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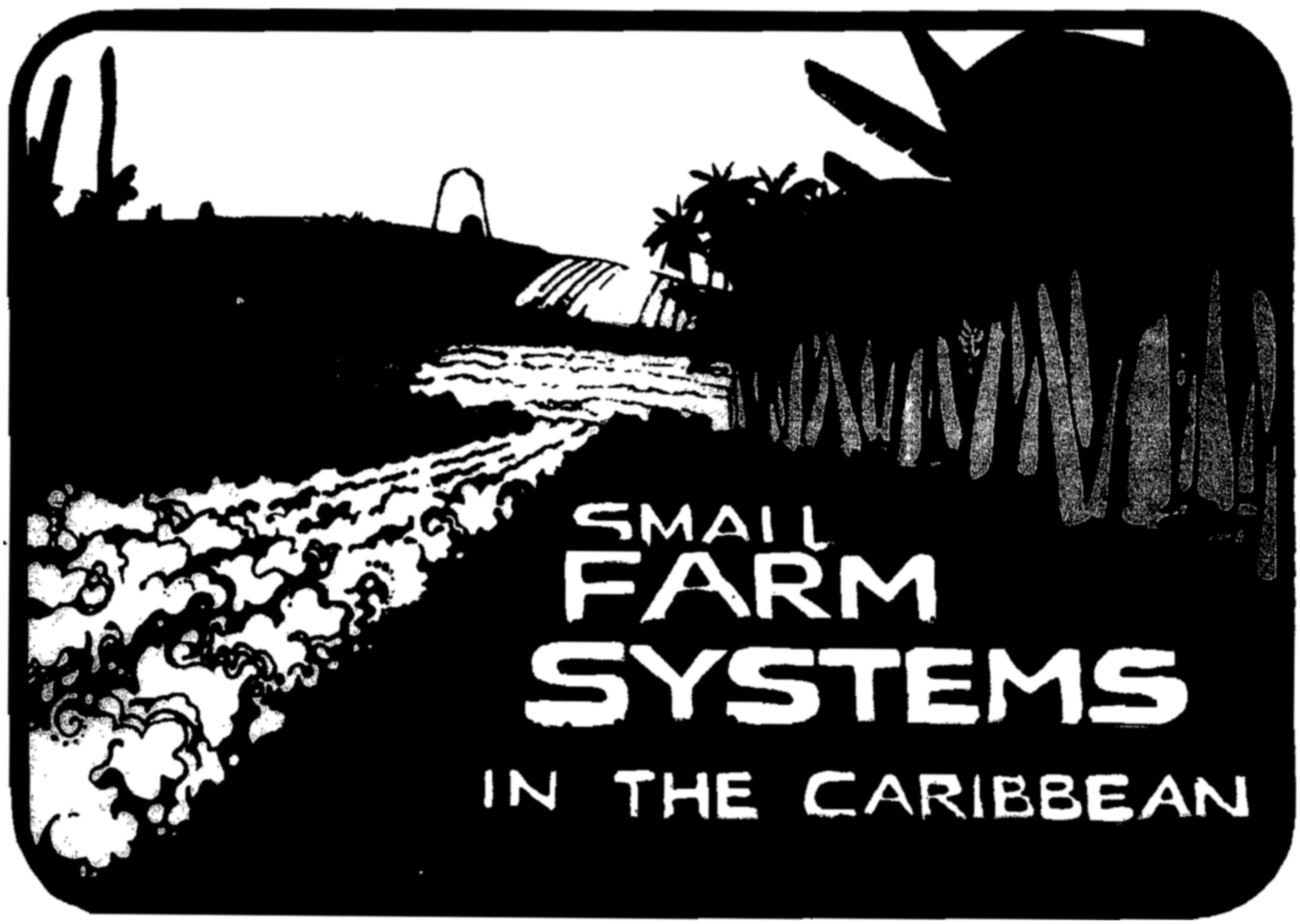

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Vagility and Probability of Survival in Two Weevils (Coleoptera, Curculionidae): the sugarcane rootstalk borer weevil (*Diaprepes abbreviatus* [L.]) and the sweet potato weevil (*Cylas formicarius* [*F.*])

Léonce Bonnefil, Ph.D.
Inter American University of Puerto Rico
243 Viena Street, College Park, Rio Piedras, PR 00921

The sugarcane rootstalk weevil borer *Diaprepes abbreiviatus* (L.) moves freely among numerous plant hosts within Puertorican agroecosystems. The sweet potato weevil, on the contrary, appears circumscribed to the family Convolvulaceae. The fecundity, life cycle and longevity of the two insects were probed to unveil the biological nature of vagility. *Diaprepes* fecundity was greatly enhanced by the shift from wild to cultivated hosts, development was not influenced appreciably, and longevity was greater in the sedentary species. It is assumed that vagile populations are briefly boosted by host shifts even ending in expansion thrusts though longevity is not necessarily extended. Under sedentary conditions populations are generally low but stable.

Historical Recount of *Diaprepes* and *Cylas* as Agricultural Pests

Beavers et al. (1978) have compiled an extensive bibliography of the sugarcane rootstalk weevil borer *Diaprepes abbreviatus* which spanned the period from 1903 to 1978. For about 30 years there was a near-loss of interest in the insect pest. Interestingly enough, this lapse coincides with the period between the release of the organochlorine insecticides for use by the public and their ultimate banning. These pesticides when applied to the soil afforded a perfect control of *Diaprepes* which thus became inconsequential.

Around 1979, however, the absence of the chemicals started to be felt through a recrudescense of the weevil borer. A survey by the U.S. Department of Agriculture revealed that 82,000 of the 115,000 acres of sugarcane in Puerto Rico were infested by the insect. The annual production of 1,000,000 metric tons/year was reduced to an estimated 150,000 metric tons/year, representing a loss of $73 million (Beavers et al., 1978).

Diaprepes was accidentally introduced into the United States presumably in 1964 and the infestation has risen steadily since (Woodruff, 1964; Selhime and Beavers, 1972). The weevil is now a serious problem in Florida where it inflicts considerable losses to the ornamental plants industry of between $140 and $150 million/year. Emergency Federal regulations took effect in Puerto Rico, making it compulsory that all exports of ornamental plants to the United States be certified by the U.S. Department of Agriculture. According to T. Dorney of the *San Juan Star* (1970), 30 of the 47 growers of ornamentals were quarantined and could not export their products. The $10 million-a-year business seemed to be in serious jeopardy with 63% of the producers unable to ship to the mainland plants, plant parts and cut flowers. It could have been said that the law was too restrictive, but hundreds of millions of dollars worth of sugarcane products, citrus plants and fruits, vegetables and ornamentals, were at stake in Florida and it was imperative to prevent the spread of the pest to other states of northern United States.

An evaluation of the damage of the sweet potato weevil in Puerto Rico could not be found. Generally *Cylas formicarius* infests the vines, tubers and roots of sweet potato and is found occasionally on morning glory (*Ipomea learii* (Pexton,) bay hops (*Ipomea pescapreae* [L.]). In commercial plantings many tubers were found to be tunnelled, even totally honey-combed, offering a repulsive appearance, foul odor and bitter taste. But in Puerto Rico, sweet potato is not of great economic importance and the losses caused by *Cylas* may not be considered significant except for such academic aspects as the one discussed hereafter.

Description of the Insect Pests

The so-called sugarcane rootstalk borer weevil *Diaprepes abbreviatus* (L.) is a fairly large otiorhynchid beetle (Coleoptera, Curculionidae). It has a stout abdomen, a trapezoidal thorax one quarter longer than wide, a narrow head with small arched compound eyes and clubbed antennae distinctly elbowed. The body is black but colored scales impart to the insect a whole variety of hues. Individuals collected or reared on different hosts did show some consistency in coloration but not enough to separate diet groups. Adult size was equally variable in both sexes, ranging from 0.85cm to 1.90cm.

The genus *Diaprepes* is apparently indigenous to the Caribbean area with species occurring in Central America and most of the West Indies. It does not appear to extend into South America or the United States (Fennah, 1942). *Abbreviatus* appears to be the main species occurring in Puerto Rico, Haiti and the Lesser Antilles with a series of other species occurring on other islands.

The Life Cycles of the Two Weevils

In its development, *Diaprepes* goes through a complete metamorphosis. The oval elongate eggs are laid in clusters of about 30 between leaves tightly held together by a sticky, transparent, elastic film. The total number of eggs produced by one female during her life is about 5,000 (Wolcott, 1936 and 1948). The incubation is fairly uniform, lasting an average of seven days. Upon hatching, the minute larvae cross the leaf surface with a "galloping" motion and reaching the edge, drop to the ground. On the soil surface they may wander for a while and finally penetrate the soil in search of tender rootlets on which to feed. These larvae are small, legless and white, with a distinct head pattern of yellow and gray. The color of the head, however, is generally not as deep as that of other larvae found in the soil along with *Diaprepes*.

The sweet potato weevil is also an otiorhynchid beetle, but considerably smaller than *Diaprepes*. It is shiny looking, somewhat like a large ant (hence its specific name). Its elongate snout and head are blue-black as well as the rounded elytra. The thorax and legs are reddish brown (hence the sub-specific name of *elegantulus*).

The reproductive cycle of *Cylas* is probably not well understood because of the cryptic behavior of the insect. The larval and pupal phases develop within vegetable tissues and cannot be observed. It is not known just where fertilization occurs in nature, though it is assumed that it occurs mostly in the open. Promptly after fertilzation the female starts burrowing into the plant leaves, stem and junction point of developing tubers. A study of egg distribution within whole plants from a highly infested field revealed that the eggs are distributed in an ascending order, precisely in the sequence indicated above (Bonnefil, 1983, unpublished data).

The minute, white, kidney-shaped eggs are laid at the bottom of shallow depressions carved by the ovipositing female in the aerial parts or directly at the offshoot, of young tubers. It is possible that they are laid within the tunnels inside mature tubers. It is known that the eggs hatch in about seven days, that the larval insrars sum up about three weeks, and the pupal stage another week inside the tuber.

One generation of the weevil lasts one month in the field or in storage. It is suspected that the adult may live up to eight months. It is also known to fly up to one mile in search of food. Flight is not an important mode of dissemination, which is done mostly through the planting of infesed cuttings. It has been shown that adults freed by cutting open a tuber or some other part of the sweet potato plant showed no dispersive urge, but lingered around or, at most, moved to the nearest planting. No reference was found in the literature as to the fecundity of the sweet potato weevil on sweet potato or any alternate host plant.

MATERIALS AND METHODS

To investigate the fundamental nature of vagility, the two weevils were to be sampled according to selected biological criteria on their apparently preferred and two incidental hosts, as shown in the following scheme:

1. Biological criteria (fecundity, oviposition, incubation, hatching success), related to *Diaprepes abbreviatus* (L.) reared and maintained on:
   a. Orange (*Citrus sinensis* [Osbeck]), Gereniales, Rutaceae
   b. Pigeon pea (*Cajanus indicus* [Spreng.]), Rosales, Leguminosae
   c. Papaya (*Carica papaya* [L.]), Violales, Caricaceae
   d. Mother-of-cocoa (*Gliricidia sepium* [Jacq.]) Steud Rosales, Leguminosae
2. Biological criteria (fecundity, oviposition, incubation, hatching success), related to *Cylas formicarius* (F.) reared and maintained on:
   a. Sweet potato (*Ipomea batatas* [Lam.]), Polemiales, Convolvulaceae
   b. Morning glory (*Ipomea learii* [Paxton]), Polemiales, Convolvulaceae
   c. Bay hops (*Ipomea pescapreae* [L.] [Sweet]), Polemiales, Convolvulaceae
3. Comparisons using the biological critera results for *Diaprepes abbreviatus* (L.):
   a. Favorite host (citrus) vs. incidental host (pigeon pea)
   b. Wild host (mother-of-cocoa) vs. cultivated host (citrus).
4. Comparison between the vagile and the sedentary weevils or the consequences of vagility.

A study of the preceding scheme showed that the vagile weevil was found on plants belonging to widely spaced orders, while the sedenrary weevil was found on plants of the same order and family.

In all cases, the plant hosts were arbusts or, at most, small trees, easily found in the vicinity of the university campus. To assure an ample supply of fresh plant material, arrangements were made to grow the plants in neighboring yards.

Diaprepes adults were collected at two experimental stations of the University of Puerto Rico where the insects had been reported in good numbers on a variety of hosts. They were transpotted in plastic containers with screen covers and fed the leaves of the plants on which they had been captured. The adults of *Cylas* were carefully extirpated from the stolons or tubers of the selected hosts.

The plastic containers were kept cool and upon arrival at the university were introduced in a constant-conditions chamber in which temperature was maintained at 75°F (23.8°C) and light programmed at 12 hours of light and 12 of darkness. The adults of *Cylas*, by copulating pairs, were introduced into plastic snapboxes covered with adhesive black plastic to simulate darkness. On the lower side of the snapboxes 6mm dia holes were drilled through which 7cm-long sections of stolons would be placed, wrapped in cotton to avoid damage. The free ends of the sections were placed in florists' waterpicks filled with 1% sucrose solution.

Probes for the two weevils were made simultaneously, and all fresh plant material was renewed every three to four days. As changes were made, observations were recorded.

RESULTS

The main objectives of the research project were largely fulfilled. Unforeseen difficulties could be overcome, thus a sizable amount of original data could be gathered. An aspect was added to the original layout which provided valuable information as to the annual cycle of infestation of the sugarcane weevil borer. It had been hypothesized that wild hosts carried over the infestation from one crop year to the next (more in the case of the vagile insect), residual populations surviving on the wild hosts scattered among the cultivated blocks.

The pattern turned out to be exactly that. In the case of *Diaprepes*, mother-of-cocoa was used as a typical wild host and morning glory in the case of *Cylas*. Eggs are laid by both insects in the known manners, the larvae drop to the ground and penetrate the soil, taking advantage of the spring rains (April, May) which loosen the soil surface and impart humidity. The sweet potato weevil is carried with the infested cuttings and, as the plants start to grow, first infest the stolons and later the starting tubers.

The criteria of comparison for fecundity, development and longevity were chosen as follows:

1. Total numbers of eggs laid throughout the residence of the insects in laboratory;
2. Duration of oviposition;
3. Daily rate of oviposition;
4. Average duration of oviposition;
5. Percent live larval births; and
6. Total days lived in the laboratory.

Although computer service was available for the statistical analysis of the data, it was decided to proceed the traditional way for the benefit of readers interested in statistical methodology. The method followed was that of unpaired observations of unequal variances. The hypothesis of equal variances was tried and then given up.

A "t'" was calculated according to a formula by Cochran and Cox (1957). The prime indicates that the criterion is not distributed as the Student's "t."

The few data obtained from the sweet potato weevil are related to the total of eggs laid in the laboratory, the duration of oviposition and the total of days lived in the laboratory.

CONCLUSIONS

1. The total number of eggs laid by *Diaprepes* on the wild host (mother-of-cocoa) does not differ significantly from the number laid on citrus, indicating that the two hosts are about equally suitable to the insect which, thus, can shift from one to the other without any significant change in the size of its populations. These are significantly enhanced coming from the wild to the cultivated host.
2. Citrus is therefore an excellent host species for *Diaprepes*. In fact, in Florida when the insect became established, it never attacked sugarcane, but became a serious pest of citrus. In agroecosystems of Puerto Rico this species may serve as a breeding site, maintaining the *Diaprepes* population at a high level. Pigeon peas, papaya and vegetables contribute presumably much less to the abundance of that insect.
3. Pigeon pea proved to be more suitable than the wild host, although not as good as citrus. It topped mother-of-cocoa for all the criteria considered (Table 6). It does not withstand well the attack of *Diaprepes*, and especially young plants may be severely damaged. The plant is very prone to develop fungi which will damage the eggs of the insect at an early stage.
4. Papaya is unquestionably a poor host and may contribute only little to the population of the insect. That host was worst for all the criteria considered.

TABLE 1. Biological criteria (fecundity, oviposition, incubation, hatching success) related to *Diaprepes abbreviatus* (L.) reared and maintained on orange leaves (*Citrus sinensis* [Osbeck]). Temperature 75°F (23.8°C), R.H. 80%.

	PCAIIa (11 Oct-) (29 Nov.) (1982)	PCAIIc (3 Nov.-) (3 Dec.) (1982)	PCAIIIc (7 Dec) (23 Feb.) (1982)	PCIId (3 Nov.-) (6 Dec.) (1982)	PCAIIId (7 Dec 82-) (26 Jan.) (1983)	PCAIIe (7 Dec.-) (31 Jan.) (1983)	PCAIIf (3 Nov.-) (15 Mar.) (1983)
1. Total eggs laid in laboratory	1616	144	230	225	655	274	1544
2. Duration of oviposition (days)	26	13	20	12	34	10	133
3. Average daily oviposition	10.26	11.07	11.50	18.75	19.26	27.40	10.80
4. Average duration of incubation	11.20	15.00	24.00	22.60	24.60	24.60	18.70
5. Number of live births	901	43	72	103	73	43	645
6. Percent hatch	55.75	29.86	31.30	42.70	11.14	15.60	11.70
7. Number days lived in laboratory	41	83	78	31	51	53	34

TABLE 2. Biological criteria (fecundity, oviposition, incubation, hatching success) related to *Diaprepes abbreviatus* (L.) reared and maintained on papaya (*Carica papaya* [L.]). Temperature 75°F (23.8°C), R.H. 80%.

	P-P-A to P-P-G (May 14, 1982)	P-P-A to P-P-G (July 2, 1982)	P-P-A to E (August 2, 1982)	P-P-A IIb (Oct 11 to Oct 28, 1982)
1. Total eggs laid in laboratory	659	779	467	369
2. Duration of oviposition (days)	-	-	-	10
3. Average daily oviposition	-	-	-	37
4. Average duration of incubation	25.5	29.3	17.2	16.1
5. Number of live births	158	127	57	229
6. Percent hatch	25.9	16.30	12.20	62.05
7. Number days lived in la laboratory	-	-	-	-

TABLE 3. Biological criteria (fecundity, oviposition, incubation, hatching success) related to *Diaprepes abbreviatus* (L.) reared and maintained on pigeon pea (*Cajanus indicus* [L.]) leaves. Temperature 75°F (23.8°C), R.H. 80%.

	PGAIIc (7 Oct.82) (25 Jan.) (1983)	PGAIId (18 Oct.-) (6 Dec.) (1982)	PGAIIId (6 Dec.-) (17 Jan.) (1983)	PGAIIIe (18 Dec.-) (23 Dec.) (1982)	PGAIIf (18 Oct) (11 nov.) (1982)	PGAIIg (18 Oct.) (3 Dec.) (1982)
1. Total eggs laid in laboratory	370	143	125	21	10	64
2. Duration of oviposition	74	19	13	2	7	17
3. Average daily oviposition	5	7.5	9.61	10.50	1.42	3.76
4. Average duration of incubation	19.06	14.75	15	16.50	:	16.50
5. Number of live births	69	42	3	8	4	28
6. Percent hatch	18.60	29.30	2.40	38.00	25.00	43.75
7. Number days of adult life in laboratory	-	-	-	-	-	-

TABLE 4. Biological criteria (fecundity, oviposition, incubation, hatching success) related to *Diaprepes abbreviatus* (L.) reared and maintained on "mother-of-cocoa" (*Gliricidia sepium*[Jacq.] Steud.). Temperature 75°F (23.8°C), R.H. 80%.

	(P-MR-A-1-a) (21 Oct.- 17 Dec) (1982)	(P-MR-II-c) (7 Dec 82-14) (March 1983)	(P-MR-II-d) (7 Dec 82-) (5 April 1983)
1. Total eggs laid in laboratory	149	955	385
2. Duration of oviposition	6	73	119
3. Average daily oviposition	24.80	13.08	3.23
4. Average duration of incubation	17.30	19.19	16.80
5. Number of live births	45	269	112
6. Percent hatch	30.20	28.16	29.90
7. Number days of adult life in laboratory	53	94	124

TABLE 5. "t" values of all the comparisons and their significance. Vagility and survival of *Diaprepes abbreviatus* (L.). Temperature 75°F (23.8°C), R.H. 80%.

Biological criteria	Host plant	tabulated t 5%	tabulated t 1%	Degrees of freedom	Calculated "t" Significance
I. WILD VS CULTIVATED HOST					
1. Total eggs laid in laboratory	Mother-of-cocoa[1]) Orange leaves[2])	2.36	3.49	3 7	1.99
2. Duration of oviposition period	Mother-of-cocoa) Orange leaves)	2.36	3.49	3 7	3.01*
3. Average daily oviposition	Mother-of-cocoa) Orange leaves)	2.36	3.49	3 7	3.10*
4. Average duration of incubation	Mother-of-cocoa) Orange leaves)	2.36	3.49	3 7	4.13*
5. Number of live births	Mother-of-cocoa) Orange leaves)	2.36	3.49	3 7	2.44*
6. Percent hatch	Mother-of-cocoa) Orange leaves)	2.36	3.49	3 7	4.33*
7. Total days lived in laboratory	Mother-of-cocoa) Orange leaves)	2.36	3.49	3 7	2.76*

* significant at 5% level; 1/ Gliricidia sepium (Jacq.) Steud 2/ Citrus sinensis Osbeck

TABLE 6. "t" values of all comparisons and their significance. Vagility and survival of *Diaprepes abbreviatus* (L.). Temperature 75°F (23.8°C), R.H. 80%.

Biological criteria	Host plant	Tabulated t 5%	Tabulated t 1%	Degrees of freedom	Calculated "t" and Significance
II. CULTIVATED VS CULTIVATED					
1. Total eggs laid in laboratory	Orange leaves) Pigeon pea)	2.36	3.49	7 3	2.44*
2. Duration of oviposition period	Orange leaves) Pigeon pea)	2.36	3.49	7 3	2.48*
3. Average daily oviposition	Orange leaves) Pigeon pea)	2.36	3.49	7 3	2.46*
4. Average duration of incubation	Orange leaves) Pigeon pea)	2.36	3.49	7 3	2.46*
5. Number of live births	Orange leaves) Pigeon pea)	2.36	3.49	7 3	2.46*
6. Percent hatch	Orange leaves) Pigeon pea)	2.36	3.49	7 ?	4.33*
7. Total days lived in laboratory	Orange leaves) Pigeon pea)	2.36	3.46	7 3	2.76*

*: significant at 5% level Orange: Citrus sinensis Osbeck Pigeon pea: Cajanus indicus L.

TABLE 7. Biological criteria (fecundity, oviposition, incubation, hatching success, longevity) related to the sweet potato weevil *Cylas formicarius* on sweet potato (*Ipomea batatas* [Lam.]).

	' 1 ' 2 ' 3 ' 4 ' 5 ' 6 ' 7 ' 8 ' 9 '10 '11 '12 '13 '14
1. Total eggs laid in the laboratory	1 1 1
2. Average duration of oviposition period	54 19 19
3. Total days lived in laboratory:	
Females	'253' '177' 253' 177253' 253' 127' 253' 253' 177' 223' 253' 253'
Males	'253' 253' 253' 177' '253' 253' 127' 253' 127' 253' 253' 177' 253'

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