A Thirty-Year Study on the Emergence and Abundance of *Phyllophaga crinita* in Mexico

Author(s): Luis A. Rodríguez-del-Bosque
Source: Southwestern Entomologist, 42(1):121-129.
Published By: Society of Southwestern Entomologists
DOI: http://dx.doi.org/10.3958/059.042.0111
URL: http://www.bioone.org/doi/full/10.3958/059.042.0111

A Thirty-Year Study on the Emergence and Abundance of *Phyllophaga crinita*[1] in Mexico

Luis A. Rodríguez-del-Bosque

Campo Experimental Río Bravo, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Apartado Postal 172, Río Bravo, Tam., México 88900.
rodriguez.luis@inifap.gob.mx

Abstract. The white grub, *Phyllophaga crinita* (Burmeister) (Coleoptera: Scarabaeidae), is an important soil insect pest in Texas, U.S.A., and Tamaulipas, Mexico. The objectives of this study were to estimate biometric parameters and develop a simulation model to determine the factors associated with interannual fluctuations of *P. crinita* adults captured with blacklight traps at Rio Bravo (irrigated area) from 1979 to 2008 and San Fernando (dryland area) during 1979-1980 and 1990-1993, in Northern Tamaulipas, Mexico. More males were captured at both Rio Bravo (89%) and San Fernando (76%). Flight activity occurred from March to September, although 97% of total captures were concentrated from April to June, with peak emergence during 1-15 May at Rio Bravo and 16-31 May at San Fernando. Protandry was observed only at Río Bravo, where males emerged 5 days before females at 50% cumulative emergence. Multiple regression analysis for testing the association between yearly captures of *P. crinita* (y) and independent variables (x_n) resulted in best-fit model: $y = -6143.5 + 1.75\, x_1^2 + 3676.8\, x_2 + 0.087\, x_2{*}x_3$ (R^2= 0.7026), where x_1 = precipitation (mm) in January, x_2 = number of rainfall events (>20 mm) + number of irrigations from April to July, and x_3 = total captures of *P. crinita* the previous year.

Introduction

White grubs in the New World genus *Phyllophaga* (Coleoptera: Scarabaeidae: Melolonthinae) comprise more than 800 species (Evans 2003, Smith and Evans 2005). Almost half of the species occur in Mexico (Morón 2010). Fifty *Phyllophaga* species have been collected from diverse Mexican agricultural systems, although crop loss has been assessed for only 11 species, mainly on field corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), grain sorghum (*Sorghum bicolor* (L.) Moench), common bean (*Phaseolus vulgaris* L.), amaranth (*Amaranthus* spp.), and sugarcane (*Saccharum officinarum* L.) (Morón and Rodríguez-del-Bosque 2010). Adults of some species of *Phyllophaga* may defoliate several trees and field crops, although damage generally is not economical (Reinhard 1940, Rodríguez-del-Bosque et al. 2003).

Phyllophaga crinita (Burmeister) is an important soil insect pest of maize, sorghum, wheat, sugarcane, grassland, and turfgrass in Texas, U.S.A. and

[1]Coleoptera: Scarabaeidae

Tamaulipas, Mexico (Reinhard 1940, Teetes 1973, Fuchs et al. 1974, Merchant and Crocker 1995, Rodríguez-del-Bosque 2010). Occasional damage also has been reported in parsley (*Petroselinum crispum* (Mill.) Nyman ex A.W. Hill), cabbage (*Brassica oleracea* L.), spinach (*Spinacia oleracea* L.), sugar beet (*Beta vulgaris* L.), onion (*Allium cepa* L.), soybean (*Glycine max* (L.) Merrill), and common bean (Reinhard 1940, Plapp and Frankie 1976, Rodríguez-del-Bosque et al. 2003). Adults have been observed feeding on foliage of pecan (*Carya illinoinensis* (Wangenh.) K. Koch.), citrus (*Citrus* spp.), salt cedar (*Tamarix* spp.), and sunflower (*Helianthus annuus* L.) (Reinhard 1940, Rodríguez-del-Bosque 1988), although diversity of host plants is numerous during the flight periods. *P. crinita* has a 1-year life cycle in northeastern Mexico and southern Texas, although a proportion of the population may have a 2-year life cycle in northern Texas (Reinhard 1940, Teetes et al. 1976, Huffman and Harding 1980, Rodríguez-del-Bosque et al. 1995). Reproductive flights of *P. crinita* in northern Tamaulipas peak from late April to early June, and adults are especially abundant 3-4 days after rainfall or irrigation (Rodríguez-del-Bosque et al. 1995, Rodríguez-del-Bosque and Stone 2006). Most larval feeding activity occurs from July to September, decreases gradually from October to December, and ceases in January-February (Rodríguez-del-Bosque 1996a).

Monoculture of poaceous crops (sorghum and field corn) during the last 6 decades on almost 1 million ha in northern Tamaulipas resulted in increased abundance of *P. crinita* in the area because the insect prefers to oviposit on grasses as compared to common bean, soybean, or sunflower (Rodríguez-del-Bosque 1984). *P. crinita* recently invaded and damaged several crops in southern Tamaulipas, eastern San Luis Potosí, and northern Veracruz, a Mexican region known as “Las Huastecas” (Rodríguez-del-Bosque et al. 2003, Hernández et al. 2014).

Some studies on biology and ecology of *P. crinita* in northern Tamaulipas emphasized insect simulation modeling to quantify the impact of biotic and abiotic factors on population dynamics (Rodríguez-del-Bosque 1989, 2003; Rodríguez-del-Bosque and Rosales-Robles 1992; Rodríguez-del-Bosque and Stone 2006). The objectives of this study were to estimate biometric parameters and determine factors associated with annual fluctuations of *P. crinita* adults during a period of 30 years in Northern Tamaulipas, Mexico.

Materials and Methods

The study was done at two locations in Northern Tamaulipas, Mexico: (a) INIFAP Campo Experimental Rio Bravo (100 ha), near Rio Bravo, an irrigated agricultural area (25º58'20”N, 98º01'08”W); and (b) INIFAP Campo Experimental El Canelo (400 ha), near San Fernando, a dryland area (25º10'48”N, 97º57'55”W), 90 km south of Rio Bravo. Both sites were surrounded by commercial fields planted mainly with sorghum and field corn, the main crops in the region. Abundance of *P. crinita* adults was surveyed daily from 1979 to 2008 at Río Bravo, and 1979-1980 and 1990-1993 at San Fernando, with a standard 15-W black light trap (Harding et al. 1966) at each location, and separated by sex. A plastic bag was placed in the trap collector and changed daily. As a killing agent, a strip of Sheltox® (Shell, Xalostoc, Mexico) was placed into the plastic bag and replaced monthly from 1979 to 1994, while Raid® aerosol (S.C. Johnson and Son, S.A. de C.V., Toluca, Mexico) was sprayed into the plastic bag daily from 1995 to 2008. Voucher specimens of *P.*

crinita were deposited at the Texas A&M University Insect Collection at College Station, TX.

Minimum and maximum air temperatures and precipitation were gathered daily from a weather station 310 m from the light trap at Rio Bravo and 115 m from the light trap at San Fernando (Silva et al. 2007). Accumulation of heat units (>0°C) was estimated as (maximum temperature – minimum temperature)/2 each year from 1 January to 5% cumulative emergence. Averages and coefficients of variation were estimated for total numbers of adults captured; calendar dates at 5, 50, and 95% cumulative emergence; and cumulative heat units. Monthly irrigation hours were registered at the Campo Experimental Rio Bravo. A multiple regression analysis using PROC REG (stepwise procedure, SAS Institute 2012) was used to determine association between weather factors (independent variables, x_n) and the annual number of *P. crinita* adults captured at Rio Bravo (dependent variable, y). The independent variable *precipitation* was expressed in two ways: millimeters (mm) and number of precipitations >20 mm; however, only the most correlated with y was used in the multiple regression analysis. The number of *P. crinita* adults captured the previous year, number of irrigations in the experimental plots adjacent to the light trap, quadratic effects (x^2_n), and interactions (all possible single combinations, i.e. x_1*x_2) were used also as independent variables in the regression analysis. The stepwise procedure found the best-fit multiple regression model when no other independent variable met the 0.15 significance level for entry into the model. The 6-year data at San Fernando did not have enough degrees of freedom and could not be analyzed.

Results and Discussion

Flight activity of *P. crinita* occurred from March to September, although 97% of the adults were captured from April to June. A total of 478,155 beetles was captured at Rio Bravo during the 30-year study (average 15,939/year) and 76,337 at San Fernando in 6 years (average 12,723/year). The largest annual capture at Rio Bravo was in 1984 (44,997) and the least in 2004 (2,021) (Table 1). Most daily emergence occurred on 24 April 1992 at Rio Bravo (10,812) and 14 June 1991 at San Fernando (8,094).

At Rio Bravo, average 5, 10, and 95% cumulative emergence occurred on 26 April, 18 May, and 11 June, respectively (Table 1). An average of 1,141 accumulated heat units starting 1 January was required for 5% adult emergence. The average 100 first emerging adults occurred on 22 April. Heat units resulted in a more variable (greater coefficient of variation) parameter than did calendar dates at 5% cumulative emergence and the first 100 adults captured for predicting *P. crinita* emergence. At San Fernando, the average 5, 10, and 95% cumulative emergence occurred on 22 April, 18 May, and 15 June, respectively. Although the average 50% of cumulative captures at San Fernando coincided with that at Rio Bravo, emergence in the dryland area occurred generally 15 days later than at the irrigated area; peak emergence occurred 1-15 May at Rio Bravo and 16-31 May at San Fernando (Fig. 1).

Significantly more males than females were captured. At Rio Bravo, 89% (range 78-97%) were males (Fig. 2), while at San Fernando, 76% (range 62-97%) were males. However, laboratory studies demonstrated that sex ratio of *P. crinita* was almost 1:1 and that differences observed in light traps might be attributed to less attraction by females because of their oviposition habits, less flight ability, and sedentary habits after emergence (Teetes et al. 1976, Stone 1986, Rodríguez-del-Bosque 1988, 1996b). Differences in proportions of males among years were not associated with any weather variable.

Protandry occurred at Rio Bravo, where *P. crinita* males emerged an average of 3, 5, and 6 days before females at 10, 50, and 90% of cumulative emergence, respectively (Fig. 3). In contrast, males and females emerged simultaneously at San Fernando. Apparently, both sexes are conditioned to emerge at the same time in a dryland area to maximize reproduction with the occurrence of precarious rainfall in the area. Protandry also has been reported for the scarab *Leucopholis*

Table 1. Yearly Captures of *P. crinita*, Calendar Dates at 5, 10, and 95% of Cumulative Emergence, Heat Units for 5% Emergence, and Calendar Dates when First 100 Adults Emerged, Rio Bravo, Tam., Mexico, 1979-2008

		Calendar date for given % of cumulative emergence			Heat units	Calendar date
Year	Total captured	5%	50%	95%	for 5% emergence	when first 100 adults emerged
1979	24585	116	125	148	1011	113
1980	14697	124	143	146	1155	118
1981	24333	119	127	150	1019	117
1982	10317	121	126	145	1018	118
1983	16693	129	149	153	1339	120
1984	44997	120	139	141	1111	113
1985	34334	118	128	143	1110	116
1986	22736	110	123	156	1167	105
1987	13416	131	136	164	1196	129
1988	11930	120	134	173	1078	116
1989	9526	116	124	151	1227	115
1990	6616	113	131	137	1223	108
1991	20994	111	137	143	1135	106
1992	41713	112	115	127	1067	101
1993	17048	123	135	151	1254	105
1994	4456	114	128	169	1135	112
1995	5728	120	153	157	1477	112
1996	2361	118	136	180	1156	118
1997	4377	115	141	161	1082	113
1998	7893	114	140	161	1267	110
1999	5898	118	135	158	1369	116
2000	13256	112	137	167	1210	110
2001	31080	115	171	174	1068	104
2002	29384	104	153	186	893	101
2003	30871	116	151	171	1015	112
2004	2021	117	128	179	1109	118
2005	5692	117	205	207	1224	111
2006	3007	109	121	189	1125	109
2007	5440	114	136	188	946	111
2008	12756	103	124	191	1051	102
Mean	15939	116	138	162	1141	112
STD	12028	6	17	19	125	6
C.V.	75.5	5.2	12.5	11.6	11.0	5.6

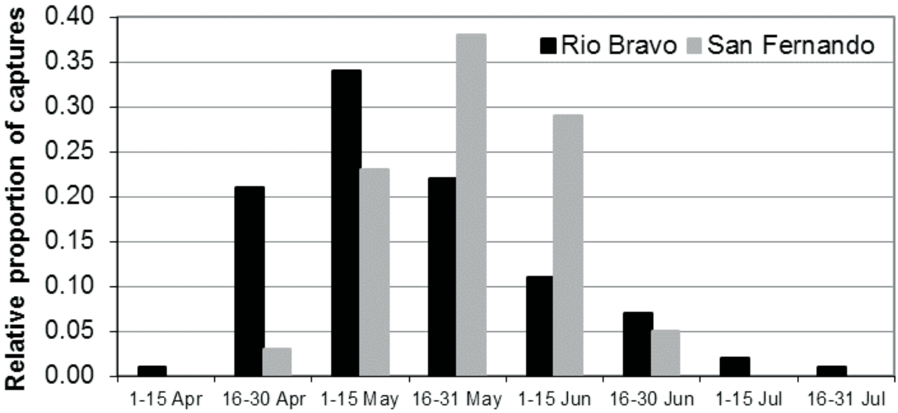

Fig. 1. Seasonal emergence of *P. crinita* at Rio Bravo (average 1979-2008) and San Fernando (average 1979-1980; 1990-1993), Tam., Mexico.

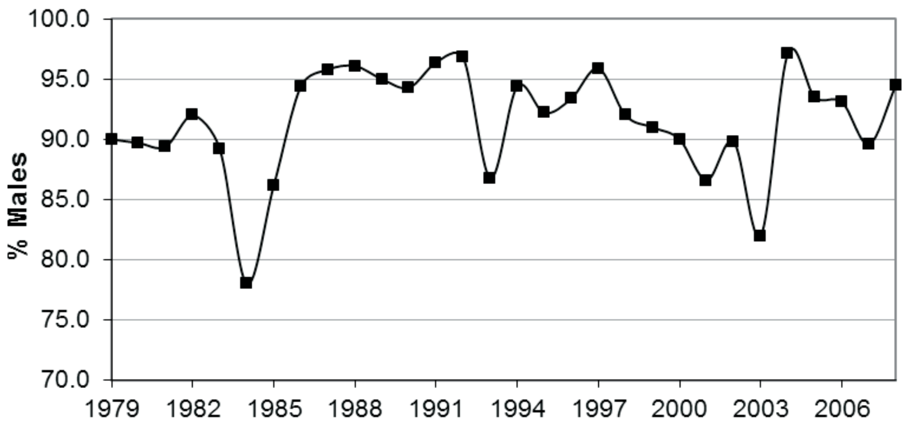

Fig. 2. Proportion of *P. crinita* males captured with a light trap, Rio Bravo, Tam., Mexico, 1979-2008.

lepidophora Blanchard in India (Kalleshwaraswamy et al. 2015) and the chrysomelid *Diabrotica virgifera virgifera* LeConte in the U.S.A. (Branson 1987).

Precipitation at San Fernando (dryland) stimulated 97% of total *P. crinita* emergence, and only 3% of the population emerged in the absence of rainfall. Similarly, in the irrigated area of Rio Bravo, only 1% emerged in the absence of rainfall or irrigation, while 67 and 32% of adults emerged after rainfall and irrigation, respectively. A wet soil is indispensable for oviposition and immature survival (Gaylor and Frankie 1979). Every rainfall event caused an average 54% greater adult emergence than did each irrigation, probably because of larger land coverage of rainfall in the area of influence of the light trap, compared to the limited areas irrigated near the trap.

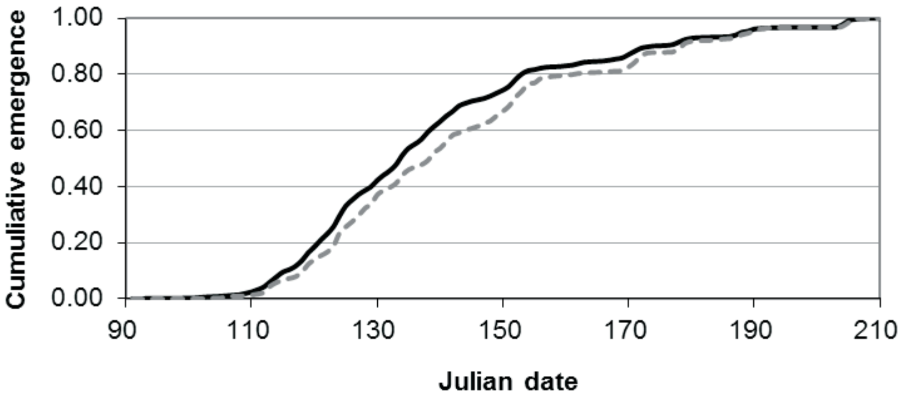

Fig. 3. Cumulative emergence of *P. crinita* males (solid line) and females (dashed line), Rio Bravo, Tam, Mexico, average 1979-2008.

Multiple regression analysis of the association between yearly capture of *P. crinita* (y) and independent variables (x_n) resulted in best-fit model: $y = -6143.5 + 1.75\ x_1^2 + 3676.8\ x_2 + 0.087\ x_2{*}x_3$ ($F = 20.48$; df = 3, 29; $R^2 = 0.7026$), where x_1 = precipitation (mm) during January, x_2 = number of precipitations (>20 mm) + number of irrigations in the plots adjacent to the trap from April to July, and x_3 = total *P. crinita* captured the previous year. Number captured during the year closely fit the multiple regression model (Fig. 4). In general, the model indicated adults were favored by rainfall during January, rainfall + irrigation from April to July, and total numbers captured the previous year. Rainfall during January had a positive effect on adult emergence, probably by avoiding dessication of hibernating larvae; irrigations during January at Campo Experimental are infrequent, so rainfall would favor larval survival during the month (Fig. 5). Total numbers of *P. crinita* captured

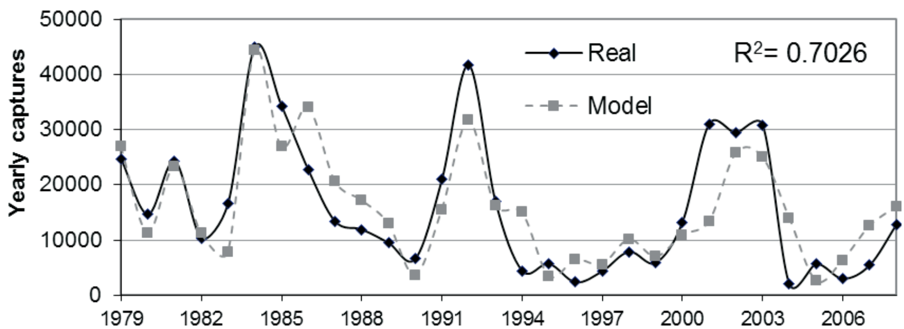

Fig. 4. Yearly captures of *P. crinita* and fitness of multiple regression model, Río Bravo, Tam., México, 1979-2008.

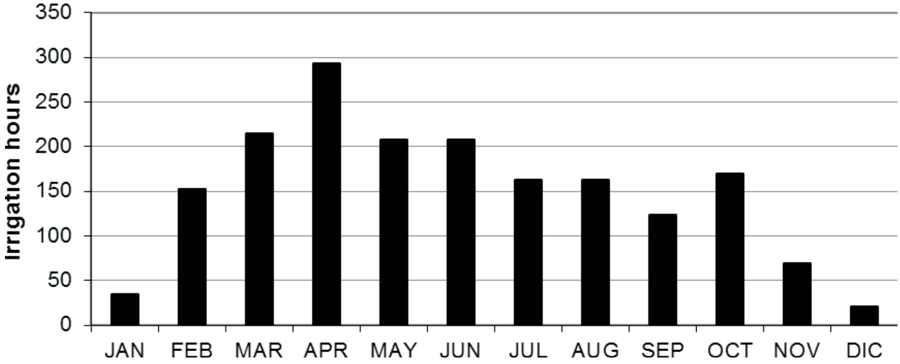

Fig. 5. Irrigation frequency at Campo Experimental, Rio Bravo, Tam., Mexico, average 1979-2008.

were favored by the sum of rainfall and irrigation events during April to July, the period when most emergence occurred. Soil humidity stimulated *P. crinita* emergence, reproductive flights, and oviposition; in the absence of rainfall or irrigation, teneral adults remain underground, and eventualy die by desiccation (Gaylor and Frankie 1979; Rodríguez-del-Bosque 1988, 1996b; Rodríguez-del-Bosque and Stone 2006). The positive effect of interaction between rainfall + irrigation during April-July and annual captures the year before suggests the factors are related to *P. crinita* abundance the following year: scarce emergence the previous year combined with dry soil during a given year would cause low emergence the following year and vice versa. Fitness of the model would probably improve if other variables were incorporated, such as crop (Rodríguez-del-Bosque 1984), tillage (Rodríguez-del-Bosque and Salinas-García 2008), soil insecticides (Rodríguez-del-Bosque 1988), and natural enemies (Rodríguez-del-Bosque et al. 2005) -- all factors that affect immature survival and hence adult emergence.

Acknowledgment

Assistance in managing the light traps, counting insects, and gathering weather data by the following people at different times was greatly appreciated: Pedro Díaz Cortés, David Castillo Moctezuma, Esteban Robles Escarreola, Rosalío Navarro Cervantes, Julián Fuentes Rocha, Enrique Vázquez Vázquez, Romualdo Tejada Zapata, Julián Robles Escarreola, Luis E. Figueroa Montes, Agustín Magallanes Estala, José Alvarez Vázquez, and Mario M. Silva Serna.

References Cited

Branson, T. F. 1987. The contribution of prehatch and posthatch development to protandry in the chrysomelid, *Diabrotica virgifera virgifera*. Entomol. Exp. Appl. 43: 205-208.

Evans, A. V. 2003. A checklist of the New World chafers (Coleoptera: Scarabaeidae: Melolonthinae). Zootaxa 211: 1-419.

Fuchs, T. W., J. A. Harding, and T. Dupnik. 1974. New technique for evaluation of insecticides against *Phyllophaga crinita*. J. Econ. Entomol. 67: 455-456.
Gaylor, M. J., and G. W. Frankie. 1979. The relationship of rainfall to adult flight activity; and of soil moisture to oviposition behavior and egg and first instar survival in *Phyllophaga crinita*. Environ. Entomol. 8: 591-594.
Harding, W. C., Jr., J. G. Hartsock, and G. C. Rohwer. 1966. Blacklight trap standards for general insect surveys. Bull. Entomol. Soc. Am. 12: 31-32.
Hernández, J. M. A. Morón, and J. A. Sánchez. 2014. Species richness of the genus *Phyllophaga* (Colepotera: Melolonthidae) in the north of the state of Veracruz, México. Southwest. Entomol. 39: 647-650.
Huffman. F. R., and J. A. Harding. 1980. Biology of *Phyllophaga crinita* (Burmeister) in the Lower Rio Grande Valley sugarcane. Southwest. Entomol. 5: 59-64.
Kalleshwaraswamy, C. M., S. K. Adarsha, N. L. Naveena, and S. Sharanabasappa. 2015. Adult emergence pattern and utilization of females as attractants for trapping males of whitegrubs, Leucopholis lepidophora (Coleoptera: Scarabaeidae) infesting Arecanut in India. J. Asia-Pacific Entomol. 19: 15-20.
Merchant, M. E., and R. L. Crocker. 1995. White grubs in Texas turfgrass. Texas Agricultural Extension Service L-1131.
Morón, M. A. 2010. Diversidad y distribución del complejo "gallina ciega" (Coleoptera: Melolonthidae), pp. 41-63. *In* L. A. Rodríguez-del-Bosque and M. A. Morón [eds.], Plagas del Suelo. Mundi-Prensa, México, D.F., México.
Morón, M. A., and L. A. Rodríguez-del-Bosque. 2010. Importancia, historia y retos, pp. 3-17. *In* L. A. Rodríguez-del-Bosque and M. A. Morón [eds.], Plagas del Suelo. Mundi-Prensa, México, D.F., México.
Plapp, F. W. Jr., and G. W. Frankie. 1976. Residues of chlorinated insecticides in white grubs and soils treated for grub control in urban areas of Texas. Texas Agricultural Experiment Station Progress Report 3343C.
Reinhard, H. J. 1940. The life history of *Phyllophaga lanceolata* (Say) and *Phyllophaga crinita* Burmeister. J. Econ. Entomol. 33: 572-578.
Rodríguez-del-Bosque, L. A. 1984. Oviposición de *Phyllophaga crinita* Burmeister sobre diferentes cultivos en el norte de Tamaulipas, México. Southwest. Entomol. 9: 184-186.
Rodríguez-del-Bosque, L. A. 1988. *Phyllophaga crinita* Burmeister (Coleoptera: Melolonthidae): historia de una plaga del suelo (1855-1988), pp. 53-79. Memorias de la III Mesa Redonda sobre Plagas del Suelo, Sociedad Mexicana de Entomología, 24 Mayo, Morelia, Michoacán, México.
Rodríguez-del-Bosque, L. A. 1989. Distribución espacial de la gallina ciega *Phyllophaga crinita* (Burmeister), p. 100. Memoria XXIV Congreso Nacional de Entomología. Oaxtepec, Mor., México, 21-24 mayo.
Rodríguez-del-Bosque, L. A. 1996a. Seasonal feeding by *Phyllophaga crinita* and *Anomala* spp. (Coleoptera: Scarabaeidae) larvae in northeastern Mexico. J. Entomol. Sci. 31: 301-305.
Rodríguez-del-Bosque, L. A. 1996b. Pupation and adult longevity of *Phyllophaga crinita*, *Anomala flavipennis* and *A. foraminosa* (Coleoptera: Scarabaeidae). Southwest. Entomol. 21: 55-58.
Rodríguez-del-Bosque, L. A. 1998. A sixteen-year study on the bivoltinism of *Anomala flavipennis* (Coleoptera: Scarabaeidae) in Mexico. Environ. Entomol. 27: 248-252.

Rodríguez-del-Bosque, L. A. 2003. Estrategias de *Phyllophaga crinita* y *Anomala flavipennis* (Coleoptera: Scarabaeidae) para coexistir en agroecosistemas del noreste de México: un modelo conceptual, pp. 167-177. *En* G. a. Aragón, M. A. Morón, y A. Marín [eds.], Estudios sobre Coleópteros del Suelo en América. 2003. Publicación especial de la Benemérita Universidad Autónoma de Puebla, México.

Rodríguez-del-Bosque, L. A. 2010. Plagas del suelo en Tamaulipas, pp. 237-249. *In* L. A. Rodríguez-del-Bosque and M. A. Morón [eds.], Plagas del Suelo. Mundi-Prensa, México, D.F., México.

Rodríguez-del-Bosque, L. A., and E. Rosales-Robles. 1992. Corn insect pests and pathogenic diseases in relationship to shattercane populations. Southwest. Entomol. 17: 210-214.

Rodríguez-del-Bosque, L. A., and J. R. Salinas-García. 2008. Impact of tillage on *Phyllophaga crinita* (Coleoptera: Scarabaeidae) and other soil invertabrates in grain sorghum in Mexico. J. Entomol. Sci. 43: 117-120.

Rodríguez-del-Bosque, L. A., and N. D. Stone. 2006. Modelo de simulación de la emergencia de *Phyllophaga crinita* (Coleoptera: Scarabaeidae), pp. 73-80. *En* A. E. Castro-Ramírez, M. A. Morón, y A. Aragón [eds.], Diversidad, Importancia y Manejo de Escarabajos Edafícolas. 2006. Publicación especial de El Colegio de la Frontera Sur, la Fundación Produce Chiapas, A. C. y la Benemérita Universidad Autónoma de Puebla, México.

Rodríguez-del-Bosque, L. A., R. L. Crocker, and E. J. Riley. 1995. Diversity and abundance of *Phyllophaga* and *Anomala* species in agroecosystems of northern Tamaulipas, Mexico. Southwest. Entomol. 20: 55-59.

Rodríguez-del-Bosque, L. A., J. Avila-Valdez, and E. Garza-Urbina. 2003. *Phyllophaga crinita* (Coleoptera Scarabaeidae): a new pest in the Huastecas area of Mexico. Southwest. Entomol. 28: 155-156.

Rodríguez-del-Bosque, L. A., F. Silvestre, V. M. Hernández, H. Quiroz, and J. E. Throne. 2005. Pathogenicity of *Metarhizium anisopliae* and *Beauveria bassiana* against *Phyllophaga crinita* and *Anomala flavipennis* (Coleoptera: Scarabaeidae). J. Entomol. Sci. 40: 67-73.

SAS Institute. 2012. SAS release 9.3 ed. SAS Institute, Inc., Cary, NC.

Silva, M. M., G. Medina, J. A. Ruiz, V. Serrano, G. Díaz, and M. A. Cano. 2007. Estadísticas climatológicas básicas del estado de Tamaulipas (período 1961-2003). Libro Técnico 2. INIFAP, Campo Experimental Río Bravo, México.

Smith, A. B. T., and A. V. Evans. 2005. A supplement to the checklist of the New World chafers (Coleoptera: Scarabaeidae: Melolonthinae) with notes on their tribal classification. Zootaxa. 1032: 29-60.

Stone, J. D. 1986. Time and height of flight of adults of *Phyllophaga crinita*. Southwest. Entomol. 15: 194-197.

Teetes, G. L. 1973. *Phyllophaga crinita*: damage assessment and control in grain sorghum and wheat. J. Econ. Entomol. 66: 773-776.

Teetes, G. L., J. Wade, R. C. McInyre, and C. A. Schaefer. 1976. Distribution and seasonal biology of *Phyllophaga crinita* in the Texas High Plains. J. Econ. Entomol. 69: 59-63.