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Authors: Hallman, Guy J., and Gould, Walter P.

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EVALUATION OF SUBTROPICAL AND TROPICAL FRUITS AS POTENTIAL HOSTS FOR THE SOUTHERN STRAIN OF PLUM CURCULIO (COLEOPTERA: CURCULIONIDAE)

GUY J. HALLMAN AND WALTER P. GOULD[1]
Subtropical Agricultural Research Center, USDA-ARS, 2413 E. Highway 83, Weslaco, TX 78596

[1]USDA-APHIS-PPQ, 4700 River Road, Unit 147, Riverdale, MD 20737

The host range of plum curculio, *Conotrachelus nenuphar* (Herbst), includes a variety of native and introduced rosaceous fruits in temperate North America, including *Prunus* spp. (stone fruits), *Crataegus* spp. (hawthorns), *Amelanchier* spp. (juneberries), and *Malus* spp. (apples) (Maier 1990). Larvae may also develop on rain-softened peach mummies caused by brown rot, *Monilinia fructicola* (Winter) Honey (Sarai 1969), or rosaceous plant tissue damaged by the diseases black knot, *Apiosporina morbosa* (Schw.) von Arx, or plum pockets, *Taphrina communis* (Sadelbeck) Giesenh. (Quaintance & Jenne 1912; Wylie 1966). The host range extends beyond the Rosaceae; plum curculio is an economic pest of blueberries, *Vaccinium* spp. (Ericaceae) and develops in gooseberries, *Ribes* spp. (Saxifragaceae) (Armstrong 1958). The pest has been observed to oviposit in a number of fruits in which larvae do not develop, and some rosaceous fruits are not hosts (Quaintance & Jenne 1912; Maier 1990). Adults prefer to oviposit in immature fruits that are a fraction of harvested size.

Two geographically overlapping strains of plum curculio are recognized; the northern is univoltine and undergoes obligate diapause, and the southern is multivoltine and undergoes facultative diapause. The two strains are somewhat reproductively incompatible (Padula & Smith 1971). Plum curculio is not found outside of its native geographical limits of North America east of the Rocky Mountains, save for a localized infestation of the northern strain in Box Elder County, Utah (D. Alston, pers. comm.). The southern limit of the plum curculio's range is about latitude 28 degrees north, which passes through mid Florida and southern Texas. These lowland areas are hot (>35°C) for several months of the year, which may be a factor in limiting its southern range. However, it is conceivable that the southern strain plum curculio might become established in more moderate tropical and subtropical regions of the world, particularly at higher altitudes.

The objective of this research was to offer southern strain plum curculio a broad taxonomic range of fruits found in the tropics and subtropics to gain insight into the possibility of it attacking other fruits if it became established in those regions.

Southern strain plum curculios were obtained from a colony at the United States Department of Agriculture, Agricultural Research Service facility in Byron, Georgia, that had originally been collected in the field near Gainesville, Florida, and had been in colony for about 10 yr. The insects were reared at about 25°C, 70% RH, on immature apples from Washington state that were picked when about 3 cm in diameter. Larvae emerging from the apples were placed on sterilized potting soil until adult emergence.

Ten 2-week-old adults of each sex were placed on 200-300 g of immature fruits listed in Table 1 for 3 days. Observations on feeding, oviposition, and mortality upon removal from the fruit were made. The fruits were held at about 25°C, 70% RH for 2 weeks after which they were examined for feeding damage and larvae. Feeding larvae were allowed to continue development. When they emerged from the fruit, larvae were placed on potting soil for pupation and adult emergence. Adults that developed on loquat were placed on immature apples for 3 days to see if the next generation would reproduce. Analysis of variance and Tukey's Multiple Comparison Test were done with Prism 3.0 (GraphPad Software, San Diego, CA).

Superficial feeding, but no oviposition, was observed on the stem wound of all fruit species. Of course, this type of feeding would not occur while the fruit was on the plant. Strong feeding occurred to apple, plum, and peach, hosts often requiring plum curculio control. Strong feeding was observed on the only other rosaceous fruit studied, loquat, and on passion fruit, a Passifloraceae (Table 1). Oviposition, assessed by opening suspected oviposition scars, was not observed on passion fruit. Because passion fruit suffered so much feeding, additional tests with 80 more adult plum curculios were conducted. The fruits in these additional tests suffered similar feeding damage, but no oviposition or larval damage was observed.

A considerable amount of feeding occurred on mango and Barbados cherry (Table 1), but no oviposition or larval damage was observed. Lesser amounts of feeding occurred on 11 other fruit species, while none (except for stem-end) was found on seven. No eggs were found on any of these fruits. There were no statistically significant differences in adult mortality upon removal from the hosts.

Larvae grew and developed to adults on all of the rosaceous fruits. The pest-host relationship between plum curculio and loquat is not well known; we know of no other studies of loquat as a

TABLE 1. FRUITS OFFERED TO PLUM CURCULIO AND MORTALITY OF ADULTS UPON REMOVAL

Fruit (Family)	Common name	Source[a] no. replicates	Fruit: Weight g (SEM)	Fruit: Diameter cm (SEM)	Feeding[b]	Mortality[c] upon removal % (SEM)
Mangifera indica L. (Anacardiaceae)	Mango	F3	144 (33)	5.6 (0.7)	much	1.7 (1.7)
Spondias purpurea L. (Anacardiaceae)	Red mombin	F3	8.3 (1.1)	2.2 (0.12)	some	3.3 (1.7)
Annona squamosa L (Annonaceae)	Sugar apple	F3	39.6 (21.8)	4.0 (0.9)	none	1.7 (1.7)
Cordia boissieri A. DC. (Boraginaceae)	Texas olive	T4	5.0 (3.1)	2.1 (0.39)	some	0
Ehretia anacua (T.&B.) Johnst. (Boraginaceae)	Sandpaper tree	T2	0.4 (0.09)	0.86 (0.1)	little	0
Carica papaya L. (Caricaceae)	Papaya	T4	31.3 (18.8)	3.6 (0.6)	v. little	7.5 (3.2)
Diospyros digyna Jacq. (Ebanaceae)	Black sapote	F3	60 (42)	4.9 (1.6)	none	0
Persea americana Miller (Lauraceae)	Avocado	F4	52.2 (32.7)	4.0 (0.95)	none	2.5 (1.4)
Malpighia glabra L. (Malpighiaceae)	Barbados cherry	F4	1.2 (0.67)	1.3 (0.27)	much	0
Eugenia uniflora L. (Myrtaceae)	Surinam cherry	F3	0.66 (0.27)	1.1 (0.17)	some	3.3 (3.3)
Psidium guajava L. (Myrtaceae)	Guava	T4	22.9 (5.0)	3.2 (0.2)	v. little	5.0 (2.0)
Syzygium jambos Alston. (Myrtaceae)	Rose apple	T3	9.6 (2.7)	2.6 (0.3)	v. little	5.0 (5.0)
Averrhoa carambola L. (Oxalidaceae)	Carambola	F3	6.8 (6.3)	2.4 (1.1)	none	2.5 (2.5)
Livistona chinensis (Jacq.) R. Br. ex Mart. (Palmae)	Chinese fan palm	T4	1.6 (0.3)	1.2 (0.09)	v. little	2.5 (1.4)
Passiflora edulis Sims. (Passifloraceae)	Passion fruit	T4	46.5 (9.8)	4.8 (0.3)	strong	5.0 (2.0)
Eriobotrya japonica Lindl. (Rosaceae)	Loquat	T4	8.9 (1.9)	2.4 (0.14)	strong	1.3 (1.3)
Malus domestica Borkhausen (Rosaceae)	Apple	W4	12.9 (1.9)	2.8 (0.3)	strong	2.5 (1.4)
Prunus domestica L. (Rosaceae)	Plum	V4	9.6 (1.9)	2.3 (0.2)	strong	13.8 (2.4)
P. persica (L.) Batch (Rosaceae)	Peach	V2	20.5 (4.4)	3.1 (0.2)	strong	10.0 (0)
Casimiroa edulis Llave & Lex. (Rutaceae)	White sapote	F3	31.2 (11.3)	3.7 (0.5)	some	3.3 (1.7)
Citrus sinensis (L.) Osbeck (Rutaceae)	Orange	T4	34.5 (15.3)	4.0 (0.6)	none	11.3 (9.7)
Litchi chinensis Sonn. (Sapindaceae)	Lychee	F3	10.9 (2.5)	2.5 (0.15)	none	3.3 (1.7)
Pouteria campechiana Baehni. (Sapotaceae)	Canistel	F3	171 (63)	6.8 (1.0)	some	3.3 (1.7)
P. sapota (Jacq.) HE Moore & Stearn (Sapotaceae)	Mamey sapote	F3	202 (285)	5.7 (2.8)	none	6.7 (3.3)
Solanum pseudocapsicum L. (Solanaceae)	Jerusalem cherry	T4	0.36 (0.09)	0.9 (0.08)	v. little	5.0 (5.0)

[a]Source: F, USDA-ARS Subtropical Horticulture Research Station, Miami, Fla.; T, USDA-ARS Subtropical Agricultural research Center, Weslaco, Tex., except for loquat, which was from nearby McAllen, Tex.; V, USDA-ARS Appalachian Fruit Research Station, Kearneysville, W. Vir.; W, USDA-ARS Yakima Agricultural Research Laboratory, Wapato, Wash.

[b]Feeding: descriptive classes in descending order of damage: strong (typical damage to known good hosts), much (considerable damage, but noticeably less than strong), some (noticeable, but limited, feeding on a few of the fruits), little (damage less than some), v. little (small and very few feeding holes on peel), none (only some superficial feeding on stem end wound).

[c]Mortality: $P = 0.30$, $F = 1.179$, $df = 24, 59$ (no significant differences).

TABLE 2. MEAN NUMBERS AND WEIGHTS OF LAST INSTAR LARVAE EMERGING FROM HOSTS OF PLUM CURCULIO INFESTED BY 10 PAIRS FOR 3 DAYS.

Host	Larvae emerged (SEM)	Larval weight mg (SEM)
Apple	10.5 (1.7)	18.4 (0.4) a
Peach	11.5 (3.5)	16.3 (0.3) ab
Loquat	4.5 (0.6)	14.0 (0.7) bc
Apple[a]	—	14.0 (1.0) bc
Plum	8.0 (2.2)	12.5 (0.6) c

Means in the same columns are not different ($P = 0.05$) if followed by the same letter (Tukey's Multiple Comparison Test). No significant differences for numbers of larvae emerged.

[a]Parent generation reared on loquat; different number of adults used; no direct comparison of larvae emerged made.

host of plum curculio. Loquat is indigenous to southeastern China and possibly southern Japan; today it is found throughout the tropics and subtropics. In the continental U.S., loquat fruits as far north as about the geographical limit of plum curculio in Florida and in southern Texas and California. The tree will grow, but not set fruit, farther north into the range of southern strain plum curculio. The occurrence of this fruit and other rosaceous fruits in the highland tropics and subtropics shows that potential hosts of plum curculio exist in these regions. Maier (1990) found that northern strain plum curculio infestations were greater in exotic than native hosts. There were no significant differences in numbers of larvae produced per 10 pairs of adult plum curculio per 3 days among the 4 rosaceous hosts ($F = 2.7$, $df = 3, 10$, $P = 0.11$). Larvae reared on apple and peach were significantly heavier than those reared on loquat and plum ($F = 13.9$, $df = 4, 13$, $P = 0.0001$) (Table 2). Mean larval weight for plum curculio reared on apple from adults reared on loquat (14 g) was significantly lower than when both generations were reared on apple (18.4 g). Rapid drying of the immature loquats and plums may have contributed to less favorable conditions for larval development than experienced with immature apples and peaches, which remained moist throughout larval development. But there is no explanation for why larvae reared on apples from adults that were reared on loquats weighed significantly less.

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SUMMARY

Southern strain plum curculio, *Conotrachelus nenuphar* (Herbst), was offered 22 immature tropical and subtropical fruits from 16 families to explore its possible host range outside of temperate regions. It fed to varying degrees on the different fruits, but oviposited and completed development only on rosaceous fruits (apple, plum, and peach), including loquat, *Eriobotrya japonica* Lindl.

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