BioOne COMPLETE

First Record of the Scarab Beetle, Phyllophaga lissopyge from South America, with Descriptions of Adult Seasonal Activity and Male Response to Sex Attractants

Authors: Morales-Rodriguez, Anuar, Peck, Daniel C., and Robbins, Paul S.

Source: Journal of Insect Science, 11(23) : 1-9

Published By: Entomological Society of America

URL: https://doi.org/10.1673/031.011.0123

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Journal of Insect Science
www.insectscience.org

First record of the scarab beetle, *Phyllophaga lissopyge* from South America, with descriptions of adult seasonal activity and male response to sex attractants

Anuar Morales-Rodriguez[1a*], Daniel C. Peck[2b], and Paul S. Robbins[2, 3c]

[1] Department of Plant Science and Plant Pathology, Montana State University, 10 Marsh Laboratory, Bozeman, MT 59717
[2] Department of Entomology, New York State Agricultural Experiment Station, Cornell University, 630 W. North Street, Geneva, NY 14456
[3] Present address: Subtropical Insects Research Unit, US Horticultural Research Laboratory, ARS, USDA, 2001 South Rock Rd., Ft. Pierce, FL 34949.

Abstract

Phyllophaga lissopyge (Bates) (Coleoptera: Scarabaeidae: Melolonthinae) is reported for the first time from South America. Male sex pheromone response is described for *P. lissopyge* and two other co-occurring *Phyllophaga* species. Adults of *P. lissopyge* and *P. menetriesi* (Blanchard) flew to traps baited with methyl 2-(methylthio) benzoate whereas adults of *P. obsoleta* (Blanchard) flew irregularly to four different pheromone compounds. Adult seasonal activity is described from males captures in Rionegro, Antioquia, Colombia.

Resumen

Se reporta por primera vez *Phyllophaga lissopyge* (Bates) (Coleoptera: Scarabaeidae: Melolonthinae) en Sur América. Se describe la respuesta de los machos de *P. lissopyge* y de otras dos species de *Phyllophaga* recolectados en trampas cebadas con feromona sexual. Los adultos de *P. lissopyge* y *P. menetriesi* (Blanchard) volaron a las trampas cebadas con metil-2 - (metiltio) benzoate mientras los adultos de *P. obsoleta* (Blanchard) volaron irregularmente a cuatro diferentes compuestos de la feromona. Se describe la actividad estacional de los adultos basada en los machos capturados en trampas en Rionegro, Antioquia, Colombia.

Keywords: Antioquia, methyl 2-(methylthio) benzoate, Coleoptera, Colombia, L-isoleucine, L-leucine, L-valine, Melolonthinae, methyl 2-(methylthio), pheromone, Scarabaeidae
Correspondence: [a*] am434@cornell.edu , [b] dp25@cornell.edu, [c] psr1@cornell.edu, *Corresponding author
Received: 11 December 2009, **Accepted:** 10 February 2010
Copyright : This is an open access paper. We use the Creative Commons Attribution 3.0 license that permits unrestricted use, provided that the paper is properly attributed.
ISSN: 1536-2442 | Vol. 11, Number 23

Cite this paper as:
Morales-Rodriguez A, Peck DC, Robbins PS. 2011. First record of the scarab beetle, *Phyllophaga lissopyge* from South America, with descriptions of adult seasonal activity and male response to sex attractants. *Journal of Insect Science* 11:23 available online: insectscience.org/11.23

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Introduction

The New World genus *Phyllophaga* (*s. lato*) (Coleoptera: Scarabaeidae: Melolonthinae) encompasses 865 extant species, including 442 from Central America, 217 from Canada and the United States, 186 from the Caribbean Islands, and 109 from South America (Evans and Smith 2009). Some overlap of species distribution occurs between these regions. Both larvae and adults of various *Phyllophaga* species are economically important pests of a variety of agricultural crops such as bean, cassava, coffee, corn, ornamentals, pasture grasses, peanut, pepper, potato, and sugarcane (King 1984, 1996a, 1996b; Morón 1986, 2006; Londoño 1993; Salvadori and Oliveira 2001; Salvadori and Silva 2004; Espinosa-Islas et al. 2005; Pardo-Locarno et al. 2005; Ortega-Ojeda et al. 2007).

Evans and Smith (2009) reported 28 species of *Phyllophaga* in Colombia (Table 1). Restrepo-Giraldo et al. (2003), however, reported 29 species in Colombia including *P. sericata* Blanchard, a species not reported by Evans and Smith (2009). Serna-Patiño (2004) added *P. gigantea* based on light-trap captures in Pereira, Risaralda. We report here the first capture of *Phyllophaga lissopyge* (Bates) (Coleoptera: Scarabidae) in South America, bringing the total number of species listed from Colombia to 31.

In Colombia, *Phyllophaga* flight activity generally occurs during the two rainy seasons, either March to May or September to November (Vallejo et al. 1998; Pardo-Locarno et al. 2002; Serna-Patiño 2004; Villegas et al. 2006, 2008). After emerging from the soil, females release sex pheromones by opening the pygidium and extruding a gland from which the pheromone volatilizes (for photos, see Leal et al. 1993; Nojima et al. 2003; Zarbin et al. 2007). Sex pheromones identified from the *Phyllophaga* include methyl 2-(methylthio) benzoate from *P. crinita* (Robbins et al. 2003); methyl esters of three amino acids, including L-valine, from *P. anxia* and *P.* (*Phytalus*) *georgiana* (Zhang et al. 1997; Robbins et al. 2009); L-isoleucine from *P. anxia* and *P. elenans* (Zhang et al. 1997; Leal et al. 2003); L-leucine from *P. lanceolata*, (Nojima et al. 2003); and phenol and *p*-cresol from *P. cuyabana* (Zarbin et al. 2007). Furthermore, an extensive trapping study by Robbins et al. (2006) demonstrated the widespread use of the methyl esters of L-valine and L-isoleucine methyl ester in the mate-finding systems of >50 species of *Phyllophaga* in the United States and Canada. This manuscript is the first part of a study of trapping *Phyllophaga* spp. with sex attractants in various regions of Colombia.

Materials and Methods

The study site was located at the "La Selva" research station of the Corporación Colombiana de Investigación Agropecuaria in Rionegro, Antioquia, Colombia (latitude 6° 9' 17.1792", longitude -75° 22' 52.845", and 2150 m elevation). This site was chosen because of its history of abundant *Phyllophaga* populations. According to the Instituto de Hidrología, Meteorología y Estudios Ambientales station in Rionegro, Antioquia, the average temperature at the location is 17º C (8.0-25.0º C) and precipitation is 1800-2500 mm per year, largely falling in a bimodal pattern from April-May and September-October.

The methodology used in the present study was similar to prior studies (Zhang et al. 1997; Leal et al. 2003; Nojima et al. 2003; Robbins

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Table 1. Checklist of the *Phyllophaga* from Colombia.

	Species	Subgenus	Authority	Source*
1	*aguadita*	Phyllophaga	Saylor, 1942	1
2	*apolinari*	Phyllophaga	Saylor, 1940	1
3	*apolinaria*	Phyllophaga	Saylor, 1942	1
4	*brevisetosa*	Phyllophaga	Moser, 1918	1
5	*caviceps*	Phyllophaga	Moser, 1918	1
6	*chiriquina*	Phyllophaga	Bates, 1888	1
7	*columbiana*	Phyllophaga	Blanchard, 1850	1
8	*densepunctata*	Phyllophaga	Moser, 1918	1
9	*fragilipennis*	Phyllophaga	Blanchard, 1850	1
10	*gigantea*	Phyllophaga	Bates, 1888	3
11	*impressipyga*	Phyllophaga	Frey, 1975	1
12	*lebasii*	Phyllophaga	Blanchard, 1850	1
13	*lissopyge*	Phyllophaga	Bates, 1888	4
14	*longicornis*	Phyllophaga	Blanchard, 1851	1
15	*luridipennis*	Phytalus	Moser, 1918	1
16	*martinezi*	Phyllophaga	Frey, 1975	1
17	*menetriesi*	Phyllophaga	Blanchard, 1851	1
18	*obsoleta obsoleta*	Phytalus	Blanchard, 1851	1
19	*pachypyga*	Phyllophaga	Burmeister, 1855	1
20	*pruinipennis*	Phyllophaga	Moser, 1918	1
21	*punctulata*	Phyllophaga	Blanchard, 1851	1
22	*rorulenta rorulenta*	Phyllophaga	Burmeister, 1855	1
23	*roscida*	Phyllophaga	Burmeister,1855	1
24	*ruficollis*	Phyllophaga	Moser, 1918	1
25	*rugipennis*	Phyllophaga	Shaufuss, 1858	1
26	*schneblei*	Phyllophaga	Frey, 1975	1
27	*sericata*	Phyllophaga	Blanchard, 1850	2
28	*setifera*	Phyllophaga	Burmeister, 1855	1
29	*thoracica*	Phyllophaga	Burmeister, 1855	1
30	*transversicollis*	Phyllophaga	Moser, 1918	1
31	*yucana*	Phyllophaga	Saylor, 1937	1

* 1 Evans and Smith 2009. 2 Restrepo-Giraldo et al. 2003, Cat. Coll. Ins. Col. 2:136. 3 Serna-Patiño 2004. 4 Morales et al. (current manuscript). Species reported first time in Colombia in this paper.

et al. 2003, 2006, 2008, 2009; Alm et al. 2004) that captured *Phyllophaga* adults using sex attractants. Cross-vane traps (see Robbins et al. 2006) were hung on a series of metal stakes such that the trap bottom was 1 m above the ground. A line of 12 traps, each separated by 20 m, were situated along the edge of a corn and cabbage field. Traps were maintained in the field from August 2003 to September 2004. Traps were emptied and re-randomized weekly. Pheromone lures were replaced every 4 weeks. Each trap was baited with an individual lure from the following: eight blends of the methyl esters of L-valine and L-isoleucine (100:0, 90:10, 80:20, 60:40, 40:60, 20:80, 10:90 and 0:100) (4 mg each rubber septa), L-leucine methyl ester (4 mg each rubber septa), methyl 2-amino benzoate (1 mg each rubber septa), methyl 2-(methylthio) benzoate (1 mg each rubber septa), and a control trap containing a blank septa. All lures were supplied by ChemTica Internacional, (www.chemtica.com). After collection, insects were frozen until identification. All specimens were identified to species using characteristics of the male genitalia (Morón 2001, 2003). The identification of *P. lissopyge* was confirmed by Dr. María Milagro Coca-Abia (Centro de Investigaciones y Tecnologías Agroalimentarias, Zaragoza, Spain) by comparison with museum specimens. Local

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

rainfall data were obtained directly from the Instituto de Hidrología, Meteorología y Estudios Ambientales station in Rionegro, Antioquia.

A male capture response curve was constructed for each *Phyllophaga* species to illustrate the proportional capture of males collected over the entire study with respect to pheromone treatment. The seasonal incidence of each species was also examined by plotting the number of captures versus weekly precipitation to reveal any correspondence between rainfall and adult activity.

Results

Material examined

A total of 156 males and no females were captured, representing three species of *Phyllophaga*. These included 135 *P.* (*Phyllophaga*) *lissopyge*, 20 *P.* (*Phytalus*) *obsoleta*, and 1 *P.* (*Phyllophaga*) *menetriesi*, representing 86.5, 12.8, and 0.7% of total captures, respectively. This is the first record of *P. lissopyge* from Colombia and South America.

Male pheromone response

For *P. lissopyge*, male captures were greatest in those traps baited with methyl 2-(methylthio) benzoate (97.8%, n = 132); the remaining males (2.2%, n = 3) all flew to L-leucine methyl ester (Figure 2). In contrast, *P. obsoleta* showed no clear preference for any pheromone treatment; males were recovered from 100% L-valine methyl ester (15.0%, n = 3), 10:90 L-valine methyl ester: L-isoleucine methyl ester (20.0%, n = 4), L-leucine methyl ester (25.0%, n = 5), methyl 2-(methylthio) benzoate (10.0%, n = 2), and untreated check trap (30.0%, n = 6). The single male *P. menetriesi* was captured in a trap baited with methyl 2-(methylthio) benzoate.

Seasonal incidence

Figure 1. Geographic distribution of *Phyllophaga lissopyge.* High quality figures are available online.

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

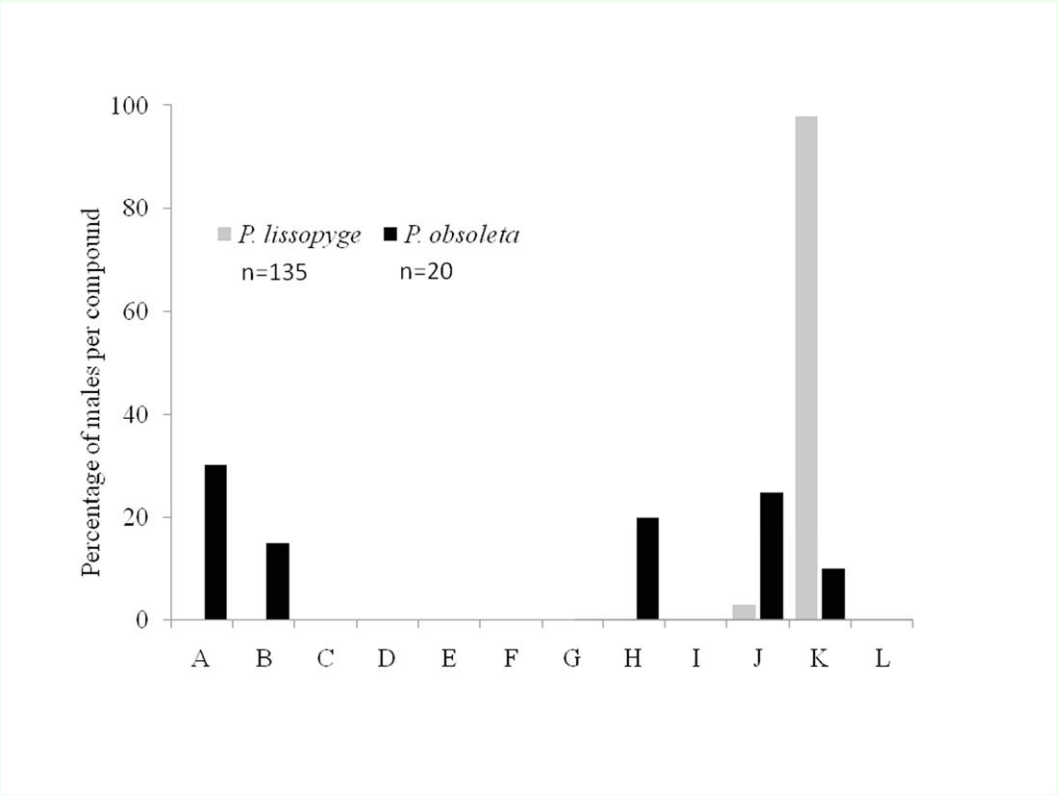

Figure 2. Proportional catch, by species, of adult *Phyllophaga lissopyge* and *P. obsoleta* in traps with 12 different blends of pheromones in Rionegro, Antioquia, Colombia. (A) untreated check, (B) 100:0, (C) 90:10, (D) 80:20, (E) 60:40, (F) 40:60, (G) 20:80, (H) 10:90, and (I) 0:100 of L-valine methyl ester: L-isoleucine methyl ester; (J) L-leucine methyl ester, (K) methyl 2-(methylthio) benzoate, (L) methyl 2-amino benzoate. High quality figures are available online.

Adults of white grub species are commonly called "marceños" (March beetles) because many species fly in March. *Phyllophaga lissopyge*, however, was captured during every month of the year with the exception of August in both 2003 and 2004 (Figure 3). Almost half of all captures (48.1%) occurred during the four months of highest precipitation, March to June 2004 (Figure 3). *Phyllophaga lissopyge* adults were captured primarily after or during a period of high precipitation (Pearson's r = 0.64364; n = 14) with the exception of January 2004 (usually the driest month in the area), when 8 males were captured after the field was heavily irrigated.

Phyllophaga obsoleta males were captured mainly during August and September of both years (9 adults in 2003 and 8 in 2004). Three *P. obsoleta* males were captured in December, January, and February (one each month) (Figure 3). The single male *P. menetriesi* was captured the second week of May.

Discussion

Three species of *Phyllophaga* were captured during the study: *P. lissopyge, P. menetriesi*, and *P. obsoleta*. This information expands the geographical distribution of *P. lissopyge* to the country of Colombia and continent of South America. Bates (1888) described this species from two specimens collected at Volcán Chiriqui, Panama and Chontales, Nicaragua. Morón (2001) reported the occurrence of this species from between southern Costa Rica to western Panama. In 2003, Morón (2003) expanded the range of *P. lissopyge* from central Nicaragua to central Panama (Figure 1). *Phyllophaga lissopyge* is usually found on mountain slopes (620 to 2136 m elevation)

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

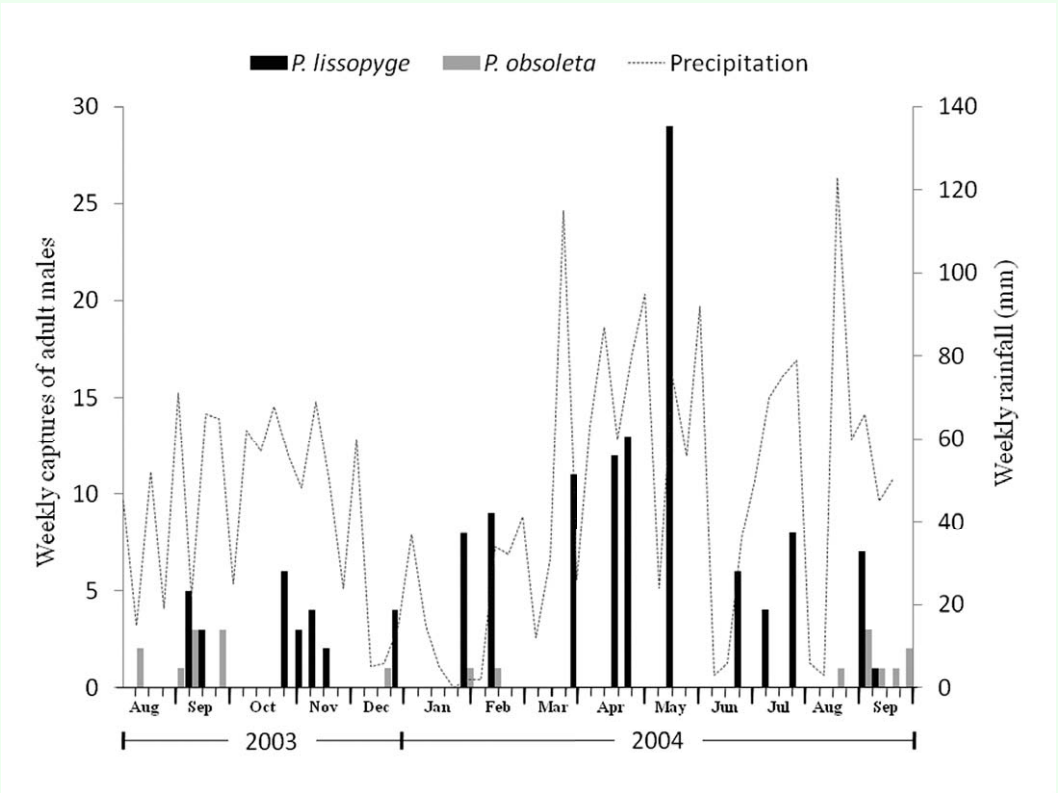

Figure 3. Numbers of adult *Phyllophaga lissopyge* and *P. obsoleta* collected weekly from pheromone traps with respect to weekly precipitation in Rionegro, Antioquia, Colombia. High quality figures are available online.

with cloud forests, tropical rain forest, and coffee plantations (Morón 2003). *Phyllophaga lissopyge* may have arrived in Colombia through natural or human-mediated dispersal. *Phyllophaga lissopyge* could have spread from Panama to the north of Chocó department through the Darien Gap, and then through the same mountain system to Antioquia. Human-mediated dispersal is also likely, the commercial interchange between Colombia and Panama in this area being very intense and unregulated. Peck et al. (2001) suggested the same route of invasion for *Prosapia simulans* (Walker) (Homoptera: Cercopidae) from Central America to Colombia.

Phyllophaga lissopyge is a member of the genus *Phyllophaga* (*sensu stricto*), and is one of 865 species of *Phyllophaga* (*s. lato*) recorded from the New World (Evans and Smith 2009). However, based on phylogenetic analysis of external morphological and genitalic characteristics, Coca-Abia (2002) proposed the re-establishment of the genus *Trichesthes* (Erichson 1847) and removed 38 species from the *Phyllophaga* and into *Trichesthes*, including *P. lissopyge* and *P. gigantea*.

The flight patterns of *P. lissopyge* in Central America (Morón 2001, 2003) mirror our observations in Colombia, in that adults fly from February to November, with the largest flights occurring during March, April, and May.

Acknowledgments

The authors thank A. Gaigl and J. Montoya for their support, M. Londoño-Zuluaga (Corporación Colombiana de Investigación Agropecuaria, La Selva, Rionegro, Colombia)

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

for care of the pheromone traps and insect captures, and M. Milagro Coca-Abia (Centro de Investigaciones y Tecnologías Agroalimentarias, Zaragoza, Spain) for confirming the identity of *P. lissopyge*. We also thank Matthew Petersen of Cornell University for assistance in preparing Figure 1. This project was funded in part by the German Federal Ministry of Economic Cooperation and Development through the project "Integrated Control of Subterranean Pests in South America" awarded to DCP.

References

Alm SR, Dawson CG, Robbins P. 2004. Optimization of a valine:isoleucine methyl ester pheromone blend and comparison of Robbins and Trécé traps for the capture of *Phyllophaga anxia* (Coleoptera: Scarabaeidae) in Rhode Island. *Journal of Economic Entomology* 97: 1983-1986.

Bates HW. 1886-1890. Pectinicornia and Lamellicornia. In: Godman FD, Salvin O, editors. *Biologia Centrali Americana*, 2, part 2, pp. 1-432. Available online, http://www.sil.si.edu/digitalcollections/bca/navigation/bca_12_02_02/bca_12_02_02select.cfm

Coca-Abia MM. 2002. Reestablishment of the genus *Trichesthes* Erichson, 1847 (Coleoptera: Scarabaeidae, Melolonthinae) based on phylogeny. *Journal of the New York Entomological Society* 110: 95-114.

Espinosa-Islas A, Morón RMA, Sánchez AH, Bautista HN, Romero NJ. 2005. Complejo gallina ciega (Coleoptera: Melolonthidae) asociado con céspedes en Montecillo, Texcoco, estado de México. *Folia Entomologica Mexicana* 44: 95-107.

Evans AV, Smith ABT. 2009. *An electronic checklist of the New World chafers (Coleoptera: Scarabaeidae: Melolonthinae). Version 3*. http://www.museum.unl.edu/research/entomology/SSSA/nwmelos.htm

King ABS. 1984. Biology and identification of white grubs (*Phyllophaga*) of economic importance in Central America. *Tropical Pest Management* 30: 36-50.

King ABS. 1996. A. Biología y identificación de (*Phyllophaga*) de importancia de economica en América Central. In: Shannon PJ, Carballo M, editors. *Biología y Control de Phyllophaga spp.: memoria*, pp. 33-43. CATIE.

King ABS. 1996. B. Biología, identificación y distribución de especies economicas de *Phyllophaga* en América Central. In: Shannon PJ, Carballo M, editors. *Biología y Control de Phyllophaga spp.: memoria*, pp. 50-61. CATIE.

Leal WS, Sawada M, Matsuyama S, Kuwahara Y, Hasegawa M. 1993. Unusual periodicity of sex pheromone production in the large black chafer *Holotrichia parallela*. *Journal of Chemical Ecology* 19: 1381-1391.

Leal WS, Oehlschlager AC, Zarbin PHG, Hidalgo E, Shannon PJ, Murata Y, Gonzalez L, Andrade R, Ono M. 2003. Sex pheromone of the scarab beetle *Phyllophaga elenans* and some intriguing minor components. *Journal of Chemical Ecology* 29: 15-25.

Londoño ME. 1993. Posibilidades del control biológico en el manejo de la chisa (Coleoptera: Scarabaeoidea) para el departamento de Antioquia. *Miscelánea Sociedad Colombiana de Entomología* 28: 85-100.

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Morón MÁ. 1986. *El genero Phyllophaga en México : morfologia, distribucion y sistematica supraespecifica (Insecta: Coleoptera)*. Instituto de Ecologia.

Morón MÁ. 2001. Revision of the rugipennis group of *Phyllophaga* (sensu stricto) (Coleoptera: Melolonthidae). *Annals of the Entomological Society of America* 94: 771-808.

Morón MÁ. 2003. Las especies de *Phyllophaga* (*s. str.*) del grupo *rugipennis* (Coleoptera: Melolonthidae). In: Melic A, editor. *Escarabaeidos de Latinoamérica: Estado del conocimiento: Monografías tercer milenio*, 3: pp. 19-34. Zaragoza, Spain: Sociedad Entomológica Aragonesa.

Morón MÁ. 2006. Revisión de las especies de *Phyllophaga* (*Phytalus*) grupos *obsoleta* y *pallida* (Coleoptera: Melolonthidae: Melolonthinae). *Folia Entomologica Mexicana* 45(Supl. 1): 1-104.

Nojima S, Robbins PS, Salsbury GA, Morris BD, Roelofs WL, Villani MG. 2003. L-leucine methyl ester: The female-produced sex pheromone of the scarab beetle *Phyllophaga lanceolata*. *Journal of Chemical Ecology* 29: 2439-2446.

Ortega-Ojeda CA, Melo-Melina EL, Gaigal A. 2997. Densidad letal de *Phyllophaga menetriesi* (Coleoptera: Melolonthidae) sobre plantas de yuca (*Manihot esculenta*). *Revista Colombiana de Entomología* 33: 17-20.

Pardo-Locarno LC. 2002. Aspectos sistemáticos y bioecológicos del complejo chisa (Col: Melolonthidae) de Caldono, Norte del Cauca, Colombia. *Facultad de Ciencias, Tesis de grado M. Sc. en Ciencias Biológicas*. pp. 139. Universidad de Valle.

Pardo-Locarno LC, Montoya-Lerma J, Bellotti AC, Van Schoonhoven A. 2005. Structure and composition of the white grub complex (Coleoptera: Scarabaeidae) in agroecological systems in Northern Cauca, Colombia. *Florida Entomologist* 88: 355-363.

Peck DC, Castro U, López F, Morales A, Rodríguez J. 2001. First records of the sugar cane and forage grass pest, *Prosapia simulans* (Homoptera: Cercopidae), from South America. *Florida Entomologist* 84: 402-409.

Restrepo-Giraldo H, Morón MÁ, Vallejo F, Pardo-Locarno LC, Lopez-Avila A. 2003. Catalogo de Coleoptera (Scarabaeidae Pleurosticti) de Colombia. *Folia Entomologica Mexicana* 42: 239-263.

Robbins PS, Crocker RL, Nojima S, Morris BD, Roelofs WL, Villani MG. 2003. Methyl 2-(methylthio)benzoate: the unique sulfur-containing sex pheromone of *Phyllophaga crinita*. *Naturwissenschaften* 90: 517-520.

Robbins PS, Alm SR, Armstrong CD, Averill AL, Baker TC, Bauernfiend RJ, Baxendale FP, Braman SK, Brandenburg RL, Cash DB, Couch GJ, Cowles RS, Crocker RL, DeLamar ZD, Dittl TG, Fitzpatrick SM, Flanders KL, Forgatsch T, Gibb TJ, Gill BD, Gilrein DO, Gorsuch CS, Hammond AM, Hastings PD, Held DW, Heller PR, Hiskes RT, Holliman JL, Hudson WG, Klein MG, Krischik VL, Lee DJ, Linn Jr. CE, Luce NJ, MacKenzie KE, Mannion CM, Polavarapu S, Potter DA, Roelofs WL, Royals BM, Salsbury GA, Schiff NM, Shetlar DJ, Skinner M, Sparks BL, Sutschek JA, Sutschek TP, Swier SR, Sylvia MM, Vickers NJ, Vittum PJ, Weidman RB, Weber DC, Williamson RC, Villani MG. 2006. Trapping *Phyllophaga* spp. (Coleoptera: Scarabaeidae: Melolonthinae) with sex attractants in the United States and Canada. *Journal of Insect Science* 6:39. Available

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

online, http://www.insectscience.org/6.39/.

Robbins PS, Cash DB, Linn Jr. CE, Roelofs WL. 2008. Experimental evidence for three pheromone races of the scarab beetle *Phyllophaga anxia* (LeConte). *Journal of Chemical Ecology* 34: 205-214.

Robbins PS, Nojima S, Polavarapu S, Koppenhöfer A, Rodriguez-Saona C, Holdcraft RJ, Consolie NL, Peck DC, Roelofs WL. 2009. Sex pheromone of the scarab beetle *Phyllophaga (Phytalus) georgiana* (Horn). *Journal of Chemical Ecology* 35: 336-341.

Salvadori JR, Oliviera LJ. 2001. *Manejo de corós em lavouras sob plantio direto*. Embrapa/CNPT.

Salvadori JR, Silva MT. 2004. Coró-dotrigo. In: Salvadori JR, Avila CJ, Silva MT, editors. *Pragas de solo no Brasil*, pp. 210-232. Embrapa Trigo.

Serna-Patiño LM. 2004. Reconocimiento de especies del complejo chisa (Coleoptera-Melolonthidae) asociados a los cultivos de yuca y pasto en el municipio de Pereira y Alrededores. *Tesis Ingeniero Agronomo* Universidad de Caldas.

Vallejo F, Morón MÁ, Orduz S. 1998. First report and description of immature stages of *Phyllophaga obsoleta* (Blanchard) (Coleoptera: Melolonthidae) in Colombia. *Coleopterists Bulletin* 52: 109-117.

Villegas NP, Gaigl A, Vallejo LF. 2006. Reconocimiento de especies del complejo chisa (Coleoptera: Melolonthidae) ascoiadas al cultivo de cebolla y pasto kikuyo del departameno de Risaralda, Colombia. *Agronomía* 14: 51-63.

Villegas NP, Gaigal A, Vallejo LF. 2008. The white grub complex (Coleoptera: Melolonthidae) associated with onion and pasture in Risaralda, Colombia. *Revista Colombiana de Entomología* 34: 83-89.

Zarbin PHG, Leal WS, Ávila CJ, Oliveira LJ. 2007. Identification of the sex pheromone of *Phyllophaga cuyabana* (Coleoptera: Melolonthidae). *Tetrahedron Letters* 48: 1991-1992.

Zhang A, Robbins PS, Leal WS, Linn CE, Jr., Villani MG, Roelofs WL. 1997. Essential amino acid methyl esters: major sex pheromone components of the cranberry white grub, *Phyllophaga anxia* (Coleoptera: Scarabaeidae). *Journal of Chemical Ecology* 23: 231-245.

Downloaded From: https://complete.bioone.org/journals/Journal-of-Insect-Science on 16 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use