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ARTICLE

A phylogeny of *Carrerapyrgota* Aczél (Diptera, Pyrgotidae)

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Abstract. *Carrerapyrgota* Aczél, 1956 is a Neotropical Diptera genus within Pyrgotidae. Currently, the genus comprise four species: *C. miliaria* Aczél, 1956 (type species), *C. personata* (Lutz & Lima, 1918), *C. aczeli* Mello, Lamas & Rafael, 2010, and *C. bernardii* Mello, Lamas & Rafael, 2010. This study investigates the phylogenetic relationships among *Carrerapyrgota* species, aiming to establish their monophyly as a genus. To achieve this, we conducted phylogenetic analyses based on 22 external morphological characters of adults, emploing the principle of parsimony. Analyses using both equal and implied character weighting support the monophyly of the genus, based on the following apomorphies: absence of the postscutellum, R_{2+3} with spurious apical vein, lower calypter with a longitudinal row of bristles, and the presence of a posterior longitudinal groove on the female fore femur. The species *C. aczeli, C. bernardii,* and *C. miliaria* form a monophyletic group, supported by the synapomorphic condition of a spot on the forehead. Within this group, *C. bernardii* and *C. miliaria* are sister species, sharing the synapomorphic condition of a less sclerotized M vein, after dm-cu compared to the anterior region, as well as the homoplastic condition of a spot on the median occipital sclerite. This phylogenetic analysis reaffirms the synonymy proposed by Bernardi (1990), which treats *Anapyrgota* Steyskal, 1967, as a junior synonym of *Carrerapyrgota.* The evolutionary relationship among the species of the genus is represented as (*C. personata* (*C. aczeli* (*C. bernardii, C. miliaria*))). Furthermore, this study includes an updated distributional map for the genus, featuring the first record of Pyrgotinae in the Andean region.

Keywords. Cladistic; Monophyly; Pyrgotinae; South America; Tephritoidea.

INTRODUCTION

Pyrgotidae is a dipteran family distributed worldwide, comprising approximately 365 species across 55 genera (Korneyev, 2006). In the Neotropics, 58 species are recognize, divided into 12 genera (Steyskal, 1967; Bernardi, 1991; Mello *et al.,* 2010; Mello & Lamas, 2014). Members of this family are nocturnal, with larvae developing as endoparasitoids of adult beetles in the Scarabaeidae family (Forbes, 1908; Davis, 1913, 1919; De Meijere, 1916; Wolcott, 1922; Aldrich, 1928; Clausen *et al.,* 1933; Moutia, 1940; Ritcher, 1940; Gardner & Parker, 1940; Paramonov, 1958).

Carrerapyrgota was proposed by Aczél (1956a) to host the new species *Carrerapyrgota miliaria,* described based on male and female specimens from Brazil and Argentina. Lutz & Lima (1918) described the species *Apyrgota personata* based on a single specimen (of unidentified sex, due to the lack of the abdomen) from Pernambuco, Brazil. Hennig (1936) and Aczél (1956b) noted the absence of the genus *Apyrgota* in the neotropics, and suggested that the species described by Lutz & Lima should be transferred to the genus *Pyrgota* (Hennig, 1936) or included in a new genus (Aczél, 1956b). Steyskal (1967) presented a taxonomic catalog of Neotropical Pyrgotidae, proposing the genus *Anapyrgota* to host the species *A. personata.* Bernardi (1990) considered *Anapyrgota* synonymous with *Carrerapyrgota,* proposing *C. personata* as a new combination with *Carrerapyrgota.*

Mello *et al.* (2010) provided a revision of *Carrerapyrgota,* which included the description of two new Brazilian species, *C. aczeli* Mello, Lamas & Rafael, 2010 and *C. bernardii* Mello, Lamas & Rafael, 2010. They retained the synonymy and new combination proposed by Bernardi (1990), reported the first South American pyrgotid species of pyrgotids associated with a host (one beetle species), and presented an identification key and a distributional map of the species.

Carrerapyrgota is defined by the following combination of characters: medial vertical seta intersecting with postocellar seta; mesofacial plate without carina; one notopleural seta; postscutellum absent; female forefemur featuring a posterior longitudinal groove; vein C with Sc break; Sc in-

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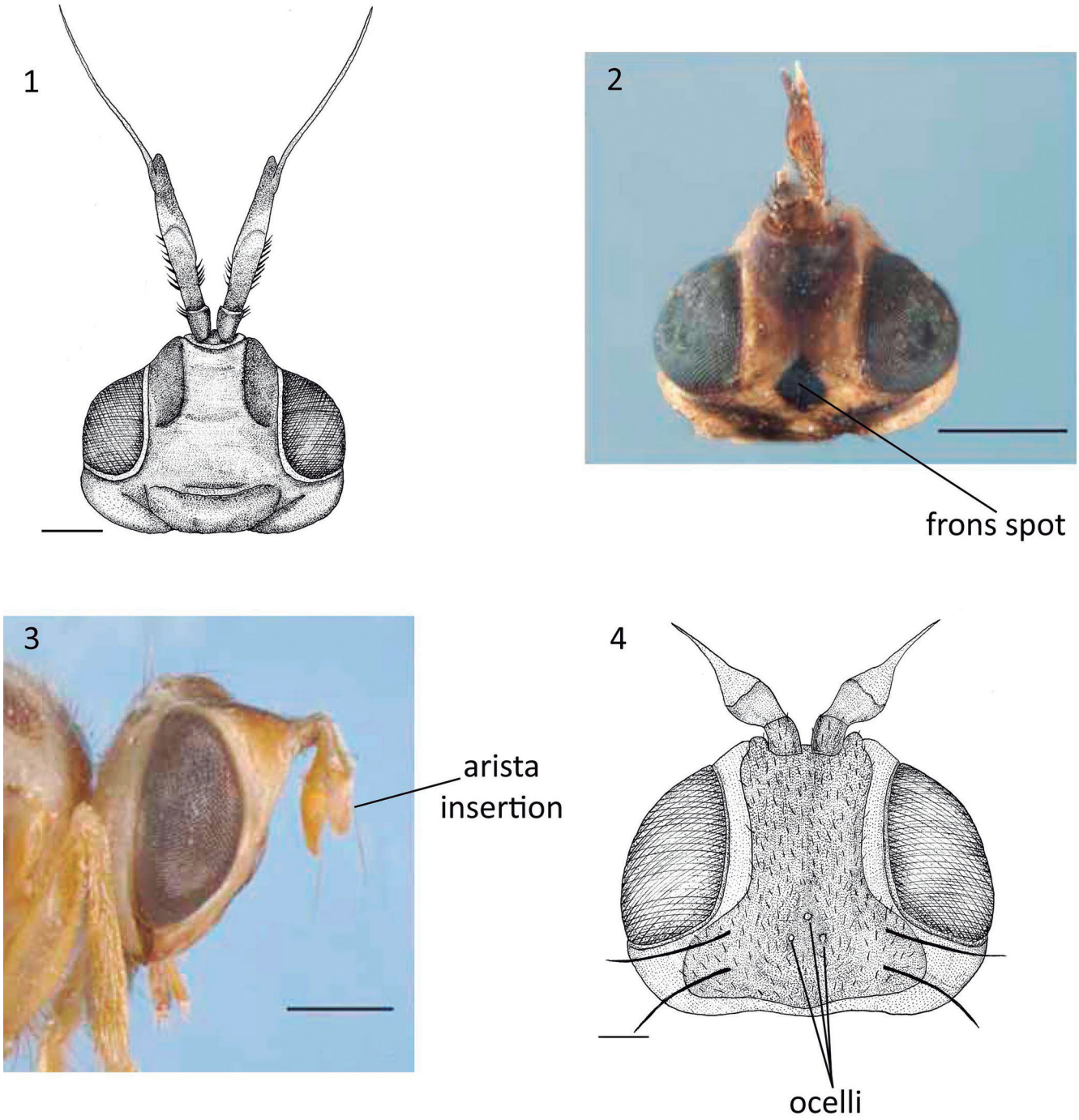
Table 1. Matrix of Morphological Characters used for *Carrerapyrgota* and outgroups.

Taxon/Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Ceratitis capitata	1	0	1	1	0	1	0	0	1	1	0	1	3	1	1	0	0	0	1	0	0	1
Descoleia teretrura	0	0	0	1	1	1	0	1	—	0	0	0	3	0	1	0	0	0	0	0	0	1
Stenopyrgota crassitiba	1	0	1	1	0	2	1	1	—	0	0	—	1	1	0	0	1	0	0	0	0	—
Idiopyrgota setiventris	0	0	0	0	—	2	1	0	2	1	0	0	2	1	0	0	1	0	0	0	0	0
Leptopyrgota sahlbergiana	0	0	1	0	1	0	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	?
C. aczeli	0	1	1	1	—	2	1	1	2	0	1	1	2	1	1	1	1	0	1	1	1	1
C. bernardii	1	1	1	0	1	2	1	1	2	1	1	1	1	1	1	1	1	1	0	1	1	1
C. miliaria	1	1	1	0	1	2	1	1	2	1	1	1	1	1	1	1	1	1	0	1	1	0
C. personata	1	0	1	0	1	2	1	1	2	0	1	1	3	1	1	1	1	0	1	1	1	—



Figures 1-4. Heads: dorsal view of *Leptopyrgota juniae* Bernardi (1); *Carrerapyrgota miliaria* Aczél (2); *Teretrura tinctipennis* Malloch (4); lateral view of *Idiopyrgota setiventris* Aczél (3). Scales: Fig. 1: 0.5 mm; Figs. 2-3: 1 mm; Fig. 4: 0.25 mm. Fig. 2 modified from Mello *et al.* (2010), Fig. 3 modified from Mello & Lamas (2008).

complete (not reaching C); R_{2+3} with an apical spur vein; lower calypter covered by a longitudinal row of hairs; and ovipositor without apical hook.

This study aims to investigate the phylogenetic relationships among *Carrerapyrgota* species, including their monophyly as a genus, and to test the synonymy proposed by Bernardi (1990). To accomplish this, phylogenetic parsimony analyses were performed based on the morphological characteristics of adults. Additionally, we present the first record of a Pyrgotinae from the Andean region, for the species *C. miliaria*.

MATERIAL AND METHODS

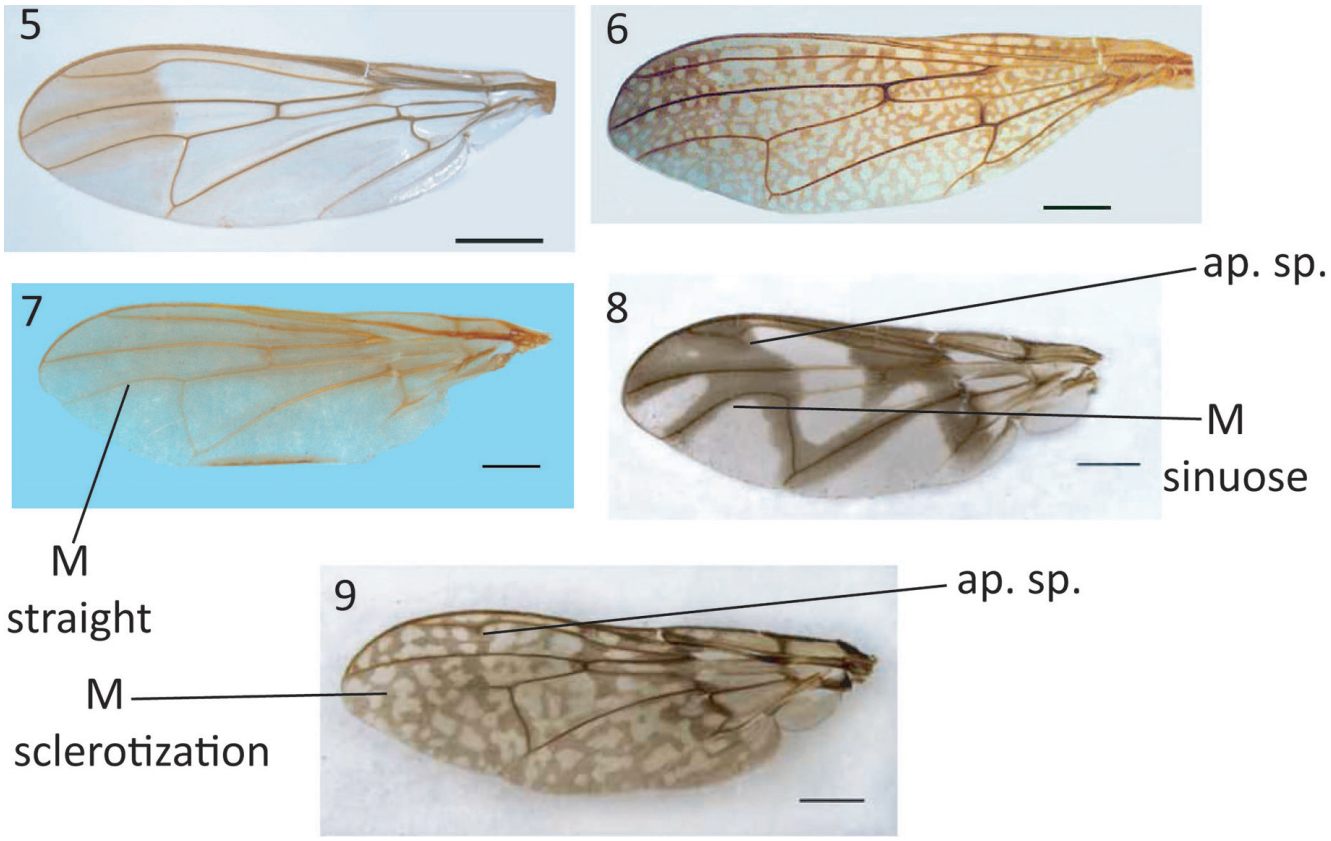
Specimens used in this study were belongs from the following institutions: Coleção Entomológica "Padre Jesus Santiago Moure", Departamento de Zoologia, Universidade Federal do Paraná, Curitiba, Brazil (DZUP); Fundação e Instituto Oswaldo Cruz, Rio de Janeiro, Brazil (FIOCRUZ); Fundación e Instituto Miguel Lillo, San Miguel de Tucumán, Argentina (IMLA); Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil (INPA); Museu de Zoologia da Universidade de São Paulo, São Paulo, Brazil (MZUSP); e Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (MNRJ). The material from MNRJ has been preserved since the 2018 fire incident (Couri, personal communication). The complete list of specimens studied here corresponds to that presented by Mello *et al.* (2010). Additional specimens were obtain from the collection of the Instituto Argentino de Investigaciones Zonas Áridas, Mendoza, Argentina (IADIZA).

Terminology in this study adheres to the conventions outlined by Korneyev (2006), Cumming & Wood (2009), and Mello *et al.* (2010). Photographs and illustrations were edited using Adobe Photoshop CC 2014, and Adobe Illustrator CS. The distribution map was crated using QGIS 3.28.2.

Outgroup taxa utilized for this analysis consisted of *Ceratitis capitata* (Wiedemann, 1824) (Tephritidae, Dacinae); *Descoleia teretrura* Aczél, 1956 (Tephritoidea *incertae sedis*); *Leptopyrgota sahlbergiana* Frey, 1918 (Pyrgotidae, Pyrgotinae); *Idiopyrgota setiventris* Aczél, 1956 (Pyrgotidae, Pyrgotinae); and *Stenopyrgota crassitibia* Aczél, 1956 (Pyrgotidae, Pyrgotinae). The cladograms were rooted between *C. capitata* and the remaining taxa.

Phylogenetic parsimony analyses were conducted using data related to the external morphology of adult males and females. Morphological characters, whether binary or multistate, were coded and organized into a matrix using the Mesquite v3.61 software. Character codification followed the logic proposed by Sereno (2007). Multistate characters were treat as unordered (Fitch, 1971). The analysis was performed using the Tree Analysis Using New Technology v1.1 (Goloboff *et al.,* 2008).

Analyses were carried out with equal weighting of characters using heuristic searches with 1,000 replicates, retaining up to 100 cladograms. Additionally analyses were conducted with implied weighting employing



Figures 5-9. Wings: *Leptopyrgota sahlbergiana* Frey (5); *Stenopyrgota crassitibia* Aczél (6); *Idiopyrgota setiventris* Aczél (7); *Carrerapyrgota personata* (Lutz & Lima) (8); *C. miliaria* Aczél (9). Scales: Fig. 5: 2 mm; Figs. 6-9: 1 mm. Fig. 6 modified from Mello & Lamas (2014), Fig. 7 modified from Mello & Lamas (2008), Figs. 8-9 modified from Mello *et al.* (2010).

concavity *K* values ranging from 1 to 10. Lower *K* values, approaching zero, imposed stronger penalties on characters displaying homoplasy (Goloboff, 1993). This range of *K* values was selected to test the phylogenetic hypothesis under differential weighting. Results for each analysis were summarized through strict consensus (Sokal & Rohlf, 1981).

Bremer's Absolute Supports were calculated for the cladograms resulting from the equal weighting analysis (Bremer, 1994), while Bremer's Relative Support was employed for the implied weighting analysis (Goloboff & Farris, 2001). Figures of the cladograms were edited using the WINCLADA v1.00.08 software (Nixon, 2002).

RESULTS AND DISCUSSION

A total of 22 morphological characters were analyzed, including one related to the general body, nine concerning the head, 11 regarding the thorax, and one specific to the male abdomen (Table 1). The length (L), consistency index (CI), and retention index (RI) are provided in parentheses.

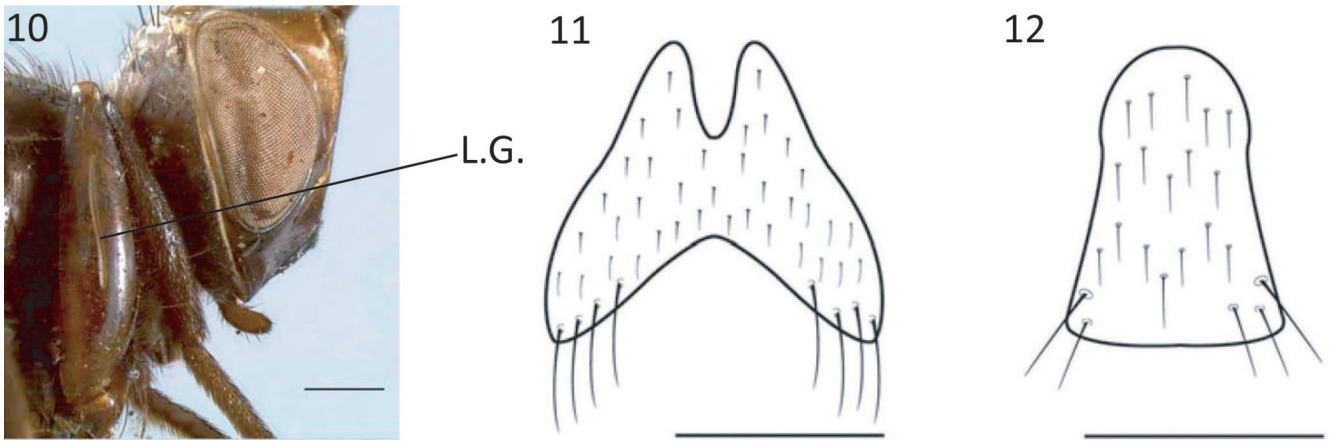
List of Characters

1. Body setae and setulae, color (L: 3; CI: 33; RI: 33): **(0)** reddish yellow; **(1)** black.
2. Frons, spot (L: 1; CI: 100; RI: 100): **(0)** absent (Fig. 1); **(1)** present (Fig. 2).
3. Antennal groove, median carina (L: 2; CI: 50; RI: 0): **(0)** present; **(1)** absent.
4. Antennal groove, lower margin, spot (L: 2; CI: 50; RI: 66): **(0)** present; **(1)** absent.
5. Pedicel, dorsal surface, size in relation to the first flagellomere (L: 2; CI: 50; RI: 0): **(0)** shorter; **(1)** longer (Fig. 1).
6. Arista, position in the dorsal surface of the first flagellomere (L: 3; CI: 66; RI: 50): **(0)** apical (Fig. 1); **(1)** basal; **(2)** middle (Fig. 3).
7. Ocelli (L: 1; CI: 100; RI: 100): **(0)** present (Fig. 4); **(1)** absent (Fig. 1).
8. Ocellar seta (L: 2; CI: 50; RI: 0): **(0)** present; **(1)** absent (Fig. 1).
9. Postocellar seta, position in relation to the medial vertical seta (L: 3; CI: 66; RI: 0): **(0)** convergent, not crossed; **(1)** parallel; **(2)** convergent, crossed like X.

Table 2. Parenthetical notation of the seven cladograms most parcimonious obtained using equal and implied weighting with k values from 1-10.

Cladograms from equal weighting from implied weighting (*K* values)	Correspondent cladograms	Parenthetical notation
*Cladogram 1	*K*3, *K*4, *K*5, *K*6, *K*7, *K*8, and *K*10	((*Ce. capitata* (*D. teretrura* (*S. crassitibia* (*I. setiventris, L. sahlbergiana*)))) (*Ca. personata* (*Ca. aczeli* (*Ca. bernardii, Ca. miliaria*))))
Cladogram 2	((*Ce. capitata* (*D. teretrura* (*S. crassitibia* (*I. setiventris, L. sahlbergiana*)))) ((*Ca. personata, Ca. aczeli*), (*Ca. bernardii, Ca. miliaria*)))	
Cladogram 3	*K*3, *K*4, *K*5, *K*6, *K*7, *K*8, and *K*10	((*Ce. capitata* (*S. crassitibia* (*L. sahlbergiana* (*I. setiventris, D. teretrura*)))) (*Ca. personata* (*Ca. aczeli* (*Ca. bernardii, Ca. miliaria*))))
Cladogram 4	*K*3, *K*4, *K*5, *K*6, *K*7, *K*8, *K*9, and *K*10	((*Ce. capitata* (*S. crassitibia* (*I. setiventris* (*L. sahlbergiana, D. teretrura*)))) (*Ca. personata* (*Ca. aczeli* (*Ca. bernardii, Ca. miliaria*))))
Cladogram 5	((*Ce. capitata* (*S. crassitibia* (*L. sahlbergiana* (*I. setiventris, D. teretrura*)))) ((*Ca. personata, Ca. aczeli*), (*Ca. bernardii, Ca. miliaria*)))	
Cladogram 6	((*Ce. capitata* (*S. crassitibia* (*I. setiventris* (*L. sahlbergiana, D. teretrura*)))) ((*Ca. personata, Ca. aczeli*), (*Ca. bernardii, Ca. miliaria*)))	
Cladogram without correspondent in equal weighting analysis *K*1, *K*2 and *K*3	((*Ce. capitata* (*D. teretrura* (*L. sahlbergiana* (*I. setiventris, S. crassitibia*)))) (*Ca. personata* (*Ca. aczeli* (*Ca. bernardii, Ca. miliaria*))))	

Number of cladogram using equal weighting: six cladograms. Number of cladogram using implied weighting with *K*1: 1 cladogram; *K*2: 1 cladogram; *K*3: 4 cladograms; *K*4-*K*8: three cladograms; *K*9: 1 cladogram; and *K*10: three cladograms, total of 25 cladograms. Number of cladograms using equal and implied weighting 31 cladograms, distributes in seven different hypothesis. *Cladogram selected to represents the phylogeny of *Carrerapyrgota.*



Figures 10-12. Female fore femur, posterior view of *Carrerapyrgota aczeli* Mello, Lamas & Rafael (10). Male sternite five of *C. miliaria* Aczél (11); *C. aczeli* (12). Scales: 1 mm. Figs. 10-12 modified from Mello *et al.* (2010).

10. Median occipital sclerite, spot (L: 3; CI: 33; RI: 33): **(0)** absent; **(1)** present.
11. Postscutelum (L: 1; CI: 100; RI: 100): **(0)** present; **(1)** absent.
12. Notopleural seta (L: 2; CI: 50; RI: 50): **(0)** two setae; **(1)** one seta.
13. Wing, color pattern (L: 6; CI: 50; RI: 40): **(0)** hyaline with apical spot (Fig. 5); **(1)** reticulate (Fig. 6); **(2)** bicolor (Fig. 7); **(3)** banded (Fig. 8).
14. Costal vein (L: 2; CI: 50; RI: 0): **(1)** ending at vein M; **(0)** ending before reach vein M.
15. Costal vein (L: 2; CI: 50; RI: 0): **(0)** unbroken on Sc; **(1)** broken on Sc.
16. Vein R_{2+3}, apical spur vein (L: 1; CI: 100; RI: 100): **(0)** absent (Figs. 5-7); **(1)** present (Figs. 8-9).
17. Vein R_{4+5}, dorsal surface (L: 1; CI: 100; RI: 100): **(0)** setulose; **(1)** bare.

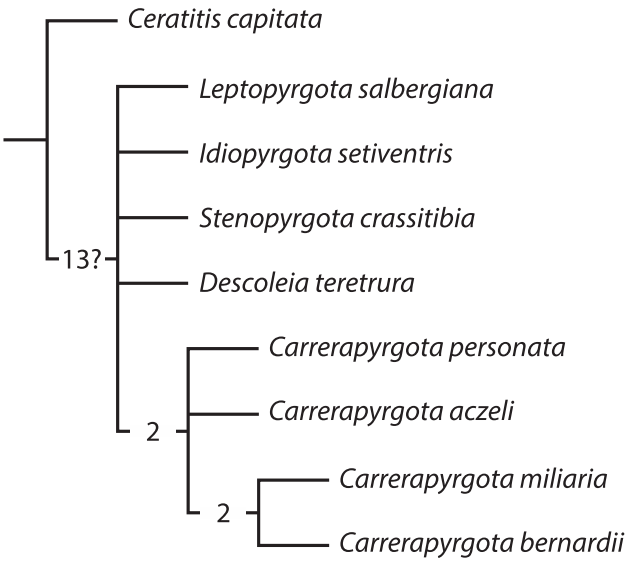


Figure 13. Strict consensus cladogram and Absolute Bremer Support of *Carrerapyrgota,* resulted from analysis with equal weighting of characters.

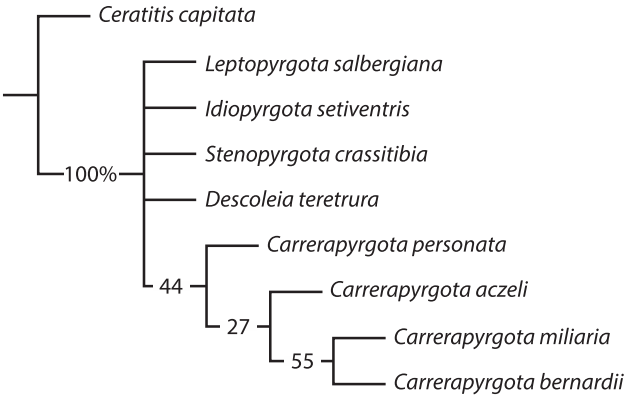


Figure 14. Strict consensus cladogram and Relative Bremer Support of *Carrerapyrgota,* resultant from analysis with implied weighting from *K*3.

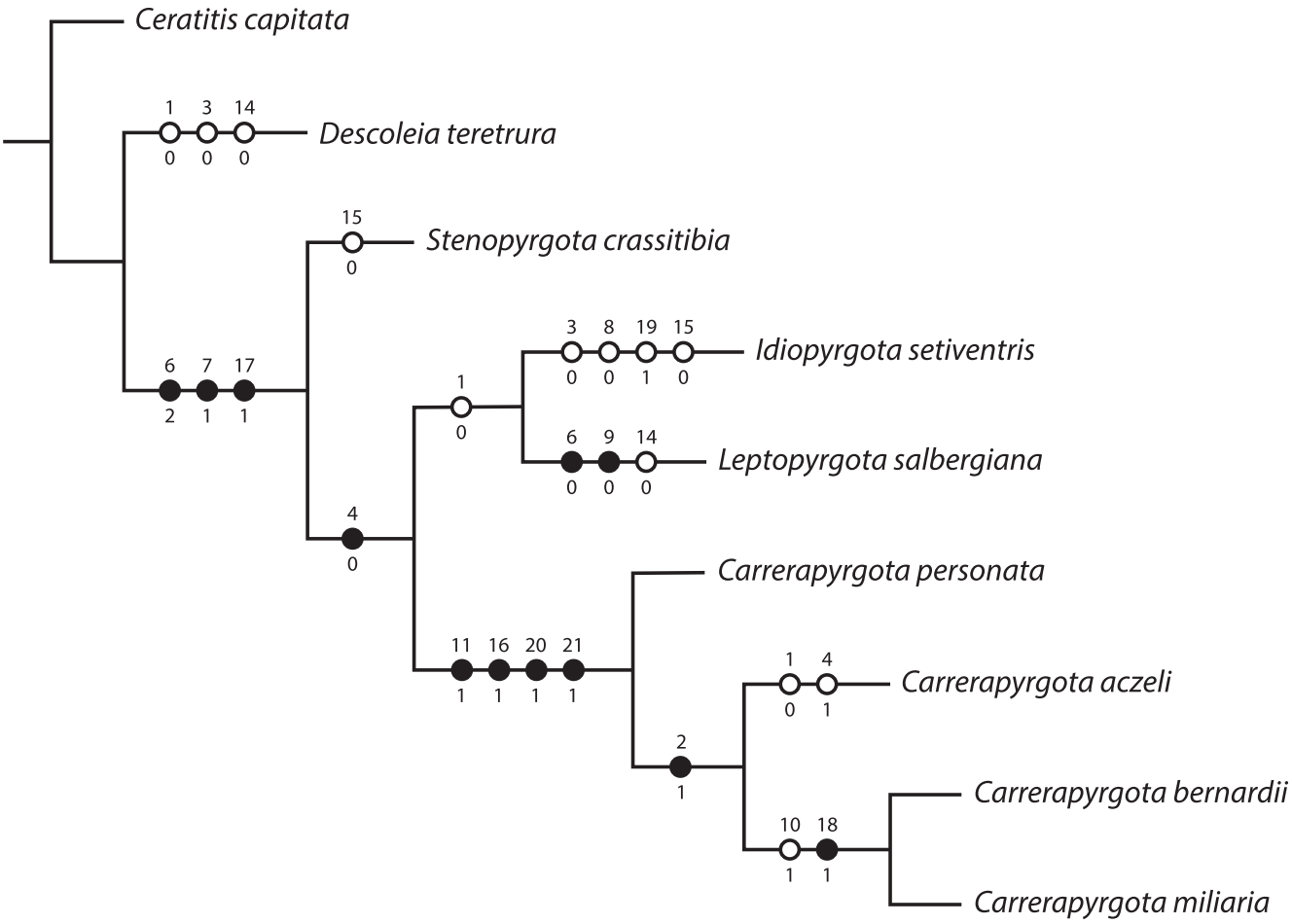


Figure 15. Optimal cladogram selected to represents the evolutionary relationship among the species of *Carrerapyrgota.* Black circles represents synapomorphies, white circles represents homoplasies.

18. Vein M, sclerotization (L: 1; CI: 100; RI: 100): **(0)** uniformly esclerotized (Figs. 5-8); **(1)** less sclerotization in front of dm-cu (Fig. 9).
19. Vein M, in front of dm-cu, position in relation to the vein R_{4+5} (L: 3; CI: 33; RI: 0): **(0)** straight (Figs. 5-7); **(1)** sinuose (Figs. 8-9).
20. Lower calypter, longitudinal row of hairs (L: 1; CI: 100; RI: 100): **(0)** absent; **(1)** present.
21. Female forefemur, posterior surface, longitudinal groove (L: 1; CI: 100; RI: 100): **(0)** absent; **(1)** present (Fig. 10).
22. Male sternite 5, anterior margin, shape (L: 3; CI: 66; RI: 0): **(0)** bilobate (Fig. 11); **(1)** straight (Fig. 12); **(2)** rounded.

The analysis with equal weighting yielded six most parsimonious cladograms, as indicated by the parenthetical notation in Table 2. These cladograms exhibited an L value of 43 steps, CI 62, and RI 60. In all six cladograms, the monophyly of the genus was supported by four synapomorphies: postscutellum absent (11:1), R_{2+3} with apical spur vein (16:1. Figs. 8-9), lower calypter with a longitudinal row of hairs (20:1), and the presence of a longitudinal groove on the posterior surface of female fore femur (21:1. Fig. 10). Furthermore, all six cladograms, consistently placed *C. bernardii* and *C. miliaria* as sister groups, supported by the synapomorphic conditions of vein M being less sclerotized after dm-cu compared to its basal half (18:1. Fig. 9), as well as the homoplasic presence of a spot on the median occipital sclerite (10:1).

In three of the cladograms, the clade consisting of (*C. aczeli,* (*C. bernardii, C. miliaria*)) was supported by the presence of a spot on the frons (2:1. Fig. 2). The strict consensus of the cladograms from the equal weighting analysis, along with Bremer's Absolute Support analysis, is presents in Fig. 13. The monophyly of the groups obtained in the equal weighting analysis, *Carrerapyrgota,* and the clade composed of (*C. bernardii, C. miliaria*), was consistently found in cladograms within two steps of the most parsimonious cladograms (Fig. 13).

Analyses with implied weighting produced a total of 25 cladograms, resulted in a single phylogenetic hypothesis for the ingroup and four distinct topologies for the outgroups (Table 2). Table 2 provides the number of

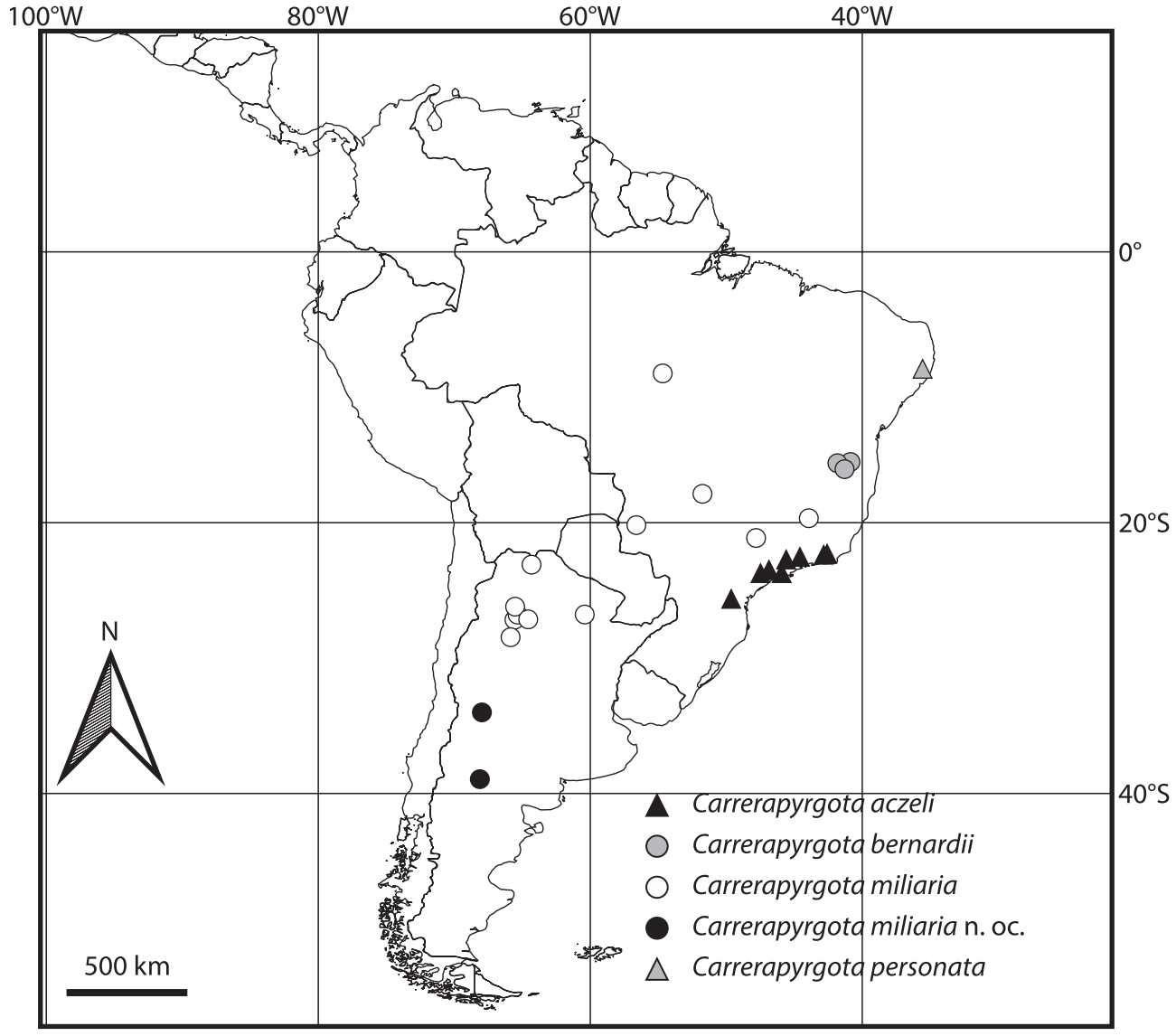


Figure 16. Distribution map of *Carrerapyrgota* species. n. oc.: new occurrences. Modified from Mello *et al.* (2010).

cladograms obtained for each *K* value, along with the corresponding phylogenetic hypotheses from the equal weighting analysis.

The optimal cladogram selected to represent the monophyly of *Carrerapyrgota* and the phylogenetic hypothesis is decipted in Fig. 15. This cladogram corresponds to one of the most parsimonious cladograms resulting from equal weighting, and seven of the most parsimonious cladograms from analyses with implied weighting using *K*3–*K*8, and *K*10 (Table 2). Adittionally, this cladogram aligns with the classification of the pyrgotids proposed by McAlpine (1990), concerning the relationship of the outgroup.

The strict consensus, along with Bremer's Relative Support, for the analyses with implied weighting, starting from *K*3, is presented in Fig. 14. The distribution of characters and their respective states pertaining to the optimal cladogram, are illustrated in Fig. 15.

New occurrences of *Carrerapyrgota miliaria* (Fig. 16): Argentina, Mendoza, Santa Rosa, Ñacuñán; 30/x/1996; G. Debandi col. 1 female (IADIZA), Mello & Núñez-Campero det. xi/2022. Idem, 18/vii-16/viii/1998. 1 male (IADIZA). Neuquén, Collón Curá; 21/x/1967; M. Gentile col. 1 female (IADIZA), Mello & Núñez-Campero det. xi/2022.

CONCLUSION

The confirmation of the monophyly of *Carrerapyrgota* provides further support for the synonymy proposed by Bernardi (1990), which regards *Anapyrgota* as a junior synonym of *Carrerapyrgota*. Additionally, the discovery of new occurrences of *C. miliaria* in Neuquén, Argentina, marks the first record of the Pyrgotinae in the Andean region. This finding expands the distributional range of the subfamily in South America.

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REFERENCES

Aczél, M.L. 1956a. Revisíon parcial de las Pyrgotidae neotropicales y Antárticas con synopsis de los géneros y especies (Diptera, Acalyptratae). *Revista Brasileira de Entomologia,* 6: 1-38.

Aczél, M.L. 1956b. Revisíon parcial de las Pyrgotidae neotropicales y Antárticas con synopsis de los géneros y especies (Diptera, Acalyptratae). *Revista Brasileira de Entomologia,* 5: 1-70.

Aldrich, J.M. 1928. Five new parasitic flies reared from beetles in China and India. *Proceedings of the United States National Museum,* 74(8): 1-7. https://doi.org/10.5479/si.00963801.74-2753.1.

Bernardi, N. 1990. Caracterização do gênero *Carrerapyrgota* Aczél, 1956 e sinonimização de *Anapyrgota* Steyskal, 1967 (Diptera, Pyrgotidae). *Biotemas,* 3(1): 101-104.

Bernardi, N. 1991. Notas sobre o gênero *Leptopyrgota* Hendel, com descrição de vinte e uma novas espécies do Brasil (Diptera, Pyrgotidae). *Revista Brasileira de Zoologia,* 7(3): 327-350. https://doi.org/10.1590/S0101-81751990000300015.

Bremer, K. 1994. Branch support and tree stability. *Cladistics,* 10(3): 295-304.

Clausen, C.P.; Jaynes, H.A. & Gardner, T.R. 1933. Further investigations of the parasites of *Popillia japonica* in the Far East. *Technical Bulletin United States Department of Agriculture,* 366: 1-58.

Cumming, J.M. & Wood, D.M. 2009. Adult Morphology and Terminology. *In:* Brown, B.V.; Borkent, A.; Cumming, J.M.; Wood, D.M.; Woodley, N.E. & Zumbado, M.A. (Eds.). *Manual of Central American Diptera.* V.1. Ottawa, NRC Research Press. p. 9-50.

Davis, J.J. 1913. Common White Grubs. *Farmers' Bulletin United States Department of Agriculture,* 543: 1-20.

Davis, J.J. 1919. Contributions to a Knowledge of the natural enemies of *Phyllophaga. Bulletin of the Illinois Natural History Survey,* 13: 53-138. https://doi.org/10.21900/j.inhs.v13.329.

De Meijere, J.C.H. 1916. Studien über südostasiatische Dipteren, XI. Zur Biologie Einiger Javanischen Dipteren Nebst Beschreibung einiger neue Javanischen Arten. *Tijdschrift Voor Entomologie,* 59: 184-213.

Fitch, W. 1971. Toward defining the course of Evolution: minimum change for a specific tree topology. *Systematic Zoology,* 20(4): 406-416.

Forbes, S.A. 1908. *13ª Report of the State Entomologist on the noxious and beneficiates insects of the States Illinois:* 24. https://www.biodiversitylibrary.org/page/15244240.

Gardner, T.R. & Parker, L.B. 1940. Investigations of the parasites of *Popillia japonica* and related Scarabeidae in the Far East from 1929 to 1933 inclusive. *Technical Bulletin United States Departament Agricola,* 738: 1-36.

Goloboff, P. 1993. Estimating Character Weights During Tree Search. *Cladistics,* 9: 83-91. https://doi.org/10.1111/j.1096-0031.1993.tb00209.x.

Goloboff, P. & Farris, J. 2001. Methods for quick consensus estimation. *Cladistics,* 17: 26-34. https://doi.org/10.1111/j.1096-0031.2001.tb00102.x.

Goloboff, P.; Farris, J. & Nixon, K. 2008. TNT a free program for phylogenetic analysis. *Cladistics,* 24: 774-786. https://doi.org/10.1111/j.1096-0031.2008.00217.x.

Hennig, W. 1936. Beiträge zur Tiergeographie und Systematik der Pyrgotiden. *Arbeiten über morphologische und taxonomische Entomologie,* 3: 243-256.

Korneyev, V. 2006. A revision of Afrotropical species of the *Eupyrgota* (Diptera, Pyrgotidae): the *spinifemur* group and *latipennis* subgroup of species. *Vestnik Zoologii,* 40: 3-25. http://www.v-zool.kiev.ua/pdfs/2006/2/02_Korneyev.pdf.

Lutz, A. & Lima, A.L. 1918. Contribuição para o estudo das Tripaneidas brasileiras. *Memórias do Instituto Oswaldo Cruz,* 10: 5-16. https://doi.org/10.1590/S0074-02761918000100001.

McAlpine, D.K. 1990. The taxonomy position of the Ctenostylidae (= Lochmostylinae; Diptera: Schizophora). *Memórias do Instituto Oswaldo Cruz,* 84: 365-371. https://doi.org/10.1590/S0074-02761989000800065.

Mello, R.L & Lamas, C.J.E. 2008. Review of the monotypic genus *Idiopyrgota* Aczél (Diptera, Pyrgotidae). *Zootaxa,* 1817: 59-64. https://doi.org/10.11646/zootaxa.1817.1.6.

Mello, R.L & Lamas, C.J.E. 2014. Review of the genera *Stenopyrgota* Malloch and *Tropidothrinax* Enderlein (Diptera, Pyrgotidae). *Revista Brasileira de Entomologia,* 58: 1-6. https://doi.org/10.1590/S0085-56262014000100001.

Mello, R.L.; Lamas, C.J.E. & Rafael, J.A. 2010. Revision of the Neotropical genus *Carrerapyrgota* Aczél (Diptera, Pyrgotidae) with the description of two new species. *Zootaxa,* 2515: 45-64. https://doi.org/10.11646/zootaxa.2515.1.3.

Moutia, L.A. 1940. The research for parasites of White grubs (Melolonthids) in Zanzibar, Algeria, Morocco and France. *Bulletin of Entomological Resource,* 31(2): 193-208. https://doi.org/10.1017/S0007485300004971.

Nixon, K.C. 2002. *Winclada ver. 1.00.08.* Ithaca, NY, Published by the author.

Paramonov, S.J. 1958. A review of Australian Pyrgotidae (Diptera). *Australian Journal of Entomology,* 6(1): 89-138. https://doi.org/10.1071/ZO9580089.

Ritcher, P.O. 1940. Kentucky White grubs. *Kentucky Agricultural Experimental Station Bulletin,* 401: 1-151.

Sereno, P.C. 2007. Logical basis for morphological characters in phylogenetics. *Cladistics,* 23(6): 565-587. https://doi.org/10.1111/j.1096-0031.2007.00161.x.

Sokal, R.R. & Rohlf, F.J. 1981. Taxonomic congruence in the *Leptopodomorpha* reexaminad. *Systematic Zoology,* 30(3): 309-325. https://doi.org/10.2307/2413252.

Steyskal, G.C. 1967. 56. Family Pyrgotidae. *In:* Papavero, N. (Ed.). *A catalogue of the Diptera of the Americas South of the United States.* São Paulo, Secretaria da Agricultura, Departamento de Zoologia. p. 1-8. https://www.biodiversitylibrary.org/item/205612#page/706/mode/1up.

Wolcott, G.N. 1922. Insect parasite introduction in Porto Rico. *Journal Departament of Agriculture,* 6: 5-20. https://doi.org/10.46429/jaupr.v6i1.15128.

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