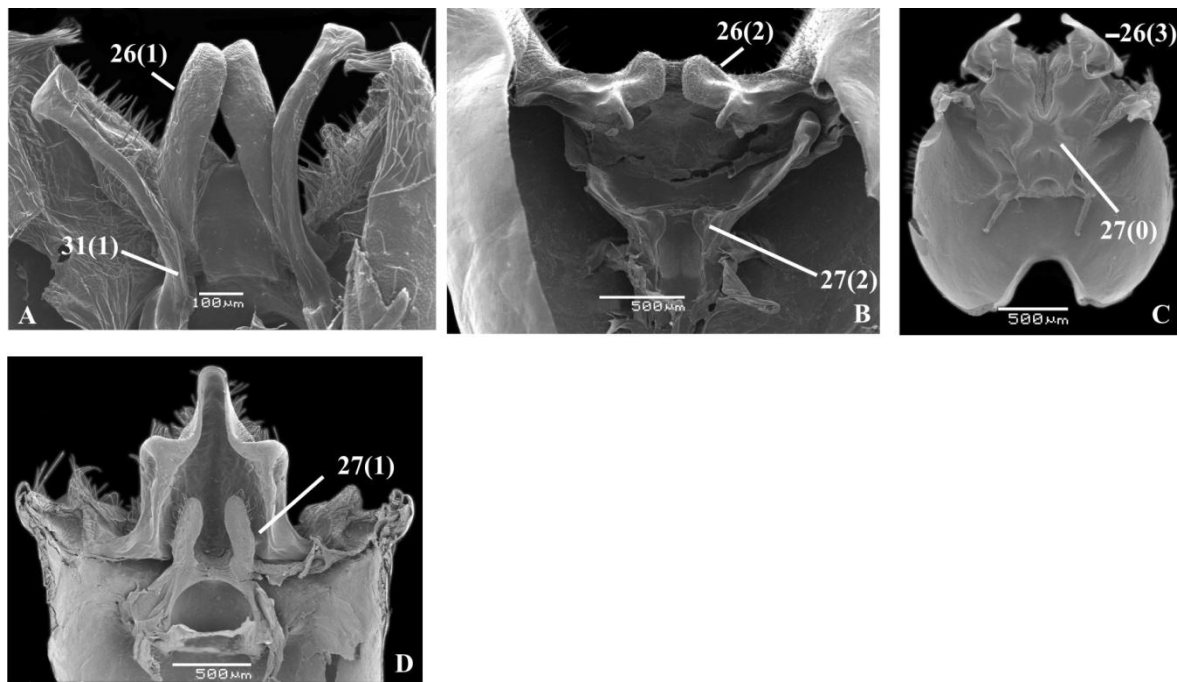




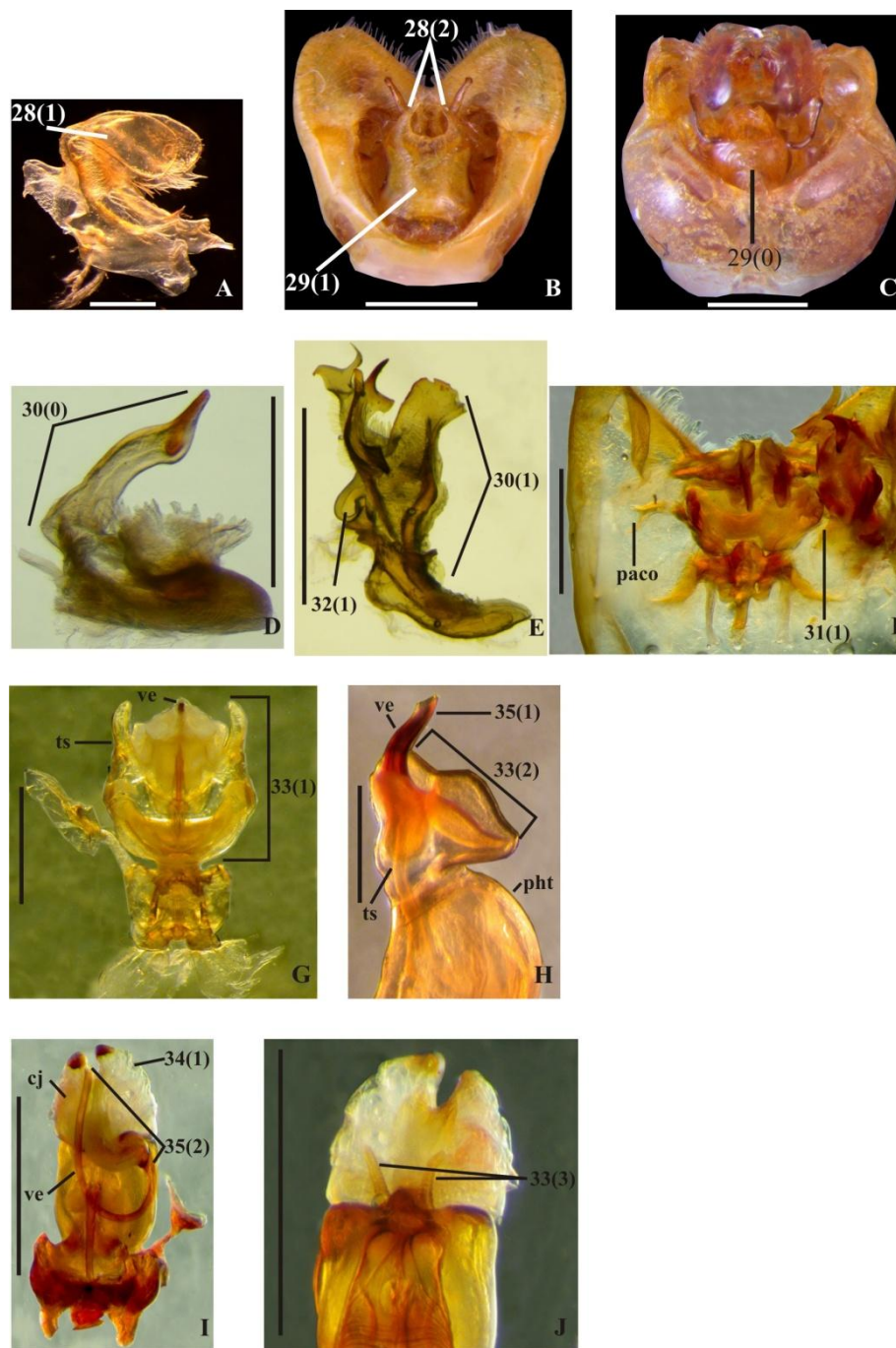
**Figure 4.** A-B. Female external genitalia (A – *R. meinanderi*, B – *C. rufopictus*). C-E. Female internal genitalia (C – *L. virescens*, D – *R. meinanderi*, E – *C. tau*). F-H. Female internal genitalia, capsula seminalis (F – *C. purpureipennis*, G – *L. virescens*, H – *A. intermedius*) (aaf – anterior annular flange; atvi – anterior thickening of vaginal intima; cs – capsula seminalis; csp – capsula seminalis process; dr – ductus receptaculi; g9 – gonapophyses 9; gc8 – gonocoxites 8; gc9 – gonocoxites 9; la8 – laterotergites 8; la9 – laterotergites 9; paf – posterior annular flange; pc – pars communis; pi – par intermedialis; pvti – posterior thickening of vaginal intima; X – tenth urosternite) (Scale: 1 mm).



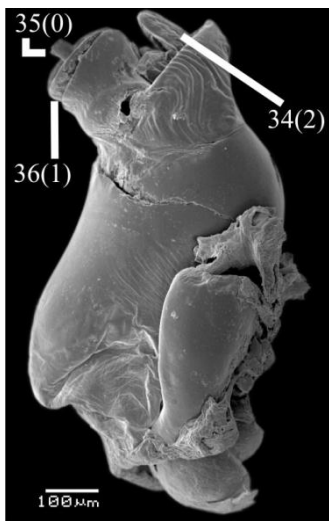
**Figure 5.** A-B. Male pygophore (A – *C. aurea*, B – *L. deducta*) (Scale: 1 mm).



**Figure 6.** A-D. Male pygophore, internal surface of male pygophore (A – *C. vicens*, B – *L. virescens*, C – *R. grandicallosa*, D – *C. complanatus*).

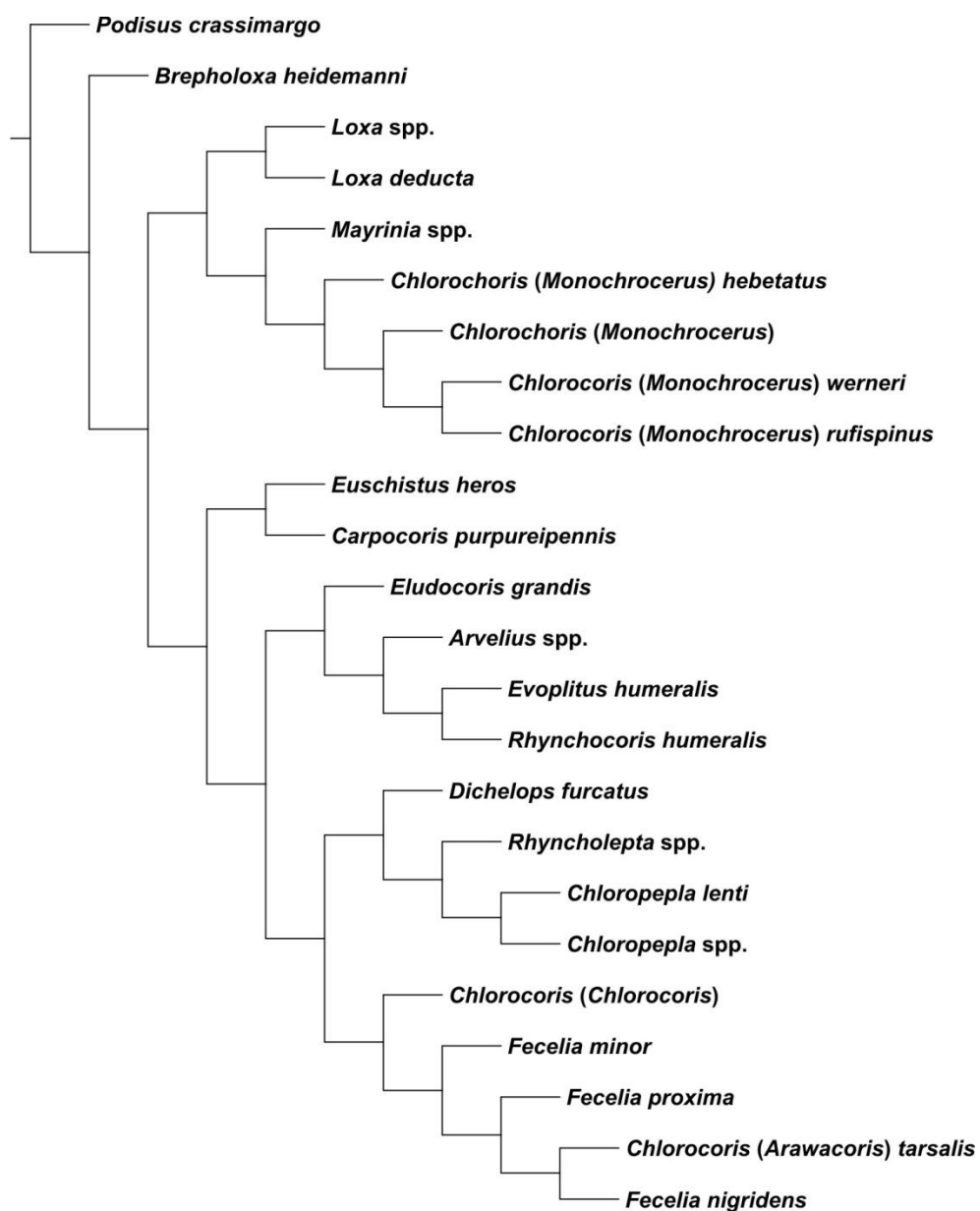


**Figure 7.** A. *C. tau*, lateral view of segment X. B-C. Male pygophore, dorsal view (B – *F. proxima*, C – *R. grandicallosa*). D-E. Parameres lateral view (D – *Chloropepla* sp. nov. 2, E – *L. deducta*). F. *Loxa deducta*, internal surface of ventral wall. G-J. Phallus (G – *L. deducta*, H – *C. tau*, I-J – *E. heros*) (Scale: 1 mm).



**Figure 8.** *C. vicens*, phallus lateral view.





**Figure 10.** Cladistic analysis of *Chlorocoris* group based on total evidence. Most parsimonious cladogram: 1,783 steps, consistency index 75, retention index 76.

## Anexo I

### Normas editorias Australian Journal of Entomology

#### Author Guidelines

#### **AIMS AND SCOPE**

The *Australian Journal of Entomology* promotes the study of the biology, ecology, taxonomy and control of insects and arachnids relevant to the Australian region. It publishes papers that report the results of original research. Reviews of research and theory are welcomed; these may be submitted or invited.

#### **EDITORIAL REVIEW AND ACCEPTANCE**

Manuscripts must not present work that has been published, accepted for publication or is currently under consideration for publication elsewhere. Submission of a manuscript must be approved by all authors.

All manuscripts are reviewed by two specialist referees and, at the discretion of the Chief Editor, by a member of the Editorial Board before acceptance. Manuscripts considered unsuitable for publication will be returned to authors who may resubmit after amendment. If a reviewed manuscript that is returned to the author for revision is not sent back to the Technical Editor within one year, it will be considered to have been withdrawn. Final acceptance or rejection rests with the Editorial Board.

The Editor and the Publisher reserve the right to modify manuscripts to eliminate ambiguity and repetition, and to improve communication between author and reader. To encourage the valuable ongoing services of highly qualified reviewers and to avoid unnecessary delays, authors are strongly advised to have their manuscripts thoroughly reviewed by impartial colleagues prior to submission.

#### **SUBMISSION OF MANUSCRIPTS**

Manuscripts should be submitted online at <http://mc.manuscriptcentral.com/aen>. All correspondence will be by email. Two files should be supplied: the covering letter and the manuscript (in Word or rich text format (.rtf)). The covering letter should be uploaded as a file not for review. Name the manuscript file as: **authorname.doc**.

All articles submitted to the Journal must comply with these instructions. Failure to do so will result in return of the manuscript.

Please note that Word 2007 is not yet compatible with journal production systems. The journal cannot accept Microsoft Word 2007 documents until a stable production version is released. Please use 'Save As' to save your document as an older version .doc file.

- Submissions should be typed in 12 pt Times New Roman and have 1.5 line spacing.
- All margins should be set to 2.5 cm.
- All pages should be numbered consecutively in the top right-hand corner, beginning with the title page.
- The first paragraph under each heading is not indented; indent following paragraphs, with no blank line between paragraphs.
- Do not use Enter at the end of lines within a paragraph.
- Turn the hyphenation option off; include only those hyphens that are essential to the meaning.
- Specify any special characters used to represent non-keyboard characters.
- Take care not to use l (ell) for 1 (one), O (capital o) for 0 (zero) or ß (German esszett) for β (Greek beta).



- Use the Table editor, not tabs, to construct tables and ensure that each data point is contained within a unique cell (i.e. do not use Enter within cells).
- Ensure that all mark-up ('Track Changes') done during manuscript preparation is removed ('Accept All Changes' on Reviewing Toolbar) so that reviewers have a clean copy on which to insert suggested changes and comments.

Figures should be inserted at the end of the manuscript. For submission, low-resolution figures (e.g. .jpg) should be used to ensure file size is not excessive. Upon acceptance of the article, high-resolution figures (at least 300 d.p.i.) saved as .eps or .tif files should be uploaded. Digital images supplied only as low-resolution files cannot be used. Further instructions are available at the submission site.

### **Covering letter**

Papers are accepted for publication in the Journal on the understanding that the content has not been published or submitted for publication elsewhere. This must be stated in the covering letter. The covering letter must also contain an acknowledgement that all authors have contributed significantly, and that all authors are in agreement with the content of the manuscript. Authors must declare any financial support or relationships that may pose conflict of interest. If tables or figures have been reproduced from another source, a letter from the copyright holder (usually the Publisher), stating authorisation to reproduce the material, must be attached to the covering letter.

### **Author material archive policy**

Authors who require the return of any submitted material that is accepted for publication should inform the Editorial Office after acceptance. If no indication is given that author material should be returned, Wiley-Blackwell will dispose of all hardcopy and electronic material two months after publication.

### **ETHICAL CONSIDERATIONS**

If relevant, authors must state that the protocol for the research project has been approved by a suitably constituted Ethics Committee of the institution within which the work was undertaken and that it conforms to the provisions of the Declaration of Helsinki (as revised in Tokyo 2004), available at <http://www.wma.net/e/policy/b3.htm>.

In taxonomic papers, type specimens and type depositories must be clearly designated and indicated. Authors are required to deposit the name-bearing type material in internationally-recognised institutions (not private collections). When the research is carried out in areas for which research permits are required (e.g. nature reserves), or when it deals with organisms for which collection or import/export permits are required (e.g. protected species), the authors must clearly detail obtaining these permits in the Acknowledgements section.

### **COPYRIGHT**

Authors publishing in the Journal will be asked to sign an Exclusive Licence Form. In signing the form it is assumed that authors have obtained permission to use any copyrighted or previously published material. All authors must read and agree to the conditions outlined in the form, and must sign the form or agree that the corresponding author can sign on their behalf. Articles cannot be published until a signed form has been received. Authors can download the form from [http://www.blackwellpublishing.com/pdf/aen\\_elf.pdf](http://www.blackwellpublishing.com/pdf/aen_elf.pdf).

### **ONLINE OPEN**

Online Open is available to authors of primary research articles who wish to make their article available to non-subscribers on publication, or whose funding agency requires grantees to archive the final version of their article. With Online Open, the author, the author's funding agency, or the author's institution pays a fee to ensure that the article is made available to non-subscribers upon publication via Wiley InterScience, as well as deposited in the funding agency's preferred archive. For the full list of terms and conditions,

see

[http://www3.interscience.wiley.com/authorresources/onlineopen.html#OnlineOpen\\_Terms](http://www3.interscience.wiley.com/authorresources/onlineopen.html#OnlineOpen_Terms).

Any authors wishing to send their paper Online Open will be required to complete the payment form available from our website at:

[http://www.blackwellpublishing.com/pdf/AEN\\_OOF.pdf](http://www.blackwellpublishing.com/pdf/AEN_OOF.pdf)

Prior to acceptance there is no requirement to inform an Editorial Office that you intend to publish your paper Online Open if you do not wish to. All Online Open articles are treated in the same way as any other article. They go through the journal's standard peer-review process and will be accepted or rejected based on their own merit.

### **STYLE OF THE MANUSCRIPT**

Manuscripts should be written in clear, concise and grammatically correct English so that they are intelligible to the professional reader who is not a specialist in any particular field. The Journal uses Australian spelling and authors should therefore set the Language in MS Word to English (Australia) (accessible under the Tools menu in MS Word) and follow the latest edition of the Macquarie Dictionary. Manuscripts that do not conform to this requirement and the following format will be returned to the author prior to review for correction.

The manuscript should be presented in the following order:

#### **Title page**

This should contain the title of the contribution, and the name(s) and address(es) of the author(s) as well as the present address of any author if different from that where the work was carried out. The email address of the author who will receive correspondence and check the proofs must be included. The main title should, where possible, contain the major key words used in the body of the manuscript; the title should contain the scientific name and authorities of the insect with the order and family placed in parentheses. A short running title (less than 40 characters including spaces) should also be provided.

#### **Abstract**

All manuscripts must include a brief but informative Abstract intelligible without reference to the main text. It should not exceed 300 words and should describe the scope of the work and the main findings. Both common and scientific names should be included; the authorities are not given if they appear in the title. References to the literature should not be included. Use the passive voice in the Abstract. DO NOT use the uninformative phrase 'Results are discussed.'

#### **Key words**

Key words (3-5) should be provided below the Abstract to assist with indexing of the article. These should not duplicate key words from the title.

#### **Introduction**

This section should include sufficient background information to set the work in context. The aims of the manuscript should be clearly stated and the introduction should not contain findings or conclusions.

#### **Materials and Methods**

This should be concise but provide sufficient detail to allow the work to be repeated by others. Do not provide manufacturer details unless it is for unique items essential to replicate the work.

#### **Results**

Results should be presented in a logical sequence in the text, tables and figures; repetitive presentation of the same data in different forms should be avoided. The results should not

contain material appropriate to the Discussion.

### Discussion

This should consider the results in relation to any hypotheses advanced in the Introduction and place the study in the context of other work.

### Acknowledgements

The source of financial grants and other funding must be acknowledged, including a frank declaration of the author's industrial links and affiliations. Financial and technical assistance may be acknowledged here. Do not acknowledge anonymous reviewers.

### References

The Harvard (author, date) system of referencing is used. In the text give the author's name followed by the year in parentheses: Sago (2000). If there are two authors use 'and': Baskin and Baskin (1998); but if cited within parentheses use '&': (Baskin & Baskin 1998). When reference is made to a work by three or more authors, the first name followed by *et al.* should be used: Powles *et al.* (1998). If several manuscripts by the same author(s) and from the same year are cited, a, b, c etc. should be put after the year of publication. Within parentheses, groups of references should be cited in chronological order. Personal communication, unpublished data and publications from informal meetings are not to be listed in the reference list but should be listed in full in the text (e.g. Smith A, 2000, unpublished data). References should be listed in alphabetical order at the end of the manuscript. Cite the names of all authors when there are six or fewer; when seven or more cite the first three plus *et al.* References should be listed in the following form:

#### Journal articles

North RC & Shelton AM. 1996. Ecology of Thysanoptera within cabbage fields. *Environmental Entomology* **15**, 520-526.

#### Books

Eberhard WG. 1985. *Sexual Selection and Animal Genitalia*. Harvard University Press, Harvard.

#### Chapters in books

Bray RA. 1994. The leucaena psyllid. In: *Forage Tree Legumes in Tropical Agriculture* (eds RC Gutteridge & HM Shelton) pp. 283-291. CAB International, Oxford.

Titles of journals should be given in full. 'In press' can only be used to cite manuscripts actually accepted for publication in a journal. Citations such as 'manuscript in preparation' or 'manuscript submitted' are not permitted. Data from such manuscripts can only be mentioned in the text as 'unpublished data'.

Authors are responsible for the accuracy of the references.

We recommend the use of a tool such as EndNote or Reference Manager for reference management and formatting. EndNote reference styles can be searched for here:

<http://www.endnote.com/support/enstyles.asp>. Reference Manager reference styles can be searched for here: <http://www.refman.com/support/rmstyles.asp>

### Tables

Tables must be constructed using the 'Table' function of your word processor and must not have the Enter key used in any cell. They should be self-contained and complement, but not duplicate, information contained in the text. Tables should be numbered consecutively in Arabic numerals. Each table should be presented on a separate page at the end of the text with a comprehensive but concise legend above the table. Tables should be double-spaced and vertical lines should not be used to separate columns. Column headings should be brief, with units of measurement in parentheses; all abbreviations should be defined in footnotes. Use superscript letters (not numbers) for footnotes and keep footnotes to a minimum. \*, \*\*, \*\*\* should be reserved for *P* values. The table and its legend/footnotes should be understandable without reference to the text.

## Figures

Only scientifically necessary illustrations should be included. All illustrations (line drawings and photographs) are classified as figures. Figures should be cited in consecutive order in the text. Figures should be sized to fit a single column width (83 mm), mid-column width (125 mm) or the full text width (171 mm). Magnifications should be indicated using a scale bar on the illustration.

Line figures should be sharp, black and white graphs or diagrams, drawn professionally or with a computer graphics package. Lettering must be included and should be sized to be no larger than the journal text.

*Figure legends.* Type figure legends on a separate page. Legends should be concise but comprehensive - the figure and its legend must be understandable without reference to the text. Include definitions of any symbols used and define/explain all abbreviations and units of measurement.

*Colour figures.* A charge of A\$550/ US\$425/ ¥50,000 for the first two colour figures and A\$275/ US\$215/ ¥25,000 for each extra colour figure thereafter will be charged to the author. (Prices in A\$ include GST.) In the event that an author is not able to cover the costs of reproducing colour figures in colour in the printed version of the journal, the Australian Journal of Entomology offers authors the opportunity to reproduce colour figures in colour for free in the online version of the article (but they will still appear in black and white in the print version). If an author wishes to take advantage of this free colour-on-the-web service, they should make that election at time of submission to ensure that the appropriate documentation is completed for the Publisher.

## Keys

Unillustrated taxonomic keys will not be accepted.

## ABBREVIATIONS AND UNITS

SI units (metre, kilogram etc.), as outlined in the latest edition of *Units, Symbols and Abbreviations: A Guide for Medical and Scientific Editors and Authors* (Royal Society of Medicine Press, London), should be used wherever possible. Give statistics and measurements in figures; that is, 10 mm, except where the number begins the sentence. When the number does not refer to a unit measurement, it is spelt out, except where the number is greater than nine. Use only standard abbreviations. Shorten the word 'Figure' to Fig. unless starting a sentence.

## SCIENTIFIC NAMES

The complete scientific name (genus, species and authority), and cultivar or strain where appropriate, should be given for all animals when first mentioned; authorities are not needed for plants. The generic name may be abbreviated to an initial in subsequent references except at the start of sentences and where intervening references to other genera would cause confusion. Common names of organisms, if used, should conform to the list on

<http://www.ento.csiro.au/aicn>. All names must conform to the Articles and

Recommendations of the fourth edition of the International Code of Zoological

Nomenclature. Common names of pesticides listed in *Pesticides - Synonyms and Chemical Names* (Australian Dept of Health, Canberra) must be used.

Nucleotide sequence data All DNA sequences must be lodged with GenBank and should not be repeated in the paper unless highly relevant.

## ONLINE GUIDELINES

Visit the *Australian Journal of Entomology* home page at

<http://www.blackwellpublishing.com/aen> for more information, and Wiley-Blackwell's web pages for submission guidelines and digital graphics standards at

<http://authorservices.wiley.com/bauthor/journal.asp> and

<http://authorservices.wiley.com/bauthor/illustration.asp> Author Services enables authors to

track their article, once it has been accepted, through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated emails at key stages of production so they do not need to contact the production editor to check on progress. Visit <http://authorservices.wiley.com/bauthor> for more details on online production tracking and for a wealth of resources, including FAQs and tips on article preparation, submission and more.

The *Australian Journal of Entomology* is also available online at Wiley InterScience. Visit <http://www3.interscience.wiley.com> to search the articles and register for table of contents and e-mail alerts.

## **CHECKLIST**

Before submitting your manuscript, please check that:

- ☐ The reference section is in the proper format.
- ☐ All references cited in the text are included in the reference section.
- ☐ All figures and tables are cited in the text.
- ☐ The pages are numbered.

## **PAGE CHARGES**

Page charges of A\$60.00 per printed page will be levied on each article appearing in the Journal. These charges are payable to Blackwell Publishing Asia Pty Ltd and will be invoiced when page proofs are sent to the authors. Contributors not in receipt of institutional or grant-based support may apply to the Chief Editor for consideration to have page charges met by the Australian Entomological Society at the time of submission.

## **PROOFS**

It is essential that corresponding authors supply an email address to which correspondence can be emailed while their article is in production.

Notification of the URL from where to download a Portable Document Format (PDF) typeset page proof, associated forms and further instructions will be sent by email to the corresponding author. The purpose of the PDF proof is a final check of the layout, and of tables and figures. Alterations other than the essential correction of errors are unacceptable at PDF proof stage. The proof should be checked, and approval to publish the article should be emailed to the Publisher by the date indicated. Otherwise, it may be signed off on by the Chief Editor or held over to the next issue.

## **OFFPRINTS**

A free PDF offprint will be supplied to the corresponding author. A minimum of 50 additional offprints will be provided upon request, at the author's expense. These paper offprints may be ordered online. Please visit <http://offprint.cosprinters.com/>, fill in the necessary details and ensure that you type information in all of the required fields. If you have queries about offprints please email [offprint@cosprinters.com](mailto:offprint@cosprinters.com)



## Anexo II

## Normas editoriais Insects Systematics and Evolution

**Insect Systematics & Evolution**

brill.nl/ise

*Instructions for Authors*

BRILL

Insect Systematics & Evolution publishes original papers on all aspects of systematic entomology and the evolutionary history of insects and related groups. Papers are of a wide international interest and priority is given to taxonomic revisions and phylogenetic studies employing morphological and molecular data.

**Online Submission**

Rather than submitting manuscripts in the traditional way authors are now strongly encouraged to submit their manuscript online via the Editorial Manager (EM) online submission system at <http://editorialmanager.com/ise>.

First users need to register. Prior to submission, authors are urged to read these Instructions for Authors and the EM instructions available by following the above link and clicking on the 'help' icon in the top left hand menu on the page. Online submission considerably shortens the overall publication time.

When submitting via the website, you will be guided stepwise through the creation and uploading of the various files and data. Authors also have the opportunity to suggest reviewers by submitting the names and addresses (including e-mail).

Various formats are allowed for the initial submission, including PDF files. The final revision must be as a Word or other suitable word processor document. When a Word or equivalent document is uploaded as the initial submission, the system automatically generates an electronic (PDF) proof, which is then used for reviewing. All correspondence, including the editor's request for revision and final decision, will be by e-mail.

Author queries should be directed to:

Dr. Lars Krogmann, Staatliches Museum für Naturkunde Stuttgart

[krogmann.smns@naturkundemuseum-bw.de](mailto:krogmann.smns@naturkundemuseum-bw.de)

When submitting a manuscript, please note:

- The editorial board tries to keep the reviewing process as short as possible and to inform the author within two months after submission.
- The author receives proofs in about 6 weeks after acceptance, which should be corrected and returned to the managing editor as fast as possible. The paper will be published in the next available journal issue.
- A PDF file of the paper will be supplied free of charge by the publisher to the corresponding author for personal use. No free reprints are provided but author(s) may order reprints at cost by returning the order form supplied with the proofs.



## Taxonomy

- All taxonomic actions must be in accordance with the International Code of Zoological Nomenclature.
- Authors of cited genera and species should be given when a name is first mentioned in the text.
- The abbreviations gen.n., sp.n., comb.n. and syn.n. are used for new taxa, new combinations and synonymies.
- The complete collection data of holotype, paratypes and all other specimens examined must be recorded; the institution in which they are deposited must be indicated.
- Sex symbols should be used instead of 'male' and 'female'.

## Manuscripts

- **Contributions** to *Insect Systematics & Evolution* must be written in English and clearly typewritten with numbered pages, double line spacing and wide margins throughout. The text should be in Times New Roman, left-justified, with font size 12, without column or page breaks and without word hyphenations. The position of figures and tables should be indicated in the text.
- **Title** in regular type (capitals only for the first letter and the first letters of proper words) should be as brief and informative as possible. In addition, a short title should be provided, which should not exceed 50 characters, spaces included.
- **Authors** in regular type with capitals as normally used by the author, first name or initials as preferred, names separated by commas and between the last two names by '&', references to institutes and addresses as superscripts (e.g. <sup>1</sup>, or <sup>1,2</sup>) in ascending order).
- **Institutes** where the work has been done should be indicated under the authors, first letters of major words in capitals. When the authors were based at different organizations this should be indicated in superscript in front of the institute (e.g. <sup>1</sup>Centre for Evolutionary Biology – corresponding to the references under 'authors').
- Each article should be accompanied by an **abstract** in English, which should mention all the principal facts and conclusions set forth in the paper.
- Three to eight **keywords** should be added.
- **E-mail addresses** of corresponding authors should be added as footnotes.
- Main **headings** in bold type (Abstract, Introduction, Material and methods, Results, Discussion, Acknowledgements, References or other variants if appropriate), capitals only for first letter of sentence and first letters proper names, separated by white lines from text. Subheadings in italic type, aligned to the left, capitals only for first letter of sentence and first letters proper names, separated by white lines from text. Sub-subheadings in regular type, aligned to the left, capitals only for first letter of sentence and first letters proper names, separated by a white line from preceding text, following text starting on next line.
- **Italic** type should only be used for subheadings, scientific species names, titles of periodicals and words that need to be emphasized (no italics for: e.g., i.e., et al., etc., cf.).



- **Bold** type should only be used in the main headings and for the volume number in the references.
- **Capitals** should only be used for first letters of sentences, first letters of proper names and first letters of specific words (e.g. tables, figures, experiments) that should be emphasized; small capitals for words that should be printed in capitals.
- **References to the literature** should consist of one or two authors and the year of publication or first author + et al. and year, totally in brackets or only the year in brackets, authors separated by '&', author(s) and year not separated by comma. Different references should be separated by semicolon, chronologically ordered. If the list contains several references of the same author(s), extra years should be added to the first entrance of an author. Differentiate between references by the same author(s) from the same year by adding a, b, etc. Examples: (Gaston 1977) or Gaston (1977); (Wingfield 1985; Wingfield & Wada 1989; Wingfield & Hahn 1994; McDonald et al. 2001); (Silverin 1993, 1998a, b; Wingfield & Hahn 1994)
- **References to tables** should consist of the complete word, first letter capital (also in the middle of a sentence or in brackets) + number in Arabic numerals. Examples: Table 7 or (Table 7).
- **References to figures** should consist of the abbreviated word, first letter capital (also in the middle of a sentence or in brackets) + number in Arabic numerals. Examples: Fig. 1 or (Fig. 1); (Figs 1A,B; 2A-C); (Figs 1,3).
- **Abbreviations** should be followed by '.' unless the abbreviation is written with the last letter of the original word at the end position (thus: i.e. – e.g. – cf. – etc. but eds – Dr – edn) – measures (such as mm cm m) without '.'.
- Use single **quotation marks** for isolated words or conceptions, double for literal quotes.
- **Tables** should be kept as simple as possible with at least 3 horizontal lines and additional lines if appropriate, data ordered in a convenient way. The title should give all details that are needed to understand the table except obvious footnotes.
- **Illustrations** must be provided in a digital format. Publication of colour figures/photographs is free of charge in the online version (print version in black and white). If colour plates in the print edition are desired, authors will be asked to contribute towards the costs. **Figures** should be drawn for reproduction within the type page (118 x 180 mm). Small illustrations should be grouped into plates. Lettering size should be the same for all figures and be matched with information density. Diagrams, maps, drawings, charts and photographs should be free of charge and copyright. All parts of a single figure should be included in one and the same file. To guarantee good resolution in printing, color figures should be saved as an original tiff, eps or pdf file with an original resolution of 600 or 1200 dpi. Files for color figures should be submitted in CMYK and not in RGB format. Figure captions should be indicated on a separate page at the end of the manuscript (after the references and the table captions). Figures should not be inserted in the main text, but added at the end of the manuscript or attached as separate file(s). Grayscale graphics must be provided as monochrome images.
- **Legends for figures** should not be attached to the figures but should be typewritten on separate sheets and attached to the end of the manuscript.





## References

**References** in the text are given as Brown (1929); (Brown 1929, 1930; Turner 1932); Brown & Turner (1932: 56); Brown et al. (1938). Titles gathered under 'References' at the end of the paper should conform to the following format:

*Papers in a journal* (note that the issue number is omitted):

- Gertsch, W.J. & Peck, S.B. (1992) The pholcid spiders of the Galápagos Islands, Ecuador (Araneae: Pholcidae). *Canadian Journal of Zoology* **70**: 1185-1199.  
 Bezděk, A. (2004a) Catalogue of the tribe Diplotaxini (Coleoptera: Scarabaeidae: Melolonthinae) of the Old World. *Zootaxa* **463**: 1-90.  
 Bezděk, A. (2004b) Revision of the genus *Ceratogonia* Kolbe, 1899 (Scarabaeidae: Melolonthinae: Diplotaxini). *Annales Zoologici* **54**: 797-801.

*Books* (give book title in full, with name of publisher and place of publication):

- Britton, E.B. (1957) A revision of the Australian Chafers (Coleoptera: Scarabaeidae: Melolonthinae). The British Museum (Natural History), London, United Kingdom: 185 pp.

*Articles in books* (give article title, followed by In: editors' names):

- Nielsen, E.S. & Common, I.F.B. (1991) Lepidoptera. In: Naumann, I.D. (ed.) The Insects of Australia Volume 2. CSIRO, Melbourne University Press, Carlton, Australia: pp. 817-915.

*Internet documents* (provide link and add accession date in brackets):

- Noyes, J.S. (2009) Universal Chalcidoidea Database.  
[www.nhm.ac.uk/entomology/chalcidoids/index.html](http://www.nhm.ac.uk/entomology/chalcidoids/index.html) (accessed 01 Jan 2009).

*Computer programs* (provide version number, add name of publisher and place of publication):

- Swofford, D.L. (2003) PAUP\*. Phylogenetic Analysis Using Parsimony (\*and other methods). Version 4. Sinauer Associates, Sunderland, United States.

## Copyright

It is a fundamental condition that submitted manuscripts have not been published and will not be simultaneously submitted or published elsewhere. By submitting a manuscript, the authors agree that the copyright for their article is transferred to the publisher if and when the article is accepted for publication. The use of general descriptive names, trade marks, etc., in this publication, even if the former are not specifically identified, is not to be taken as a sign that such names are exempt from the relevant protective Instructions to Authors laws and regulations and may accordingly be used freely by anyone.



## **Consent to publish**

### *Transfer of copyright*

By submitting a manuscript, the author agrees that the copyright for the article is transferred to the publisher if and when the article is accepted for publication. For that purpose the author needs to sign the **Consent to Publish** which will be sent with the first proofs of the manuscript.

### *Open Access*

In case the author wishes to publish the article in **Open Access** he/she can choose the **Brill Open** option, which allows for a non-exclusive Open Access publication in exchange for an Article Publishing Fee, and sign a special **Brill Open Consent to Publish**.

More information on Brill's policy on Open Access can be found on <http://brill.nl/openaccess>. The Brill Open Consent to Publish can be downloaded from <http://brill.nl/downloads/BrillOpen-Consent-to-Publish.pdf>.

## Anexo III

### Normas editoriais Zootaxa

#### Aim and scope

*Zootaxa* is a peer-reviewed international journal for rapid publication of high quality papers on any aspect of systematic zoology, with a preference for large taxonomic works such as monographs and revisions. *Zootaxa* considers papers on all animal taxa, both living and fossil, and especially encourages descriptions of new taxa. All types of taxonomic papers are considered, including theories and methods of systematics and phylogeny, taxonomic monographs, revisions and reviews, catalogues/checklists, biographies and bibliographies, identification guides, analysis of characters, phylogenetic relationships and zoogeographical patterns of distribution, descriptions of taxa, and nomenclature. Open access publishing option is strongly encouraged for authors with research grants and other funds. For those without grants/funds, all accepted manuscripts will be published but access is secured for subscribers only. All manuscripts will be subjected to peer review before acceptance. *Zootaxa* aims to publish each paper within one month after the acceptance by [editors](#).

Based on length, two categories of papers are considered.

#### 1) Research article

Research articles are significant papers of four or more printed pages reporting original research. Papers between 4 and 59 printed pages are published in multi-paper issues of 60, 64 or 68 pages. Monographs (60 or more pages) are individually issued and bound, with ISBNs.

*Zootaxa* encourages large comprehensive taxonomic works. There is no upper limit on the length of manuscripts, although authors are advised to break monographs of over 1000 pages into a multi-volume contribution simply because books over 1000 pages are difficult to bind and too heavy to hold.

Very short manuscripts with isolated descriptions of a single species are generally discouraged, especially for taxa with large number of undescribed species. These short manuscripts may be returned to authors without consideration. Short papers on species of economic, environmental or phylogenetic importance may be accepted at the discretion of editors, who will generally encourage and advise authors to add value to the paper by providing more information (e.g. checklist of or key to species of the genus, biological information.....). Short papers of 4 or 5 pages accepted for publication may be shortened for publication in the Correspondence section.

#### 2) Correspondence

High quality and important short manuscripts of 1 to 4 pages are considered to fill blank pages in multi-paper issues. *Zootaxa* publishes the following six types of correspondence:

- opinions and views on current issues of interests to systematic zoologists (e.g. [Zootaxa 1577: 1-2](#))
- commentary on or additions/corrections to papers previously published in *Zootaxa* (e.g. [Zootaxa 1494: 67-68](#))
- obituary in memory of deceased systematic zoologists (e.g. [Zootaxa 545: 67-68](#))
- taxonomic/nomenclatural notes of [importance](#)
- book reviews meant to introduce readers to new or rare taxonomic monographs (interested authors/publishers must write to subject editors before submitting books for review; editors then prepare the book review or invite colleagues to prepare the review; unsolicited reviews are not published)
- and short papers converted from manuscripts submitted as research articles but are too short to qualify as formal research articles.

These short contributions should have no more than **20 references** and its **total length should not exceed four printed pages (except editorials)**. Neither an abstract nor a list of key words is needed; major headings (Introduction, Material and methods...) should NOT be used, except for new taxon heading and references. A typical correspondence should consist of (1) a short and concise title, (2) author name and address (email address), (3) a series of paragraphs of the main text, and (4) a list of references if any. For correspondence of 3 or 4 pages, the first or last paragraph may be a summary.

Commentaries on published papers are intended for scholarly exchange of different views or interpretations of published data and should not contain personal attack; authors of concerned papers may be invited to reply to comments on their papers.

#### Special issues

Special issues with collected papers such as a Festschrift (see [Zootaxa 1325](#) and [Zootaxa 1599](#)) within the scope of the journal are occasionally published. Guest editors should send the proposal to the chief editor for approval and instructions. Although guest editors for special issues are responsible for organising the peer review of papers collected within these issues, they must follow Zootaxa's style, standard and peer review procedures. If any papers by the guest editors are to be included in the special issue, then these papers must be handled by editors/colleagues other than the editor(s) involved. Special issues must be 60 or more pages. Normally funding is required to offset part of the production cost. Author payment for open access is strongly encouraged. Reprints can be ordered for the entire issue or for individual papers.

## Preparation of manuscripts

1) **General.** All papers must be in English. Authors whose native language is not English are encouraged to have their manuscripts read by a native English-speaking colleague before submission. Nomenclature must be in agreement with the [International Code of Zoological Nomenclature](#) (4th edition 1999), which came into force on 1 January 2000. Author(s) of species name must be provided when the scientific name of any animal species is first mentioned (the year of publication needs not be given; if you give it, then provide a full reference of this in the reference list). Authors of plant species names need not be given. Metric systems should be used. If possible, use the common font New Times Roman and use as little formatting as possible (use only **bold** and *italics* where necessary and indentions of paragraphs except the first). Special symbols (e.g. male or female sign) should be avoided because they are likely to be altered when files are read on different machines (Mac versus PC with different language systems). You can code them as m# and f#, which can be replaced during page setting. The style of each author is generally respected but they must follow the following general guidelines.

2) The **title** should be concise and informative. The higher taxa containing the taxa dealt with in the paper should be indicated in parentheses: e.g. *A taxonomic revision of the genus *Aus* (Order: family).*

3) The **name(s) of all authors** of the paper must be given and should be typed in the upper case (e.g. ADAM SMITH, BRIAN SMITH & CAROL SMITH). The address of each author should be given in *italics* each starting a separate line. E-mail address(es) should be provided if available.

4) The **abstract** should be concise and informative. Any new names or new combinations proposed in the paper should be mentioned. Abstracts in other languages may also be included in addition to English abstract. The abstract should be followed by a list of **key words** that are not present in the title. Abstract and key words are not needed in short correspondence.

5) The arrangement of the **main text** varies with different types of papers (a taxonomic revision, an analysis of characters and phylogeny, a catalogue etc.), but should usually start with an **introduction** and end with a list of **references**. References should be cited in the text as Smith (1999), Smith and Smith (2000) or Smith *et al.* 2001 (3 or more authors), or alternatively in a parenthesis (Smith 2000; Smith & Smith 2000; Smith *et al.* 2001). All literature cited in the text must be listed in the references in the following format (see a [sample page here](#) in PDF).

### A) **Journal paper:**

Smith, A. (1999) Title of the paper. *Title of the journal in full*, volume number, page range.

### B) **Book chapter:**

Smith, A. & Smith, B. (2000) Title of the Chapter. In: Smith, A, Smith, B. & Smith, C. (Eds), *Title of Book*. Publisher name and location, pp. x–y.

### C) **Book:**

Smith, A., Smith, B. & Smith, C. (2001) *Title of Book*. Publisher name and location, xyz pp.

### C) **Internet resources**

Author (2002) *Title of website, database or other resources*, Publisher name and location (if indicated), number of pages (if known). Available from: <http://xxx.xxx.xxx/> (Date of access).

Dissertations resulting from graduate studies and non-serial proceedings of conferences/symposia are to be treated as books and cited as such. Papers not cited must not be listed in the references.

Please note that (1) **journal titles must be written in full (not abbreviated)**; (2) journal titles and volume numbers are followed by a ", "; (3) page ranges are connected by "n dash", not hyphen "-", which is used to connect two words. For websites, it is important to include the last date when you see that site, as it can be moved or deleted from that address in the future.

On the use of dashes: (1) Hyphens are used to link words such as personal names, some prefixes and compound adjectives (the last of which vary depending on the style manual in use). (2) En-dash or en-rule (the length of an 'n') is used to link spans. In the context of our journal that means numerals mainly, most frequently sizes, dates and page numbers (e.g. 1977–1981; figs 5–7) and also geographic or name associations (Murray–Darling River; a Federal–State agreement). (3) Em-dash or em-rule (the length of an 'm') are used far

more infrequently, and are used for breaks in the text or subject, often used much as we used parentheses. In contrast to parentheses an em-dash can be used alone; e.g. What could these results mean—that Niel had discovered the meaning of life? En-dashes and em-dashes should not be spaced.

6) Legends of **illustrations** should be listed after the list of references. Small illustrations should be grouped into plates. When preparing illustrations, authors should bear in mind that the journal has a matter size of 25 cm by 17 cm and is printed on A4 paper. For species illustration, line drawings are preferred, although good quality B&W or colour photographs are also acceptable. See a guide [here](#) for detailed information on preparing plates for publication.

7) **Tables**, if any, should be given at the end of the manuscript. Please use the table function in your word processor to build tables so that the cells, rows and columns can remain aligned when font size and width of the table are changed. Please do not use Tab key or space bar to type tables.

8) **Keys** are not easy to typeset. In a typical dichotomous key, each lead of a couplet should be typed simply as a paragraph as in the box below:

```
1 Seven setae present on tarsus I ; four setae present on tibia I; leg I longer than the body; legs black in color ...
Genus A
- Six setae present on tarsus I; three setae present on tibia I; leg I shorter than the body; legs brown in color ...
2
2 Leg II longer than leg I ... Genus B
- Leg II shorter than leg I ... Genus C
```

Our typesetters can easily convert this to a proper format as in this [PDF file](#).

## Deposition of specimens

Whenever possible, authors are advised to deposit type specimens in national or international public museums or collections. Authors are also advised to request registration numbers of deposited material in advance of the acceptance of papers to avoid unnecessary delay of publication. Some countries (e.g. Australia) require that primary type specimens be deposited in collections of the country of origin; authors are advised to take this into consideration.

## Submission

Please follow the above basic guidelines and check if your manuscript has been prepared according to the style and format of the journal. Authors are encouraged to submit manuscripts by e-mail as attachments to the subject [Editors](#) responsible for your taxa or subject areas; manuscripts on small insect orders without subject editors should be submitted to Dr **Ernest Bernard** ([ebarnard@utk.edu](mailto:ebarnard@utk.edu)); manuscripts on other invertebrate taxa without subject editors should be submitted to the [Chief editor](#).

Prior to submitting a manuscript and figures to an editor, please check our [website](#) if there are two or more editors per subject, and then contact one of these to announce your intention to submit a manuscript for review. Please indicate the size of the manuscript, the number of figures and the format of these files. Your editor can then respond with special instructions, especially for the submission of many image files.

When you submit your manuscript to your editor, it will be more expedient to the review process if you offer the names of three or more potential reviewers with their complete postal and email addresses. It is also important to include the following statements in your cover letter:

1) All authors agree to its submission and the Corresponding author has been authorized by co-authors; 2) This Article has not been published before and is not concurrently being considered for publication elsewhere (including another editor at Zootaxa); 3) This Article does not violate any copyright or other personal proprietary right of any person or entity and it contains no abusive, defamatory, obscene or fraudulent statements, nor any other statements that are unlawful in any way.

Otherwise, your manuscript will not be processed.

For manuscripts with numerous illustrations, which might be saved as separate TIFF or JPG files, for the purpose of review, it will be easier and more efficient for the subject editors and reviewers to have the figures converted into one larger [PDF](#) (Portable Document Format) file, instead of requiring the subject editor to save many files, cutting and copying these into a string of messages/files to the reviewers. You should retain the original figures in a higher resolution format for the final production of the accepted paper. For the text, PDF file along with RTF (Rich Text format) files are preferred. The advantage of submitting a rtf file for the text part of the manuscript is that the reviewers can emend the manuscript electronically. If you can not prepare PDF files, then submit text in RTF and the figures in TIFF (line drawing scanned at 600 dpi and half tone at 300 dpi; please use LZW compression, if you can, to reduce the size of e-files for easy transmission); if halftone TIFF files are too big (exceeding 2 MB), then submit them in jpeg. See [here](#) for detailed information on preparing plates for publication.



Vector files (charts, maps etc) are best submitted as EMF.

If you do not have access to e-mail, you can send three copies of the manuscript by post. Please double space your ms and leave ample margins for printed manuscripts.

Authors of accepted papers will be asked to submit an electronic version of the manuscript so that the publisher needs not to re-key or scan the ms. At this stage, the text part of the ms must be submitted as RTF or MS Word files and figures as TIFF files. Authors please be aware that line drawings must be scanned at 600 or 900 dpi as line art (=1 bit); they must NOT be scanned as 8 bit or full colour images. Please read details [here](#).

In submitting the final version of revised manuscript to editors, authors are asked to provide the following information to all proper typesetting and indexing of the manuscript:

- 1) Corresponding author name and email
- 2) Author last name and running title (<60 characters; to be used in footer)
- 3) Number of plates and cited references
- 4) High taxon name (i.e. taxon section in Zootaxa website) and number of new taxa described in the paper

Authors need to complete and return an [Assignment of Copyright](#) form when paper is accepted for publication. Authors of institutions that do not allow transfer of copyrights to publishers (e.g. government institutions such as USDA, CSIRO) should attach a copyright waiver or similar documents.

## Review process

When a manuscript is received by the [Editor](#), he/she will have it reviewed by at least two peers qualified to evaluate the manuscript and he/she normally asks the reviewers to complete the review in one month.

However, the reviewing process will normally take longer, depending on the length of the manuscript and reviewer's responses.

## Publication

Once the manuscript is accepted by your subject editor, final files, produced according to [Zootaxa requirement](#), will be forwarded by your subject editor to the chief editor, who will then link with author and the printer to ensure that the paper is published without unnecessary delay. Normally the proof will be sent to the author for checking 1 to 3 weeks after the final files are accepted. The paper will usually be published with two weeks (for larger papers it will take longer) once the corrections to the proof are received.

**Page charge and colour plates.** There is **no page charge** for publishing with *Zootaxa*. Publication of **colour figures/photographs** in online edition is also free of charge (print version in black and white). If colour plates in the print edition are desired, authors will be asked to contribute towards the full cost. Current rates: 300 USD for the first colour page; 200 USD for each additional colour page.

**Open access.** Zootaxa endorses the open access of taxonomic information and has published more open access taxonomic papers than any other journal. Authors who have funds to publish are strongly encouraged to pay a fee of 20 US\$ per printed page to give free online access of their papers to all readers at this site or their own site. Open access papers are read by more people and are expected to have higher citation rates.

**Reprints.** Each author will be given a **free e-reprint** (PDF) for personal use (printing a copy for own use or exchange with other researchers, but not for deposition in a library/website/ftp-site for public access).

Printed copies of each paper/monograph in the form of the regular reprint can also be produced by the Publisher for purchase by authors [at cost to authors](#), with a discount based on the number of copies ordered.

**Interactive links** can be set up for authors at US\$10 for the first five links and US\$1.00 for each additional link for the online edition of their paper. Typical links are: to an e-mail address, link to another online paper or website and to other parts of the same documents [e.g. linking "Smith 2000" cited in the **Introduction** to the full details "Smith, A. (2000) Title of paper. *Journal title in full*, 0, 000-000" listed in the **References**]. All details and instructions (what to mark and where to link) should be provided when the final revision is returned to the Editor